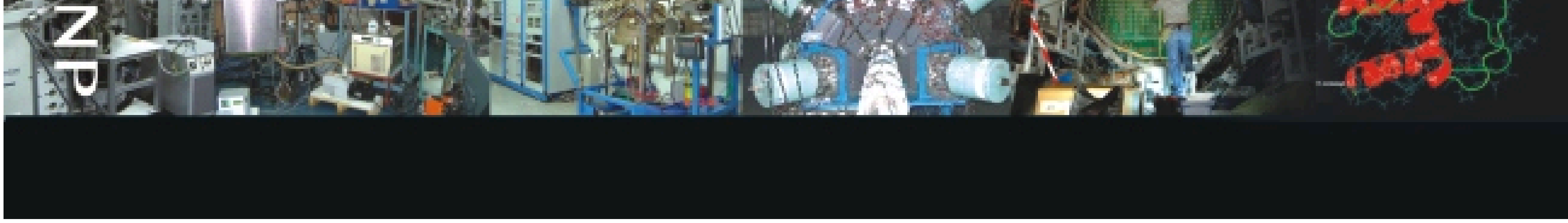
TRIENNIAL REPORT
2007-2010

Saha Institute of Nuclear Physics
Kolkata



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SINP

Contents

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Contents

Foreword

We are celebrating Diamond Jubilee year of our institute. Our institute was formally inaugurated by Nobel Laureate Madame Irene Joliot-Curie on 11th January 1950. Professor Meghnad Saha – the founder and a visionary scientist wanted this institute to be multidisciplinary in nature and "decided to concentrate" on the subjects of (a) Particle Accelerator, (b) Nuclear Physics Proper, (c) Electronics and Radio Instrumentation, (d) Neutron Physics, (e) Nuclear Chemistry and (f) Theoretical Nuclear Science. Right from the inception the institute started setting up state-of-the-art experimental facilities to carry out basic research in Physics, Chemistry and Biology - Cyclotron and Transmission Electron Microscope were set up first in our country. Professor Saha also wanted to set up an 'electron synchrotron' in the institute way back in 1956 - we are proud to be associated with the name of this visionary scientist.

At present we are working on FIVE broad subject areas (a) Experimental Nuclear and Particle Physics, (b) Condensed Matter Physics including Surface Physics and Nanoscience, (c) Plasma Physics, (d) Biophysical science including chemistry and (e) Theoretical Physics including Mathematics. We have just completed "Science Review" process for the first time on all these subjects with renowned scientists from India and abroad (refer the list of names in the report) to evaluate ourselves and to decide 'inclusive' growth directions of our institute. I would like to express my personal gratitude to all the members of the five 'review committees' for spending their valuable time for the growth of our institute. Substantial amount of research publications are being made in top-ranking international journals on the work done in our institute. From this TRIENNIAL REPORT we have decided to include only published research work and related developmental work in our annual reports. Professor Abhijit Chakrabarti and other members of the editorial board have done enormous amount of work to bring out this volume in time – I would like to congratulate them. As this report is being published after three years, we have decided to include the present administrative structure of the institute as well.

It should be mentioned here that President of our country Smt. Pratibha Devisingh Patil and Minister for Science & Technology and Earth Sciences, Government of India Shri Prithviraj Chavan visited our institute recently. Three Nobel Laureates, Professor Carlo Rubbia, Professor Anthony J. Leggett and Professor Klaus van Klitzing, also visited our institute to deliver Meghnad Saha Memorial Lectures. Finally I would like to thank the Chairman and Members of the 'Governing Council' of our institute that supported us in taking several important steps to improve academic environment of our institute. Apart from 'Science Review', these steps include open rolling advertisement for faculty positions, entry of large number of research students through selection centres in major cities of India and substantial increase in research funding. I am quite sure that 'science output' and 'visibility' of our institute will increase substantially in coming years - all the employees is striving hard to make this institute one of the best place of 'learning' internationally.

Milan K. Sanyal
Director

31, December 2010

From the desk of the Editorial Team

The annual reports of Saha Institute of Nuclear Physics for the last three years (2007-2010) are published as a single volume. The reports for previous years remained pending for various reasons beyond our control. The nature of research work and developmental activities carried out during this period for a multi-disciplinary institute like ours is naturally voluminous in number and wide in spectrum. In order to accommodate the accomplished research work, the editorial team collated the research papers published by our institute members during the period from April 1, 2007 to March 31, 2010 in journals enlisted in the ISI Web of Science. Each document in the research activities section for each of the five major areas of research pursued at Saha Institute of Nuclear Physics contains title of the paper, summary of the work as described in the abstract, and list of authors for each paper. The corresponding reference is given in the list of publication appended for each research area.

Needless to say that research at SINP and other academic institutes are enriched by collaboration across the boundaries of divisions and institutes. Accordingly, the authors' lists on many of the research activities include researchers belonging to other institutes. It has not been possible to publish the very long list of collaborators along with their affiliations this time for the triennial report, as we realize that it would be prone to many errors. We will certainly look into it in future. For convenience of reference, the names of external collaborators are marked with dagger (†) in the research activities section. Affiliation of the external collaborators could be found by looking at the authors list in the publication.

The editorial team wishes to thank all the institute members for their input, support and feedback on the triennial report.

31, December 2010

Senior faculty members of SINP and other dignitaries
with the honorable President of India

Honorable President in the Structural Genomics Laboratory

Director , Prof. Milan K Sanyal felicitating the honorable President

Honorable former minister of Science and Technology, Prithviraj Chavan and Chairman,
Atomic Energy Commission, Dr. Srikumar Banerjee visiting Angle Resolved Photoemission Spectrometer

Dr. Anil Kakodkar, former Chairman, Atomic Energy Commission watching the Science Gallery

Prof. Carlo Rubbia, Nobel Laureate after delivering the 45th Saha Memorial Lecture. Beside him standing is Prof. Bikash Sinha, former Director, SINP

Honorable members of SINP Governing Council

Prof. Sidney Nagel delivering J.C Bose Lecture

Dr. Srikumar Banerjee and Prof. Milan K Sanyal addressing the Press after 60th Foundation Day celebration beside them is Dr. R.K. Bhandari, Director. VECC

Poster & Exhibition during Outreach Program on the Large Hadron Collider

Prof. Antony Leggate, Nobel Laureate is being felicitated by the Director after delivering 48th Saha Memorial Lecture

Prof. Ruz Altaba delivering a colloquium

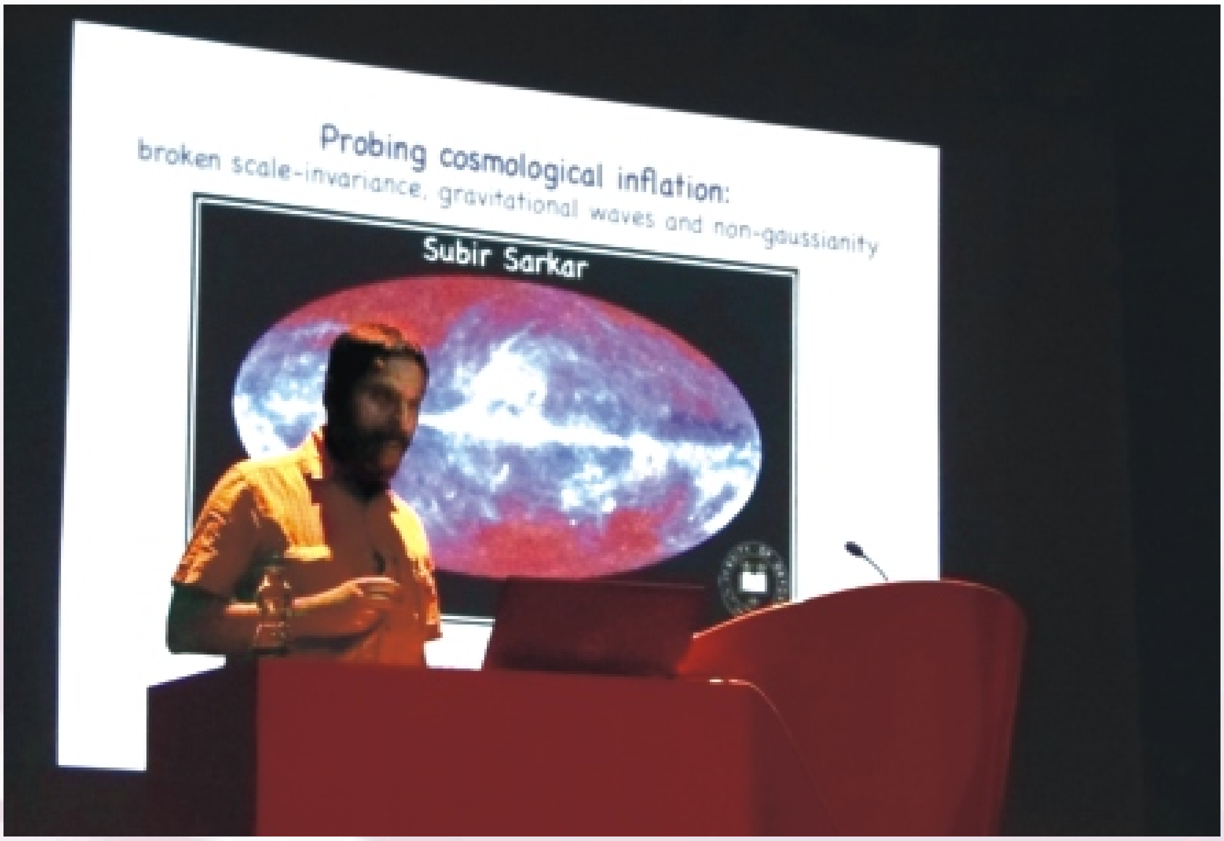
Prof. Sir Michel Pepper delivering 46^{th} Meghnad Saha Memorial lecture

Prof. M Vijayan during a poster session

Prof. Peter Littlewood delivering a colloquium

Audience listening to the colloquium lecture of Prof. Akira Ishiama

Prof. Gilles de France delivering a colloquium

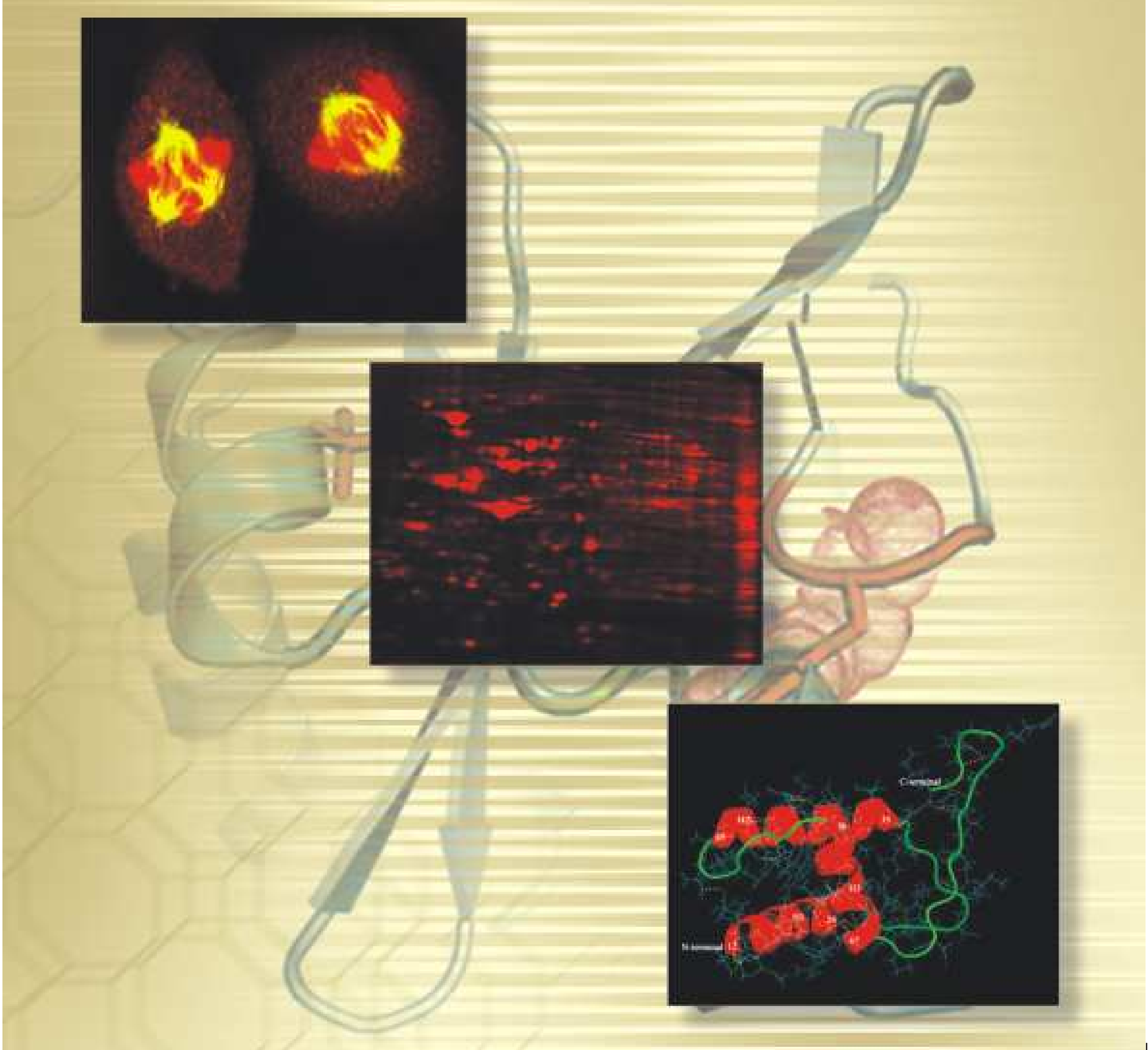


Prof. Subir Sarkar delivering a colloquium

Prof. Tony Noble delivering a colloquium

Prof. Peter Weisz delivering a colloquium

Biophysical Sciences Including Chemistry



Griper

1 Biophysical Sciences Including Chemistry

Summary of Research Activities of Divisions

Biophysics

The research activities in Biophysics Division spans both experimental and *in silico* biology. The specific areas are as follows: Chemical and Structural Biology, Biomolecular Spectroscopy, Structural Bioinformatics and Computational Chemistry and Microbiology. Some of the research activities have collaborative components.

Chemical and Structural Biology:

Small molecules from natural and synthetic sources have long been employed as human medicine. In the last three years chemical biology of two classes of small molecules with therapeutic potential has been studied. The first type includes DNA binding molecules which function at the chromatin level modulating DNA templated phenomena and inhibition of (core) histone modification enzymes. The studies on the second class of molecules have been aimed to explore alternate intracellular targets for generic drug(s). In this class of anticancer antibiotics, mithramycin and chromomycin, have been shown to possess potential for chelation therapy arising from their bivalent metal ion binding potential. The antibiotic(s) inhibit the activity of metalloenzymes like alcohol dehydrogenase, alkaline phsphatase, beta metallolactamase and superoxide dismutase.

In the area of structural biology two problems are being addressed. Sanguinarine and ellipicin are two putative anticancer agents. They bind to human telomere sequence forming quadruplex DNA. Telomeric sequences are short stretches of guanine (G)-rich DNA that occur at the termini of chromosomes and play an important role in chromosome duplication and are attractive targets for anticancer drugs. The structural modulation induced by these agents upon the quadruplex structure and the associated energetics are being investigated. The results show that sanguinarine (SGR) exhibits two distinct interactions with human telomere d[(TTAGGG)4] (H24) in presence of K+. Up to about 1:2 molar ratio of H24:SGR, two molecules of SGR bind H24. Above this molar ratio, SGR induces a conformational transition in H24 from the K+- form to the Na+- form. The demonstration of drug-induced conformational transition in a G-quadruplex formed by a human telomeric sequence would provide new insights into interaction of the drugs with quadruplex DNA structure.

Biomolecular Spectroscopy :

The Biomolecular Spectroscopy laboratory focuses on biophysical and relevant biomedical applications. During 2007-2010, the research in this laboratory was directed toward exploring target binding and nanoencapsulation of some natural product based drugs. We have pioneered novel uses of the exquisitely sensitive 'two color' intrinsic fluorescence of therapeutically important plant flavonoids (which are effective against free radical mediated and other diseases, including atherosclerosis, ischemia, cancers, diabetes, viral diseases etc) to explore their interactions with macromolecular targets , and with model as well as natural membranes. The encapsulation of these compounds (which have poor solubility in water, which restricts their bioavailability) in cyclodextrin based 'nanovehicles' for drug deliverywas explored. Using the novel fluorescence based approach, target binding sites of the flavonoids together with binding constants/ partition coefficients were successfully determined. Binding of flavonoids were found to have significant protective (antioxidant and antihemolytic) effects in RBC membranes, which crucially depend on their locations (inferred from fluorescence studies) in the membrane matrix. Several flavonoids were found to bind normal human hemoglobin with different affinities, and prevent hemoglobin glycosylation (which is a major complication of diabetes mellitus). Steady state and time resolved fluorescence studies were performed to explore the qualitative as well as quantitative aspects of hemoglobin-flavonoid and serum albumin-flavonoid interactions. As part of the research on developing efficient drug delivery strategies, fluorescence, along with other related spectroscopic techniques (electronic absorption and circular dichroism), as well as theoretical (molecular docking) studies were employed to understand the encapsulation of various therapeutically important flavonoids and serotonin (a monoamine neurotransmitter); such studies revealed the superiority of some of the chemically modified derivatives of beta cyclodextyrin as a drug carrier, compared to natural beta cyclodextrin.

Structural Bioinformatics and Computational Chemistry:

In order to understand base sequence dependent DNA structural rigidity quantum chemical potential energy surface of DNA base pair stacking by varying different relative orientation parameters between successive base pairs are being explored using Density Functional Theory. We are also characterizing potential energy surface of DNA and RNA in torsion angle hyperspace. We have adopted a special technique of molecular dynamics to simulate polymeric DNA double helices and showed its applicability to emulate the true polymeric nature of DNA, in terms of regularity of structural parameters. This technique would be utilized to understand effect of base sequence, temperature and ligand in DNA structure and flexibility. Different types of base pairs have been found to be extremely important in structure, stability and function of most RNA molecules. We are analyzing origin of such structural variability of RNA base pairs by quantum chemical calculations and molecular dynamics simulation studies.

Microbiology:

In continuation of the previous work on the effect of turmeric extracts in bacterial system, which revealed both genotoxic as well as radio-protective properties, attempts were made to look into the conditions under which the expression of these two altogether different properties take place in a bacterial system subsequent to a radiation exposure. It was found that these two properties were selectively expressed into the bacterial system depending on the nature and extent of DNA damage inflicted in the system. Studies on the effect of four other spices in a bacterial system are also being undertaken.

The studies on the environmental impact on Rhizobium sp. cells revealed that different fertilisers and pesticides have detrimental effect on growth and ultra structure of Rhizobium sp. cells in liquid culture medium.

Crystallography & Molecular Biology

Members of the Crystallography & Molecular Biology (C&MB) Division are engaged in broader research areas of (a) macromolecular crystallography and (b) cellular and molecular biology for understanding biological processes in cancer, infectious diseases and Huntington's disease (HD). In macromolecular crystallography, the major activities center on cloning, expression, purification, crystallization and determination of protein structures using X-ray diffraction and other spectroscopic techniques. Structure based protein engineering approaches have been used to enhance the stability and to impart collagenolytic activity in papain, and enhance catalytic efficiency of ervatamin-C, a thermostable protease belonging to the papain family. Protein structures complexed with the substrates/inhibitors/ drug have also been solved. Various cell and molecular biology techniques are used to decipher the signaling pathways in *Entamoeba histolytica*, mRNA turn over in *Leishmania donovani* and telomerase regulation in mammalian cells in culture. Similar techniques are used to determine mechanism(s) of transcriptional deregulation either by HIPPI or by deregulation micro RNA in HD model.

Macromolecular crystallography

Cloning, expression, purification and preliminary X-ray diffraction analysis of Psu, an inhibitor of the bacterial transcription terminator Rho and CheY3, a response regulator that directly interacts with the flagellar 'switch complex' in Vibrio cholerae have been reported. Through crystal structure and biochemical studies on three chimeric proteins ECI (L)-WCI(S), ETI(L)-WCI(S), and STI(L)-WCI(S), where the inhibitory loop of ECI, ETI, and STI is placed on the scaffold of their homolog WCI, a set of novel scaffolding residues have been identified that remotely controls the inhibitory property so much so that a set of loop residues (SRLRSAFI) offering strong trypsin inhibition in ETI, act as a substrate when they seat on the scaffold of WCI *i. e.* in ETI(L)-WCI(S). Absence of these three novel scaffolding residues Trp88, Arg74, and Tyr113 makes the inhibitory loop flexible in ETI(L)-WCI(S) leading to a loss of canonical conformation, explaining its substrate-like behavior. Incorporation of this barrier back in ETI(L)-WCI(S) through mutations increases its inhibitory power, supporting our proposition. Analysis of the structure of NP24-I, a thaumatin-like protein, explains its glucanase and allergenic properties. Structures of cyclophilin from *Leishmania donovani* at 1.97 Å resolution and the complex of cyclophilin with cyclosporin at 2.6 Å resolutions have been solved.

Crystal structures of two papain-like cysteine proteases ervatamin-A and ervatamin-C, complexed with an irreversible inhibitor, together with enzyme kinetics and molecular dynamic simulation studies are reported. Comparisons of these results with the earlier structures solved from this division, indicates a higher enzymatic activity of ervatamin-A, which can be explained from the three-dimensional structure of the enzyme and in the context of its helix polarizibility and active site plasticity. Simple and efficient expression and purification procedure to obtain a yield of active recombinant papain, a plant cysteine protease, which is the highest reported so far for any recombinant plant cysteine protease, was developed. A structure-based rational design approach has been used to improve the thermostability of papain, without perturbing its enzymatic activity, by introducing three mutations (K174R, V32S and G36S) at its interdomain region. A double (K174RV32S) and a triple (K174RV32SG36S) mutant of papain have been generated, of which the triple mutant shows maximum thermostability with the half-life (t(1/2)) extended by 94 min at 60 degrees C and 45 min at 65 degrees C and the temperature of maximum enzymatic activity (T(max)) and 50% maximal activity (T(50)) increased by 15 and 4 degrees C, respectively compared to the wild type (WT).The values of t(1/2) and T(max) for the double mutant lie between those of the WT and the triple mutant. These results have been substantiated by molecular modeling studies.

Cell biology and Molecular Biology

Stress related signaling in Entamoeba histolytica

Survival strategies of the parasite *Entamoeba histolytica*, the causative agent of amoebic dysentery, are important in the propagation of the disease. We observed that heat stress does not cause cell death but hydrogen peroxide stress induces cell death in the parasite. Investigations also revealed that the only typical MAPK in the Entamoeba genome, identified and characterized earlier by us, was activated by stresses the parasite can withstand but not by lethal stresses. The activation mechanisms of EhMAPK in terms of autophosphorylation and substrate phosphorylation were characterized. Another key protein kinase from *E. histolytica*, a p21 activated Kinase (EhPAK3), was identified and characterized. The EhPAK3 enzyme was localized in the caps of parasite membranes during capping, a process the parasite may use during evasion of the host immune mechanism.

Regulation of mRNA turnover in *Leishmania donovani*

We characterized a multi-domain protein LdCSBP from *Leishmania donovani*, which interacts with RNA containing the (C/A)AUAGAA(G/A) motif in the UTR of S phase specific mRNAs through its unique CCCH-type Zn-finger motifs. This protein possesses RNA endonuclease activity, which is down regulated due to its ubiquitination, suggesting a novel regulatory mechanism of mRNA turnover through the post-translational modification in *Leishmania donovani*.

Cancer Biology: Effects of natural products on the pro-survival signal transduction pathways

We observed that some of the signaling pathways associated with the anti-apoptotic effects of oxidative stress and heat stress were common but there were important divergences in the activation of signaling pathways caused by the two forms of stress. The key controlling element for regulation of survival genes in chronic heat/H_2O_2 stress was found to be p38MAPK. We also observed that Resveratrol, a phytoallexin, when used simultaneously with the stress exposure can impede the anti-apoptotic pathways activated by stress and inhibit the activities of the survival kinases p38MAPK and Akt. We demonstrated that Resveratrol downregulated a survival gene Hsp70 and induced apoptosis in chronic myeloid leukaemia cells K562. The involvement of upstream Akt and ERK1/2 pathways in the transcriptional regulation of Hsp70 were elucidated.

Studies of J-domain containing proteins in mammalian stress response and cell cycle regulatory pathways

Human J-domain containing chaperonin Mrj was shown to be upregulated in mitosis phase of cell cycle implicating its role in mitosis. Interestingly, the protein is dispersed throughout the cell during late mitosis and is localized in the nucleolus during interphase, confirming that the activity of Mrj is regulated by its cell cycle specific expression together with its differential sub cellular localization.

Telomerase regulation and apoptosis induction by the inhibitors of poly (ADP-ribose) polymerase

Inhibitors of poly(ADP-ribose) polymerase (PARP) reduce telomerase activity and induce apoptosis in cultured cells. Reduction of expression of PARP-1 by siRNA increased cellular NAD(+) level, decreased general poly(ADP-ribosyl)ation of proteins and telomerase activity. Telomerase reverse transcriptase (hTERT) was poly(ADP-ribosyl)ated in HeLa cells and such modification was decreased in cells with reduced PARP-1 expression. In addition, the expression of telomerase-associated protein 1 (TEP1/TP1) subunit of human telomerase holoenzyme reduced significantly in PARP-1 knock down HeLa cells.

Huntingtin interacting protein HYPK and HIP1: possible role in HD pathogenesis

HYPK, known to interact with hutingtin (HTT) is characterized to be an "intrinsically unstructured protein", posses chaperone like activity in vitro and in vivo, reduces mutant HTT aggregates and the toxicity in cell model of HD. HIP-1, another HTT interacting protein that interacts with HIPPI is required for translocation of HIPPI into the nucleus from cytoplasm. Nuclear HIPPI then interacts with specific motif present at promoter sequences of capase-1 gene through R393 and regulates expression of caspase-1 and other genes. Among many micro RNA altered in the cell model of HD, down regulated miR-146a targets HTT interacting protein TBP.

Structural Genomics

The Structural Genomics Division was constituted in May 2010 with the objective to carry out basic and applied research to understand the underlying mechanism of human diseases. Starting initially as a Section in the Xth Plan period, the first proteomics laboratory in eastern India and one among the few labs in the country was established in 2005. Currently, the division is primarily carrying out research in two major areas - hematological disorders and neurodegenerative diseases. The widely prevalent disease of eastern India, β-thalassemia along with, sickle cell anemia, hereditary spherocytosis and leukemia are being studied as a model for hematological disorders while Alzheimer's, Huntington's, and the prion diseases are being studied for the neurodegenerative diseases.

Hematological Disorders:

Red cell diseases e.g. thalassemia, other types of hemolytic anemia and different categories of haematological malignancies have been the main focus of some of our members. Studies on folding of heme proteins in presence of erythroid spectrin led to discovery of chaperone-like activity in spectrin. Differential interactions of HbE and HbA with erythroid spectrin have been shown to be implicated in β- & HbEβ-thalassemia. Greater losses of phosphatidylserine (PS) asymmetry and cell surface glycophorins were observed in younger erythrocytes compared to the aged ones in thalassemia, hereditary spherocytosis and haemolytic anemia compared to the normal red cells in circulation. Such drastic loss of PS asymmetry leads to faster eryptosis, mediated by shedding of glycophorin-containing microvesicles leaving highly PS exposed erythrocytes accessible to the phagocytes. Over the years our members have characterized and annotated about 100 proteins from the erythrocytes of peripheral blood using two dimensional gel electrophoresis based separation followed by MALDI/ToF/ToF tandem mass spectrometry. Differential regulation of redox proteins e.g. PRDX2, SOD, and chaperones e.g. AHSP and Hsp70 in erythrocyte proteomes for HbEβ-thalassemia and membrane associated proteins, Flotilin 1, β-spectrin & dematin in HbE?-thalassemia with unique appearance of calpastatin in hereditary spherocytosis were demonstrated.

In order to design an effective method to eliminate leukemic cells, an episomal vector was designed to synthesize siRNA for the BCR-ABL gene to target CD34+ hematopoietic stem cells isolated from CML patients. In order to understand how the leukemic cells evade the immune surviellance, transcriptional downregulation of MHC genes were observed. Specific transcription factors that regulate the expression of MHC enhanceosome viz. CIITA, RFX, NF-Y etc. were therefore cloned and expressed to elucidate their role in immune evasion. Our studies in cell proliferation and differentiation have implicated the role of self renewal pathways and cross talk between the cell signalling pathways in chronic to blast transformation of CD34+ CML stem cells isolated from patients. Moreover, we have established that cytoplasmic sequestration of the cell cycle inhibitor, p27 leads to its interaction with polycomb group of genes (Bmi1, EZH2) and activation of the Rho/Rac GTPase pathway resulting in actin depolymerization which in turn causes cellular egression/ mobilization from the bone marrow. Currently this pathway is also being investigated in understanding the process of metastasis in epithelial cancer using in vitro matrigel assay.

Neurodegenerative Diseases:

Among the various diseases that affect the nervous system, some of the most debilitating are neurodegenerative disorders such as Alzheimer's, Huntington and Prion Disease. These late onset, but eventually fatal diseases are all caused by altered metabolism of individual proteins that interfere with normal cellular homeostasis. The normal 'life cycle' of a protein characterized by its biogenesis, trafficking and degradation are deviated in these disorders resulting in misfolding, misprocessing or mislocalization of the protein. Most likely, the aberrant protein can then engage in atypical interactions and ultimately lead to a series of unknown events culminating in cell death. The major focus of our research in Alzheimer's disease (AD) is to study the downstream pathogenesis of the disease, mediated through AICD and its adaptor network. AICD possesses many conserved motifs that are now known to interact with cytosolic "adaptor" proteins and these interactions in turn affect different signaling pathways. We have shown that Grb2, one such adaptors, interact with AICD in late endosomal compartments. The excess protein, thus entrapped, could be degraded by autophagy. The structure of AICD-YENPTY motif takes a different conformation in presence of its binding partner Grb2-SH2 vis- a-vis that of other AICD structures. Currently our members are interested in understanding the molecular pathways that lead to the extensive neuronal death in late-onset prion disease too.

Chemical Sciences

Faculty members of Chemical Sciences Division work on topics covering a somewhat broad area, such as biophysical chemistry including protein folding and molecular mechanism of action of drugs (NSAIDs), photophysics and photochemistry of small organic molecules and biomolecules, synthesis and characterization of conducting polymers and nanocomposite materials, and nuclear and radiochemistry.

Protein Folding, Misfolding and Aggregation

The folding/unfolding behaviour of the intrinsically unstructured proteins, caseins, was studied as a function of pH and temperature and in presence of surfactants and metal ions. Caseins, which are 'intrinsically unstructured' in the native state, were shown to adopt partially folded structures on binding with μM concentrations of Zn^{2+} and Al^{3+}. Their chaperonic activity was also found to be severely inhibited by binding with the metals. The conformational tendencies and cellular toxicity of synthetic peptides, which mimic the polyalanine segments of the disease-related protein PAPB2, were studied as a function of the number of alanine repeats to elucidate the mechanism behind protein aggregation. It was found that β-sheet formation was the most likely trigger for the aggregation process, which occurred for peptides with more than ten alanine repeats, and for the highly enhanced cellular toxicity of those peptides. Incubation of the peptides at high pH (>10) or in aqueous mixtures of simple (MeOH, EtOH) or fluorinated (TFE, HFIP) alcohols led to formation of well defined fibrils via the nucleation-controlled polymerization pathway, as indicated by the measured time and concentration dependence of the process. The fibrils, in turn, formed fractal-like superstructures on precipitation from solution, raising the possibility of growing novel peptide-based materials. In another study on the effect of glycation on hemoglobin structure, reduction of native α-helix structure and concomitant growth of β-type structure was shown to correlate with the extent of glycation damage (including aggregation).

Molecular mechanism behind new functions for the commonly used painkillers, NSAIDs

Although the principal function of Non Steroidal Anti-Inflammatory Drugs (NSAIDs) is to combat pain and inflammation, they show other functions, e.g. chemoprevention and chemo-suppression against different cancers, protection against neurodegenerative diseases, UV photo-sensitization and UV photoprotection. To elucidate the poorly understood molecular mechanism behind these diverse functions, the following studies are being pursued:

a) Spectroscopic characterization of NSAIDs in different environments to enable the use of their spectral properties as intrinsic reporters of their interaction with different biomolecules.

b) Interaction of NSAIDs with membrane mimetic systems/membranes.

c) Effect of NSAIDs on mitochondria and its consequences on downstream apoptotic signaling, since mitochondrial outer membrane permeabilization is a strategy for chemotherapy.

d) Interaction of NSAIDs with lipid monolayers to understand the physical reason behind the perturbing effect of these drugs on monolayer geometry.

e) Possible biological applications of complexes of NSAIDs with bioactive metals.

Some important results emerging from these studies are:

a) The oxicam NSAIDs, viz. piroxicam, meloxicam and tenoxicam, can cause membrane fusion in absence of any other fusogenic agents even at the very low drug/lipid ratio of 0.018. This is very interesting since such small drug molecules cannot rely on conformational reorganization to drive membrane fusion, an advantage shared by the most common fusogenic agents, viz. proteins/ peptides. The detailed mechanism behind this phenomenon, including the effect of different physical and chemical parameters of the drugs and the participating lipids, is being deciphered.

b) Indomethacin, a traditional painkiller, can probe structures of local clusters in binary mixtures of primary alcohols and water.

c) Cu(II) complexes of some oxicam NSAIDs can directly bind to the DNA backbone.

Photoinduced molecular phenomena probed by spectroscopy and magnetic field effect

Photophysical and photochemical studies were performed on (i) inter- and intra-molecular electron/proton transfer and hydrogen abstraction reactions with small chemically and biologically important molecules and (ii) interactions of small drug-like molecules with proteins and DNA bases in homogeneous and heterogeneous confined media. Steady-state and time-resolved spectroscopic techniques, magnetic field effects and theoretical modeling were employed. Experiments were designed to unravel some of the physical aspects, mainly the role of structure of participating molecules and the solvent matrix, in these reactions. In keeping with current interest in drug-DNA and drug-protein interactions, studies were extended from small organic molecules to some model biomolecules. Experiments with polymeric film grafted with suitable chromophore provided a mimic situation of solid phase interactions. Although steady-state and time-resolved absorption and fluorescence help to identify steady-state products and transient intermediates respectively, the presence of magnetic field enables identification of the initial spin state (one of the deciding factors for ultimate products) as well as assessment of the intermediate distance in geminate spin-correlated radical ion pairs/ radical pairs produced as transients (very useful for studying 'distance-dependent' interactions in biomacromolecules). For the field-dependent studies, a setup was fabricated which could generate a DC/AC magnetic field of ~0.1 tesla with phase sensitive detection (S/N ~1000:1) to monitor the enhancement of fluorescence intensity and free ion formation in the presence of magnetic field. The time resolution of these measurements will be improved from the present nanosecond to the picosecond level to identify and characterize the photoinduced intermediates more precisely.

Transport and Electronic Properties of Conducting Polymers and Nanocomposites

A set of poly-3,4 ethylenedioxythiophene (PEDOT) samples were synthesized by varying the oxidizing agent and its molar ratio with the monomer. The temperature dependence of their conductivity is in excellent agreement with that in the model prescribed by Aharony et al., which predicts a smooth crossover from the Coulomb-gap dominated variable-range hopping (VRH) at low temperatures to Mott's 3d-VRH at high enough temperatures. Electrical transport and magnetic properties of conducting polymer nanocomposites of PEDOT and different ferrite (Fe_3O_4, $NiFe_2O_4$, $CoFe_2O_4$) nanaoparticles were studied. The samples were characterized by TEM, XRD and TGA. Electrical, thermal and crystalline properties of the pure PEDOT were found to have improved after composite formation. In the temperature range 77-300 K, dc resistivity data for pure PEDOT as well as all the nancomposites fit well to the Mott VRH scaling relation, suggesting that the conduction mechanism does not change on inclusion of nanoparticles. However, the hopping parameters change in the nanocomposites. Magnetic study of ferrite nanoparticles and nanocomposites show superparamagnetic blocking. A distribution of particle size and freezing of surface spins are responsible for the difference of the temperature points TB (at the maximum of MZFC) and TS (at the point of separation between MZFC and MFC).

Electrochemical properties of PEDOT based $NiFe_2O_4$ conducting nanocomposites were studied for their suitability as electrode materials for supercapacitor. Nanocrystalline nickel ferrites (5-20 nm) have been synthesized by sol-gel method. Reverse micro emulsion polymerization in n-hexane medium for PEDOT nanotube and aqueous miceller dispersion polymerization for bulk PEDOT formation using different surfactants were adopted. Cyclic voltammetry, galvanostatic charge-discharge and electrochemical impedance were used to study charge transfer, ion diffusion and capacitance of the PEDOT composite samples in an electrolyte containing 1M LiC_lO_4 in acetonitrile. Highest specific capacitance for the nanocomposites was found to be ~230 F/gm.

Nuclear and Radiochemistry:

The thrust of activity in this area has been in (i) accelerator based research and (ii) green chemistry. A systematic study of production and separation of no-carrier-added radionuclides by heavy ion activation has been carried out and alternative radionuclides with better nuclear properties for clinical application have been proposed. Exotic projectiles like ^{9}Be have been used to search for alternative production routes of longer-lived radionuclides ^{93,94,94m}Tc and $^{219-211}$At, which are termed 'ultimate radionuclides for targeted therapy'. The cross-section data generated in these studies are regularly updated in the widely used IAEA EXFOR database. Successful combination of green chemistry with radiochemical methods of analysis has been achieved; preparation of radioactive gold and gold-palladium bimetallic nanoparticles using minuscule amount of radioactivity and polyethylene glycol, an environmentally benign chemical, has been reported for the first time. Contribution in trans-disciplinary research areas has been made through development of a method of separation of ultra-trace nuscule amount of the Supernova-produced radionuclides ^{53}Mn, ^{146}Sm and ^{182}Hf from the interfering stable isobars ^{53}Cr, ^{146}Nd and ^{182}W, respectively. This research will have significant contribution in cosmochemistry. Several international collaborations have been established, of which the one with the superheavy element chemistry group of GSI, Germany and CERN-ISOLDE, Technical University of Munich, Germany are noteworthy. Co-discovery with an international group of scientists of the new radionuclide ^{277}Hs has been achieved.

Research Activities

Inhibition of a Zn(II)-containing enzyme, alcohol dehydrogenase, by anticancer antibiotics, mithramycin and chromomycin A(3)

One of the major attributes for the biological action of the aureolic acid anticancer antibiotics chromomycin A(3) (CHR) and mithramycin (MTR) is their ability to bind bivalent cations such as Mg(II) and Zn(II) ions and form high affinity 2:1 complexes in terms of the antibiotic and the metal ion, respectively. As most of the cellular Zn(II) ion is found to be associated with proteins, we have examined the effect of MTR/CHR on the structure and function of a representative structurally well characterized Zn(II) metalloenzyme, alcohol dehydrogenase (ADH) from yeast. MTR and CHR inhibit enzyme activity of ADH with inhibitory constants of micromolar order. Results from size-exclusion column chromatography, dynamic light scattering, and isothermal titration calorimetry have suggested that the mechanism of inhibition of the metalloenzyme by the antibiotics is due to the antibiotic-induced disruption of the enzyme quaternary structure. The nature of the enzyme inhibition, the binding stoichiometry of two antibiotics per monomer, and comparable dissociation constants for the antibiotic and free (or substrate-bound) ADH imply that the association occurs as a consequence of the binding of the antibiotics to Zn(II) ion present at the structural center. Confocal microscopy shows the colocalization of the antibiotic and the metalloenzyme in HepG2 cells, thereby supporting the proposition of physical association between the antibiotic(s) and the enzyme inside the cell.

Devi, Pukhrambam Grihanjali; Chakraborty, Prabir Kumar; Dasgupta, Dipak

Sanguinarine Interacts with Chromatin, Modulates Epigenetic Modifications, and Transcription in the Context of Chromatin

DNA-binding anticancer agents cause alteration in chromatin structure and dynamics. We report the dynamic interaction of the DNA intercalator and potential anticancer plant alkaloid, sanguinarine (SGR), with chromatin. Association of SGR with different levels of chromatin structure was enthalpy driven with micromolar dissociation constant. Apart from DNA, it binds with comparable affinity with core histones and induces chromatin aggregation. The dual binding property of SGR leads to inhibition of core histone modifications. Although it potently inhibits H3K9 methylation by G9a in vitro, H3K4 and H3R17 methylation are more profoundly inhibited in cells. SGR inhibits histone acetylation both in vitro and in vivo. It does not affect the in vitro transcription from DNA template but significantly represses acetylation-dependent chromatin transcription. SGR-mediated repression of epigenetic marks and the alteration of chromatin geography (nucleography) also result in the modulation of global gene expression. These data, conclusively, show an anticancer DNA binding intercalator as a modulator of chromatin modifications and transcription in the chromatin context.

B, Ruthrotha Selvi†; Pradhan, Suman Kalyan; Shandilya, Jayasha†; Das, Chandrima†; Sailaja, Badi Sri†; G, Naga Shankar†; Gadad, Shrikanth S†; Reddy, Ashok†; Dasgupta, Dipak; Kundu, Tapas K†

Mechanism of p300 Specific Histone Acetyltransferase Inhibition by Small Molecules

Dysfunction of histone acetyltransferases (HATs) leads to several diseases including cancer, diabetes, and asthma. Therefore, small molecule inhibitors and activators of HATs are being considered as new generation therapeutics. Here, we report the molecular mechanisms of p300 HAT inhibition by specific and nonspecific HAT inhibitors: garcinol, isogarcinol, and 1 (LTK 14). The p300 specific HAT inhibitor 1 behaves as a noncompetitive inhibitor for both acetyl-CoA and histone, unlike nonspecific HAT inhibitors garcinol and isogarcinol. The isothermal calorimetric data suggest that there is a high affinity enthalpy driven single binding site for 1 on p300HAT domain in contrast to two binding sites for garcinol and isogarcinol. Furthermore, the precise nature of molecular interactions was determined by using fluorescence, docking, and mutational studies. On the basis of these observations, we have proposed the mechanisms of specific versus nonspecific HAT inhibition by these small molecule compounds, which may be useful to design therapeutically favorable HAT inhibitors.

Arif, M†; Pradhan, Suman Kalyan; Thanuia, GR†; Vedamurthy, BM†; Agrawal, Shipra†; Dasgupta, Dipak; Kundu, Tapas K†

Multiple functions of generic drugs: Future perspectives of Aureolic acid group of anti-cancer antibiotics and non-steroidal anti-inflammatory drugs

Non-steroidal anti-inflammatory drugs and aureolic acid group of anti-cancer drugs belong to the class of generic drugs. Research with some members of these two groups of drugs in different laboratories has unveiled functions other than those for which they were primarily developed as drugs. Here we have reviewed the molecular mechanism behind the multiple functions of these drugs that might lead to employ them for treatment of diseases in addition to those they are presently employed.

Chakraborty, Hirak; Devi, Pukhrambam Grihanjali; Sarkar, Munna; Dasgupta, Dipak

Self-association of the anionic form of the DNA-binding anticancer drug mithramycin

The aqueous-phase self-association of mithramycin (MTR), an aureolic acid anticancer antibiotic, has been studied using different spectroscopic techniques such as absorption, fluorescence, circular dichroism, and H-1 nuclear magnetic resonance spectroscopy. Results from these studies indicate self-association of the anionic antibiotic at pH 8.0 over a concentration range from micromolar to millimolar. These results could be ascribed to the following steps of self-association: M + M reversible arrow M-2, M-2 reversible arrow M reversible arrow M-3, and M-3 + M reversible arrow M-4, where M, M-2, M-3, and M-4 represent the monomer, dimer, trimer, and tetramer of mithramycin, respectively. Dynamic light scattering and isothermal titration calorimetry studies also support aggregation. In contrast, an insignificant extent of self-association is found for the neutral drug (at pH 3.5) and the [(MTR)(2)Mg2+] complex (at pH 8.0). Analysis of 2D NMR spectra of 1 mM MTR suggests that the sugar moieties play a role in the self-association process. Self-association of the drug might occur either via hydrophobic interaction of the sugar residues among themselves or water-mediated hydrogen bond formation between sugar residue(s). On the other hand, absence of a significant upfield shift of the aromatic protons from 100 mu M to 1 mM MTR suggests against the possibility of stacking interactions between the aromatic rings as a stabilizing force for the formation of the dimer and higher oligomers.

Lahiri, Shibojyoti; Devi, Pukhrambam Grihanjali; Majumder, Parijat; Das, Suman; Dasgupta, Dipak

Interactions of therapeutically active plant flavonols with biological targets : Insights from fluorescence spectroscopic studies

Plant flavonols have attracted much recent attention in view of their novel therapeutic properties (effective against various free radical mediated and other diseases) which make them promising alternatives to conventional therapeutic drugs. However, till date, not much is known, regarding their mode of interactions and binding affinities with relevant biological targets. This article presents perspectives highlighting the usefulness of the exquisitely sensitive 'two color' fluorescence behavior of flavonols (which arise due to highly efficient photoinduced excited state intramolecular proton transfer (ESIPT) reactions) for exploring their interactions, at the molecular level, with biomembranes and proteins, which are the principal biological targets of such drug molecules. In this context, we made exploratory studies on the interactions of some representative therapeutically important flavonols with model and natural membranes (composed of phosphatidylcholine liposomes and red blood cell ghost membranes respectively) and serum albumin proteins. Since the ESIPT process is highly sensitive to external hydrogen bonding perturbation effects, the relative contribution between the two colors is strongly modulated by the local environment of the fluorophore, with dramatic changes in the emission yield, energy, anisotropy (r), lifetime (x) and related parameters of both ESIPT tautomer and normal fluorescence bands. This provides multiparametric fluorescence probing opportunities, revealing salient details about the nature and location or binding sites as well as quantitative estimates or partition coefficients/binding constants. This promising new approach may be expected to open up new avenues for the 'screening' of the most appropriate flavonoid derivatives, from among numerous structural variants found in nature, as well as the design of relevant synthetic derivatives with improved features.

Sengupta, Pradeep K; Chaudhuri, Sudip

Binding of the bioflavonoid robinetin with model membranes and hemoglobin: Inhibition of lipid peroxidation and protein glycosylation

Recent years have witnessed burgeoning interest in plant flavonoids as novel therapeutic drugs targeting cellular membranes and proteins Motivated by this scenario, we explored the binding of robinetin (3,7,3',4',5'-pentahydroxyflavone, a bioflavonoid with remarkable 'two color' intrinsic fluorescence properties), with egg yolk phosphatidylcholine (EYPC) liposomes and normal human hemoglobin (HbA), using steady state and time resolved fluorescence spectroscopy Distinctive fluorescence signatures obtained for robinetin indicate its partitioning (K-p = 8.65 x 10(4)) into the hydrophobic core of the membrane lipid bilayer HbA-robinetin interaction was examined using both robinetin fluorescence and flavonoid-induced quenching of the protein tryptophan fluorescence Specific interaction with HbA was confirmed from three lines of evidence: (a) bimolecular quenching constant K-q >> diffusion controlled limit, (b) closely matched values of Stern-Volmer quenching constant and binding constant, (c) tau(0)/

tau = 1 (where tau(0) and tau are the unquenched and quenched tryptophan fluorescence lifetimes, respectively) Absorption spectrophotometric assays reveal that robinetin inhibits EYPC membrane lipid peroxidation and HbA glycosylation with high efficiency.

Chaudhuri, Sudip; Pahari, Biswapathik; Sengupta, Bidisha[†]; Sengupta, Pradeep K

Ground- and excited-state proton transfer and antioxidant activity of 3-hydroxyflavone in egg yolk phosphatidylicholine liposomes: absorption and fluorescence spectroscopic studies

Excited-state intramolecular proton transfer (ESIPT) and dual luminescence behaviour of 3-hydroxyflavone (3-HF) have been utilized to monitor its binding to liposomal membranes prepared from egg yolk phosphatydilcholine (EYPC). Additionally, absorption spectrophotometric assay has been performed to evaluate the antioxidant activity of 3-HF against lipid peroxidation in this membrane system. When 3-HF molecules are partitioned into EYPC liposomes, a weak long-wavelength absorption band with lambda(max)(abs) similar to 410 nm appears in addition to the principal absorption at lambda(max)(abs) = 345nm. Selective excitation of the 410 nm band produces the characteristic emission (lambda(max)(em) similar to 460 nm) of the ground-state anionic species, whereas excitation at the higher energy absorption band leads to dual emission with predominatly ESIPT tautomer fluorescence (lambda(max)(em) = 528 nm). Both ESIPT tautomer and the anionic species exhibit fairly high fluorescence anisotropy (r) values (r = 0.122 and 0.180, respectively). Biexponential fluorescence decay kinetics are observed for the ESIPT tautomer as well as the ground-state anionic forms, indicating heterogeneity in the microenvironments of the corresponding emitting species. Furthermore, we demonstrate that lipid peroxidation of EYPC liposomes is significantly inhibited upon 3-HF binding, suggesting that 3-HF can be potentially useful as an inhibitor of peroxidative damage of cell membranes.

Chaudhuri, Sudip; Basu, Kaushik[†]; Sengupta, Bidisa[†]; Banerjee, Anwesha[†]; Sengupta, Pradeep K

Ground and excited state proton transfer and antioxidant activity of 7-hydroxyflavone in model membranes: Absorption and fluorescence spectroscopic studies

Steady state and time resolved fluorescence spectroscopy have been used to probe microenvironments of the therapeutically active intrinsically fluorescent flavonoid, 7-hydroxyflavone (7-HF), in model membranes consisting of multilamellar phosphatidylcholine liposomes. Additionally, the antioxidant effects of 7-HF against lipid peroxidation have been evaluated using spectrophotometric assay. Large Stokes shifted emissions with distinct spectroscopic signatures, are observed from the excited state proton transfer (ESPT) tautomer (which is generated by a solvent mediated mechanism) and the ground state anion of 7-HF. The neutral (7-HFN) and anionic (7-HFA) species' appear to be located in the non-polar acyl chain and the polar head group regions of the lipid vesicles respectively. The partition coefficients of 7-HFN and 7-HFA in these vesicles have also been estimated using their intrinsic fluorescence. Anisotropy (r) versus temperature (T) measurements reveal the utility of the tautomer fluorescence anisotropy as a sensitive parameter for exploring structural changes in the membranes. Fluorescence decay kinetics studies indicate heterogeneity in the microenvironments of both 7-HFN and 7-HFA. Furthermore, we demonstrate that lipid peroxidation of the model membranes is partially arrested upon 7-HF binding, suggesting its potential usefulness as an inhibitor of peroxidative damage of cell membranes.

Chaudhuri, Sudip; Pahari, Biswapathik; Sengupta, Pradeep K

Interaction of 7-hydroxyflavone with human serum albumin: A spectroscopic study

Numerous recent investigations have revealed that various synthetic as well as therapeutically active natural flavonoids possess novel luminescence properties that can serve as highly sensitive monitors for exploring their interactions with relevant physiological targets. Here we report a detailed study on the interactions of the model flavone, 7-hydroxyflavone (7HF) with the plasma protein human serum albumin (HSA), employing electronic absorption, fluorescence (steady state and time resolved) and induced circular dichroism (ICD) spectroscopy. The spectral data indicate that in the protein matrix, the neutral 7HF molecules are predominantly transformed to a conjugate anion (7HFA) by a proton abstraction in the ground state. The protein (HSA) environment induces dramatic enhancements in the fluorescence emission intensity, anisotropy (r) and lifetime (tau) values, as well as pronounced changes in the fluorescence excitation and emission profiles of the fluorophore. Moreover, evidence for efficient Forster type resonance energy transfer (FRET, from tryptophan to 7HFA) is presented,. from which we infer that. the binding site of 7HF in HSA is proximal (estimated distance, R = 23.6 angstrom) to the unique tryptophan - 214 residue present in the inter-domain (between IIA and IIIA domains) loop region of the protein. The binding constant (K = 9.44 x 10(4) M-1) and the Gibbs free energy change (Delta G = -28.33 kJ/mol) for 7HFA-HSA interaction have been estimated from the emission data. Finally, the near-UV circular dichroism (CD) studies show that the electronic transitions of 7HF are strongly perturbed on binding to the chiral host (HSA), leading to the appearance of ICD bands. Implications of these results are discussed.

Banerjee, Anwesha[†]; Basu, Kaushik[†]; Sengupta, Pradeep K

Effect of beta-cyclodextrin nanocavity confinement on the photophysics of robinetin

We have studied the confinement of robinetin, a therapeutically active plant flavonol, in cyclodextrin (CDx) nanocavities, using steady state and time resolved fluorescence spectroscopy. Enhanced tautomer emission (arising from excited state intramolecular proton transfer (ESIPT)) as well as dramatically blue shifted (similar to 10 mn in beta-CDx and similar to 33 nm in SHP beta-CDx) normal fluorescence observed upon addition of the beta-CDxs indicate that robinetin readily enters the doughnut-shaped hydrophobic cavity of beta-CDx where the chromone moiety is well shielded from external hydrogen bonding perturbations. Detailed analyses of the fluorescence data (emission profile,anisotropy, decay times) indicate that robinetin forms 1:1 inclusion complexes with both natural and chemically modified beta-cyclodextrins (beta-CDx and SHP beta-CDx) with affinity constant values K = 195 +/- 17 M-1 and 1055 +/- 48 M-1 respectively, indicating the prospective utility of SHP beta-CDx in particular as an effective drug carrier. Unlike beta-CDxs, alpha-CDxs do not form inclusion complexes with robinetin. To further characterize the robinetin/beta-CDxs complexes, circular dichroism (CD) spectroscopic studies have been performed, which reveal that incorporation of robinetin molecules in the chiral environment of the beta-CDxs strongly affects the electronic transitions of robinetin leading to the occurrence of positive induced circular dichroism (ICD) bands in the near ultra-violet (UV) region. Molecular mechanics calculations show that the inclusion complex with the chromone ring inserted into the beta-CDx cavity is most favorable, in agreement with our spectroscopic data.

Banerjee, Anwesha[†]; Basu, Kaushik[†]; Sengupta, Pradeep K

Interaction of flavonoids with red blood cell membrane lipids and proteins: Antioxidant and antihemolytic effects

Plant flavonoids are emerging as potent therapeutic drugs effective against a wide range of free radical mediated diseases. Hence their interactions with cell membranes, which generally serve as targets for lipid peroxidation, are of enormous interest. Here we report in vitro studies, via absorption and fluorescence spectroscopy, on the effects of several flavonoids (namely fisetin, quercetin, chrysin, morin, and 3-hydroxyflavone, 3-HF) in goat RBC membranes. Owing to the presence of functionally relevant membrane protein components embedded in the lipid bilayer RBC ghosts provide a more realistic system for exploring drug actions in biomembranes than simpler membrane models like phosphatidylcholine liposomes used in our previous studies [e.g. B. Sengupta, A. Banerjee, P.K. Sengupta, FEBS Lett. 570 (2004) 77-81]. Here, we demonstrate that binding of the flavonoids to the RBC membranes significantly inhibits lipid peroxidation, and at the same time enhances their integrity against hypotonic lysis. Interestingly, the antioxidant and antihemolytic activities are found to be crucially dependent on the locations of the flavonoids in the membrane matrix as revealed by fluorescence studies. Furthermore, we observe that FRET (from membrane protein tryptophans to flavonoids) occurs with significant efficiency indicating that the flavonoid binding sites lie in close proximity to the tryptophan residues in the ghost membrane proteins.

Chaudhuri, Sudip; Banerjee, Anwesha[†]*; Basu, Kaushik*[†]*; Sengupta, Bidisa*[†]*; Sengupta, Pradeep K*

On the Role of the cis Hoogsteen: Sugar-Edge Family of Base Pairs in Platforms and Triplets-Quantum Chemical Insights into RNA Structural Biology

Base pairs belonging to the cis Hoogsteen:sugar-edge (H:S) family play important structural roles in folded RNA molecules. Several of these are present in internal loops, where they are involved in interactions leading to planar dinucleotide platforms which stabilize higher order structures such as base triplets and quartets. We report results of analysis of 30 representative examples spanning 16 possible base pair combinations, with several of them showing multimodality of base pairing geometry. The geometries of 23 of these base pairs were modeled directly from coordinates extracted from RNA crystal Structures. The other seven were predicted structures which were modeled oil the basis of observed isosteric analogues. After appropriate satisfaction of residual valencies, these Structures were relaxed using the B3LYP/6-31G(d,p) method and interaction energies were derived at the RIMP2/aug-cc-pVDZ level of theory. The geometries for each of the Studied base pairs have been characterized in terms of the number and nature of H-bonds, rmsd values observed on optimization, base pair geometrical parameters, and sugar pucker analysis. In addition to its evaluation, the nature of intermolecular interaction in these complexes was also analyzed using Morokuma decomposition. The gas phase interaction energies range between -5.2 and -20.6 kcal/mol and, in contrast to the H:S trans base pairs, show enhanced relative importance of he electron correlation component, indicative of the greater role of dispersion energy ill stabilization of these base pairs. The rich variety of hydrogen bonding pattern, involving the flexible sugar edge, appears to hold the key to several features of structural motifs, such as planarity and propensity to participate in triplets, observed in this family of base pairs. This work explores these aspects by integrating database analysis, and detailed base pairing geometry analysis at the atomistic level, with ab initio Computation of interaction energies. The Study, involving alternative classification of base pairs and triplets, provides insights into intrinsic properties of these base pairs and their possible structural and functional roles.

Sharma, Purshotam†; Sponer, Judit E†; Sponer, Jiri†; Sharma, Sitansh†; Bhattacharyya, Dhananjay; Mitra, Abhijit†

Structure and Dynamics of Double Helical DNA in Torsion Angle Hyperspace: A Molecular Mechanics Approach

Analysis of the conformational space populated by the torsion angles and the correlation between the conformational energy and the sequence of DNA are important for fully understanding DNA structure and function. Presence of seven variable torsion angles about single covalent bonds in DNA main chain puts a big challenge for such analysis. We have carried out restrained energy minimization studies for four representative dinucleosides, namely d(ApA):d(TpT), d(CpG):d(CpG), d(GpC):d(GpC) and d(CpA):d(TpG) to determine the energy hyperspace of DNA in context to the values of the torsion angles and the structural properties of the DNA conformations populating the favorable regions of this energy hyperspace. The torsion angles were manipulated by constraining their values at the reference points and then performing energy minimization. The energy minima obtained on the potential energy contour plots mostly correspond to the conformations populated in crystal structures of DNA. Some novel favorable conformations that are not present in crystal structure data are also found. The plots also suggest few low energy routes for conformational transitions or the associated energy barrier heights. Analyses of base pairing and stacking possibility reveal structural changes accompanying these transitions as well as the flexibility of different base steps towards variations in different torsion angles.

Borkar, Aditi†; Ghosh, Indira†; Bhattacharyya, Dhananjay

Changes in Thermodynamic Properties of DNA Base Pairs in Protein-DNA Recognition

The mechanism of protein-DNA recognition, particularly the induced fit mechanism, is poorly understood due to ineffective analysis of the protein-DNA complex crystal structures. It is expected that upon protein binding the DNA becomes structurally more rigid. However, a previous analysis (W.K. Olson, A. A. Gorin, X. Lu, L. M. Hock and V. Zhurkin, Proc. Natl. Acad. Sci. USA, 95, 11163 (1998)) indicates increase in the flexibility of the DNA segment complexed with protein. We have considered an ensemble of configurations from crystallographic data of the TBP-TATA box complex structures under a given thermodynamic condition. Analysis of the ensemble of structures of this complex indicates that the DNA deforms significantly to form specific hydrogen bonds and as a consequence, its structure attains more rigidity. We calculate the free energy profiles in term of the DNA base pair (bp) step parameters via the binding patterns in the ensemble of the given complex, and for free DNA bp steps as well. The rigidities estimated from these free energies for small deformations around the minimum indicate enhanced structural rigidities of DNA upon complexation with protein. Further, the changes in the thermodynamic properties of the bp steps upon complex formation have been estimated from the two sets of free energy profiles. These results indicate differential role played by different bp steps in the thermodynamic stabilization of the complex.

Samanta, Sudipta†; Chakrabarti, Jaydeb†; Bhattacharyya, Dhananjay

Structural properties of polymeric DNA from molecular dynamics simulations

Most of the reported DNA structural studies are based on oligonucleotide structures, which have artifacts due to unstable terminal base pairs (bps). We have carried out molecular dynamics simulation of DNA oligonucleotides in such a manner that gives rise to properties of polymeric DNA of infinite length. Molecular dynamics simulation studies of six homo- and heteropolymeric DNA sequences are reported here to understand structural features of all ten unique dinucleotide sequences. We observe that each of these dinucleotide sequences has unique features in agreement with Calladine's rule [C. R. Calladine, J. Mol. Biol. 161, 343 (1982)]. We noticed significant structural alternation between B-I and B-II forms for d(CA).d(TG) dinucleotide, where one of the strands showed frequent transitions between usual and unusual epsilon and zeta torsion angles associated with bp stacking geometry. In terms of the calculated bending rigidity and persistence length, pyrimidine-purine bp steps, namely, d(TA).d(TA), d(CA).d(TG), and d(CG).d(CG) are the most flexible dinucleotide bp steps. We estimated the major groove widths from our simulations. We did not observe much variation in major and minor groove widths depending on the base sequence. However, the distribution of water molecules in the minor groove shows sensitivity to the DNA sequence.

Samanta, Sudipta[†]*; Mukherjee, Supti*[†]*; Chakrabarti, Jaydeb*[†]*; Bhattacharyya, Dhananjay*

Trans Hoogsteen/Sugar Edge Base Pairing in RNA. Structures, Energies, and Stabilities from Quantum Chemical Calculations

Trans Hoogsteen/sugar edge (H/SE) RNA base pairs form one of the six families of RNA base pairs that utilize the 2'-hydroxyl group of ribose for base pairing and play key roles in stabilizing folded RNA molecules. Here, we provide a detailed quantum chemical characterization of intrinsic structures and interaction energies of this base pair family, along with the evaluation of solvent screening effects by a continuum solvent approach. We report DFT-optimized geometries and MP2 interaction energies for all 10 crystallographically identified members of the family, for a representative set of them, using complete basis set extrapolation. For 6 of the 10 base pairs, we had to apply geometric constraints to keep the geometries relevant to RNA. We confirm that the remaining, hitherto undetected, possible members of this family do not have appropriate steric features required to establish stable base pairing in the trans H/SE fashion. The interaction patterns in the trans H/SE family are highly diverse, with gas-phase interaction energies in the range from -1 to -17 kcal/mol. Except for the C/rC and G/rG trans H/SE base pairs, the interaction energy is roughly evenly distributed between the HF and correlation components. Thus, in the trans H/SE base pairs, the relative importance of electron correlation is noticeably smaller than in the cis WC/SE or cis and trans SE/SE base pairs, but still larger than in canonical base pairs. The trans H/SE A/rG base pair is the intrinsically most stable member of this family. This base pair is also known as the sheared AG base pair and belongs to the most prominent set of RNA base pairs utilized in molecular building blocks of functional RNAs. For all trans H/SE base pairs that we identified, in addition to conventional base pairing, viable alternative structures were stabilized by amino-acceptor interactions. In the QM calculations, these amino-acceptor complexes appear to be equally as stable as those with common H-bonds, and more importantly, the switch to amino-acceptor interaction does not require any significant geometrical rearrangement of the base pairs. Such interactions are worthy of further investigations, as X-ray crystallography cannot unambiguously distinguish between conventional and amino-acceptor interactions involving the 2'-hydroxyl group, formation of such interactions is usually not considered, and molecular modeling force fields do not include such interactions properly as a result of neglect of aminogroup pyramidalization.

Mladek, Arnost[†]; Sharma, Purshotam[†]; Mitra, Abhijit[†]; Bhattacharyya, Dhananjay; Sponer, Jiri[†]; Sponer, Judit E[†]

Quantum chemical studies of structures and binding in noncanonical RNA base pairs: The trans Watson-Crick : Watson-Crick family

The trans Watson-Crick/Watson-Crick family of base pairs represent a geometric class that play important structural and possible functional roles in the ribosome, tRNA, and other functional RNA molecules. They nucleate base triplets and quartets, participate as loop closing terminal base pairs in hair pin motifs and are also responsible for several tertiary interactions that enable sequentially distant regions to interact with each other in RNA molecules. Eleven representative examples spanning nine systems belonging to this geometric family of RNA base pairs, having widely different occurrence statistics in the PDB database, were studied at the HF/6-31G (d, p) level using Morokuma decomposition, Atoms in Molecules as well as Natural Bond Orbital methods in the optimized gas phase geometries and in their crystal structure geometries, respectively. The BSSE and deformation energy corrected interaction energy values for the optimized geometries are compared with the corresponding values in the crystal geometries of the base pairs. For non protonated base pairs in their optimized geometry, these values ranged from -8.19 kcal/mol to -21.84 kcal/mol and compared favorably with those of canonical base pairs. The interaction energies of these base pairs, in their respective crystal geometries, were, however, lesser to varying extents and in one case, that of A:A W:W trans, it was actually found to be positive. The variation in RMSD between the two geometries was also large and ranged from 0.32-2.19 angstrom. Our analysis shows that the hydrogen bonding characteristics and interaction energies obtained, correlated with the nature and type of hydrogen bonds between base pairs; but the occurrence frequencies, interaction energies, and geometric variabilities were conspicuous by the absence of any apparent correlation. Instead, the nature of local interaction energy hyperspace of different base pairs as inferred from the degree of their respective geometric variability could be correlated with the identities of free and bound hydrogen bond donor/acceptor groups present in interacting bases in conjunction with their tertiary and neighboring group interaction potentials in the global context. It also suggests that the concept of isostericity alone may not always determine covariation potentials for base pairs, particularly for those which may be important for RNA dynamics. These considerations are more important than the absolute values of the interaction energies in their respective optimized geometries in rationalizing their occurrences in functional RNAs. They highlight the importance of revising some of the existing DNA based structure analysis approaches and may have significant implications for RNA structure and dynamics, especially in the context of structure prediction algorithms.

Sharma, Purshotam[†]; Mitra, Abhijit[†]; Sharma, Sitansh[†]; Singh, Harjinder[†]; Bhattacharyya, Dhananjay

Structure, stability, and dynamics of canonical and noncanonical base pairs: Quantum chemical studies

The importance of non-Watson-Crick base pairs in the three-dimensional structure of RNA is now well established. The structure and stability of these noncanonical base pairs are, however, poorly understood.

We have attempted to understand structural features of 33 frequently occurring base pairs using density functional theory. These are of three types, namely (i) those stabilized by two or more polar hydrogen bonds between the bases, (ii) those having one polar and another C-H center dot center dot center dot O/N type interactions, and (iii) those having one H-bond between the bases and another involving one of the sugars linked to the bases. We found that the base pairs having two polar H-bonds are very stable as compared to those having one C-H center dot center dot center dot O/N interaction. Our quantitatively analysis of structures of these optimized base pairs indicates that they possess a different amount of nonplanarity with large propeller or buckle values as also observed in the crystal structures. We further found that geometry optimization does not modify the hydrogen-bonding pattern, as values of shear and open angle of the base pairs remain conserved. The structures of initial crystal geometry and final optimized geometry of some base pairs having only one polar H-bond and a C-H center dot center dot center dot O/N interaction, however, are significantly different, indicating the weak nature of the nonpolar interaction. The base pair flexibility, as measured from normal-mode analysis, in terms of the intrinsic standard deviations of the base pair structural parameters are in conformity with those calculated from RNA crystal structures. We also noticed that deformation of a base pair along the stretch direction is impossible for all of the base pairs, and movements of the base pairs along shear and open are also quite restricted. The base pair opening mode through alteration of propeller or buckle is considerably less restricted for most of the base pairs.

Roy, Ashim[†]*; Panigrahi, Swati; Bhattacharyya, Malyasri*[†]*; Bhattacharyya, Dhananjay*

Twist-dependent stacking energy of base-pair steps in B-DNA geometry: A density functional theory approach

Stacking energy of all the 10 unique DNA base-pair steps (bp step) are calculated using density functional theory within the ultrasoft pseudopotential plane wave method and local density approximation for the exchange-correlation functional. We have studied the dependence of stacking energy on twist angle, an aspect found difficult to explain using classical theory. We have found that the twist angle for different bp steps at stacking energy minimum matches extremely well with the values of average twist obtained from B-DNA crystal structure data. This indicates that the use of a proper quantum chemical method to calculate the pi-pi electronic interactions may explain stacking energy without incorporating hydrophobic interaction through solvent or effect of backbone through pseudobond. From the twist angle-dependent stacking energy profile, we have also generated the probability distributions of twist for all the bp steps and calculated the variance of the distribution. Our calculated variances show similar trend to that of the experimental data for which sufficient numbers of data are available. The TA, AT, and CG doublets show large variances among the 10 possible bp steps, indicating their maximum flexibility. This might be the case of unusual deformation observed at the TATA-box while binding to TBP protein.

Sanianta, Sudipta[†]*; Kabir, Mukul*[†]*; Sanyal, Biplab*[†]*; Bhattacharyya, Dhananjay*

Theoretical analysis of noncanonical base pairing interactions in RNA molecules

Noncanonical base pairs in RNA have strong structural and functional implications but are currently not considered for secondary structure predictions. We present results of comparative ab initio studies of stabilities and interaction energies for the three standard and 24 selected unusual RNA base pairs reported in the literature. Hydrogen added models of isolated base pairs, with heavy atoms frozen in their 'away from equilibrium' geometries, built from coordinates extracted from NDB, were geometry optimized using HF/6-31G** basis set, both before and after unfreezing the heavy atoms. Interaction energies, including BSSE and deformation energy corrections, were calculated, compared with respective single point MP2 energies, and correlated with occurrence frequencies and with types and geometries of hydrogen bonding interactions. Systems having two or more N-H...ON hydrogen bonds had reasonable interaction energies which correlated well with respective occurrence frequencies and highlighted the possibility of some of them playing important roles in improved secondary structure prediction methods. Several of the remaining base pairs with one N-H...ON and/or one C-H...ON interactions respectively, had poor interaction energies and negligible occurrences. High geometry variations on optimization of some of these were suggestive of their conformational switch like characteristics.

Bhattacharyya, Dhananjay; Koripella, Siv Chand[†]; Mitra, Abhijit[†]; Rajendran, Vijay Babu[†]; Sinha, Bhabdyuti[†]

Conformational specificity of non-canonical base pairs and higher order structures in nucleic acids: crystal structure database analysis

Non-canonical base pairs contribute immensely to the structural and functional variability of RNA, which calls for a detailed characterization of their spatial conformation. Intra-base pair parameters, namely propeller, buckle, open-angle, stagger, shear and stretch describe structure of base pairs indicating planarity and proximity of association between the two bases. In order to study the conformational specificities of non-canonical base pairs occurring in RNA crystal structures, we have upgraded NUPARM software to calculate these intra-base pair parameters using a new base pairing edge specific axis system. Analysis of base pairs and base triples with the new edge specific axis system indicate the presence of specific structural signatures for different classes of non-canonical pairs and triples. Differentiating features could be identified for pairs in cis or trans orientation, as well as those involving sugar edges or C-H-mediated hydrogen bonds. It was seen that propeller for all types of base pairs in cis orientation are generally negative, while those for trans base pairs do not have any preference. Formation of a base triple is seen to reduce propeller of the associated base pair along with reduction of overall flexibility of the pairs. We noticed that base pairs involving sugar edge are generally more non-planar, with large propeller or buckle values, presumably to avoid steric clash between the bulky sugar moieties. These specific conformational signatures often provide an insight into their role in the structural and functional context of RNA.

Mukherjee, Shayantani; Bansal, Manju[†]; Bhattacharyya, Dhananjay

Role of turmeric in ultraviolet induced genotoxicity in a bacterial system

Turmeric extracts contain more than one bioactive component, which have different properties when used to modulate ultraviolet induced genotoxicity. These differences were found depending on the nature and extent of the damage to the bacterial DNA, which indicates the existence of a natural switching process in sensing the dama

Pal, Arijit; Ghosh, Mita; Pal, Arun Kumar

Transcription regulation of caspase-1 by R393 of HIPPI and its molecular partner HIP-1

Earlier we have shown that exogenous expression of HIPPI, a molecular partner of Huntingtin interacting protein HIP-1, induces apoptosis and increases expression of caspases-1, -8 and -10 in HeLa and Neuro2A cells. The C-terminal pseudo death effector domain of HIPPI (pDED-HIPPI) specifically interacts with the putative promoter sequences of these genes. In the present manuscript, we predict from structural modeling of pDED-HIPPI that R393 of HIPPI is important for such interaction. R393E mutation in pDED-HIPPI decreases the interaction with the putative promoter of caspase-1 in cells. Expression of caspase-1 is decreased in cells expressing mutant pDED-HIPPI in comparison to that observed in cells expressing wild type pDED-HIPPI. Using HIP-1 knocked down cells as well as over expressing HIP-1 with mutation at its nuclear localization signal and other deletion mutations, we demonstrate that translocation of HIPPI to the nucleus is mediated by HIP-1 for the increased expression of caspase-1. HIPPI-HIP-1 heterodimer is detected in cytoplasm as well as in the nucleus and is associated with transcription complex in cells. Taking together, we are able to show the importance of R393 of HIPPI and the role of HIPPI-HIP-1 heterodimer in the transcription regulation of caspase-1.

Banerjee, M; Datta, M; Majumder, P; Mukhopadhyay, D; Bhattacharyya, NP

Interaction of aurintricarboxylic acid (ATA) with four nucleic acid binding proteins DNase I, RNase A, reverse transcriptase and Taq polymerase

In the investigation of interaction of aurintricarboxylic acid (ATA) with four biologically important proteins we observed inhibition of enzymatic activity of DNase I, RNase A, M-MLV reverse transcriptase and Taq polymerase by ATA in vitro assay. As the telomerase reverse transcriptase (TERT) is the main catalytic subunit of telomerase holoenzyme, we also monitored effect of ATA on telomerase activity in vivo and observed dose-dependent inhibition of telomerase activity in Chinese hamster V79 cells treated with ATA. Direct association of ATA with DNase I (K-d = 9.019 μ M)), RNase A (K-d = 2.33 μ M) reverse transcriptase (K-d = 0.255 μ M) and Taq polymerase (K-d = 81.97 μ M) was further shown by tryptophan fluorescence quenching studies. Such association altered the three-dimensional conformation of DNase I, RNase A and Taq polymerase as detected by circular dichroism. We propose ATA inhibits enzymatic activity of the four proteins through interfering with DNA or RNA binding to the respective proteins either competitively or allosterically, i.e. by perturbing three-dimensional structure of enzymes.

Ghosh, Utpal; Giri, Kalyan; Bhattacharyya, Nitai P

Induction of apoptosis by the inhibitors of poly (ADP-ribose)polymerase in HeLa cells

To investigate the role of poly(ADP-ribose) polymerase (PARP) in the physiological condition of cell growth, we studied the ability of PARP inhibitors to induce apoptosis. Benzamide (BA) and 4-amino-1,8-naphthalimide (NAP), two well-known inhibitors of PARP, treatment increased nuclear fragmentation and caspase-3 activity in HeLa (Human cervical cancer cell line) cells. The increase of cellular NAD(+) level was observed in HeLa cells treated with BA in comparison with untreated control cells. For unrevealing the specific PARP family member responsible for such induction of apoptosis we knocked down and over-expressed PARP-1 gene in HeLa cells. PARP-1 knock down cells were sensitive to BA induced nuclear fragmentation and caspase-3 activation while exogenous expression of PARP-1 rendered cells resistant to BA induced apoptosis. This result indicated that inhibition of PARP-1 resulted in induction of apoptosis.

Ghosh, Utpal; Bhattacharyya, Nitai P

Huntington's disease: roles of huntingtin-interacting protein 1 (HIP-1) and its molecular partner HIPPI in the regulation of apoptosis and transcription

Huntingtin protein (Htt), whose mutation causes Huntington's disease (HD), interacts with large numbers of proteins that participate in diverse cellular pathways. This observation indicates that wild-type Htt is involved in various cellular processes and that the mutated Htt alters these processes in HD. The roles of these interacting proteins in HD pathogenesis remain largely unknown. In the present review, we present evidence that Htt-interacting protein 1 (HIP-1), an endocytic protein, together with its interacting partner HIPPI, regulates apoptosis and gene expression, both processes being implicated in HD. Further studies are necessary to establish whether the HIPPI-HIP-1 complex or other interacting partners of HIPPI regulate apoptosis and gene expression that are relevant to HD.

Bhattacharyya, Nitai P; Banerjee, Manisha; Majumder, Pritha

Huntingtin interacting protein HYPK is intrinsically unstructured

To characterize HYPK, originally identified as a novel huntingtin (Htt) interacting partner by yeast two hybrid assay, we used various biophysical and biochemical techniques. The molecular weight of the protein, determined by gel electrophoresis, was found to be about 1.3-folds (similar to 22 kDa) higher than that obtained from mass spectrometric analysis (16.9 kDa). In size exclusion chromatography experiment, HYPK was eluted in three fractions, the hydrodynamic radii for which were calculated to be similar to 1.5-folds (23.06 angstrom) higher than that expected for globular proteins of equivalent mass (17.3 angstrom). The protein exhibited predominantly (63%) random coil characteristics in circular dichroism spectroscopy and was highly sensitive to limited proteolysis by trypsin and papain, indicating absence of any specific domain. Experimental evidences with theoretical analyses of amino acids composition of HYPK and comparison with available published data predicts that HYPK is an intrinsically unstructured protein (IUP) with premolten globule like conformation. In presence of increasing concentration of Ca2+, HYPK showed conformational alterations as well as concomitant reduction of hydrodynamic radius. Even though any link between the natively unfolded nature of HYPK, its conformational sensitivity towards Ca2+ and interaction with Hit is yet to be established, its possible involvement in Huntington's disease pathogenesis is discussed.

Raychaudhuri, Swasti; Majumder, Pritha; Sarkar, Somosree[†]; Giri, Kalyan; Mukhopadhyay, Debashis; Bhattacharyya, Nitai P

Increased caspase-2, calpain activations and decreased mitochondrial complex II activity in cells expressing exogenous huntingtin exon 1 containing CAG repeat in the pathogenic range

(1) Huntington's disease (HD) is an autosomal dominant neurodegenerative disease caused by the expansion of polymorphic CAG repeats beyond 36 at exon 1 of huntingtin gene (htt). To study cellular

effects by expressing N-terminal domain of Huntingtin (Htt) in specific cell lines, we expressed exon 1 of htt that codes for 40 glutamines (40Q) and 16Q in Neuro2A and HeLa cells. (2) Aggregates and various apoptotic markers were detected at various time points after transfection. In addition, we checked the alterations of expressions of few apoptotic genes by RT-PCR. (3) Cells expressing exon 1 of htt coding 40Q at a stretch exhibited nuclear and cytoplasmic aggregates, increased caspase-1, caspase-2, caspase-8, caspase-9/6, and calpain activations, release of cytochrome c and AIF from mitochondria in a time-dependent manner. Truncation of Bid was increased, while the activity of mitochondrial complex II was decreased in such cells. These changes were significantly higher in cells expressing N-terminal Htt with 40Q than that obtained in cells expressing N-terminal Htt with 16Q. Expressions of caspase-1, caspase-2, caspase-3, caspase-7, and caspase-8 were increased while expression of Bcl-2 was decreased in cells expressing mutated Htt-exon 1. (4) Results presented in this communication showed that expression of mutated Htt-exon 1 could mimic the cellular phenotypes observed in Huntington's disease and this cell model can be used for screening the agents that would interfere with the apoptotic pathway and aggregate formation.

Majumder, Pritha; Raychaudhuri, Swasti; Chattopadhyay, Biswanath[†]*; Bhattacharyya, Nitai P*

HYPK, a Huntingtin interacting protein, reduces aggregates and apoptosis induced by N-terminal Huntingtin with 40 glutamines in Neuro2a cells and exhibits chaperone-like activity

Expansion of polymorphic glutamine (Q) numbers present at the protein Huntingtin (Htt) beyond 36Q results in its misfolding and aggregation, and the aggregates recruit several other proteins. Here we show that HYPK, initially identified as an Htt-interacting partner by yeast two-hybrid assay, physically interacts with N-terminal Htt in Neuro2A cells and alters the numbers and distribution of aggregates formed by N-terminal Htt with 40Q. HYPK also alters the kinetics of mutated N-terminal Htt-mediated aggregate formation. Fluorescence recovery after photobleaching studies reveal that over-expression of HYPK results in the appearance of Htt poly Q aggregates, which upon bleaching recovers similar to 80% of initial fluorescence intensity within 6 min. Fluorescence loss in photobleaching studies indicate loss off fluorescence intensity of the aggregates with time in presence of HYPK. Over-expression of this protein reduces poly Q-mediated caspase-2, caspase-3 and caspase-8 activations, whereas gamma ray-induced activations of these enzymes are not affected. In vitro and in vivo studies demonstrate that HYPK possesses a novel chaperone-like activity. We conclude that HYPK, without having any sequence similarity with known chaperones, plays an effective role in protecting neuronal cells against apoptosis induced by mutated N-terminal Htt by modulating the aggregate formation.

Raychaudhuri, Swasti; Sinha, Mithun; Mukhopadhyay, Debashis; Bhattacharyya, Nitai P

Resistance to induction of micronuclei, chromosomal aberrations and apoptosis by Co-60 gamma-ray in a cell strain M5, derived from Chinese hamster V79 cells

The paper aims to investigate cytogenetic and apoptotic responses of gamma-irradiation in a radio-resistant cell strain designated as M5. Induced micronuclei, chromosomal aberrations, nuclear fragmentation and nucleosomal ladders by gamma-irradiation were less at equal doses in M5 cells in comparison with that obtained in the parental Chinese hamster V79 cells. However, at equal survival, there were no differences in the end points studied. Results indicate that the residual damages that lead to reproductive cell death also resulted in the cytogenctic and apoptotic responses. We speculate that the repair efficiency in M5 cells was more efficient and increased DNA repair could be the cause of radiation resistance observed in M5 cells.

Pathak, R; Bukhsh†, A R Khuda†; Dey, SK†; Ghosh, U; Sen Gupta, B†; Semwal, M†; Bhattacharyya, NP

Interactions of HIPPI, a molecular partner of Huntingtin interacting protein HIP1, with the specific motif present at the putative promoter sequence of the caspase-1, caspase-8 and caspase-10 genes

To investigate the mechanism of increased expression of caspase-1 caused by exogenous Hippi, observed earlier in HeLa and Neuro2A cells, in this work we identified a specific motif AAAGACATG (-101 to -93) at the caspase-1 gene upstream sequence where HIPPI could bind. Various mutations in this specific sequence compromised the interaction, showing the specificity of the interactions. In the luciferase reporter assay, when the reporter gene was driven by caspase-1 gene upstream sequences (-151 to -92) with the mutation G to T at position - 98, luciferase activity was decreased significantly in green fluorescent protein-Hippi-expressing HeLa cells in comparison to that obtained with the wild-type caspase-1 gene 60 bp upstream sequence, indicating the biological significance of such binding. It was observed that the C-terminal ‘pseudo’ death effector domain of HIPPI interacted with the 60 bp (-151 to -92) upstream sequence of the caspase-1 gene containing the motif. We further observed that expression of caspase-8 and caspase-10 was increased in green fluorescent protein-Hippi-expressing HeLa cells. In addition, HIPPI interacted in vitro with putative promoter sequences of these genes, containing a similar motif. In summary, we identified a novel function of HIPPI; it binds to specific upstream sequences of the caspase-1, caspase-8 and caspase-10 genes and alters the expression of the genes. This result showed the motifspecific interaction of HIPPI with DNA, and indicates that it could act as transcription regulator.

Majumder, P; Choudhury, A; Banerjee, M; Lahiri, A†; Bhattacharyya, NP

Production and recovery of recombinant propapain with high yield

Papain (EC 3.4.22.2), the archetypal cysteine protease of C1 family, is of considerable commercial significance. In order to obtain substantial quantities of active papain, the DNA coding for propapain, the papain precursor, has been cloned and expressed at a high level in Escherichia coli BL21(DE3) transformed with two T7 promoter based pET expression vectors - pET30 Ek/LIC and pET28a(+) each containing the propapain gene. In both cases, recombinant propapain was expressed as an insoluble Histagged fusion protein, which was solubilized, and purified by nickel chelation affinity chromatography under denaturing conditions. By systematic variation of parameters influencing the folding, disulfide bond formation and prevention of aggregate formation, a straightforward refolding procedure, based on dilution method, has been designed. This refolded protein was subjected to size exclusion chromatography to remove impurities and around 400 mg of properly refolded propapain was obtained from 1 L of bacterial culture. The expressed protein was further verified by Western blot analysis by crossreacting it with a polyclonal anti-papain antibody and the proteolytic activity was confirmed by gelatin SDS-PAGE. This refolded propapain could be converted to mature active papain by autocatalytic processing at low pH and the recombinant papain so obtained has a specific activity closely similar to the native papain. This is a simple and efficient expression and purification procedure to obtain a yield of active papain, which is the highest reported so far for any recombinant plant cysteine protease.

Choudhury, Debi; Roy, Sumana; Chakrabarti, Chandana; Biswas, Sampa; Dattagupta, JK

Crystal structure analysis of NP24-I: a thaumatin-like protein

The crystal structure of NP24-I, an isoform of the thaumatin-like protein (TLP) NP24 from tomato, has been reported. A prominent acidic cleft is observed between domains I and II of the three-domain structure of this antifungal protein, a feature common to other antifungal TLPs. The defensive role of the TLPs has also been attributed to their beta-1,3-glucanase activity and here too the acidic cleft is reported to play a vital role. NP24 is known to bind beta-glucans and so a linear beta-1,3-glucan molecule has been docked in the interdomain cleft of NP24-I. From the docked complex it is observed that the beta-glucan chain is so positioned in the cleft that a Glu and Asp residue on either side of it may form a catalytic pair to cause the cleavage of a glycosidic bond. NP24 has been reported to be an allergenic protein and an allergenic motif could be identified on the surface of the helical domain II of NP24-I. In addition, some allergenic motifs bearing high similarity/identity with some predicted Ig-E binding motifs of closely related allergenic TLPs like Jun a 3 (Juniperus ashei, from mountain cedar pollen) and banana-TLP have been identified on the molecular surface of NP24-I.

Ghosh, Raka; Chakrabarti, Chandana

Structural insights into the substrate specificity and activity of ervatamins, the papain-like cysteine proteases from a tropical plant, Ervatamia coronaria

Multiple proteases of the same family are quite often present in the same species in biological systems. These multiple proteases, despite having high homology in their primary and tertiary structures, show deviations in properties such as stability, activity, and specificity. It is of interest, therefore, to compare the structures of these multiple proteases in a single species to identify the structural changes, if any, that may be responsible for such deviations. Ervatamin-A, ervatamin-B and ervatamin-C are three such papain-like cysteine proteases found in the latex of the tropical plant Ervatamia coronaria, and are known not only for their high stability over a wide range of temperature and pH, but also for variations in activity and specificity among themselves and among other members of the family. Here we report the crystal structures of ervatamin-A and ervatamin-C, complexed with an irreversible inhibitor 1-[L-N-(trans-epoxysuccinyl)leucyl]amino-4-guanidinobutane (E-64), together with enzyme kinetics and molecular dynamic simulation studies. A comparison of these results with the earlier structures helps in a correlation of the structural features with the corresponding functional properties. The specificity constants (kcat/Km) for the ervatamins indicate that all of these enzymes have specificity for a branched hydrophobic residue at the P2 position of the peptide substrates, with different degrees of efficiency. A single amino acid change, as compared to ervatamin-C, in the S2 pocket of ervatamin-A (Ala67 -> Tyr) results in a 57-fold increase in its kcat/Km value for a substrate having a Val at the P2 position. Our studies indicate a higher enzymatic activity of ervatamin-A, which has been subsequently explained at the molecular level from the three-dimensional structure of the enzyme and in the context of its helix polarizibility and active site plasticity.

Ghosh, Raka; Chakraborty, Sibani; Chakrabarti, Chandana; Dattagupta, Jiban Kanti; Biswas, Sampa

Modulation of Akt and ERK1/2 Pathways by Resveratrol in Chronic Myelogenous Leukemia (CML) Cells Results in the Downregulation of Hsp70

Resveratrol is known to downregulate the high endogenous level of Heat shock protein 70 (Hsp70) in Chronic Myelogenous Leukemia (CML) K562 cells and induce apoptosis. Since Heat Shock Factor 1 (HSF1) controls transcription of Hsp70, we wanted to probe the signaling pathways responsible for transcriptional activation of HSF1.

Cells exposed to 40 mu M Resveratrol rapidly abolished serine473 phosphorylation of Akt and significantly reduced its kinase activity. Inactivation of Akt pathway by Resveratrol subsequently blocked serine9 phosphorylation of Gsk3 beta. Active non-phosphorylated Gsk3b rendered HSF1 transcriptionally inactive and reduced Hsp70 production. Blocking PI3K/Akt activity also demonstrated similar effects on Hsp70 comparable to Resveratrol. Inactivation of Gsk3b activity by inhibitors SB261763 or LiCl upregulated Hsp70. Resveratrol significantly modulated ERK1/2 activity as evident from hyper phosphorylation at T302/Y304 residues and simultaneous upregulation in kinase activity. Blocking ERK1/2 activation resulted in induction of Hsp70. Therefore, increase in ERK1/2 activity by Resveratrol provided another negative influence on Hsp70 levels through negative regulation of HSF1 activity. 17-allylamino-17-demethoxygeldanamycin (17AAG), a drug that inhibits Hsp90 chaperone and degrades its client protein Akt concomitantly elevated Hsp70 levels by promoting nuclear translocation of HSF1 from the cytosol. This effect is predominantly due to inhibition of both Akt and ERK1/2 activation by 17AAG. Simultaneously treating K562 with Resveratrol and 17AAG maintained phosho-ERK1/2 levels close to untreated controls demonstrating their opposite effects on ERK1/2 pathway. Resveratrol was found not to interfere with Bcr-Abl activation in K562 cells.

Thus our study comprehensively illustrates that Resveratrol acts downstream of Bcr-Abl and inhibits Akt activity but stimulates ERK1/2 activity. This brings down the transcriptional activity of HSF1 and Hsp70 production in K562 cells. Additionally, Resveratrol can be used in combination with chemotherapeutic agents such as 17AAG, an Hsp90 inhibitor reported to induce Hsp70 and hence compromise its chemotherapeutic potential.

Banerjee Mustafi, Soumyajit; Chakraborty, Prabir K; Raha, Sanghamitra

Heat stress upregulates chaperone heat shock protein 70 and antioxidant manganese superoxide dismutase through reactive oxygen species (ROS), p38MAPK, and Akt

Chinese hamster lung fibroblasts V79 cells were treated with heat stress for 4 weeks with short duration (15 min) heat shock every alternate day in culture. It was observed that Hsp 70 and the antioxidant enzyme MnSOD became overexpressed during the chronic heat stress period. Both p38 MAPK and Akt became phosphorylated by chronic heat stress exposure. Simultaneous exposure to SB203580, a potent and specific p38MAPK inhibitor drastically inhibited the phosphorylation of p38MAPK and

Akt. Furthermore, exposure to SB203580 also blocked the increase in Hsp70 and MnSOD levels and the elevated SOD activity brought about by chronic heat stress. Heat shock factor 1 (HSF1) transcriptional activity and nuclear translocation of HSF1 were prominently augmented by chronic heat stress, and this amplification is markedly reduced by concomitant exposure to SB203580. Also, activations of p38MAPK and Akt and upregulations of Hsp70 and MnSOD were observed on exposure to heat shock for a single exposure of longer duration (40 min). siRNA against p38MAPK notably reduced Akt phosphorylation by single exposure to heat stress and drastically diminished the rise in Hsp70 and MnSOD levels. Similarly, siRNA against Akt also eliminated the augmentation in Hsp70 and MnSOD levels but p38MAPK levels remained unaffected. Heat stress produced reactive oxygen species (ROS) in V79 fibroblasts. N-acetyl cysteine blocked the increase in phosphorylation of p38MAPK, amplification of Hsp70, and MnSOD levels by heat stress. Therefore, we conclude that heat stress-activated p38MAPK which in turn activated Akt. Akt acted downstream of p38MAPK to increase Hsp70 and MnSOD levels.

Concise summary: Thermal injury of the skin over a long period of time has been associated with development of cancerous lesions. Also, in many cancers, the cytoprotective genes Hsp70 and MnSOD have been found to be overexpressed. Therefore, we considered it important to identify the signaling elements upstream of the upregulated survival genes in heat stress. We conclude that heat stress activated p38MAPK which in turn activated Akt. Akt mediated an augmentation in Hsp70 and MnSOD levels working downstream of p38MAPK.

Mustafi, Soumyajit Banerjee; Chakraborty, Prabir Kumar; Dey, Rakhi Sharma; Raha, Sanghamitra

Pro-survival effects of repetitive low-grade oxidative stress are inhibited by simultaneous exposure to Resveratrol

V79 lung fibroblasts were subjected to repetitive oxidative stress in culture through exposures to 30 mu M H2O2 for 4 weeks. Repetitively stressed cells were found to be significantly resistant to apoptosis-inducing agent such as ultraviolet radiation (UVR). Concurrent treatment with Resveratrol completely restored the normal apoptotic response after UVR. p38MAPK became dually phosphorylated during the stress period. Akt also became phosphorylated on Ser(473) in cells subjected to repetitive oxidative stress. In these cells, NF kappa B p65 became phosphorylated and appreciable nuclear localization of p65 was observed. NF kappa B transcriptional activity also became augmented during repetitive stress. Treatment of the repetitively stressed cells concurrently with Resveratrol or SB203580, a p38MAPK inhibitor, robustly blocked activation of p38MAPK, NF kappa B transcriptional activity, phosphorylation and nuclear localization of p65, and Akt phosphorylation. Pre-exposure to short interfering RNA (si RNA) to p38MAPK, resulted in a blockage of the Akt and NF kappa B p65 phosphorylation. However, inhibition of Akt activity through P13 kinase inhibitor LY294002 did not result in obstruction of p38MAPK phosphorylation by H2O2. Also, Resveratrol was effective as an antioxidant in counteracting a rise in reactive oxygen species (ROS) and p38MAPK activation by H2O2 was completely blocked by antioxidant N-acetyl cysteine (NAC). We conclude that Resveratrol acts as an antioxidant and completely reverses the anti-apoptotic effects of repetitive stress by blocking oxidative stress-induced p38MAPK activation which is the key regulatory step for the activation of down-stream survival elements Akt and NF kappa B.

Chakraborty, Prabir Kumar; Mustafi, Soumyajit Banerjee; Raha, Sanghamitra

Resveratrol induces apoptosis in K562 (chronic myelogenous leukemia) cells by targeting a key survival protein, heat shock protein 70

Chronic myelogenous leukemia (CML) is a myeloproliferative disease associated with a characteristic chromosomal translocation called the Philadelphia chromosome. This results in the expression of the Bcr-Abl fusion protein, a constitutively active protein tyrosine kinase. Although there are a few treatment options with Bcr-Abl kinase inhibitors, drug resistance is often encountered. One of the major obstacles in overcoming drug resistance in CML is the high endogenous levels of heat shock protein 70 (Hsp70). Resveratrol is a phytoalexin produced by several plants. We studied the chemotherapeutic effects and mode of action of resveratrol on K562 (CML) cells. Resveratrol induced apoptosis in K562 cells in a time-dependent manner. This was established by increased annexin V binding, corroborated with an enhanced caspase-3 activity and a rise in the sub-G(0)/G(1) population. Resveratrol treatment also caused suppression of Hsp70 both in mRNA and protein levels. The downregulation of Hsp70 by resveratrol exposure was correlated with a diminished presence of heat shock factor 1 (HSF1) in the nucleus, and the downregulation of transcriptional activity of HSF1. High endogenous levels of Hsp70 have been found to be a deterrent for sensitivity to chemotherapy. We show here that resveratrol could considerably enhance the apoptosis induction in K562 cells by 17-allylamino-17-demethoxygeldanamycin, an anticancer agent that inhibits Hsp90 but augments Hsp70 levels. We conclude that resveratrol significantly downregulated Hsp70 levels through inhibition of HSF1 transcriptional activity and appreciably augmented the pro-apoptotic effects of 17-allylamino-17-demethoxygeldanamycin.

Chakraborty, Prabir K; Banerjee Mustafi, Soumyajit; Ganguly, Sudipto; Chatterjee, Mitali; Raha, Sanghamitra

Molecular and functional characterization of EhPAK3, a p21 activated kinase from Entamoeba histolytica

p21-activated kinases (PAKs) are a family of serine/threonine kinases whose activity is regulated by the binding of the small Rho family GTPases as well as by RhoGTPase independent mechanisms. PAKs have wide-ranging functions which include cytoskeletal organisation, cell motility, cell proliferation and survival. We have identified a PAK from Entamoeba histolytica-EhPAK3 that is distributed in the cytoplasm of unstimulated cells and localizes to the caps after induction of capping with Concanavalin A. EhPAK3 contains a GTPase interacting (CRIB) domain, an N-terminal pleckstrin homology (PH) domain and a C-terminal kinase domain. Among the PAKs of E. histolytica studied so far, EhPAK3 bears the maximum similarity to Dictyostelium discoideum PAKC (DdPAKC). Phylogenetic analysis showed that EhPAK3 was closely related to DdPAKC and forms a group with DdPAKA, Dd Myosin I heavy chain kinase (DdMIHCK), and a PAK reported earlier from E. histolytica EhPAK2. Recombinant full-length EhPAK3 undergoes anotophosphorylation and phosphorylates histone HI in vitro in the absence of any small GTPase. This is the first comprehensive characterization of a PAK protein from E. histolytica, which has constitutive activity and has demonstrated a strong involvement in receptor capping.

Dutta, Suman; Sardar, Anupama; Ray, Doel; Raha, Sanghamitra

Structure of cyclophilin from Leishmania donovani bound to cyclosporin at 2.6 Å resolution: correlation between structure and thermodynamic data

Drug development against Leishmania donovani, the pathogen that causes visceral leishmaniasis in humans, is currently an active area of research given the widespread prevalence of the disease and the emergence of resistant strains. The immunosuppressive drug cyclosporin is known to have antiparasitic activity against a variety of pathogens. The receptor for cyclosporin is the protein cyclophilin, which is a ubiquitous peptidylprolyl isomerase. The crystal structure of cyclophilin from L. donovani complexed with cyclosporin has been solved at 2.6 Å resolution. The thermodynamic parameters of the interaction have been determined using spectroscopic and calorimetric techniques. A detailed effort has been made to predict the thermodynamic parameters of binding from computations based on the three-dimensional crystal structure. These results were in good agreement with the corresponding experimental values. Furthermore, the structural and biophysical results have been discussed in the context of leishmanial drug resistance and could also set the stage for the design of potent non-immunosuppressive antileishmanials.

Venugopal, Vandavasi; Datta, Alok K[†]*; Bhattacharyya, Dhananjay; Dasgupta, Dipak; Banerjee, Rahul*

Amino acid residues of Leishmania donovani cyclophilin key to interaction with its adenosine kinase: Biological implications

Cyclophilins (CyPs), by interacting with a variety of proteins, often modulate their biological activities and thus have been implicated in several cellular functions. However, mechanisms that determine such interactions are poorly understood. We earlier reported that an endoplasmic reticulum (ER)-located cyclophilin (LdCyP) from the purine auxotrophic parasitic protozoan Leishmania donovani reactivated its adenosine kinase (AdK). The AdK-reactivating property of LdCyP was however abolished at high ionic strength but not by nonionic detergents. Modeling of LdCyP, based on its crystal structure solved at 1.97 Å resolution, revealed several solvent-exposed hydrophobic and charged residues. Mutagenesis of several of such solvent-exposed residues was performed and their corresponding activities with regard to their (i) AdK reactivation property, (ii) ability to form complex with the enzyme, (iii) capacity to induce red shift in the intrinsic tryptophan fluorescence maxima of AdK, and (iv) efficiency to withdraw the ADP inhibition from the AdK-mediated reaction were compared to the wild-type protein. Results indicated that while the replacement of R147 with either A or D severely impaired all of the above characteristics displayed by the wild-type LdCyP, the effect of mutating K114 and K153 was although relatively less but nevertheless noticeable. Alteration of other exposed hydrophobic and charged residues apparently did not have any discernible effect. Under the condition of cellular stress, the ER-located LdCyP is released into the cytoplasm with concomitant increase both in the specific activity of the cytosol-resident AdK and the uptake of radiolabeled Ado into the cells. These experiments, besides demonstrating the importance of the positive charge, identified R147 as the most crucial residue in the LdCyP-AdK interaction and provide evidence for the stress-induced retrograde translocation of LdCyP from the ER to the cytoplasm. A possible implication of this interaction in the life cycle of the parasite is proposed.

Sen, Banibrata[†]*; Venugopal, V; Chakraborty, Anutosh*[†]*; Datta, Rupak*[†]*; Dolai, Subhankar*[†]*; Banerjee, Rahul; Datta, Alok K*[†]

Identification of a novel set of scaffolding residues that are instrumental for the inhibitory property of Kunitz (STI) inhibitors

For canonical serine protease inhibitors (SPIs), scaffolding spacer residue Asn or Arg religates cleaved scissile peptide bond to offer efficient inhibition. However, several designed “mini-proteins,” containing the inhibitory loop and the spacer(s) with trimmed scaffold behave like substrates, indicating that scaffolding region beyond the spacer is also important in the inhibitory process. To understand the loop-scaffold compatibility, we prepared three chimeric proteins ECIL-WCIS, ETIL-WCIS, and STIL-WCIS, where the inhibitory loop of ECI, ETI, and STI is placed on the scaffold of their homolog WCI. Results show that although ECIL-WCIS and STIL-WCIs behave like good inhibitors, ETIL-WCIS behaves like a substrate. That means a set of loop residues (SRLRSAFI), offering strong trypsin inhibition in ETI, act as a substrate when they seat on the scaffold of WCI. Crystal structure of ETIL-WCIS shows that the inhibitory loop is of noncanonical conformation. We identified three novel scaffolding residues Trp88 Arg74, and Tyr113 in ETI that act as barrier to confine the inhibitory loop to canonical conformation. Absence of this barrier in the scaffold of WCI makes the inhibitory loop flexible in ETIL-WCIS leading to a loss of canonical conformation, explaining its substrate-like behavior. Incorporation of this barrier back in ETIL-WCIS through mutations increases its inhibitory power, supporting our proposition. Our study provides structural evidence for the contribution of remote scaffolding residues in the inhibitory process of canonical SPIs. Additionally, we rationalize why the loop-scaffold swapping is not permitted even among the members of highly homologous inhibitors, which might be important in the light of inhibitor design.

Khamrui, Susmita; Majumder, Sudip; Dasgupta, Jhimli; Dattagupta, Jiban K; Sen, Udayaditya

Crystallization and preliminary X-ray analysis of Psu, an inhibitor of the bacterial transcription terminator Rho

Psu, a coat protein from bacteriophage P4, inhibits Rho-dependent transcription termination both in vivo and in vitro. The Psu protein is alpha-helical in nature and appeared to be a dimer in solution. It interacts with Rho and affects the ATP binding and RNA-dependent ATPase activity of Rho, which in turn reduces the rate of RNA release from the elongation complex. Crystals of Psu were grown in space group I422 in the presence of PEG, with unit-cell parameters a = b = 148.76, c = 63.38 angstrom and a calculated Matthews coefficient of 2.1 angstrom(3) Da(-1) (41.5% solvent content), assuming the presence of two molecules in the asymmetric unit. A native data set was collected to 2.3 angstrom resolution.

Khamrui, Susmita; Ranjan, Amitabh[†]; Pani, Bibhusita[†]; Sen, Ranjan[†]; Sen, Udayaditya

A thermostable cysteine protease precursor from a tropical plant contains an unusual C-terminal propeptide: cDNA cloning, sequence comparison and molecular modeling studies

We report here the cloning and characterization of the entire cDNA of a papain-like cysteine protease from a tropical flowering plant. The 1098-by ORF of the cDNA codify a protease precursor having a signal peptide of 19 amino acids, a cathepsin-L like N-terminal proregion of 114 amino acids, a mature enzyme part of 208 amino acids and a C-terminal proregion of 24 amino acids. The derived amino acid sequence of the mature part tallies with the thermostable cysteine protease Ervatamin-C-as was aimed at. The C-terminal proregion of the protease has altogether a different sequence pattern not observed in other members of the family and it contains a negatively charged helical zone. The three-dimensional model of the precursor, based on the homology modeling and X-ray structure, show that the extended peptide stretch region of the N-terminal propeptide, covering the interdomain cleft, contain protruding side chains of positively charged residues. This study also indicates that the negatively charged zone of C-terminal propeptide may interact with the positively charged zone of the N-terminal propeptide in a cooperative manner in the maturation process of this enzyme.

Ghosh, Raka; Dattagupta, Jiban K; Biswas, Sampa

Cell cycle specific expression and nucleolar localization of human J-domain containing co-chaperon Mrj

J-domain containing co-chaperone Mrj (mammalian relative to DnaJ) has been implicated in diverse cellular functions including placental development and inhibition of Huntingtin mediated cytotoxicity. It has also been shown to interact with keratin intermediate filaments. Since keratins undergo extensive reorganization during cell division, its interactor Mrj might also play an important role in the regulation of cell cycle. In support of this hypothesis, we report the up-regulation of Mrj protein in M-phase of HeLa cells implicating its role in mitosis related activities. The protein is dispersed throughout the cell during late mitosis and is localized in nucleolus during interphase, confirming that the activity of Mrj is regulated by its cell cycle specific expression together with its differential subcellular localization.

Dey, Sanjib; Banerjee, Paromita; Saha, Partha

mRNA cycling sequence binding protein from Leishmania donovani (LdCSBP) is covalently modified by ubiquitination

The lack of transcriptional regulation in trypanosomatids suggests the presence of distinct posttranscriptional mechanisms to control differential gene expression. In fact, the stability of S-phase specific mRNAs in these parasites is determined primarily by the presence of the octanucleotide sequence (C/A)AUAGAA(G/A) in the UTRs of the transcripts. Here, the characterization of LdCSBP is reported, which specifically binds to the octanucleotide containing RNA. The LdCSBP protein contains multiple putative functional domains, including two types of ubiquitin binding domains (UBA and CUE), two CCCH-type Zn-finger motifs probably responsible for specific RNA binding activity and a speculative endonuclease domain SMR. Interestingly, the protein is covalently modified through ubiquitination. This observation and the occurrence of multiple ubiquitin binding domains in the protein raise the possibility of regulation of the activity of LdCSBP by ubiquitination.

Bhandari, Dipankar; Saha, Partha

Deregulation and cross talk among Sonic hedgehog, Wnt, Hox and Notch signaling in chronic myeloid leukemia progression

Deciphering the BCR-ABL-independent signaling exploited in chronic myeloid leukemia (CML) progression is an important aspect in cancer stem-cell biology. CML stem-cell compartment is dynamic as it progresses to terminal blast crisis where myeloid and lymphoid blasts fail to differentiate. We demonstrate cross-regulation of signaling network involving Sonic hedgehog (Shh), Wnt, Notch and Hox for the inexorable blastic transformation of CD34(+) CML cells. Significant upregulation in Patched1, Frizzled2, Lef1, CyclinD1, p21 ($P \le 0.0002$) and down-regulation of HoxA10 and HoxB4 ($P \le 0.0001$) transcripts in CD34(+) cells distinguish blast crisis from chronic CML. We report Shh-dependent Stat3 activation orchestrates these mutually interconnected signaling pathways. Stimulation of CD34(+) CML cells with either soluble Shh or Wnt3a did not activate Akt or p44/42-mitogen activated protein kinase (MAPK) pathways. Interestingly, unlike dominant negative Stat3 beta, introduction of constitutive active Stat3 in CD34(+) CML cells induces cross-regulation in gene expression. Additionally, Shh and Wnt3a-dependent regulation of cyclin-dependent kinase inhibitors (CDKI) in CML suggests their role in the network. Taken together, our findings propose that deregulation in the form of hyperactive Shh and Wnt with repressed Notch and Hox pathways involving Stat3, Gli3, beta-catenin, CyclinD1, Hes1, HoxA10 and p21 might act synergistically to form an important hub in CML progression.

Sengupta, A; Banerjee, D[†]; Chandra, S[†]; Banerji, SK[†]; Ghosh, R[†]; Roy, R[†]; Banerjee, S

Erythrocyte membrane defects and asymmetry in paroxysmal nocturnal hemoglobinuria and myelodysplastic syndrome

Paroxysmal nocturnal hemoglobinuria (PNH) and myelodysplastic syndromes (MDS) are clonal disorder of haematopoietic stem cells that may eventually lead to chronic anemia. The ultrastructural defects in erythrocyte membranes may have a role in early red cell destruction within circulation. The lifespan of the erythrocyte primarily correlates to externalization of phosphatidylserine (PS) and loss of glycophorins from the erythrocyte surface. The span of survival of mature erythrocytes in the circulation in case of MDS and PNH is yet unclear and has been studied by measuring simultaneous exposure of PS and loss of glycoconjugates, primarily glycophorins from membrane surface. The extent of the loss of PS asymmetry and cell surface glycophorins in density separated erythrocytes of six MDS and three PNH patients has been probed by fluorochrome conjugated annexin V and wheat germ agglutinin using flow cytometry. The cells with lighter density showed a higher amount of PS on the outer surface compared to those of heavier cells in all PNH and MDS cases, showing the opposite trend to that observed in normal erythrocytes. In addition, the lighter cells had more cell surface glycophorins compared to heaver cells in all the cases. Such lowering of glycophorin levels from the lighter to heavier cells was maximum in refractory anaemia (RA) and minimum in the normal cells studied. Greater loss of PS asymmetry and cell surface glycophorin in the lighter or younger erythrocytes together could be responsible for their faster destruction and removal (eryptosis) in PNH and MDS.

Basu, Sumanta; Banerjee, Debasis[†]; Ghosh, Malay[†]; Chakrabarti, Abhijit

Structure and conformational studies on dityrosine formation in the DNA binding domain of RFX5

The DNA binding protein RFX5 is a subunit of RFX complex involved in transcription regulation of MHCII molecules The RFX complex binds to the X-box DNA through the DNA binding domain of

RFX5. We have examined the formation of intramolecular tyrosine cross linking, dityrosine, in RFX5DBD under oxidative stress, through UV irradiation and enzymatic action of H2O2/peroxidase by fluorescence spectroscopic studies. Dityrosine (DT) was formed predominantly in alkaline condition showing its intense characteristic fluorescence emission Homology modeling indicated Y-39 and Y-42 could be the potential tyrosine residues undergoing oxidative cross-linking Conformational changes in RFX5DBD under oxidative stress were observed by CD measurements The in vitro association of X-box DNA with RFX5DBD increased DT fluorescence significantly and protected RFX5DBD from UV irradiation as observed in SDS-PAGE followed by mass spectrometric analysis Results indicate cross protection in both RFX5DBD and DNA under oxidative stress playing important role in protein modification

Chakraborty, Madhumita; Bhattacharya, Dipankar; Mukhopadhyay, Chaitali[†]*; Chakrabarti, Abhijit*

Differential regulation of redox proteins and chaperones in HbE beta-thalassemia erythrocyte proteome

In (hemoglobin, Hb) HbE beta-thalassemia, HbE (beta-26 Glu -> Lys) interacts with beta-thalassemia to produce clinical manifestation of varying severity. This is the first proteomic effort to study changes in protein levels of erythrocytes isolated from HbE beta-thalassemic patients compared to normal. We have used 2-DE and MALDI-MS/MS-based techniques to investigate the differential proteome profiling of membrane and Hb-depleted fraction of cytosolic proteins of erythrocytes isolated from the peripheral blood samples of HbE beta-thalassemia patients and normal volunteers.

Our study showed that redox regulators such as peroxiredoxin 2, Cu-Zn superoxide dismutase and thioredoxin and chaperones such as alpha-hemoglobin stabilizing protein and HSP-70 were upregulated in HbE beta-thalassemia. We have also observed larger amounts of membrane associated globin chains and indications of disruption of spectrin-based junctional complex in the membrane skeleton of HbE beta-thalassemic erythrocytes upon detection of low molecular weight fragments of beta-spectrin and decrease in beta-actin and dematin content.

We have observed interesting changes in the proteomic levels of redox regulators and chaperons in the thalassemic hemolysates and have observed strong correlation or association of the extent of such proteomic changes with HbE levels. This could be important in understanding the role of HbE in disease progression and pathophysiology.

Bhattacharya, Dipankar; Saha, Sutapa; Basu, Sumanta; Chakravarty, Sudipa[†]*; Chakravarty, Amit*[†]*; Banerjee, Debashis*[†]*; Chakrabarti, Abhijit*

Oxidative crosslinking, spectrin and membrane interactions of hemoglobin mixtures in HbE beta-thalassemia

We have studied the interactions of intact hemoglobin mixtures of HbE and HbA, with the major erythroid membrane skeletal protein, spectrin and tailor-made phospholipids membranes containing aminophospholipids to understand the role of spectrin and phospholipids of erythrocytes in the overall pathophysiology of the hemoglobin disorders. Hemoglobin mixtures were isolated and purified from the peripheral blood samples of HbE carriers and different HbE beta-thalassemia patients, taken for diagnosis. Spectrin binding was studied by fluorescence and oxidative crosslinking, by SDS-PAGE. Membrane perturbation experiments were carried out to study the leakage of the self-quenching fluorophore, carboxyfluorescein, entrapped in the phospholipid vesicles. Hemoglobin mixtures with elevated levels of HbE showed stronger interactions with spectrin reflected in the decrease in binding dissociation constant from 17 to 5 mu M upon increase in HbE% from about 30 to 90% in the hemolysates. The yield of the spectrin crosslinked complexes of such hemoglobin mixtures also increased with increase in HbE levels. Presence of ATP/Mg and DPG were found to decrease the overall yield of such complexes and the binding affinity of hemoglobins to spectrin. HbE rich hemolysates also induced greater leakage of entrapped carboxyfluorescein (CF) from phospholipid membranes containing aminophospholipids. Results from this study indicate the roles of skeletal proteins and aminophospholipids, particularly under oxidative stress conditions to be important in the premature destruction of erythrocytes in hemoglobin disorders, e. g. HbE beta-thalassaemia.

Chakrabarti, Abhijit; Datta, Poppy; Bhattacharya, Dipankar; Basu, Sumanta; Saha, Sutapa

Porous red cell ultrastructure and loss of membrane asymmetry in a novel case of hemolytic anemia

Transmission electron microscopic study revealed large pores on the erythrocyte ghost membranes, disrupted cytoskeleton and microcytosis of circulating erythrocytes in a novel case of hemolytic anemia. Greater loss of phosphatidylserine (PS) asymmetry was observed in younger erythrocytes compared with the aged ones in contrast to the normal red cells. Levels of sialylated glycoconjugates, such as glycophorin, measured by the binding of wheat germ agglutinin, showed greater loss upon aging. Such drastic loss of PS asymmetry leads to faster eryptosis, mediated by shedding of glycophorin-containing microvesicles leaving highly PS-exposed erythrocytes accessible to the phagocytes.

Banerjee, Debasis[†]; Saha, Sutapa; Basu, Sumanta; Chakrabarti, Abhijit

Loss of phospholipid membrane asymmetry and sialylated glycoconjugates from erythrocyte surface in haemoglobin E beta-thalassaemia

This study aimed to investigate any correlation between the extent of phosphatidylserine (PS) asymmetry and sialylated glycoconjugate levels with the faster clearance of circulating erythrocytes in haemoglobin E (HbE) beta-thalassaemia. Erythrocytes from peripheral blood samples of different HbE beta-thalassaemia patients showed loss of PS asymmetry measured by annexin V binding using flow cytometry. Maximum PS exposure was found when HbE was 50-60% and HbF was < 20% indicating a possible correlation with severity of the disease. Separation of erythrocytes into aged and younger cells showed higher loss of PS asymmetry in the younger erythrocytes of HbE beta-thalassaemia patients when compared with normal blood, where PS asymmetry was lost only in the older cells. Sialylated glycoconjugate measurement using the lectins wheatgerm agglutinin and pokeweed mitogen showed loss of sialic acid and N-acetyl-D-glucosamine-bearing glycoproteins in the order normal < homozygous E < HbE beta-thalassaemic upon ageing. A possible correlation was found between the loss of PS asymmetry with HbE level and the reduction of glycophorins from the cell surface, mediated by membrane vesiculation. A more facilitated vesiculation process in HbE beta-thalassaemic erythrocytes could lead to faster shedding of glycophorin-containing microvesicles, leaving highly PS-exposed erythrocytes accessible to phagocytes.

Basu, Sumanta; Banerjee, Debasis†; Chandra, Sarmila†; Chakrabarti, Abhijit

Membrane interactions of hemoglobin variants, HbA, HbE, HbF and globin subunits of HbA: Effects of aminophospholipids and cholesterol

The interaction of hemoglobin with phospholipid bilayer vesicles (liposomes) has been analyzed in several studies to better understand membrane-protein interactions. However, not much is known on hemoglobin interactions with the arninophospholipids, predominantly localized in the inner leaflet of erythrocytes, e.g., phosphatidylserine (PS), phosphatidylethanolamine (PE) in membranes containing phosphatidyleholine (PC). Effects of cholesterol, largely abundant in erythrocytes, have also not been studied in great details in earlier studies. This work therefore describes the study of the interactions of different hemoglobin variants HbA, HbE and HbF and the globin subunits of HbA with the two aminophospholipids in the presence and absence of cholesterol. Absorption measurements indicate preferential oxidative interaction of HbE and alpha-globin subunit with unilamellar vesicles containing PE and PS compared to normal HbA. Cholesterol was found to stabilize such oxidative interactions in membranes containing both the aminophospholipids. HbE and alpha-globin subunits were also found to induce greater leakage of membrane entrapped carboxyfluorescein (CF) using fluorescence measurements. HbE was found to induce fusion of membrane vesicles containing cholesterol and PE when observed under electron microscope. Taken together, these findings might be helpful in understanding the oxidative stress-related mechanism(s) involved in the premature destruction of erythrocytes in peripheral blood, implicated in the hemoglobin disorder, HbE/beta-thalassemia.

Datta, Poppy; Chakrabarty, Sudipa†; Chakrabarty, Amit†; Chakrabarti, Abhijit

Spectrin interactions with globin chains in the presence of phosphate metabolites and hydrogen peroxide: implications for thalassaemia

We have shown the differential interactions of the erythroid skeletal protein spectrin with the globin subunits of adult haemoglobin (HbA); these indicate a preference for alpha-globin over that for beta-globin and intact HbA in an adenosine 5'-triphosphate (ATP)-dependent manner. The presence of Mg/ATP led to an appreciable decrease in the binding affinity of the alpha-globin chain to spectrin and the overall yield of globin-spectrin cross-linked complexes formed in the presence of hydrogen peroxide. Similar effects were also seen in the presence of 2-,3-diphosphoglycerate (2,3 DPG), the other important phosphate metabolite of erythrocytes. The binding affinity and yield of cross-linked high molecular weight complexes (HMWCs) formed under oxidative conditions were significantly higher in alpha-globin compared with intact haemoglobin, HbA and the beta-globin chain. The results of this study indicate a possible correlation of the preferential spectrin binding of the alpha-globin chain over that of the beta-globin in the haemoglobin disorder beta-thalassaemia.

Datta, Poppy; Chakrabarty, Sudipa†; Chakrabarty, Amit†; Chakrabarti, Abhuit

Grb2-Mediated Alteration in the Trafficking of A beta PP: Insights from Grb2-AICD Interaction

The amyloid-beta protein precursor (A beta PP) is processed by various proteases located along the endosomal lysosomal pathway and any alteration in its trafficking would be important in the pathogenesis of Alzheimer's disease (AD). Our current study is based on the clinical evidence that an A beta PP intracellular domain (AICD) "adaptor" protein, growth factor receptor protein binding protein 2 (Grb2), gets concentrated in neuronal cell bodies in AD patients. Here we show that both endogenous and exogenously transfected Grb2 interact with A beta PP in Neuro 2A cells. Endogenous Grb2 partially co-localizes to late endosomal compartments along with A beta PP and AICD. Increase in the concentration of Grb2 confines it in enlarged late endosomes leading to more sequestration of A beta PP and AICD within these compartments. This confinement of A beta PP due to Grb2 overexpression affects its turnover by inhibiting its release via exosomal vesicles. As a consequence, the level of intracellular A beta PP and AICD increases. The effect of Grb2 overexpression has been verified by knocking down Grb2 as well as by overexpressing Grb2 in Grb2 knocked down cells. Having established the Grb2-mediated trafficking of AICD and its impairment, the significance of its consequence has now become apparent in the downstream events of AD pathogenesis.

Raychaudhuri, Mithu; Mukhopadhyay, Debashis

Transcription regulation of caspase-1 by R393 of HIPPI and its molecular partner HIP-1

Earlier we have shown that exogenous expression of HIPPI, a molecular partner of Huntingtin interacting protein HIP-1, induces apoptosis and increases expression of caspases-1, -8 and -10 in HeLa and Neuro2A cells. The C-terminal pseudo death effector domain of HIPPI (pDED-HIPPI) specifically interacts with the putative promoter sequences of these genes. In the present manuscript, we predict from structural modeling of pDED-HIPPI that R393 of HIPPI is important for such interaction. R393E mutation in pDED-HIPPI decreases the interaction with the putative promoter of caspase-1 in cells. Expression of caspase-1 is decreased in cells expressing mutant pDED-HIPPI in comparison to that observed in cells expressing wild type pDED-HIPPI. Using HIP-1 knocked down cells as well as over expressing HIP-1 with mutation at its nuclear localization signal and other deletion mutations, we demonstrate that translocation of HIPPI to the nucleus is mediated by HIP-1 for the increased expression of caspase-1. HIPPI-HIP-1 heterodimer is detected in cytoplasm as well as in the nucleus and is associated with transcription complex in cells. Taking together, we are able to show the importance of R393 of HIPPI and the role of HIPPI-HIP-1 heterodimer in the transcription regulation of caspase-1.

Banerjee, M; Datta, M; Majumder, P; Mukhopadhyay, D; Bhattacharyya, NP

The Role of Intrinsically Unstructured Proteins in Neurodegenerative Diseases

The number and importance of intrinsically disordered proteins (IUP), known to be involved in various human disorders, are growing rapidly. To test for the generalized implications of intrinsic disorders in proteins involved in Neurodegenerative diseases, disorder prediction tools have been applied to three datasets comprising of proteins involved in Huntington Disease (HD), Parkinson's disease (PD), Alzheimer's disease (AD). Results show, in general, proteins in disease datasets possess significantly enhanced intrinsic unstructuredness. Most of these disordered proteins in the disease datasets are found to be involved in neuronal activities, signal transduction, apoptosis, intracellular traffic, cell differentiation etc. Also these proteins are found to have more number of interactors and hence as the proportion of disorderedness (i.e., the length of the unfolded stretch) increased, the size of the interaction network simultaneously increased. All these observations reflect that, “Moonlighting” i.e. the contextual acquisition of different structural conformations (transient), eventually may allow these disordered proteins to act as network “hubs” and thus they may have crucial influences in the pathogenecity of neurodegenerative diseases.

Raychaudhuri, Swasti; Dey, Sucharita; Bhattacharyya, Nitai P; Mukhopadhyay, Debashis

Biomolecule-metal interactions: Applications in extraction and separation techniques

We have isolated and characterized an alkaloid, piperine and a protein arachin, from black pepper and groundnut respectively. Interactions of these compounds with various metal ions in trace scale from different domains of the periodic table were studied using radiometric method. It is revealed that piperine has high selectivity and specificity towards gold. The protein arachin shows high specificity towards mercury only. The high selectivity of these two bioreagents for the specific metal ions Au and Hg show that the bioreagents have considerable potential to replace the synthetic chemicals and sometime they are superior to synthetic one.

Roy, Kamalika; Ghosh, Kalpita; Banerjee, Anupam; Mukhopadhyay, Debashis; Lahiri, Susanta

AICD and its adaptors - In search of new players

In view of the emerging evidence that amyloid-beta load in the brain and neuronal deficits are possibly independent events and the increasing importance of downstream molecular cascades in Alzheimer’s Disease (AD) pathogenesis, the role of Amyloid Intracellular C-terminal Domain (AICD) is evaluated. This C-terminal fragment of Amyloid-beta protein precursor (A beta PP) is cytotoxic and is a major component of AD brain. Different portions of AICD bind to different ‘adaptors’ and are seen to take part in various cellular events including A beta PP processing and trafficking, apoptosis, neuronal growth and regulation of gene transcription. Phosphorylation also plays an important role in terms of choice of binding partners. The review emphasizes the dynamics of the network created by AICD interactions and points to possible alternative routes of AD like neurodegeneration.

Raychaudhuri, Mithu; Mukhopadhyay, Debashis

Nanoparticle Induced Conformational Change in DNA and Chirality of Silver Nanoclusters

Nano-clusters formed on macromolecular templates carry the symmetry information of the template. Templates with broken symmetry thus lead to formation of asymmetric clusters. In response, such clusters induce a compensatory stress on the embedded template. Silver nanoparticles grown on a covalently closed negatively supercoiled plasmid DNA (pUC19) exhibit chiral behavior and as a reciprocal response, one observes alteration in DNA conformation. The inference was drawn using gel mobility-shift studies in which a silver nanoparticle (but not ions) induces a mobility shift implying a drift from supercoiled to relaxed state of the plasmid. Supporting evidences for such structural alterations were obtained from circular dichroism (CD) and fourier transform infrared spectroscopy (FT-IR). Silver ion and silver nanoparticles induce differential FT-IR signals reflected in the fingerprint regions 1720, 1666, 1611, 1529 cm(-1) that respectively corresponds to binding in GT ATGC, C, and AC (A, T, G, and C representing the four nucleoticles). Existence of CID signal in the silver plasmon region (350-550 nm) suggests formation of a chiral clustering of nanoparticles. The reciprocal effect on the covalently closed circular (CCC) pUC19 DNA, namely the transition to a relaxed state, can be regarded as a mimicry of the topological enzyme acting on such CCC DNA.

Roy, Sarita†; Basak, Soumen; Dasgupta, Anjan Kr†

Interaction with Al and Zn induces structure formation and aggregation in natively unfolded caseins

Caseins are phosphoproteins that form the principal protein component of milk, their chief function being the transport of inorganic calcium and phosphate to the neonates. The four major members of the casein family are alpha(s1)-, alpha(s2)- (together referred to as alpha(s)-casein), beta- and kappa-casein, each having a characteristic high negative net charge as well as high hydrophobicity and preferring extended conformational states in solution. We have investigated the influence of the polyvalent metal cations Zn(II) and AI(III) on the structure of bovine caseins, using fluorescence and circular dichroic (CD) spectroscopy and light scattering. Changes in Trp and ANS fluorescence parameters (blue shifts of the emission maxima and enhancement of fluorescence intensity) and in the far-UV CD spectra of the caseins caused by the presence of both metals suggest that conformational changes are induced in them by low concentrations (20-40 mu M) of the metal cations. These changes lead to formation of solvent-accessible hydrophobic clusters or cavities that, in turn, cause self-association and precipitation of caseins at higher concentration of the metals. These conclusions are supported by increased binding of ThT to the caseins, as well as enhancement of light scattering intensity, observed in presence of AI(III). The chaperonic property of alpha(s)-casein, which enables it to inhibit thermal aggregation of alcohol dehydrogenase, is shown to be partially destroyed by Zn(II)-induced structural alterations, due possibly to loss of flexibility of the natively unfolded casein chains.

Chakraborty, Asima; Basak, Soumen

Binding interaction of cationic phenazinium dyes with calf thymus DNA: A comparative study

Absorption, steady-state fluorescence, steady-state fluorescence anisotropy, and intrinsic and induced circular dichroism (CD) have been exploited to explore the binding of calf thymus DNA (ctDNA) with three cationic phenazinium dyes, viz., phenosafranin (PSF), safranin-T (ST), and safranin-O (SO). The absorption and fluorescence spectra of all the three dyes reflect significant modifications upon interaction with the DNA. A comparative study of the dyes with respect to modification of fluorescence and fluorescence anisotropy upon binding, effect of urea, iodide-induced fluorescence quenching, and CD measurements reveal that the dyes bind to the ctDNA principally in an intercalative fashion. The effect of ionic strength indicates that electrostatic attraction between the cationic dyes and ctDNA is also an important component of the dye-DNA interaction. Intrinsic and induced CD studies help to assess the structural effects of dyes binding to DNA and confirm the intercalative mode of binding as suggested by fluorescence and other studies. Finally it is proposed that dyes with bulkier substitutions are intercalated into the DNA to a lesser extent.

Sarkar, Deboleena†; Das, Paramita†; Basak, Soumen; Chattopadhyay, Nitin†

Effect of surfactants on casein structure: A spectroscopic study

Fluorescence and circular dichroism spectroscopy were used to study the effect of two surfactants having oppositely charged head groups cationic cetyltrimethyl ammonium bromide (CTAB) and anionic sodium dodecyl sulphate (SDS) - on the structure of the intrinsically unstructured proteins alpha(s)-, beta- and kappa-caseins. Although globular proteins are generally known to denature on interacting with surfactants, the caseins were found to adopt more ordered conformations in presence of both SDS and CTAB. The folding induced by CTAB was more efficient than by SDS, as implied by the behaviour of fluorescence and circular dichroic spectra of the caseins in solutions containing varying concentrations of the surfactants. The differential response of the proteins to the two surfactants may lie in the fact that the negatively charged caseins experience a repulsive electrostatic interaction with the negatively charged head groups of SDS, while their interaction with the positively charged head groups of CTAB is attractive in nature. Our results are consistent with two different types of the ‘necklace and bead’ model for the structure of surfactant-casein complexes: while groups of SDS molecules converge tail first around exposed hydrophobic surfaces of the caseins to form micelle-like structures, the protein itself wraps around micellar aggregates of CTAB that have cationic head groups in close association with its negatively charged/polar residues.

Chakraborty, Asima; Basak, Soumen

pH-induced structural transitions of caseins

Caseins are relatively small (molecular mass similar to 20 kDa), unstructured milk proteins of which the main components are referred to as alpha(s)-, beta- and kappa-casein. All three components lack a compact folded conformation, which can be ascribed to a combination of their low overall hydrophobicity and high net charge. Structural transitions of the three caseins in response to variation of pH were investigated using fluorescence and circular dichroism (CD) spectroscopy. Tryptophan emission parameters (intensity and wavelength of emission maximum) and CD spectra showed that at neutral and alkaline pH the caseins exist predominantly in random coil conformation. As the solvent is made acidic the added protons compensate the negative charges on the caseins and reduce the repulsion between like charged residues, allowing the casein chains to fold. At the pI (pH 4-5), the net charge on the protein tends to zero and the protein should approach its maximally structured state. Below pI, the uncompensated charges and their interactions reappear, resulting in slackening of the compact structure and formation of a partially unfolded intermediate. These conclusions were borne out by the biphasic pH-dependence of the fluorescence emission parameters of Trp as well as of ANS incubated with the caseins. Measurement of the efficiency of energy transfer between Trp (donor) and ANS (acceptor) and of the CD spectra of caseins as functions of pH was also consistent with this scenario.

Chakraborty, Asima; Basak, Soumen

Magnetic field effect in homogeneous medium for triplet born radical ions: a way for assessment of inter-radical distance in intermolecular photoinduced electron transfer

Photoinduced electron transfer (PET) reaction involves excitation of either donor or acceptor prior to electron transfer. The PET reaction might occur in the singlet or in the triplet electronic state of the chromophore. These reactions could be influenced by the presence of internal or external magnetic field since radical ions with free electrons are generated as intermediates. Magnetic field effect (MFE) in homogeneous medium could be observed on exciplex luminescence, however the change is very small as the rate of recombination is very high owing to the singlet spin correlation of the geminate radical ion pair (RIP). On the other hand for the triplet born RIPs the detection of MFE needs confinement of the triplet species because at ambient temperature the lifetime of the solvent cages containing spin correlated RIP in homogeneous solvent is 10(-10) s whereas the rate of intersystem crossing is 10(-8) s. It is possible to confine the triplet born radicals by using organized assemblies like micelles, reverse micelles, etc., highly viscous solvents at low temperature or long chain biradicals which help to reduce fast escape and thus retain the spin-correlation between the partners of the geminate RIP. MFE is a composite of diffusion dynamics, spin dynamics leading to intersystem crossing and recombination of free ion formation. The effect is optimized only when the inter-radical distance through diffusion becomes sufficient to make exchange interaction between free electrons negligible retaining the original spin-correlation in the solvent cage. In this review we would-like to highlight a few systems where MFE for the triplet born radicals could be observed even in homogeneous media due to some specific interactions other than covalent linking, which also helps to assess the inter-radical distance in such intermolecular PET, which is very rare.

Dey, Debarati; Basu, Samita

Interaction of proflavin with aromatic amines in homogeneous and micellar media: Photoinduced electron transfer probed by magnetic field effect

Photoinduced electron transfer (PET) between proflavin PF^+ and two aromatic amines viz., dimethylaniline (DMA) and 4,4'-bis(dimethylamino)diphenylmethane (DMDPM) is studied in homogeneous and heterogeneous media using steady-state as well as time-resolved fluorescence spectroscopy and laser flash photolysis with an associated magnetic field. Ionic micelles have been used to study the effect of charge of proflavin on PET with amines. Magnetic field effect on PET reactions reveals that the parent spin-state of precursors of PET for DMA-PF^+ system is singlet while for DMDPM-PF^+ system is triplet, implying that the dynamics of PET is influenced by the structure of the donor.

Chakraborty, Brotati; Basu, Samita

Interaction of quinones with three pyrimidine bases: A laser flash photolysis study

The interaction between three different pyrimidine bases, uracil (U), cytosine (C) and thymine (T) and two quinones, 2-methyl-1,4-naphthoquinone or menadione (MQ) and 9,10-anthraquinone (AQ) have been studied using laser flash photolysis technique in organic homogeneous medium, The three pyrimidines have revealed a difference in their extent of reactivity towards the quinones. which has been attributed to their structural difference. Our works have revealed that the difference in structural dimension of the quinones is also responsible for affecting the reactivity of these pyrimidines in homogeneous medium.

Bose, Adity; Basu, Samita

Role of sugar in controlling reaction pathways: A study with thymine and thymidine

Magnetic field effect in conjunction with laser flash photolysis have been used for studying interactions of 9,10-anthraquinone and 2-methyl 1,4-naphthoquinone (menadione) with a DNA base, thymine (Thy) and its nucleoside, thymidine (dThd). Irrespective of medium Thy has been found to support both electron transfer (ET) and hydrogen abstraction with the quinones while dThd has exhibited a complete reluctance towards ET. This unique behavior of dThd has been attributed to a failure in attaining aromaticity by virtue of keto-enol tautomerism upon addition of a sugar moiety. Electron withdrawing effect of sugar unit is also considered responsible for reduction of ET from dThd. Again both Thy and dThd have exhibited hydrogen abstraction in homogeneous medium, which is normally unexpected. The above behaviors of the bases have been explained on the basis of their chemical structures.

Bose, Adity; Sarkar, Achintya, K[†]*; Basu, Samita*

Study of interaction of proflavin with triethylamine in homogeneous and micellar media: Photoinduced electron transfer probed by magnetic field effect

Interaction of triethylamine (TEA) with cationic proflavin PF^+ in homogeneous and micellar media is studied using absorption spectroscopy, steady-state as well as time-resolved fluorescence spectroscopy and laser flash photolysis in conjunction with an external magnetic field. The two prime phenomena that have been highlighted in this study are photoinduced electron transfer (PET) and ground-state complex formation. This study shows that it is the medium which determines the reaction pathways to be followed. Magnetic field effect (MFE) helps to elucidate the reaction mechanism involved and this work also highlights the distance dependence factor associated with MFE.

Chakraborty, Brotati; Basu, Samita

A comparative study of astaxanthin level in mangrove species

The astaxanthin levels in the leaves of seven dominant mangrove species, sampled from four different stations of deltaic complex of Indian Sundarbans at the apex of the Bay of Bengal (Lat 21(0) 13'-22(0) 40' N and Long 88(0) 03'-89(0) 07' E), were measured by the ultraviolet-visible spectrophotometry, during the early summer, 2007. The selected sampling stations exhibited variation with respect to changes in aquatic salinity. Relatively higher astaxanthin level was observed in the plants sampled from high saline zone which confirms the accelerated synthesis of this carotenoid pigment under stress (saline ambient medium) condition. The inundated leaves showed more astaxanthin levels relative to the leaves that were not inundated. This is again due to the stress exerted by salinity to which the inundated leaves arc exposed. The astaxanthin content of the mangrove leaves was in the order: Heritiera fomes > Avicennia alba >Avicennia marina >Avicennia officinalis > Sesuvium sp. > Sonneratia apetala > Porterasia coarctata at all the sampling stations. It points towards the species specificity of the carotenoid pigments.

Banerjee, Kakoli[†]*; Ray, Debajyoti*[†]*; Basu, Samita; Chakraborty, Bratoti; Mitra, Abhijit*[†]

Exploring the Mechanism of Electron Transfer between DNA and a Ternary Copper Complex

Photoinduced intramolecular electron transfer occurs in the triplet state within the complex [Htyr-Cu-phen](+) (Htyr = L-tyrosinato; phen = 1,10-phenanthroline) from tyrosine to phenanthroline. For this linked donor-acceptor system, a prominent magnetic field effect (MFE) is observed for the triplet-born radicals. The competitive binding study in the presence of ethidium bromide suggests that the complex interacts with calf thymus DNA (CT DNA) through partial intercalation. The photoexcited copper complex can oxidize DNA in a deoxygenated environment. Though the oxidation of tyrosine is thermodynamically more favorable than the oxidation of guanine, the primary electron transfer occurs from the DNA base to the phen ligand. A prominent MFE is observed for this noncovalently bound triplet-born guanine radical and phen radical anion. The process of partial intercalation of the copper complex within DNA is responsible for this rare observation.

Dey, Debarati; Pramanik, Nikhil R[†]*; Basu, Samita*

Medium-dependent interactions of quinones with cytosine and cytidine: A laser flash photolysis study with magnetic field effect

Laser flash photolysis and an external magnetic field have been used for the study of the interaction of two quinone molecules, namely, 9,10-anthraquinone (AQ) and 2-methyl 1,4-naphthoquinone (or menadione, MQ) with a DNA base, cytosine (C) and its nucleoside cytidine (K) in two media, a homogeneous one composed of acetonitrile/water (ACN/H_2O, 9: 1, v/v) and a SDS micellar heterogeneous one. We have applied an external magnetic field for the proper identification of the transients formed during the interactions in micellar media. Cytosine exhibits electron transfer (ET) followed by hydrogen abstraction (HA) while dC reveals a reduced ET compared to C, with both quinones in organic homogeneous medium (ACN/H_2O). Due to a higher electron affinity, AQ supports more faciler ET than MQ with dC in ACN/H_2O but observations in SDS have been just the reverse. In SDS, ET from dC is completely quenched and a dominant HA is all that could be discerned. This work reveals two main findings: first, a drop in ET on addition of a ribose unit to C, which has been attributed to a role of keto-enol tautomerism in inducing ET from electron-rich nucleus and second, the effect of medium in controlling reaction mechanism by favoring HA with AQ although it is intrinsically more prone towards ET.

Bose, Adity; Basu, Samita

Role of sugar in controlling reaction pattern: A comparative study with adenine and 2 '-deoxyadenosine

Interaction between 2-methyl-1,4-naphthoquinone (MQ) and adenine (A) and 2'-deoxyadenosine (dA) reveals interesting differences with respect to electron transfer (ET) and hydrogen abstraction (HA). In our case A and dA exhibited ET from different sites, which has been associated to the presence of a sugar unit in dA. Sugar unit has also reduced the rate of ET from dA. We have utilized an external magnetic field in conjunction with our laser flash photolysis set-up to establish our data. In a polar MeCN/H_2O medium A and dA are found to promote ET but HA from dA is seen to be insignificant. However shifting to a heterogeneous micellar medium has been found to have a marked effect in increasing the HA rate for dA only. Separate experiments with 2'-deoxyribose sugar have revealed sugar moiety to be more susceptible to HA in SIDS medium.

Bose Nee Chowdhury, Adity; Basu, Samita

Laser Flash Photolysis and Magnetic Field Effect Studies on the Interaction of Uracil and Its Derivatives with Menadione and 9,10-Anthraquinone

Laser flash photolysis and an external magnetic field have been used to study the interaction of two quinone molecules, namely, 9,10-anthraquinone (AQ) and 2-methyl-1,4-naphthoquinone, commonly known as menadione (MQ), with the RNA base uracil (U) and two of its derivatives, 1,3-dimethyluracil (dmU) and uridine (dU). We have conducted our studies in homogeneous organic and heterogeneous micellar media in order to investigate the effect of media on the molecules and any change in reactivity on account of substitution. In organic homogeneous medium, both the quinones have behaved similarly with the bases. Here U has undergone both electron transfer (ET) and hydrogen (H) transfer, while dU and dmU have failed to exhibit any ET. Failure to support ET has been attributed to keto-enol tautomerism, which has been found to have a significant role in determining the occurrence of ET from these pyrimidine bases. However, in SDS micelles some variations regarding the reactivity of these molecules have been discerned. The variations are 2-fold. Here ET from U has been found to get completely eclipsed by a dominant H abstraction with both the quinones, and AQ reveals a difference in the extent of H abstraction with the bases in SDS. With U and dU, the prevailing H abstraction with AQ has succeeded in formation of only AQH(center dot), while dmU has produced both AQH(center dot) and AQH(2), the latter being formed by two successive H abstraction. Explanations of this intriguing behavior with U and its derivatives with quinone molecules have been the main concern in this work.

Bose, Adity; Basu, Samita

Interaction of BSA with proflavin: A spectroscopic approach

The interaction of bovine serum albumin (BSA) with proflavin was investigated by spectroscopic tools like absorption and fluorescence spectroscopy as well as laser flash photolysis. Absorption spectroscopy proved the formation of ground-state BSA-proflavin complex. Proflavin was found to quench the intrinsic fluorescence of BSA via static quenching. High value of quenching constant suggested that energy transfer occurred from BSA to proflavin. Distance between the fluorophore in the protein and the ligand (proflavin) was evaluated. Binding constant and number of binding site were determined for proflavin-BSA interaction both in phosphate buffer (pH similar to 6.8) and in sodium dodecylsulphate media. The values of the thermodynamic parameters suggested that the key interacting forces are van der Waal's interaction and hydrogen bonding. Laser flash photolysis study reconfirmed the formation of complex between BSA and proflavin.

Chakraborty, Brotati; Basu, Samita

Laser flash photolysis and magnetic-field-effect studies on interaction of thymine and thymidine with menadione: role of sugar in controlling reaction pattern

The magnetic field effect (MFE) in conjunction with laser flash photolysis has been used for the study of the interaction of one of the small drug like quinone molecules, 2-methyl, 1,4-naphthoquinone, commonly known as menadione (MQ), with one of the DNA bases, thymine (THN), and its corresponding nucleoside, thymidine (THDN), in acetonitrile (ACN) and sodium dodecylsulfate (SDS) micelles. It has been observed that THN undergoes electron transfer (ET) and hydrogen (H) abstraction with MQ, while THDN undergoes only H abstraction in both the media. However, our earlier studies showed that a purine base, adenine (ADN), and its nucleoside, 2 2 -deoxyadenosine (ADS), undergo ET in ACN and H abstraction in SDS. Here we have attempted to explain the differences in the reactions of these DNA bases with MQ. We also reveal the crucial role of a sugar unit in altering the behavior of purine and pyrimidine bases with respect to ET and H abstraction.

Bose, Adity; Dey, Debarati; Basu, Samita

Interaction of 9,10-anthraquinone with adenine and 2 ‘-deoxyadenosine

Laser flash photolysis has been used for the study of the interaction of 9,10-anthraquinone (AQ) with the DNA base, adenine (A) and its corresponding nucleoside, 2'-deoxyadenosine (dA). This study has provided two very important observations. AQ has been found to support electron transfer in different categories of media, acetonitrile/water on one hand and SDS micelles on other. While in our earlier work 2-methyl 1,4-naphthoquinone was found to undergo a switchover in reactivity a. Am. Chem. Soc. 126 (2004) 1058910593). Again A and dA are found to behave differently on account of an extra sugar unit, which not only affects the rate of reaction but the reaction pathway has been found to be modified too.

Bose, Adity; Sarkar, Achintya K†; Basu, Samita

Interactions of guanine and guanosine hydrates with quinones: A laser flash photolysis and magnetic field effect study

Laser flash photolysis and an external magnetic field have been used to study the interaction of two quinone molecules, namely, 9,10-anthraquinone (AQ) and 2-methyl 1,4-naphthoquinone, commonly known as menadione (MQ), with one of the DNA bases, guanine (G) and its nucleoside guanosine hydrate (dG). In organic homogeneous medium, it has been observed that G undergoes a predominant hydrogen (H) abstraction reaction with both the quinones while dG supports photoinduced electron transfer (PET) along with H abstraction. On the other hand, in SDS medium, G supports PET with AQ but not with MQ. However, behavior of dG remains unperturbed toward AQ and MQ with the change in medium. All of these observations have been explained on the basis of stabilization of radical ion pair and difference in size of the quinones, which can affect the distance of approach among the interacting molecules.

Bose, Adity; Dey, Debarati; Basu, Samita

Magnetic field effect on photoinduced electron transfer between [Cu(phen)(2)](2+) and DNA

The magnetic field effect (MFE) on the photoinduced electron transfer (PET) reaction between the $[Cu(phen)_2]^{2+}$ complex and DNA has been studied in homogeneous buffer medium and in reverse micelles. The copper complex on photoexcitation can oxidize DNA in a deoxygenated environment. A prominent MFE is found even in a homogeneous aqueous medium for the triplet born radicals. The process of partial intercalation of $[Cu(phen)_2]^{2+}$ complex within DNA is responsible for such a rare observation. In reverse micelles, the MFE is not very much prominent because of the large separation distance between the component radicals of the geminate radical ion pairs generated through PET.

Dey, Debarati; Bose, Adity; Pramanik, Nikhil†; Basu, Samita

Dibenzo[a,c]phenazine: A polarity-insensitive hydrogen-bonding probe

A derivative of phenazine, dibenzo[a,c]phenazine (DBPZ), can be used as a very good hydrogen-bonding probe unlike its parent phenazine molecule. Steady-state absorption and fluorescence studies reveal that DBPZ is completely insensitive to polarity of the medium. However, DBPZ can form a hydrogen bond very efficiently in its first excited singlet state. The extent of this excited-state hydrogen-bond formation depends both on size and on hydrogen-bond donor ability of the solvents. Time-resolved fluorescence studies and theoretical calculations also suggest that this hydrogen-bond formation is much more favorable in the excited state as compared to the ground state. In the excited state, the electron density is pushed toward the nitrogen atoms from the benzene rings, thereby increasing the dipole moment of the DBPZ molecule. Although the dipole moment of DBPZ increases upon photoexcitation, like other polarity probes, the molecule remains fully insensitive to the polarity of the interacting solvent. This unusual behavior of DBPZ as compared to simple phenazine and other polarity probes is due to the structure of the molecule. Hydrogen atoms at the I and 8 positions of DBPZ are sterically interacting with a lone pair of electrons on the proximate nitrogen atoms and make both of the nitrogen atoms inaccessible to solvent molecules. For this reason, DBPZ cannot sense the polarity of the medium. However, DBPZ can only sense solvents, those that have hydrogen with some electropositive nature, that is, the hydrogen-bond donating solvents. Hydrogen being the smallest among all elements can only interact with the lone pair of electrons of nitrogen atoms. Thus, DBPZ can act as a sensor for the hydrogen-bond donating solvents irrespective of their dielectrics.

Dey, Debarati; Bose, Adity; Bhattacharyya, Dhananjay; Basu, Samita; Maity, Shyam Sundar†; Ghosh, Sanjib†

Photoinduced electron transfer between hen egg white lysozyme and anticancer drug menadione

The protein, hen egg white lysozyme, on photoexcitation undergoes electron transfer with menadione (2-methyl-1,4-naphthoquinone), a widely known anticancer drug. With the addition of menadione the fluorescence of lysozyme is quenched with the simultaneous formation of an excited state charge-transfer complex in the longer wavelength and a ground state complex. The former is further evident from laser flash photolysis studies, which indicate a tryptophan to menadione electron transfer. From fluorescence quenching studies the binding constant is found to be ~ 1.7×10^4 M^{-1} with the corresponding changes in enthalpy (ΔH_0) and entropy (ΔS_0) as 12.24 kJ mol^{-1} and 124.12 J $mol^{-1}K^{-1}$, respectively, indicative of an entropy-driven process. The circular dichroism studies also show some structural changes with increase in α-helical content in the protein on interaction with menadione. Finally, docking studies give some insight into the role of Trp 108 of lysozyme in the interaction.

Banerjee, Swagata; Dutta Choudhury, Sharmistha; Dasgupta, Swagata†; Basu, Samita

Synthesis, characterization, electrical transport and magnetic properties of PEDOT-DBSA-Fe3O4 conducting nanocomposite

Electrical transport and magnetic properties of newly synthesized conducting polymer nanocomposites involving poly(3,4-ethylenedioxythiophene) (PEDOT) and Fe3O4 nanoparticles are studied. Nanocomposite samples of varying proportions of inorganic to organic components were synthesized by adding EDOT monomer stabilized in miceller solution of DBSA (dodecylbenzene sulphonic acid) to aqueous colloidal dispersion of Fe3O4 nanoparticles, followed by oxidative polymerization using ammonium peroxodisulphate (APS). Transmission electron microscopic (TEM) photographs show presence of distinct spherical Fe3O4 naonparticles having diameter range of 20-40 nm and they are incorporated within the polymer chain in the nanocomposite samples. Temperature-dependent DC conductivity analysis indicates a smooth cross-over of the charge conduction from the high temperature 3D Mott's variable range hopping (VRH) mechanism to the 2D ES (Efros and Shklovoskii)-VRH behaviour at low temperature. Temperature-dependent DC magnetization studies reveal enhancement of blocking temperature (T-B) in the nanocomposite samples compared to that of bare Fe3O4 nanoparticles. Core shell morphology of the nanoparticles seems to be the cause for lowering the value of saturation magnetization of the Fe3O4 nanoparticles. Estimated magnetic domain sizes are comparable to those of grain sizes for the nanocomposite samples having lower content of nanoparticles (P-50 and P-100). Temperature-dependent AC-susceptibility data also supports the superparamagnetic behaviour.

De, Amitabha; Sen, Pintu[†]; Poddar, A; Das, A

New routes for production of proton-rich Tc isotopes

Proton-rich Tc radionuclides have been identified as potential candidates for specific clinical and biological applications in the last decade. So far, these radionuclides have been produced either by proton-induced reaction on Mo targets or alpha-particle-induced reaction on Nb targets. This article lightens two heavy-ion-induced production routes of Tc-93,Tc-94,Tc-95,Tc-96 radionuclides through Li-7 + Zr-nat and Be-9 + Y-nat reactions and provides important cross-sectional information in the projectile energy ranges 37-45 MeV and 30-48 MeV, respectively. Excitation functions of those reactions have been measured using the stacked-foil technique followed by the off-line gamma-spectrometric studies. Measured cross-sectional data have been interpreted comparing theoretical predictions of the two nuclear reaction model codes PACE-II and ALICE91. Experimental cross sections agreed with the theory. Measured production cross sections of Tc-94,Tc-95 have been compared with those produced from the alpha + Nb-93 reaction.

Maiti, Moumita; Lahiri, Susanta

Separation of no-carrier-added Tc-93,Tc-94,Tc-94m,Tc-95,Tc-96 from Li-7 induced natural Zr target by liquid-liquid extraction

Charged particle activation was carried out on Zr-nat foil by 42.5 MeV Li-7 beam to produce Tc-93,Tc-94,Tc-94m,Tc-95,Tc-96 radionuclides. No-carrier-added (nca) technetium radionuclides were separated from co-produced Nb-90.96 and bulk Zr employing liquid-liquid extraction with the help of anion exchanger trioctylamine (TOA) diluted in cyclohexane and HCI. Bulk Zr was monitored by spiking Zr-88,Zr-89 produced by 20 MeV proton induced reaction on Y-nat target. The optimum separation was achieved at 0.1 M TOA and 0.01 M HCl. Technetium radionuclides were recovered from the TOA phase by stripping with 0.1 M DTPA (diethylene triamine pentaacetic acid) dissolved in NaOH.

Maiti, Moumita; Dutta, Binita; Lahiri, Susanta

Separation of no-carrier-added Nb-90 from proton induced natural zirconium target

No-carrier-added (nca) Nb-90 (14.6 h) was produced by irradiating a natural zirconium foil of 4.9 mg/ cm(2) thickness by 13 MeV proton beam. Nca Nb-90 of similar to 27 kBq activity was produced in the target matrix. Liquid-liquid extraction technique was applied using trioctylamine (TOA) in cyclohexane to separate nca Nb-90 from bulk zirconium matrix. About 70% radiochemical yield of nca Nb-90 was achieved with a separation factor of 1.4 x 10(4).

Maiti, Moumita; Lahiri, Susanta

Separation of Mo-99 and Tc-99m by liquid-liquid extraction using trioctylamine as extractant

Amongst various radionuclides of molybdenum, Mo-90 and Mo-99 have suitable beta energy for clinical uses. In this paper we report separation of Mo-99 from Mo-99-Tc-99m equilibrium mixture. The liquid-liquid extraction technique has been employed using trioctylamine (TOA) diluted in cyclohexane as organic phase and HCl as aqueous phase. At 10(-5) M HCl and 0.5 M TOA concentration Tc-99m quantitatively transferred to the organic phase leaving Mo-99 in the aqueous phase. The developed separation method is efficient and provides very high separation factor.

Maiti, Moumita; Lahiri, Susanta

Production and separation of no-carrier-added Tc-93,Tc-94,Tc-95 from Be-9 activated yttrium target

Proton rich Tc radionuclides have been produced for the first time through Y-89(Be-9, xn)Tc-93,Tc-94,Tc-95 reactions. In order to optimize the yield of a particular radionuclide of choice, batch yield of Tc-93, Tc-94 and Tc-95 have been measured at different incident energies using stacked-foil technique followed by off-line gamma-spectrometry. No-carrier-added (nca) Tc-93,Tc-94,Tc-95 radionuclides have been separated from bulk yttrium by liquid-liquid extraction (LLX) and solid-liquid extraction (SLX) techniques. Trioctylamine (TOA) diluted in cyclohexane was used as liquid anion exchanger in LLX in presence of HCl. SLX was carried out using cation and anion exchanger resin, DOWEX-50 and DOWEX-1, respectively, in HCl medium.

Maiti, M; Lahiri, S

Extraction of long-lived radionuclides Eu-152,Eu-154 and Cs-134 using environmentally benign aqueous biphasic system

A polyethylene glycol based aqueous biphasic system has been studied for the extraction and separation of long-lived radionuclides, Eu-152.154 and Cs-134. The effects of pH variation of the salt rich phases on the extraction properties of these radionuclides were Studied and the experimental results were found to be supported by theoretical calculations. It has been observed that at neutral pH of sodium sulphite and at pH 11 of sodium phosphate salt rich phase Cs-134 could be separated from Eu-152,Eu-154 radionuclides. The exact phase forming concentrations of the salt rich phases were determined by measuring the volume of salt rich phase after equilibration.

Roy, K; Paul, R; Banerjee, B; Lahiri, S

Production and separation of no-carrier-added At-208,At-209,At-210 produced from heavy ion activation on natural thallium target

No-carrier-added (nca) At-208,At-209,At-210 was produced for the first time from Be-9 induced reaction on thallium carbonate target at BARC-TIFR pelletron, Mumbai, India. The target of 4 mg/cm(2) thickness was prepared by centrifugation technique. Nca At was separated from the thallium target by liquid-liquid extraction using liquid cation exchanger HDEHP dissolved in cyclohexane and liquor ammonia.

Maiti, Moumita; Lahiri, Susanta

A green approach for sequential extraction of heavy metals from Li irradiated Au target

An aqueous biphasic extraction system was designed using different molecular weights of polyethylene glycol and concentrated salt solutions of sodium sulphate to separate the heavy metals, Hg, Tl and Pb from Li irradiated Au matrix. All the four elements could be separated from one another by this extraction process by simply optimizing the salt rich phase, the pH of the salt rich phase and the molecular weight of the polymer rich phase.

Lahiri, Susanta; Roy, Kamalika

Production of Zr-88,Zr-89 by proton induced activation of Y-nat and separation by SLX and LLX

Y-nat foil was irradiated by 20 MeV proton to produce no-carrier-added Zr-88,Zr-89. A comparative evaluation on radioanalytical separation methods of Zr-88,Zr-89 was carried out from irradiated target matrix by both liquid-liquid (LLX) and solid-liquid (SLX) extraction methods using di-(2-ethylhexyl) phosphoric acid (HDEHP) dissolved in cyclohexane as liquid cation exchanger and Dowex 50W-X8 H+ form (20-50 mesh) as solid cation exchanger. Both the methods offer good separation and high yield of nca Zr-88,Zr-89 but SLX offers much higher separation factor and better yield.

Dutta, Binita; Maiti, Moumita; Lahiri, Susanta

Extraction of Hg(I), Hg(II) and methylmercury using polyethylene glycol based aqueous biphasic system

Extraction behavior of three different salts of mercury, HgCl2, Hg2Cl2 and CH3HgCl, were studied in a polyethylene glycol based aqueous biphasic extraction system (ABS). The results were compared with extraction pattern in a liquid-liquid system using methylisobutyl ketone (MIBK), against HCl and a solid chelating ion exchanger, Chelex 100. The results showed a variable extent of partitioning of different salts of mercury using MIBK and Chelex 100 as ion exchangers. However, when ABS was employed, complete extractions of all the three species of mercury were achieved irrespective of their chemical form.

Roy, Kamalika; Lahiri, Susanta

Immobilisation of no-carrier-added Mo-93m on a biopolymer calcium alginate: a candidate radiopharmaceutical

No-carrier-added Mo-93m radionuclide with high specific activity is a potential candidate radionuclide in the field of nuclear medicine due to its suitable half-life and gamma energy with significant intensity. In the present paper, we report the immobilization of radioisotopically and radiochemically pure no-carrier-added (nca) Mo-93m onto calcium alginate biopolymer. The experiment has been performed to examine the possibility of polymeric delivery of Mo-93m radionuclide by measuring the adsorption of Mo-93m on calcium alginate beads. Maximum adsorption was found at pH 2.

Nayak, D; Lahiri, S

Studies on bio-accumulation of Cr-51 by Piper nigrum

The present study is performed to examine the accumulation efficiency of Cr-51(III) and Cr-51(VI) by the alkaloid piperine, derived from the fruits of Piper nigrum (Family Piperaceae) as well as using the fruit commonly known as black pepper by radiometric technique. The pH dependence and the effect of the concentration of chromium on the accumulation have also been examined. The maximum accumulation (52%) of Cr(III) is found by black pepper at pH 4 whereas piperine shows slight accumulation at this condition. Accumulation of Cr(VI) by black pepper is always negligible. It has also been observed that some other constituents of the black pepper like gum, terpenoid, etc., besides piperine is responsible for the accumulation of chromium.

Nayak, D; Ghosh, K; Lahiri, S

Determination of dynamic dissociation constant of chromium-poly(N-vinylpyrrolidone) complex by the radiotracer technique

The binding ability of polyvinylpyrrolidone (PVP) With chromium in its different oxidation states has been investigated. The complexation of PVP towards Cr(III) and Cr(VI) labeled with Cr-51 radionuclide has been studied with the dialysis technique. The stability of the complexes has been examined by measuring the dynamic dissociation constant from the slope of the plot of In {Cr(VI)/(III)-PVP} versus time. It has been observed that both Cr(VI)-PVP and Cr(III)-PVP complexes are most stable at pH 7. However. the Cr(III)-PVP complex is more stable than the Cr(VI)-PVP complex at all pH values. This study shows the comparative stability of the complexes of the two different species of chromium with PVP, which may be useful in radiopharmaceutical sciences.

Nayak, Dalia; Banerjee, Anupam; Ghosh, Kingshuk[†]; Das, Ayan[†]; Lahiri, Susanta

Studies on separation of no-carrier-added W-177 from bulk lutetium

Irradiation of natural lutetium oxide target with Li-7 beam results in the formation of no-carrier-added W-177 radionuclide in the matrix. An efficient radiochemical procedure for the separation of no-carrier-added (nca) W-177 (T (1/2) = 2.21 h) radionuclide is presented using liquid-liquid extraction (LLX). A high separation factor between nca W-177 from the target Lu has been achieved with 0.1 M TOA and 8 M HCl. About 85% of W-177 has been extracted in the organic phase keeping Lu in the aqueous phase in a single run. Using this production and separation method radiochemically pure W-177 can be obtained. The separation has also been tried with a greener approach viz. aqueous biphasic extraction. In this case, aqueous biphasic extraction is not a good method for separation of W-177. The radionuclide W-177 thus obtained can be used to study the extraction pattern of lighter homologue of the element 106 (Sg) together with Mo, which in turn is important to investigate the chemistry of Sg.

Nayak, D; Lahiri, S

Albumin metal interaction: A multielemental radiotracer study

Interaction of albumin with no-carrier-added metal radionuclides was studied in multielemental environment using dialysis technique. No-carrier-added Hg-197m, Tl199-201, Pb199-200, Bi-204 and Po-204,Po-205 were produced by irradiating Au target consecutively with Li-7 and C-12 beams. Similarly, Cu-61, Ga66-68, Zn-62,Zn-63, Ge-66,Ge-67,Ge-69, As-71,As-72 and Se-73 were produced by irradiating cobalt target consecutively with O-16, Li-7 and C-12 projectiles. These no-carrier-added radionuclides were chemically separated from the bulk target before studying their interaction with albumin. It was found that Hg and Ga strongly bind with albumin, whereas Bi, Po, As, and Se do not bind at all with albumin. The binding affinities of Pb, Tl, Cu and Zn radionuclides towards albumin are moderate.

Banerjee, A; Lahiri, S

Theoretical approach to explore the production routes of astatine radionuclides

To fulfill the recent thrust of astatine radionuclides in the field of nuclear medicine, various production routes have been explored in the present work. The possible production routes of At209-211 comprise both light- and heavy-ion-induced reactions at the bombarding energy range starting from threshold to a maximum of 100 MeV. Excitation functions of those radionuclides, produced through various production routes, have been calculated by using nuclear reaction model codes TALYS, ALICE91, and PACE-II and are compared with the available measured data. Contributions of various reaction mechanisms, such as direct, pre-equilibrium, and equilibrium reactions, to the total reaction cross section have been studied using the codes. Results show that the equilibrium reaction dominates in all cases over other reaction mechanisms.

Maiti, Moumita; Lahiri, Susanta

Biorecovery of gold using cyanobacteria and an eukaryotic alga with special reference to nanogold formation - a novel phenomenon

Pro- and eukaryotic algal genera, i.e. Lyngbya majuscula, Spirulina subsalsa (Cyanophyceae) and Rhizoclonium hieroglyphicum (Chlorophyceae), were used for bio-recovery of gold (Au) out of aqueous solution. Au (III) spiked with Au-198 was used for the experiment. Batch laboratory experiments indicated quick metabolic independent binding of Au to the algae followed by active accumulation and subsequent reduction. Gold accumulation by different algal genera was found in order of R. hieroglyphicum > L. majuscula > S. subsalsa (3.28, 1.93 and 1.73 mg g^{-1}, respectively). It was observed that the algal biomass and the media used for the experiment turned purple in colour indicating reduction of Au (III) to Au (0) at intra- and extracellular level. This was confirmed by TEM studies of L. majuscula biomass exposed in $HAuCl_4$ solution where < 20-nm-sized gold particles were found both inside as well as on the surface of the cell. Up to 90-100% of accumulated gold was recovered from the algal biomass by using nitric acid and acidic thiourea solution.

Chakraborty, Nabanita[†]*; Banerjee, Anupam; Lahiri, Susanta; Panda, Arpita*[†]*; Ghosh, Amar Nath*[†]*; Pal, Ruma*[†]

Production of Mo-93m through Y-nat(Li-7, 3n) reaction and subsequent studies on separation and extraction behaviour of no-carrier-added Mo-93m from an yttrium target

The present work reports heavy-ion-assisted production of Mo-93m from a natural yttrium target using the Y-89(Li-7, 3n)Mo-93m reaction. Three different methodologies based on liquid-liquid extraction (LLX), aqueous biphasic extraction and precipitation, have been developed for separation and extraction of no-carrier-added (nca) (MO)-M-93m ($T_{1/2}$=6.85h) radionuclide from bulk yttrium target. Complete separation of nca Mo from the target Y has been achieved by employing LLX technique with 0.1 M trioctylamine (TOA) dissolved in cyclohexane and 8 M HCl. Quantitative separation of (MO)-M-93m from the yttrium target is also possible by precipitating bulk yttrium with 1 M oxalic acid. However, for this particular case, studies have shown that the aqueous biphasic extraction is not the method of choice for separation of nca Mo. Nevertheless, the extraction pattern is important in the context of simulation experiments for studying the behaviour of ^{106}Sg. Similarity or dissimilarity between the extraction patterns in various analytical systems will be helpful to decisively place Sg in the right position in the periodic table.

Nayak, Dalia; Lahiri, Susanta

Complexation study on no-carrier-added astatine with insulin: A candidate radiopharmaceutical

No-carrier-added astatine radionuclides produced in the Li-7-irradiated lead matrix were separated from bulk lead nitrate target by complexing At with insulin, followed by dialysis. The method offers simultaneous separation of At from lead as well as its complexation with insulin. The At-insulin complex might be a potential radiopharmaceutical in the treatment of hepatocellular carcinoma. The stability of At-insulin complex was checked by dialysis against deionized water and Ringer lactate (RL) Solution. It has been found that the half-life of At-insulin complex is about similar to 12 h, when dialyzed against deionized water and is only 6 h, when dialyzed against RL solution having the same composition as blood serum. The 6h half-life of this Insulin-At complex is perfect for killing cancer cells from external cell surfaces as the half-life of internalization of insulin molecule inside the cell is 7-12 h.

Lahiri, Susanta; Roy, Kamalika; Sen, Souvik[†]

Rare-earth elemental analysis of banded iron-formations by instrumental neutron activation analysis

Representative banded iron-formations (BIFs) from various locations of the eastern Indian geological belt were investigated by instrumental neutron activation analysis (INAA). After pre-concentration, irradiation was carried out using a neutron flux of $5.1.10^{16}$ $m^{-2}.s^{-1}$, $1.0.10^{15}$ $m^{-2}.s^{-1}$ and $3.7.10^{15}$ $m^{-2}.s^{-1}$, with thermal, epi-thermal and fast neutrons, respectively. The activities in these samples were measured by a HPGe detector. Ten rare-earth elements, such as La, Ce, Nd, Sm, Eu, Tb, Ho, Tm, Yb and Lu, have been qualitatively identified and quantitatively estimated in these samples. The present investigation is an example of employing a pre-concentration method for high iron-containing ores prior to neutron activation analysis.

Nayak, PK; Wierczinski, B[†]; Lahiri, S

Separation of no-carrier-added Tl and Pb radionuclides using poly(N-vinylpyrrolidone)

No-carrier-added (nca) Tl199-201 has been separated from nca Pb199-201 using an environmentally friendly biocompatible polymer, poly(N-vinylpyrrolidone). The method uses no harmful chemicals and is based on the process of dialysis of PVP-Pb and PVP-Tl complexes against triple-distilled water. It has been observed after one hour of dialysis that 75-85% Tl (in both +3 and +1 oxidation states) comes out of dialysis sack without any contamination from lead.

Lahiri, S; Sarkar, S

In situ gamma-radiation: One-step environmentally benign method to produce gold-palladium bimetallic nanoparticles

Synthesis of gold-palladium bimetallic nanoparticles using in situ radioactivity from Au-198 isotope is reported in this paper. Gold solution spiked with Au-198(III) has been mixed with PdCl2 solution in measured proportions in 50% polyethylene glycol solution. Au(III) and Pd(II) are reduced, and nanoparticles are formed due to radiolysis of the polymer solution. The solution has been characterized by UV-visible spectra, and the actual size has been determined using transmission electron microscopy in conjugation Midi energy dispersive X-ray measurements.

Roy, Kamalika; Lahiri, Susanta

Immobilization of long-lived radionuclides Eu-152,Eu-154 by selective bioaccumulation in Saccharomyces cerevisiae from a synthetic mixture of Eu-152,Eu-154, Cs-137 and Co-60

Yeast cells of Saccharomyces cerevisiae were found to accumulate Eu-152.154 radioisotopes selectively from a synthetic mixture of Eu-152.154, Cs-137, and Co-60 radiotracers at neutral pH in both trace and macro level. The extent of Eu uptake increased with time. The uptake of Co was observed only when concentration of cobalt was more than 10 mg kg–1 at pH 6.5. None of the strains selected in our study showed any accumulation for Cs, even at trace level. Transmission electron microscopic (TEM) images of thin sections of the Eu accumulated yeast strains showed that it was accumulated inside the cell. The growth of four different strains of Saccharomyces cerevisiae was monitored at different concentrations of these metal salts. The yeast cells can grow upto 4.6 mM (700 mg kg^{-1}) Eu concentration and 7.3 mM (1 g kg^{-1}) Cs concentration irrespective of their histidine auxotrophy. In agreement with earlier reports it was observed that at 1.2 mM Co concentration, His' could grow at a pH range 5-6.5, whereas His(-) strains could not grow at any pH. Thus, the mechanism of uptake of the rare earth element, Eu, was found to follow a different pathway than the transition element Co, which causes toxicity to yeast cells in the absence of histidine in the biosynthetic pathway. The result may encourage for pilot experiments in preconcentration of rare earths using bioreagents in commercial scale.

Roy, Kamalika; Sinha, P†; Lahiri, Susanta

Production and separation of Astatine Radionuclides: Some new addition to Astatine Chemistry

For the first time no-carrier-added (nca) At-209, At-210 radionuclides were produced by heavy ion (Li-7) activation from 4 mg/cm(2) lead nitrate target. Astatine was separated from the bulk target by three different approaches. Nca astatine radionuclide was selectively partitioned in the (i) polymer rich phase of an aqueous biphasic system consisting of polyethylene glycol (PEG) 4000 (50% w/w) and 2 M Na2SO4 solution (ii) aqueous phase of a liquid liquid extraction system being comprised of a liquid cation exchanger, HDEHP (di-2-ethylhexyl phosphoric acid) (0.5%) and liquor ammonia (iii) liquid phase of a solid liquid extraction system of cation exchange resin Dowex-50 and 10(-6) M HCl. Very high separation factors have been achieved in all the three methods.

Roy, Kamalika; Lahiri, Susanta

Uptake studies of environmentally hazardous Cr-51 in Mung beans

Attempt has been made to study the accumulation behaviour of a common plant, Mung bean (Vigna radiata) towards Cr(III) and Cr(VI) to have an insight on the migration and bio-magnification of Cr. For this purpose healthy germinated Mung bean seeds were sown in the sand in the 5 presence of Hoagland's nutrient solution containing measured amount of ($K_2Cr_2O_7$)-Cr-51 and Cr-51$(NO_3)_3$ center dot 9H(2)O. Growth rate was also studied in the presence and absence of phosphate salts in the medium. It has been found that the transfer of chromium from soil to plant is significantly low (maximum 5% for both Cr(III) and Cr(VI)). Maximum accumulation of Cr occurs in the root with respect to the total chromium accumulation by the plant. Other parts of the Mung bean plant, e.g. cotyledons, shoot and leaves, show negligible accumulation. Therefore, the chance of direct intake of Cr through food as well as through the grazing animals to human body is less.

Banerjee, Anupam; Nayak, Dalia; Chakrabortty, Dipanwita†; Lahiri, Susanta

Preconcentration of gold by Mimusops elengi seed proteins

The present study has been performed to preconcentrate gold using the proteins extracted from Mimusops elengi Linn. (Family: Sapotaceae) seed by radiometric technique using Au-198. Effects of buffer and pH dependence on the binding affinity of the gold have also been examined. It has been found that the binding of gold with M. elengi protein neither depends on the addition of buffer nor the composition (phosphate/citrate) of buffer. The adsorption of gold is also independent of pH of the solution. To verify the gold-protein interaction, inter-comparisons have been made between four different approaches, (1) notably extraction with anion-exchange resin Amberlite IRA 400, (2) trichloroacetic acid (TCA) precipitation, (3) isoelectric precipitation and (4) dialysis of protein after incubation with gold. Good agreement has been observed for all the cases. Binding of gold have been studied with three different concentrations of gold, 1, 10 and 50 ppm spiked with Au-198.

Nayak, D; Hazra, KM†; Laskar, S†; Lahiri, S

Species dependent radiotracer study of Cr(VI) and Cr(III) using an aqueous biphasic system

The speciation study of Cr(III) and Cr(VI) was carried out using a polyethylene glycol (PEG) based aqueous biphasic extraction system (ABS). Neutron activated Cr(III) and Cr(VI) salts were assayed in a HPGe detector before and after employing aqueous biphasic extraction. Different salts of various salting out abilities were taken as the salt rich phase. The best condition for extraction of Cr(VI) and the maximum differential attitude of ABS to Cr(VI) and Cr(III) was observed when 2M Na2SO4 and PEG #4000 (50% w/w) solutions were used. Cr(III) can also be extracted by the PEG with prior complexation with diphenylthiocarbazone (dithizone). The chromium dithizonate complex is quantitatively extracted by the PEG rich phase.

Roy, K; Lahiri, S

Speciation dependent studies on chromium absorption using calcium alginate and iron doped calcium alginate biopolymer

Attempt has been made to develop methodologies for preconcentration of chromium in the biodegradable polymer beads. The uptake behaviors for chromium have been studied with Ca-alginate (CA) and Fe-doped calcium alginate (Fe-CA) beads. The work also aims to study the differential attitude of CA and Fe-CA towards Cr(III) and Cr(VI) so that, depending on the oxidation state of chromium effluent, environmentally sustainable methodologies can be prescribed for removal of chromium. Radiotracer Cr-51 has been chosen as precursor of stable chromium throughout the experiment. It was found that Fe-CA beads are suitable for removal of Cr(III) and Cr(VI) while CA beads can be used for the speciation and separation of Cr(III) and Cr(VI) at pH 5.

Nayak, D; Banerjee, A; Roy, S; Lahiri, S

Radiometric study on bioaccumulation of gold by an alkaloid extracted from fruits of Piper nigrum

Piperine, an alkaloid derived from the fruits of Piper nigrum, has been tested as an extracting bioreagent for gold. It has been observed that piperine as well as the fruits of Piper nigrum itself can act as an efficient exchanger for gold both in trace and macro scale. The accumulation of gold by these bioreagents is highly pH dependent.

Ghosh, K; Lahiri, S

Studies on the interaction of poly(N-vinylpyrrolidone) with no-carrier-added Cu-61, Zn-62, Ga-66, Ge-69 and As-71 using tracer packet technique

Interactions of no-carrier-added radionuclides Cu-61, (62) Zn, (66) Ga, Ge-69 and As-71 with poly(N-vinylpyrrolidone) (PVP) were studied in multi-elemental environment by dialysis with the help of tracer packet technique. It has been observed that in acidic pH gallium has a high tendency for formation of Ga-PVP complex while the same is true for Cu and Zn in neutral and basic pH. Germanium is always inert towards the interaction with PVP at all pH values. No interaction of arsenic was observed in acidic and neutral pH; while in basic pH the tendency to form As-PVP complex is considerably higher. The result can be considered as a model of in-vivo interaction of PVP-Ga/Cu/Zn/As complexation.

Sarkar, S; Nayak, D; Lahiri, S

Separation of no-carrier-added Ga-66,Ga-67 produced in heavy ion-induced cobalt target using alginate biopolymers

Heavy ion activation of natural cobalt foil with 84 MeV C-12 results in the formation of no-carrier-added (nca) As-66,As-67 radionuclides, along with their corresponding decay products, Ge-66,Ge-67 and Ga-66,Ga-67, in the matrix. Because arsenic and germanium radionuclides are short-lived, after a cooling period of 10 h only nca gallium radionuclides remain in the matrix. We attempted to separate the nca gallium radionuclides from the target matrix cobalt by biopolymeric calcium alginate (CA) and Fe-doped calcium alginate (Fe-CA) beads. A complete separation has been achieved by adsorbing Ga-66,Ga-67 and a lesser amount of bulk cobalt at pH 3 on Fe-CA beads, followed by desorbing cobalt from the beads with 0.4 M NaNO2.

Nayak, Dalia; Banerjee, Anupam; Lahiri, Susanta

Studies on metal-protein interactions: Inter-comparison among various approaches

Binding ability of mercury, thallium, lead and bismuth with Erythrina variegata seed protein have been investigated using tracer packet technique. Due to the lack of standard methods, inter-comparisons have been made among three different approaches, like trichloroacetic acid (TCA) precipitation, isoelectric precipitation and dialysis of protein after incubation with the metals. Good agreement was observed for all the cases except that of lead.

Samanta, T Datta[†]; Laskar, S[†]; Nayak, D; Lahiri, S

Accumulation of radiocesium by Pleurotus citrinopileatus species of edible mushroom

Pleurotus citrinopileatus, a species of edible mushrooms, is widely accepted food component, especially in Indian subcontinent. The accumulating susceptibility of this edible mushroom species towards long-lived radioisotopes of cesium was studied in controlled laboratory condition using the Cs-134 (T-1/2 = 2.06 y) radioisotope. It was observed that the experimental mushroom species accumulated Cs-134 and maximum accumulation took place in the cap portion. The pileus (cap)/stipes (stem) ratio of each Cs-134 accumulated mushroom sample was determined and found 2.22 +/- 0.74. The protein and fat fractions of the experimental mushroom species were extracted separately after accumulation of radiocesium and it was found that most of the radiocesium accumulation occurred in the protein fraction of the mushroom. The mushroom Pleurotus citrinopileatus which is white in color, turned completely black after radiocesium accumulation. The black mushroom so obtained was produced upto fourth generation by tissue culture method without using any radiocesium further. All the successors were found to be black indicating a permanent mutation of the mushroom species.

Mukhopadhyay, B†; Nag, M†; Laskar, S†; Lahiri, S

Adsorption of Sb-125 on alumina and titania surfaces

Adsorption of long-lived Sb-125 radioisotope (T-1/2 = 2.75 y) on alumina (Al_2O_3) and titania (TiO_2) has been studied at different pH. Both the oxides have good adsorption capability for the Sb-125 radioisotopes but the TiO_2 is much superior. Adsorption kinetics of Sb-125 radioisotopes on TiO_2 surface and desorption of Sb-125 radioisotopes from TiO_2 surface in acidic and alkaline media have also been studied. The Sb-125-TiO_2 phase has been subjected to gamma-irradiation and found to be radiation stable against antimony release.

Mukhopadhyay, B†; Lahiri, S

Speciation-dependent studies on removal of arsenic by iron-doped calcium alginate beads

This work aims to study the differential attitude of Fe-doped calcium alginate (Fe-CA) beads towards As(III) and As(V) compounds so that speciation-dependent environmentally sustainable methodologies can be developed for removal of arsenic from contaminated water. Throughout the experiment, As-76 has been used as precursor of stable arsenic. The affinity of As(V) towards the Fe-CA beads is greater than that of As(III). Removal efficiency of Fe-CA beads for As(V) increases with increasing number of beads and longer shaking times. At pH 3, 30 Fe-CA beads remove As(V) completely from a solution containing 20 mg kg(-1) As(V). The technique has been successfully applied to the ground water collected from an arsenic-contaminated area.

Banerjee, Anupam; Nayak, Dalia; Lahiri, Susanta

Production of no-carrier-added I-123 via heavy-ion activation of natural antimony oxide

Activation of natural Sb2O3 with 48 MeV Li-7(3+) beam results in the formation of no-carrier- added I-123 in the matrix along with the radionuclides Xe-123.125 and Sb-122. The I-123 yield amounts to about 400kBq/mu Ah and the radionuclidic impurity of I-124 to similar to 1.2% of I-123. Attempts to separate no-carrier-added iodine from bulk antimony target involved liquid-liquid extraction with TOA and HDEHP as well as precipitation of Sb2S3 with thioacetamide. The precipitation technique was found to be the most effective for quantitative separation of I-121 from the bulk antimony oxide target.

Maji, S; Lahiri, S

Separation of iron and cobalt using Fe-59 and Co-60 by dialysis of polyvinylpyrrolidone-metal complexes: A greener approach

An environmentally benign method to separate iron and cobalt has been developed using a safe chemical, polyvinylpyrrolidone (PVP). The method involves dialysis of PVP-Fe and PVP-Co complexes against triple-distilled water. Fe-59 and Co-60 were used as radioactive tracers of iron and cobalt throughout the experiment. No other chemicals are required for clean separation of cobalt from iron. The optimum condition for separation has been obtained at pH 5 using 10% aqueous solution of PVP. The method is applicable from trace scale to macro-scale. Very high separation factors have been obtained.

Lahiri, Susanta; Sarkar, Soumi[†]

Non-Steroidal Anti-Inflammatory Drug Induced Membrane Fusion: Concentration and Temperature Effects

Membrane fusion is a critical step in many biological events. The fusion process is always induced by different fusogenic agents of which proteins and peptides form the largest group. The mechanistic details of the fusion process vary depending on the nature of the fusogenic agents. However, membrane fusion induced by small drug molecules at physiologically relevant concentration has not been observed. Only recently our group has shown that three painkillers, namely, meloxicam, piroxicam, and tenoxicam, belonging to the oxicam group of non-steroidal anti-inflammatory drugs (NSAIDs) share this property. In this work, we present the effect of drug concentration and temperature on the kinetics of the fusion process. Small unilameller vesicles (SUVs) formed by dimyristoylphosphatidylcholine (DMPC) with an average diameter of 50-60 nm were used as model membranes. Fluorescence assays were used to probe the time dependence of lipid mixing, content mixing, and leakage whereas transmission electron microscopy (TEM) was used to image the fusion process and to calculate the average diameter of the vesicles. The results show that, in this fusion process, lipid mixing and content mixing are two sequential events and can Occur even at a very low drug to lipid ratio (D/L) of 0.018. For a D/L ratio greater than 0.045, leakage of the vesicles leading to rupture compete with the fusion thereby inhibiting it. Temperature variation in the presence of drugs gives linear Arrhenius Plots and is used to calculate the activation energies For the lipid mixing and content mixing, which are less compared to that seen in SUVs with a smaller diameter of 45 nm. Thermodynamic parameters of the transition state are Calculated. The fusogenic property of the drugs has been interpreted in terms of the ability of the drugs to introduce membrane perturbation even at Such low D/L ratios as studied here.

Mondal, Sutapa; Sarkar, Munna

Membrane fusion: A new function of non steroidal anti-inflammatory drugs

Membrane fusion is an important event in many biological processes and is characterized by several intermediate steps of which content mixing between the two fusing vesicles signals the completion of the process. Fusion induced solely by small drug molecules is not a common event. Non Steroidal Anti-inflammatory Drugs (NSAIDs), that control pain and inflammation, are also capable of exhibiting diverse functions. In this study we present a new function of NSAIDs belonging to the oxicam group, as membrane fusogenic agents. Small Unilamellar Vesicles (SUVs) formed by the phospholipid, dimyristoylphosphatidylcholine (DMPC), were used as model membranes. Fluorescence assays using terbium/dipicolinic acid (Tb/DPA) were used to monitor content mixing and corresponding leakage in presence of the drugs. Transmission Electron Microscope (TEM) was also used to image fusion bodies in drug treated vesicles as compared to the untreated ones. The results show that the three oxicam NSAIDs viz. Meloxicam, Piroxicam and Tenoxicam can induce fusion of DMPC vesicles and lead the fusion process to completion at a very low drug to lipid ratio (D/L) of 0.045. The oxicam drugs exhibit differential fusogenic behavior as reflected in the kinetics of content mixing and leakage, both of which can be described by a single exponential rate equation. Moreover, not all NSAIDs can induce membrane fusion. Indomethacin, an acetic acid group NSAID and ibuprofen, a propionic acid group NSAID, did not induce fusion of vesicles. This new property of NSAIDs has important applications in biochemical processes.

Chakraborty, Hirak; Mondal, Sutapa; Sarkar, Munna

Indomethacin: A NSAID sensitive to micro heterogeneity in alcohol-water mixtures

UV-vis absorption, steady state and time resolved fluorescence studies on the photo physical behavior of indomethacin, a traditional NSAID in binary water ethanol mixtures have been presented. Our results reveal that indomethacin can sense the micro heterogeneity in the binary mixtures forming ground state fluorescent complex with two predominant types of clusters viz. ethanol self-association clusters and hydrogen bonded water clusters.

Ghatak, Archana; Mandal, Parikshit C[†]*; Sarkar, Munna*

Interaction of piroxicam with mitochondrial membrane and cytochrome c

Modulation of surface properties of biomembranes by any ligand leading to permeabilization, fusion, rupture, etc. is a fundamental requirement for many biological processes. In this work, we present the interaction of piroxicam, a long acting Non-Steroidal Anti-Inflammatory Drug (NSAID) with isolated mitochondria, membrane mimetic systems, intact cells and a mitochondrial protein cytochrome c. Dye permeabilization study on isolated mitochondria indicates that piroxicam can permeabilize mitochondrial membrane. Direct imaging by Scanning Electron Microscope (SEM) shows that piroxicam induces changes in mitochondrial membrane morphology leading to fusion and rupture. Transmission Electron Microscope (TEM) imaging of piroxicam treated DMPC vesicles and mixed micelles formed from CTAB and SDS show that causing membrane fusion is a general property of piroxicam at physiological pH. In intact cells viz., V79 Chinese Hamster lung fibroblast, piroxicam is capable of releasing cytochrome c from mitochondria into the cytosol in a dose dependent manner along with the enhancement of downstream proapoptotic event viz., increase in caspase-3 activity. We have also shown that piroxicam can reduce cytochrome c within a time frame relevant to its lifetime in blood plasma. UV-visible spectroscopy has been used to study the reaction mechanism and kinetics in detail, allowing us to propose and validate a Michaelis-Menten like reaction scheme. CD spectroscopy shows that small but significant changes occur in the structure of cytochrome c when reduced by piroxicam.

Chakraborty, Hirak; Chakraborty, Prabir K; Raha, Sanghamitra; Mandal, Parikshit C[†]*; Sarkar, Munna*

Developmental Work

Construction of a Fluorescence Correlation Spectrometer (FCS)

Fluorescence correlation spectroscopy (FCS) is a single-molecule detection technique that measures and correlates fluctuations in fluorescence intensity within a very small detection volume (on the order of femtoliters). The small detection volume required in FCS is created by using confocal optics to efficiently detect the 'in-focus' or confocal volume within a sample. It is typically on the order of femtoliters. The temporal autocorrelation function of intensity fluctuations yields the diffusion coefficent of the fluorophore across the probe volume, which in turn allows calculation of the size of the molecule (R_h). This information can be used to study a number of molecular processes including protein folding/unfolding and aggregation, protein-protein or protein-DNA interaction rom the temporal correlation , host-guest complextion, lipid membrane fusion and others. We are constructing an apparatus to do Fluorescence Correlation Spectroscopy, mostly using components purchased from the Institute's funds as well as some received from the DIT through a grant awarded to the Biophotonics Laboratory of Dr. S. Maiti, TIFR, Mumbai.

Soumen Basak, Kallol Bera, Moupriya Nag, S Maiti

Commissioning of Class-10000 clean room

A class 10000 clean laboratory for trace element analysis has been commissioned under the XIth Five Year Plan project "Trace Analysis: Detection, Dynamics and Speciation (TADDS). Professor Bikash Sinha, the then Director, SINP inaugurated this laboratory on June 17, 2009. This laboratory is equipped with Inductively Coupled Plasma Optical Emission Spectroscopy (ICPOES), Inductively Coupled Plasma Mass Spectroscopy (ICPMS) along with HPLC and gas chromatography, UV-VIS spectrophotometer, and Laser Ablation (LA). This trace analysis laboratory is expected to offer wide area of basic research. Avenue has been opened for trace analysis down to 1 in 10^{11} to maximum 1 in 10^{5} levels.

Susanta Lahiri

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Debarati Dey and Samita Basu, Magnetic field effect in homogeneous medium for triplet born radical ions: a way for assessment of inter-radical distance in intermolecular photoinduced electron transfer (Invited Review), J Ind Chem Soc **87** (2010) 117

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S Chaudhuri, BP Pahari, B Sengupta and PK Sengupta, Binding of the bioflavonoid robinetin with model membranes and hemoglobin: Inhibition of lipid peroxidation and protein glycosylation, J Photochem Photobiol **B** (2010) 9812

S Dutta, R Ghosh, JK Dattagupta and SBiswas, Heterologous expression of a thermostable plant cysteine protease in *Escherichia coli* both in soluble and insoluble forms, Process Biochemistry, **45** (2010) 1307

S Khamrui, S Majumder, J Dasgupta, J K Dattagupta, U Sen, Identification of a novel set of scaffolding residues that are instrumental for the inhibitory property of Kunitz (STI) inhibitors, Protein Sci **19** (2010) 593

S Khamrui, A Ranjan, B Pani, R Sen, U Sen, Crystallization and preliminary X-ray analysis of Psu, an inhibitor of the bacterial transcription terminator Rho, Acta Crystallogr **F66** (2010) 204

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S Samanta, J Chakrabarti and D Bhattacharyya, Changes in Thermodynamic Properties of DNA Base Pairs in Protein-DNA Recognition, J Biomol Struct Dynam **27** (2010) 429

Sandipan Chakraborty, Soumalee Basu, Ansuman Lahiri and Soumen Basak, Inclusion of chrysin in beta-cyclodextrin nanocavity and its effect on antioxidant potential of chrysin: A spectroscopic and molecular modeling approach, J. Mol Struct **977** (2010) 180

Sarita Roy, Soumen Basak and Anjan Kumar Dasgupta, Nanoparticle Induced Conformational Change in DNA and Chirality of Silver Nanoclusters, J Nanosci Nanotech **10** (2010) 819

Ph D Awarded

Adity Bose (nee Chowdhury) [Samita Basu], Interactions of quinones with bases: a laser flash photolysis and magnetic field effect study, Jadavpur University, December 2009

Amitabha Sengupta [Subrata Banerjee], Development of a novel EBV based vector to gene therapy and deciphering molecular mechanism of stem cell biology in Hematological malignancies, University of Calcutta, 2007

Anwesha Bhattacharyya (nee Banerjee) [Pradeep K Sengupta], Spectroscopic Investigation of Some Biologically Important Molecules, Jadavpur University, 2008

Anupam Banerjee [Susanta Lahiri], Radiochemical studies on the utilization of some Bioreagents for preconcentration of Trace elements multielemental environment, University of Calcutta, 2009

Asima Chakraborty [Soumen Basak], Effect of structural perturbants on globular and natively unfolded proteins, Jadavpur University, 2008

Debarati Dey [Samita Basu], Environmental effect on photoinduced electron transfer reactions involving some N-heterocyclic compounds and related inorganic complexes, Jadavpur University, December 2009

Doel Ray [Sanghamitra Raha], Stress-related signaling in Entamoeba histolytica, Jadavpur University, 2008

Manisha Banerjee [Nitai P Bhattacharyya], Role of Huntingtin (Htt) interacting proteins in apoptosis induction in cultured cells expressing exon1 of mutated Huntingtin gene, Jadavpur University, July 2009

P Grihanjali Devi [Dipak Dasgupta], Effect of complex formation between Zn^{2+} ion and the aureolic acid group of anticancer antibiotics upon the structure and function of Zn(II)-containing enzymes, Jadavpur University, 2009

Poppy Datta [Abhijit Chakrabarti], Study of the Interaction of Hemoglobin and its Subunits with Erythroid Spectrin, Jadavpur University, November 2007

Prabir K Chakraborty [Sanghamitra Raha], Signalling pathways involved in the chemopreventive and chemotherapeutic action of natural products, Jadavpur University, August 2009

Pritha Majumder [Nitai P Bhattacharyya], Mechanism (s) of apoptosis induction by ectopic expression of huntingtin gene fragment and Hippi, an interactor of huntingtin interacting protein Hip-1, Calcutta University, January 2008

Raka Ghosh [Chandana Chakrabarti], Structural and biological studies on some plant proteins, Jadavpur University, 2009

Santanu Roy [Partha Saha], Studies on cell cycle related proteins of \it{Leishmania} parasites, Jadavpur University, December 2008

Sanjib Dey [Partha Saha], Studies of J-domain containing proteins in Cellular Processes, Jadavpur University, November, 2009

Shaonly Samanta [Malay Chatterjee & Radha Bhattacharya], Anticarcinogenicity of vanadium and 1, 25-dihydroxyvitamin D3 In chemical rat colon carcinogenesis- a mechanistic approach, Jadavpur University, March 2008

Shayantani Mukherjee [Dhananjay Bhattacharya], Some Aspects Governing Biomolecular Recognition through Deoxyribonucleicacid (DNA)/Ribonucleicacid (RNA): Theoretical Computational Studies, Jadavpur University, December 2007

Suman Dutta [Sanghamitra Raha], p21 Activated Kinase and Small GTPase Signaling in Entamoeba histolytica, Jadavpur University, December 2009

Sumanta Basu [Abhijit Chakrabarti], Role of aminophospholipids, cytoskeletal proteins and hemoglobin on membrane asymmetry of erythrocytes, Jadavpur University, August 2009

Susmita Khamrui [Udayaditya Sen & Chandana Chakrabarti], Knowledge based protein engineering on a chymotrypsin inhibitor protein, Jadavpur University, 2007

Swasti Raychaudhuri [Nitai P Bhattacharyya & Debasish Mukhopadhyay], Biophysical and biological characterization of Huntingtin interacting protein HYPK, Calcutta University, July 2008

Seminar/Lecture given in conference or elsewhere

Dipak Dasgupta

- *Chemical Biology of DNA :* I2CAM School on Emergent phenomena of genome matter: an inter disciplinary approach to understand the human genome organization organized by Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore, February 8-16, 2009
- *A revisit of the mode of interaction of small DNA binding transcription inhibitors at the chromatin level :* XIIth Transcription Assembly National Meeting 24-25Feb, 2010 in JNU, New Delhi
- *Metal binding ability of Aureolic Acid Group of antibiotics and its Consequence upon their activity inside the cell,* : South Asian Bio Inorganic Chemistry, TIFR, Mumbai, Nov4-6, 2009
- *Modulation of chromatin structure by DNA - binding anticancer agents :* Chromatin Structure and Function, International Symposium held in CCMB, Hyderabad, November 27, 2008
- *A thermodynamic and docking approach to understand the role of high affinity GTP binding in T7RNA polymerase using nucleotide analogue cibacron blue :* Asian Conference on Transcription (Act X), IISc, Bangalore, Jan 13, 2008
- *Alternate Therapeutic Potential of The Generic Drug Plicamycin* : Symposium in Bioorganic & Medicinal Chemistry, 16-17 Sept, 2007, Mysore University, Mysore
- *A revisit of the DNA binding drugs in the context of their effects upon chromatin structure and function :* TIFR, Mumbai, January 11, 2010
- *Chemical Biology – a burgeoning subject where chemistry meets biology : Whither Chemical Biology ?* Refresher Course in Chemistry Department, Jadavpur University, Kolkata, January 4, 2010
- *Alteration of chromatin structure by DNA - binding anticancer agents :* Biomedical Group, BARC, Mumbai, February 10, 2009
- *Chemical Biology of two anticancer antibiotics with additional therapeutic potential*, Central Drug Research Institute, Lucknow , March 25, 2009
- *Chemical Biology – Symbiosis of Chemistry and Biology*, Refresher course in Jadavpur University, Kolkata , January 4, 2008

P K Sengupta

- *Nanoencapsulation of plant based drugs: New challanges and emerging trends*, Bidhanchandra Krishi Vishyavidyalaya, Kalyani, West Bengal, India, April 26, 2007
- 4th Asia and Oceania Conference on Photobiology (AOCP 2008), BHU, Varanasi, Nov 24-26, 2008
- *Nanoencapsulation of therapeutically important plant flavonoids:* National Symposium on Biophysics in Medicine and Biology (Indian Biophysical Society and Dept. of Biophysics, Punjab University), Chandigarh, Nov 15-17, 2008

- *Membrane-flavonoid interactions:Insights from fluorescence spectroscopic studies*, National Symposium on Cellular & Molecular Biophysics (under the aegis of Indian Biophysical Society), CCMB, Hyderabad, January 22-24, 2009
- *Interactions of Plant flavonoids with biomembranes; Steady state and time resolved fluorescence studies*, National Seminar on Current Trends in Chemistry, Department of Chemistry, University of Kalyani, Kalyani, March 20-21, 2009
- *Nano-encapsulation of natural product based drugs: Insights from steady state and time resolved fluorescence studies,* National Symposium on “Frontiers in Photobiology” (organized by Indian Photobiology Society & BARC), Mumbai, Aug. 24-26, 2009
- *Nano-encapsulation of natural product based drugs: Fluorescence spectroscopic studies,* 46th Annual Convention of Chemists (organized by Indian Chemical Society and VIT University) Vellore, Dec. 2-6, 2009
- *Protein-flavonoid interactions; Insights from fluorescence studies,* Symposium on Recent Trends in Biophysics and Workshop on Emerging Techniques in Biophysics (organized by Indian Biophysical Society and Dept. of Physics, BHU), Varanasi, Feb 11-17, 2010
- *Nanoencapsulation of therapeutically active plant flavonoids: Insights from spectroscopic studies*, Indian Institute of Technology, Bombay, December 3, 2007

Dhananjay Bhattacharya

- *Structure, Stability and Dynamics of Canonical and Noncanonical Basepairs,* National Conference on Frontiers in Computational Biology organized by CDAC, Pune, July 23-24, 2009
- *HD-RNAS: An Automated Hieearchical Database of RNA Structures*, International Conference on Frontiers of Interface between Statistics and Science, University of Hyderabad and C.R. Rao AIMSCS, December 30, 2009 to January 2, 2010
- *Molecular Dynamics Simulations of Nucleic Acids,* School on Introduction to Parallel Computing organized by SN Bose National Centre for Basic Sciences, Kolkata, October 6-8 2009
- *Structure, Stability and Dynamics of Canonical and Non-canonical Base Pairs,* National Symposium on Recent Trends In Biophysics organized by Indian Biophysical Society and Banaras Hindu University, Varanasi, February 13-15, 2010
- *Molecular Dynamics Simulations Methods,* Workshop on Emerging Techniques of Biophysics, Benaras Hindu University, Varanasi, February 16, 2010
- *RNA Structural Classification*, Protein Structure and Interactions – Computational Approaches, Bose Institute, Kolkata, February 4, 2010
- *Structure and Dynamics of non-canonical basepairs in RNA: Quantum Chemical and Molecular Dynamics Studies,* National Annual Meeting of RNA Group (RNA 2008), Jawharlal Nehru University, New Delhi, March 28-29, 2008

- *Molecular Dynamics Simulation of Biomolecules*, 2nd Annual National Level Workshop, National Institute of Cholera and Enteric Diseases (NICED), Kolkata, May 22-23, 2008
- *Structural Bioinformatics*, 3-Day workshop on Bioinformatics (Organized jointly by NICED, and Apt Software Avenues (P) Ltd), December 5-7, 2008
- *(i) Nucleic Acid Structure, (ii) Biomolecular Interaction and (iii) Molecular Dynamics Simulation*, MHRD/AICTE Summer School on Bioinformatics, National Institute of Technology, Durgapur, July 7-18, 2008
- *DNA Double Helix Structural Variations and (ii) Role of DNA Flexibility in Protein Binding*, I2CAM School on Emergent phenomena of genome matter: an inter disciplinary approach to understand the human genome organization, Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore, February 8-16, 2009
- *Hydrogen Bonding in Biomolecular Recognition*, National Symposium on Genes to Drugs: In-silico Approaches, Center for Development of Computing (CDAC), Pune, April 29-30, 2008
- *Molecular Simulation of Nucleic Acids*, Two day workshop on Structural Bioinformatics, Dept of Microbiology, Vidyasagar University, October 8-9, 2007
- *Hydrogen Bonds in Bimolecular Structure and Recognition*, National Workshop on Macromolecular-Ligand Interaction and Drug Design, Department of Biophysics and Biochemistry, University of Kalyani, January 2-4, 2008
- *Hydrogen Bonds in Biomolecular Structure and Recognition - Variety and Strength*, International Workshop on Physics in Biology: A Synergy, School of Physics, University of Hyderabad, December 12-14, 2007
- *Structure, Stability and Dynamics of Canonical and Non-canonical Base Pairs: Quantum Chemical Studies*, Bioconvene 2007: International Conference on Bioinformatics & Drug Discovery, University of Hyderabad, December 19-22, 2007
- *Molecular Dynamics Simulation of Nucleic Acids*, Instructional Workshop in Bioinformatics and Drug Discovery, University of Hyderabad, December 16-19, 2007
- *Non-canonical Base Pairs in RNA: An Algorithmic Approach for DataBase Analysis*, National Symposium on Biophysics: Trends in Biomedical Research, IBS 2007, Department of NMR and MRI Facility, All India Institute of Medical Sciences, New Delhi, Feb 13-15, 2007
- *Hydrogen bonds in Biomolecular Structure and recognition and (ii) Non-canonical base pairs in RNA: Hydrogen bonded systems*, Workshop on Structure and Dynamics of Biomolecules 2007, SN Bose Center for Basic Sciences, Kolkata, Dec 3-8, 2007
- *Protein-DNA Recognition through Induced-Fit Mechanism*, Pune University, May 13, 2009
- *Structure, Stability and Dynamics of Canonical and Non-canonical Basepairs*, Department of Biophysics, Molecular Biology and Bioinformatics, University of Calcutta, Aug 8, 2009

Nitai P Bhattacharyya

- *Polymorphic variations at apoptotic genes caspase-9, PARP-1 and purinergic receptor P2X gene among normal individuals and patients affected by chronic myeloid leukemia (CML),* Symposium on “Recent trends in Cancer Research and treatment”, Chittaranjan National Cancer Institute Golden Jubilee celebration, CNCI, Kolkata, Nov1 –3, 2007 (Kanad Baksi, Saikat Mukhopadhyay, Utpal Choudhury, Subrata Banerjee and Nitai P. Bhattacharyya)

- *Huntingtin interacting proteins and their partners: modulation of aggregates formation and apoptosis induction by huntingtin exon1 containing CAG repeats in the pathogenic range*, International Symposium on Advances in Neurosciences & Silver Jubilee Conference of Indian Academy of Neurosciences Banaras Hindu University, Department of Zoology, Varanasi, November 22-25, 2007 (Manisha Banerjee, Swasti Raychaudhuri, Pritha Majumder and Nitai P. Bhattacharyya)
- *Intrinsically Disordered Proteins among Huntingtin interacting proteins: HYPK as a model protein*, XIIIth All India Congress of Cytology and Genetics and International Symposium on Proteomics and Genomics Approaches to Decipher the Molecular Basis of Pathogenesis, Department of Zoology, Osmania University, Hyderabad, December 28-30, 2007(Swasti Raychaudhury, Sucharita Dey, Debashis Mukhopadhyay, Nitai P Bhattacharyya)
- *Regulation of micro RNA by mutant huntingtin (htt) and Hippi, a molecular partner of Huntingtin (Htt) interacting protein HIP-1*, RNA 2008, *Jawaharlal Nehru University* (JNU), New Delhi, March 28-29, 2008 (Mithun Sinha, Susmita Mookherjee, Saikat Mukhopadhyay and Nitai P. Bhattacharyya)
- *Methods for mutation detection and Human Genome and its application in human diseases*, GenDioT – Genetic Diagnostics training for medical fraternity & Young Scientists of Gujarat, State Biotechnology Mission, Govt. of Gujarat, December 18, 2007-January 7, 2008
- *Huntingtin interacting protein HYPK and its molecular partners: possible involvement in Huntington’s disease*, International Symposium on “Ethics, Culture and Population Genomics” and 34th Annual Conference of the Indian Society of Human Genetics, New Delhi March 27-20(?), 2009 (Kamalika Roychoudhury, Swasti Raychaudhuri, Debashis Mukhopadhyay and N. P. Bhattacharyya)
- *Role of Huntingtin interacting proteins in aggregate formation and apoptosis induction in a cell model of Huntington’s disease*, Neurocon2009: International Symposium on Neurodegeneration and brain aging: basic Science to therapy, Department of Biochemistry, IPGMER, Kolkata
- *Micro RNAs: new players in gene regulation and diseases*, Fourth Workshop on Genetic Epidemiological Methods for Dissection of Complex Human Traits, (TCG-ISI Centre for population Genomics, Kolkata and University Pittsburgh, Pittsburg, USA), SINP, Kolkata, February 23–28, 2009
- *Integrative approach to understand Huntington’s disease*, International Conference on Biomedical and Genomic Research, Department of Zoology, Gujarat University, Ahmedabad, January 29–31, 2009
- *Huntingtin interacting proteins: involvement in diverse molecular functions, biological processes*, 14th All India Congress of Cytology and Genetics and Fogarty International Workshop on Molecular Epidemiology, Environmental Health and Arsenic Exposure

Assessment, Indian Institute of Chemical Biology, Dec 1-4, 2009 (Moumita Datta, Manisha Banerjee, Saikat Mukhopadhyay Srijit Das and Nitai P. Bhattacharyya)

- *Integrative approaches to study the human genetic disease: Huntington's disease as a model, Global Challenges in Biology,* The journey From Genes To Disease, Minisymposium organized by Department of Microbiology, West Bengal State University, Barasat, December 18, 2009
- *Human Genome (DNA) Variations: Population relationship and Diseases,* DBT sponsored National Workshop on Bioinformatics in Evolutionary Studies, Bioinformatics Infrastructure Facility at Department of Biochemistry and Biophysics, Kalyani University, February 23-26, 2010

Sanghamitra Raha

- *Survival and death of Entamoeba histolytica under conditions of stress,* Workshop on Amebiasis, side meeting of the 5th European Congress on Tropical Medicine and International Health, Amsterdam, The Netherlands, May 24-25, 2007
- *The dual effect of Resveratrol : Resveratrol hinders the anti-apoptotic conditions prevailing in malignancy and also reverses the establishment of the survival advantage of chronically stressed cells*, International Conference on "Perspectives of Cell Signaling and Molecular Medicine" at Bose institute, Kolkata in 27-29November 2008
- *The Chaperone Heat Shock Protein 70 and the Antioxidant Manganese Superoxide Dismutase are upregulated in chronic heat stress through p38MAPK and Akt,* The European Molecular Biology Organization(EMBO) and Federation of European Biochemical Societies (FEBS) sponsored meeting on "The Biology of Molecular Chaperones" Dubrovnik, Croatia, May 23-28, 2009
- *Downregulation of Heat Shock Protein 70 (Hsp70) by Resveratrol in Chronic Myelogenous Leukemia (CML) cells is modulated by Akt and ERK1/2 Pathways*, Third International Symposium on Translational Research: Cancer Cell Signaling and Therapy, Bhubneshawar, India, December 18 -21, 2009
- *Adaptive mechanisms and survival strategies of Bellamya bengalensis: a fresh water mollusc species with potential as bioindicator through suitable biochemical and molecular biomarkers*, Conference on Bioremediation and global climate change. Indian Science News Association (ISNA). Kolkata, February 24-26, 2010
- Pro-survival effects of chronic/repetitive stress : Expression of survival genes, National Workshop on Interaction of Ionizing Radiation with Biological Systems Visva-Bharati, Santiniketan, March 29-30, 2010
- *Reversal of the anti-apoptotic conditions prevailing in chronic stress and malignancy by Resveratrol*, Interdisciplinary Research Center, Justus-Liebig University of Giessen, Germany, May 30, 2007
- *Reversal of the anti-apoptotic conditions prevailing in chronic stress and malignancy by Resveratrol*, Central Drug Research Institute, Lucknow, January 30, 2008

- *Pro-survival effects of chronic/repetitive stress and malignancy are inhibited by Epigallocatechin 3-gallate (EGCG) and Resveratrol,* Institut für Pharmakologie und Toxikologie,Fachbereich Pharmazie, Philipps-Universität Marburg, Germany.May 29, 2009
- *Resveratrol and Epigallocatechin 3-gallate (EGCG) impede the pro-survival milieu prevailing in chronic/repetitive stress and malignancy,* Fakultät für Medizin,Universität Witten/Herdecke, Stockumer Str. 12 (Thyssenhaus), D-58453 Witten,Germany, June 2, 2009
- *How Do Cells Die?,* Academic Staff College, University of Calcutta, 79th Orientation Program for College and University teachers, July 14, 2009
- *Molecular Aspects of Stress Response In Eukaryotes-Simple and Complex*, Lecture Series in Modern Areas in Life Sciences, Dept. of Botany, Visva Bharati, Santiniketan, March 13, 2010
- Fourth International Symposium on Recent Trends in Macromolecular Structure and Function, Crystallography and Biophysics Department, University of Madras, Chennai, January 21 -23, 2010

Sampa Biswas

- *Structural and biochemical characterization of an unusual C-terminal extension of a thermostable plant cysteine protease precursor*, Fourth International Symposium on Recent Trends in Macromolecular Structure and Function, Crystallography and Biophysics Department, University of Madras, Chennai, January 21 -23, 2010
- *Enhancing thermostability of Papain by increasing interdomain interactions*, School of Biotechnology, Banaras Hindu University, December 18-20, 2009
- *Structural biology and protein engineering of plant proteases and inhibitors*, meeting on Macromolecular Crystallography has been organized by DST, India and Brazil Academy of Science, Indian Institute of Science, Bangalore, February 23 -25, 2009
- *Structure-based design of Papain-like plant cysteine proteases for industrial application*, UGC-sponsored one day national level seminar on 'Recent trends in biological research, Deparment of biophysics, molecular biology and genetics, University of Calcutta. January 22, 2008
- *Single mutations lead to a significant change in substrate specificity, activity and stability: The basis of designing proteins of industrial interest*, INSA-CAS workshop on structural biology, Indian Institute of Science, Bangalore December 21-23, 2007
- *Single mutations lead to a significant change in substrate specificity, activity and stability: structural, enzyme kinetics and molecular modeling studies for Papain-like cysteine proteases,* Molecular Biology Unit, BHU, Varanasi, October 5, 2007

Partha Saha

- *Regulation of S-phase specific gene expression in Leishmania parasites*, WorldLeish 4 : 4th World Congress on Leishmaniasis 2009, Central Drug Research Institute, Lucknow, India, February 3-7, 2009

- *RNA-Protein interaction regulates the S-phase specific gene expression in Leishmania donovani*, RNA 2008 - Annual Meeting of the RNA Group, Jawaharlal Nehru University, New Delhi, India, March 28-29, 2008

Swasti Raychaudhuri

- *Intrinsically unstructured proteins in neurodegenerative disorder: characterization of Htt interacting protein HYPK, a case study*, Department of Pathology, University of Melbourne, Melbourne, Australia, July 18, 2007

Abhijit Chakrabarti

- *Organization and dynamics of membranes: Fluorescence probing(ii) Proteomics – Clinical Application in Thalassemia* (Two lectures), Symposium on Gene Testing – A Great Challenge in Genetic Health Care, organized by Institute of Genetic Engineering & Thalassemia Foundation, Kolkata, EZCC Auditorium, Salt Lake, on International Thalassemia Day, May 8, 2007
- *Loss of PS asymmetry and sialylated glycoconjugates from red cell membranes in HbEb-thalassemia : implications in eryptosis,* 8th International Symposium on Biochemical Roles of Eukaryotic Cell Surface Macromolecules, Centre for Cellular and Molecular Biology (CCMB), Hyderabad, January 21-25, 2008.
- *Chaperone potential of a membrane skeletal protein*, Symposium on *Protein Stability, Folding and Aggregation*, Biochemistry Department, Indian Institute of Science, Bangalore, March 1, 2008
- *Chaperone potential of spectrin*, W. Mejbaum-Katzenellebogen's Molecular Biology Seminars, on *Membrane Skeleton, Recent Advances and Future Research Directions*, European Membrane Skeleton Club, Zakopane (Tatra Mountains), Poland, June 15–18, 2008
- *Clinical Proteomics in HbEb-thalassemia,* New Frontiers *on Haematology & Oncology*, Netaji Subhash Chandra Bose Cancer Research Institute, Swabhumi, Kolkata, April 9-10, 2009
- *"Salting out" the hidden plasma proteome*, 11th ISMAS Triennial International Conference on Mass Spectrometry, 11th ISMAS-TRICON-2009, Ramoji Film City, Hyderabad, November 24-28, 2009
- *Salting out the hidden plasma proteins implicated in B-ALL,* National seminar on Proteomics: Advances, Applications and Challenges (PRAAC), Institute of Bioinformatics and Applied Biotechnology, Bangalore, February 19- 20, 2010
- *Fluorescence study on association of the membrane skeletal protein, Spectrin with Aminophospholipids,* Max Planck Institute of Biophysics, Frankfurt, June 20, 2008
- *Chaperone Potential of Erythrocyte Membrane Skeletal Protein*, Spectrin, Society of Biological Chemists, Department of Biotechnology, University of Calcutta, Ballygunge Science College, July 24, 2008
- *Proteomics of Blood*, West Bengal University of Technology, Kolkata, April 13, 2007
- *Proteins, Proteome and Proteomics*, Veriable Energy Cyclotron Centre, Kolkata, May 15, 2007

- *Clinical Proteomics in HbEbeta-thalassemia*, Institute of Genetic Engineering, Kolkata, March 4, 2008

Soumen Basak

- *Solvent dependent conformation and aggregation properties of polyalanine peptides*, National Symposium on Cellular and Molecular Biophysics (Annual Meeting of Indian Biophysical Society), CCMB, Hyderabad, January 22-24, 2009
- *Interaction with Al and Zn induces structure fiormation and aggregation in natively unfolded caseins*, Fourth Asian Biological Inorganic Chemistry Symposium (ASBIC IV), Jeju, Korea, November 10-13, 2008
- *Misfolding and aggregation of polyalanine peptides*, National Workshop on Protein Folding and Bioinformatics, Bose Institute, Calcutta, March 4-5, 2008
- *Protein Folding and Misfolding,*. UGC Refresher Course in Biophysics, Department of Biochemistry, Calcutta University, March 2008

Samita Basu

- *Importance of magnetic field effect in understanding dissimilar behaviour of phenazine derivatives towards amines in homogeneous aprotic/protic and heterogeneous media* , 10th International Symposium on Spin and Magnetic Field Effects in Chemistry and Related Phenomena (Spin Chemistry Meeting 2007)" S. Servolo, Venice – Italy, June 18-21, 2007 (Debarati Dey, Adity Bose and Samita Basu)
- *Interactions of Phenazine derivatives with amines: a spectroscopic study with magnetic field effect*, International Symposium on Light and Life, Department of Plant Sciences, University of Hyderabad, August 29-31, 2007
- *Investigation of the quinine drug like molecules with DNA bases: a magnetic field effect study,* International Conference on Magneto-Science: Magnetic field effects in Chemistry, Physics, Biology and related phenomena, International Conference Center Hiroshima, Horoshima, Japan, November 11-15, 2007(Adity Bose (neé Chowdhury), Debarati Dey and Samita Basu)
- *Magnetic field effect: an efficient tool to investigate the mechanism of reactions using laser flash photolysis technique,* International Conference on Magnetic Material (ICMM- 2007), Saha Institute of Nuclear Physics, Kolkata, December 11-16, 2007
- *Identification of electron transfer between DNA and $[Cu(phen)_2]^{2+}$ complex by laser flash photolysis and magnetic field effect*, Trombay Symposium on Radiation & Photochemistry (TSRP-2008) (Board of Research in Nuclear Sciences, Department of Atomic Energy and Indian Society for Radiation & Photochemical Sciences, BARC, Mumbai), YASHADA, Pune, January 7-11, 2008 (Samita Basu, Debarati Dey and Adity Bose)
- *Importance of organized assemblies in investigation of magnetic field effect on chemical reactions,* International Conference on Soft System (Indian Society for Surface Science and

Technology (ISST) (Silver Jubilee Celebration)), Jadavpur University, Kolkata, February 13-15, 2008

- *Spectroscopy – an elegant tool for elucidation of structural behaviour of molecules,* U.G.C. sponsored one-day state level seminar "Understanding the Fundamentals of Physical and Chemical Sciences", Dum Dum Motijheel College, Kolkata, March 28, 2008
- *Interaction of DNA and its bases with small molecule: laser flash photolysis and magnetic field effects,* 4th Asia Oceania Conference on Photobiology, Department of Department of Zoology, Banaras Hindu University, Varanasi, India, November 24-26, 2008 (Adity Bose, Debarati Dey and Samita Basu)
- *Application of UV-visible spectroscopy in elucidation of structural behavior of molecules* UGC sponsored National Level Seminar on "Application of Spectroscopy: Atomic to Molecular Systems", Post Graduate Department of Chemistry, Vivekananda Mahavidyalaya, Sripalli, Burdwan, March 20-21, 2009
- *UV-visible Spectroscopy as an efficient tool for elucidation of structural behavior of molecules,* UGC sponsored National Level Seminar on "Application of Spectroscopy in Understanding Molecular Structure: its relevance to the undergraduate curriculum in Chemistry", Department of Chemistry, Charuchandra College, Kolkata, February 23-24, 2009
- *Importance of laser flash photolysis with magnetic field in the study of interactions of small ligands with biomacromolecules*, Acharya Prafulla Chandra Ray Memorial Symposium on Chemistry Today, Indian Chemical Society, Kolkata, India, August 1-2, 2009 (Brotati Chakraborty, Debarati Dey and Samita Basu)
- *The Structural Behaviour of Chemical Species Probed by Magnetic Fields* 27. 11th International Symposium on Spin and Magnetic Field Effects in Chemistry and Related Phenomena, Brock University, St. catharines, Ontario, Canada, August 9-14, 2009 (Botati Chakraborty and Samita Basu)
- *Uv-vis spectroscopic studies of the interactions of Acridine Yellow and Proflavine with Human Serum Albumin: evidence of electron transfer probed by laser flash photolysis with magnetic field,* National Symposium on Frontiers in Photobiology (BARC and Indian Photobiology Society), Bhaba Atomic Research Centre, Mumbai, India, August 24-26, 2009 (Botati Chakraborty and Samita Basu).
- *Magnetic field effect on photoinduced electron transfer between calf thymus DNA and ternary copper complex containing amino acids*, International Conference on Magneto Science, Radboud University, Nijmegen, The Netherlands, October 26–29, 2009 (Samita Basu and Debarati Dey)
- *Investigation of modes of interactions of DNA and its components with small biologically relevant molecules using laser flash photolysis and magnetic field,* National Symposium on Atomic & Molecular Spectroscopy (NSAMS-2010) , Visva Bharati, Santiniketan, West Bengal, India, March 27-28, 2010
- *Properties of Molecules in Excited state and their Applications* (Two lectures), Academic Staff College, University of Calcutta, Kolkata, November 29, 2007

- *Quenching of Fluorescence* Academic Staff College, Jadavpur University, Kolkata, January 15, 2008
- *Some aspects of fluorescence and its quenching*(Three lectures), Academic Staff College, University of Calcutta, Kolkata, August 23 & 27 and November 2, 2008
- *Basics in UV-Visible Spectroscopy: applications in Biophysics*, St. Xavier's College, September 27, 2008 UV-Visible Spectroscopy and its applications in Biophysics, **S** JBNSTS, Kolkata, November 2, 2008
- *Application of UV-visible spectroscopy in elucidation of probable mechanism of interactions between small organic molecules and biological macromolecules*, Academic Staff College, Calcutta University, September 2, 2009
- *Assessment of distance for intermolecular interactions in excited state from fluorescence quenching*, Academic Staff College, Jadavpur University, January 6, 2010
- *Applications of Spectroscopy in Chemistry*, JBNSTS, Kolkata, March 21, 2010

Amitabha De

- *Synthesis, Characterization, Transport and Magnetic Properties of Conducting Polymer Nanocomposites*, the Hybrid Materials Section of the 10th International Conference on Advanced Materials organized by Materials Research Society of India, Bangalore, October 8-13, 2007
- *Conducting Polymer Nanocomposites as Bifunctional Material: Study of Transport and Magnetic Properties*, International Seminar on Frontiers in Polymer Science and Technology (Tezpur University, Assam and Jadavpur University, Kolkata), Guwahati, Assam, November 1-3, 2007
- Application of Conducting PEDOT and its Nanocomposite as Electrochemical Capacitor, National Seminar on Emerging Trends in Polymer Science and Technology (Prof. Sukumar Maity Polymer Award Foundation, Kolkata and the Department of Chemistry, Saurashtra University, Rajkot), Rajkot, Gujarat, October 8-10 2009

Susanta Lahiri

- *Nuclear Chemistry Research at SINP, India*, Japan Atomic Energy Agency, Tokai, Japan, January 29, 2010
- *Nuclear Chemistry Research at SINP*, India, St. Petersburg University, Russia, March 5, 2009
- *Green Chemistry: Scope and Responsibilities of Radiochemists*, PSI, Switzerland, February 18, 2009
- *Nuclear Chemistry Research at SINP, India*, , CERN, Geneva, Switzerland, September 5, 2008

- *Accelerator Mass Spectrometry: Its principles and applications* (two lectures) and *Plant and human biomonitoring* (two lectures), Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China, November 28 and December 05, 2007
- *Role and responsibilities of radiochemists to develop green chemistry methods*, Lanzhou University, Lanzhou, China, December 03, 2007
- *Role and responsibilities of radiochemists to develop green chemistry methods*, Institut fuer Radiochemie, TU Muenchen, Germany, October 22, 2007
- *Nuclear Chemistry Research at SINP, India*, St. Petersburg University, Russia March 5, 2009
- *Green Chemistry: Scope and Responsibilities of Radiochemists*, Switzerland, February 18, 2009
- *Nuclear Chemistry Research at SINP, India*, CERN, Geneva, Switzerland, September 5, 2008
- *Accelerator Mass Spectrometry: Its principles and applications* (Two lectures), Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China, November 28, 2007
- *Production of 93mMo through natY(7Li, 3n) reaction and subsequent studies on separation and extraction behavior of no-carrier-added 93mMo from yttrium target*, Gesellschaft für Schwerionenforschung, GSI, Darmstadt, Germany, October 24, 2007
- *Role and responsibilities of radiochemists to develop green chemistry methods*, Institut fuer Radiochemie, TU Muenchen, Germany, October 22, 2007
- *How laws give birth of an important branch of sciences*, RCVP Noronha, Academy of Administration and Management, November 10, 2009
- *Towards building a Radionuclide Bank from proton irradiated Hg and Pb-Bi targets*, ISOLDE Workshop and Users Meeting 2009, CERN, Geneva, Switzerland, November 18-20, 2009
- *Role of radiochemistry towards solving astronomical puzzles*, Seventh International Conference on Nuclear and Radiochemistry, Budapest, Hungary 24-29 August 2008
- *Searching materials from nature for green chemistry research*, National Seminar on Current Trends in Chemistry-I, University of Kalyani, Kalyani , January 08, 2008
- *Role and Responsibility of Radiochemists in Developing Green Chemistry Methods*, 50 years of Radiochemistry in DAE, Bhabha Atomic Research Centre, Trombay, Mumbai, January 02, 2008
- *Important of chemistry and statistics in AMS experimentsm*, Workshop on Accelerator Mass Spectrometry, Inter University Accelerator Centre, New Delhi, October 05, 2007
- *Towards building a Radionuclide Bank from proton irradiated Hg and Pb-Bi targets*", ISOLDE Workshop and Users Meeting 2009, CERN, Geneva, Switzerland November 18-20, 2009 (Susanta Lahiri, Moumita Maiti)
- *Role of radiochemistry towards solving astronomical puzzles*, Seventh International Conference on Nuclear and Radiochemistry, Budapest, Hungary, August 24-29, 2008
- *Green Chemistry Research at Saha Institute of Nuclear Physics*, National Seminar on Advanced Spectroscopy, Theoretical Chemistry, Synthesis, Reactivity and Structural Evaluation, Department of Chemistry, The University of Burdwan, April 25-27, 2008

- *Searching materials from nature for green chemistry research*, National Seminar on Current Trends in Chemistry-I, University of Kalyani, Kalyani, January 08, 2008
- *Role and Responsibility of Radiochemists in Developing Green Chemistry Methods*, 50 years of Radiochemistry in DAE, Bhabha Atomic Research Centre, Trombay, Mumbai , January 02, 2008
- *Important of chemistry and statistics in AMS experimentsm*, Workshop on Accelerator Mass Spectrometry, Inter University Accelerator Centre, New Delhi October 05, 2007

Munna Sarkar

- *Membrane fusion induced by small molecules: Non Steroidal Anti-Inflammatory Drugs (NSAIDs*), Acharya Prafulla Chandra Ray Memorial Symposium on Chemistry Today (2008), University College of Science and Technology, Kolkata, August 01-02, 2008 (Sutapa Mondal, Hirak Chakraborty, Munna Sarkar)

Dalia Nayak

- *Radiochemistry Research at SINP: An overview*, Institute of Modern Physics (IMP), Lanzhou, China, July 12, 2007

Teaching elsewhere

PK Sengupta

- Spectroscopy of Biomolecules (approx. 15 lectures/session), M.Sc (Biophysics & Molecular Biology) and M.Sc (Biophysics & Bioinformatics), University of Calcutta ,2007-08, 2008-09, 2009-10 sessions
- Spectroscopy of Biomolecules (14 lectures) M.Sc (Life sciences combined classes) West Bengal State University, Barasat, 2009-2010
- Spectroscopy in Life Sciences (2 lectures) Feb 3-4, 2010; Tools of Cell Biology(1 lecture), February 4, 2010; Nano-vehicles for Natural Product Based Drugs: Perspectives and Prospects(1 lecture), Feb 5, 2010, UGC Sponsored Refresher Course in Life Sciences, Sambalpur University, Sambalpur

Dhananjay Bhattacharya

- Nucleic Acid structure and Molecular Modeling in West Bengal University of Technology.
- Molecular Modeling and Molecular Dynamics in National Institute of Pharmaceutical Education and Research, Kolkata
- Structural Biology in Biochemistry Department, University of Calcutta
- Taught Molecular Modeling at Bioinformatics Department, University of Pune

Nitai P Bhattacharyya

- Introduction to Genomics and Proteomics (20), February 1, 2008 to March 30, 2008, MSc (General) West Bengal University of Technology, Kolkata
- Genomics and Proteomics tools for understanding human disease (10), March 1-30, 2008, MSc (Special) BC Guha Centre for Genetic Engineering and Biotechnology, University of Calcutta, Kolkata and West Bengal University of Technology, Kolkata
- Introduction to Genomics and Proteomics (20 lectures, 2009) and Microbiology (15 lectures, 2009), Biochemistry Department, North-Eastern Hill University, Shillong

Partha Saha

- DNA Replication (15), September 1-December 15, 2007, MSc, University of Calcutta

Abhijit Chakrabarti

- TEM Applications in Membrane Biology (1), January 29, 2008, (Applications of Transmission Electron Microscopy in Biology) West Bengal University of Technology, Kolkata
- Organization and dynamics of membranes: Fluorescence probing (2), December 5, 2007, Workshop (Structure & Dynamics of Biomolecules 2007) SN Bose National Centre for Basic Sciences, Kolkata
- Immunofluorescence (1), October 5, 2007, (CME in Non-Hodgkin Lymphoma) Ramakrishna Mission Seva Pratishthan, Kolkata

Samita Basu

- Teaching: M.Sc (Physical & Inorganic Chemistry special) in Department of Chemistry, University of Calcutta on Spectroscopy

Susanta Lahiri

- Analytical Chemistry Special paper for PG II students, Department of Chemistry, University of Calcutta

Miscellany

Soumen Basak

- **International Conference on Physics Biology Interface (ICPBI-2009)"** on the occasion of Seventyfive years of the Indian Physical Society, Saha Institute of Nuclear Physics, December 13-16, 2009 (Convener)

Samita Basu

- *Interaction of proflavin with Bovine Serum albumin – a spectroscopic approach***,** U.G.C. sponsored National Level Three-Day Seminar on Advanced Spectroscopy, Theoretical

Chemistry, Synthesis, Reactivity and Structure Evaluation, Department of Chemistry, The University of Burdwan, Burdwan April 25-27, 2008

Brotati Chakraborty (**Best oral presentation**) and Samita Basu

- *Role of Ribose unit in altering the reactivity of a DNA base with Quinones* Acharya Prafulla Chandra ray Memorial Symposium on Chemistry Today (2008) in commemoration of the 148th Birthday of Acharya Prafulla Chandra Ray, Indian Chemical Society, Kolkata, August 01-02, 2008

  Adity Bose (**Best oral presentation**) and Samita Basu

- *A study of spin dynamics of Photoinduced Electron-transfer reactions*, University Golden Jubilee Seminar on Chemistry Today, Department of Chemistry, University of Burdwan, Burdwan, 18-20th March, 2010

  Brotati Chakraborty (Best oral presentation) and Samita Basu

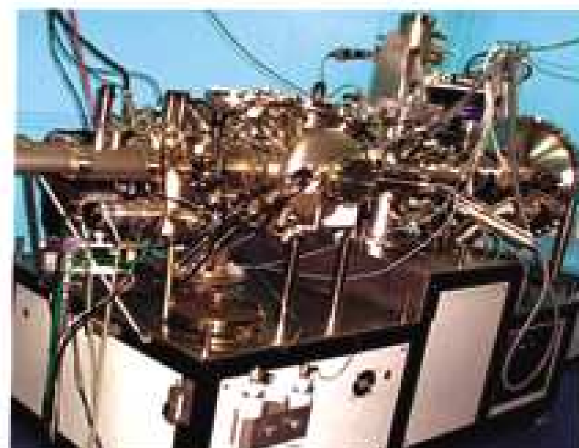
Susanta Lahiri

- Awarded D Sc, University of Calcutta, 2009
- International Conference on Physics Biology Interface (ICPBI-2009) on the occasion of Seventyfive years of the Indian Physical Society, held at Saha Institute of Nuclear Physics, December 13-16, 2009, Joint Convener Soumen Basak and Ansuman Lahiri of the Department of Biophysics and Molecular Biology, University of Calcutta)
- School cum Workshop on Trace Element Speciation, (SElS-08) November 24-28, 2008, organized by Centre for Advanced Research and Education, The Ffort Radisson, Raichak, West Bengal (Convener: Susanta Lahiri)
- School on Trace Analysis, (TRACE-07)) October 3-13, 2007, organized by Centre for Advanced Research and Education, The Ffort Radisson, Raichak, West Bengal (Convener: Susanta Lahiri)
- INDIA-CERN ISOLDE MEETING, 21-22 January 2009, Saha Institute of Nuclear Physics (Convener : Susanta Lahiri)
- Susanta Lahiri, Member of editorial board, Journal of Radioanalytical and Nuclear Chemistry, 2009
- Selected for INSA-DFG Bilateral Exchange Programme, 2007 (to visit Technical University of Munich)
- Principal Investigator, Awarded Indo-Hungary Bi-lateral project (2007-2009)
- Principal Investigator: Awarded Indo-Russian Bi-lateral project (2008-2010)

Dalia Nayak

- Associate Membership of Third World Academy of Sciences (TWAS) in Centre of Excellence at South, 2007-2009.

Condensed Matter Physics Including Surface Physics and NanoScience



2 Condensed Matter Physics Including Surface Physics and NanoScience

Summary of Research Activities of Divisions

Experimental Condensed Matter Physics

The Experimental Condensed Matter Physics (ECMP) Division carries out research in (i) the design and development of advanced experimental systems suitable for measurements using high pressure, low temperature and high magnetic field, and (ii) to process new materials and study their macroscopic and microscopic properties. Research in experimental condensed matter physics was conducted in the general areas of conducting nano-composites, rare-earth based intermetallics, perovskites, double perovskites, quasi low-dimensional system, quantum spin chains, strongly correlated systems and nanocrystalline materials.

Magnetism/Transport of magnetic and Superconducting oxide materials

Magnetic, transport, thermoelectric power, and NMR measurements are being made in the newly discovered Fe-base superconductor RFeAsO (R = La, Ce, Pr, Nd, Sm, and Gd). Evidence of strong electron-phonon coupling was observed from normal and super conducting state transport properties of PrFeAsOF superconductor. The resistivity and ^{75}As NMR results of superconducting $CeFeAsO_{0.84}F_{0.16}$ and its parent compound CeFeAsO reveal formation of vortex lattice in the superconducting state. Spin-fluctuation dominated ferromagnetically ordered state was revealed in Co based LaCoPO. Large low field magnetoresistance ([R(H)-R(0)]/R(0) ~100%) due to charge order melting was observed in nanocrystalline $Pr_{0.65}(Ca_{0.6}Sr_{0.4})_{0.35}MnO_3$ sample. This is in contrast to the general belief that charge order melting is a high field phenomenon. Magnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$, critical behavior and electronic properties of Sm-Nd-Sr and $LaxSr_{1-x}CoO$ under pressure and field have been investigated. Glassy magnetic behaviour in $La_{0.5}Sr_{0.5}CoO_3$ nanoparticles, orbital ordering in $LaMnO_3$ spin polarised transport, charge ordering and related phenomena in magnetic nanostructures are some of the important findings in manganite/cobaltite system. Large magnetocaloric effect in $Sm_{0.52}Sr_{0.48}MnO_3$, $RMnO_3$ crystals, $NdCeCuO_6$ superconductors was observed. Transport properties of Sr_2FeMoO_6 systems were also reported. Large Energy gap (230 K) in the excitation of Cu^{2+} electron spin in $BaCu_2V_2O_8$ confirms alternating chain model. A small band gap of 25 K at the low energy excitation in $SrNi2V_2O_8$, (S=1 quasi-one-dimensional antiferromagnet) suggests its ground state as a disordered "spin liquid" Haldane state. A Core-shell model for AFM small particles have been proposed to discuss the increase of magnetization below AFM ordering ~ 20K for both in bulk and nano particles and unconventional relaxation of spinel oxide $CoRh_2O_4$.

Magnetism and transport of intermetallic alloys

Transverse vibrations driven negative thermal expansion behaviour in $GdPd_3B_{0.25}C_{0.75}$, an AFM anti-pervoskite material, magnetism of ordered metallic compound $GdPd_3B_xC_{1-x}$, and the possibility of negative temperature coefficient of resistivity (NTCR) in the absence of chemical/structural disorder have been studied. Valence fluctuation behaviour in filled/ vacant antiperovskite compounds, intermediate valency of Eu stimulated by the valence instability of dopant Ce in cubic $Ce_{0.5}Eu_{0.5}Pd_3$ and $Ce_{0.5}Eu_{0.5}Pd_3B_x$ have been reported. Magneto-resistance changes sign upon boron doping in $TbPd_3$ and shows highest GMR ~30% in the series of RPd_3 compounds. Novel method of generating magnetic phase diagram using magneto-caloric effect has been proposed. Evidence of Largest Magnetic Cooling Power was obtained from the Magnetocaloric Effect in Ho_5Pd_2**.** The evaluated value of relative cooling power (RCP) is 6.32 J/cm^3 for a magnetic field change of 5 T. Interplay of RKKY, Kondo and crystal field interactions governs the fascinating ground state in RNi_2Al_5 (La, Ce and Pr). In the heavy fermion compound $CePt_2B_2C$, a suppression of the effect of magnetic correlation, due to the dominance of the Kondo effect over the RKKY interaction was observed. Microstructure, magnetic and Mossbauer studies on spark-plasma sintered (SPS) nano composite comprising Sm-Co-Fe (hard magnet) intermetallic phases and Fe(Co) (soft phase) suggest magnetically single phase behaviour of the SPS magnets. Structural and Magnetic studies on SPS $SmCo_5$/Fe bulk nanocomposite magnet shows stronger exchange coupling between the hard and soft magnetic phases in $SmCo_5$ with 5 wt % Fe than 10 wt % Fe containing sample.

Microwave spectroscopy

Conventional microwave spectroscopic studies of organic molecules like phenol and benzonitrile compounds in the gas phase reveals the ground state molecular constants and molecular structures. An indigenously built millimeterwave spectrometer was used to study the rotational spectra of DC discharge produced species like halogen cyanides (XCN, X= Cl, Br, I) and analysis leads to the assignment of many new transitions and determination of accurate rotational parameters and geometry of the molecules.

Non-linear transport in disordered system

In case of field-dependent conduction in disordered systems, a sample with localised states is found to possess a field-scale. This observation leads to a phenomenological scaling, and to a nonlinearity exponent. The exponents in various systems are found to be integer multiples of a number ~0.08. 1/f-noise measurements reveal that bias exponents as well as noise levels may be good indicators of any changes in conduction mechanisms. The suggested model seamlessly fit the resistance minima data in composites. The higher temperature data are described by the Weibull distribution. An ultra low-noise current source has been developed.

Ultrasonic related activity

Study on the propagation characteristics of ultrasound through material medium has been done and a computational Fourier transform method for the characterization of materials has been proposed. Variations of ultrasound propagation parameters near structural phase transition in b- brass and simulation studies of some model systems have been reported.

Surface Physics

Surface physics (SPD) is pursuing basic research in the frontline areas of synthesis, characterization and study of physical properties of surfaces and interfaces of ultra thin films and nanomaterials. The molecules situated at the surfaces and interfaces dictate properties of nanomaterials in most cases and the number of these molecules increases as the size of particles gets reduced. Hence physics of surfaces and interfaces is essential to carry out research in nanoscience and nanotechnology. In the last two plan periods (IXth and Xth) SPD has set up some advanced experimental facilities and generated a strong research base in this area through significant funding from Department of Atomic Energy (DAE), keeping in focus the futuristic developments and the fast pace of progress in the fields of nanoscience and surface physics. Faculty members of SPD, with their diversified fields of expertise, work in a unified manner sharing a common interest to understand the role of surfaces and interfaces in nanomaterials. A new **Center for Nanoscience and Surface Physics (CENSUP)** has been created in SPD to promote national and international scientific exchanges involving cutting-edge research on nanoscience and surface physics.

Morphology and structure of surfaces/interfaces – X-ray scattering and Scanning Probe Microscopy studies

One of our primary research activities is to understand growth mechanism of various nano-structured materials through studies of morphology and structure of grown materials using various x-ray scattering techniques like reflectivity, grazing incidence diffraction and diffuse scattering and using scanning probe microscopy (SPM) techniques. We are also utilizing SPM techniques to investigate elastic properties, chemical changes in thin films and to study wetting property of surfaces and edges. In addition to facilities available in our division, we use various synchrotron and neutron scattering facilities for this purpose. We also use scanning and transmission electron microscopy techniques some times to get additional information.

We use various techniques to grow these films like magnetron sputtering for metallic systems, MBE and MOCVD for semiconductors, spin-coating for polymer and Langmuir-Blodgett growth for organo-metallic systems. For example, we have carried out x-ray scattering study to understand structure and morphology of monolayer of thiol-capped gold nanoparticles on the water surface and associated restructuring when these monolayer films are transferred to a solid substrate by Langmuir techniques. We have also studied formation and ordering of gold-nanoparticles through chemical reaction at the water-toluene interface. We have developed a method to study the swelling dynamics of water soluble polymer films using X-ray and neutron reflectivity techniques. We observed that the dynamics are strongly affected by the interaction of the substrate surface. To understand the driving force behind growth of different initial structures and their evolution with time, and its implication in different properties, especially transport properties and electronic structure, a systematic study has been initiated with Si surface having various passivation. For example, Au on Si shows inter-diffusion dominated growth while Ag on Si shows wetting/dewetting dominated growth.

Modification of surface morphology and properties by ion beam

Ion implantation is known to be an effective method for improving the surface properties of materials, such as hardness, elastic modulus, and wear and corrosion resistance. The defect generation, solution hardening and precipitate hardening are thought to be the main mechanisms to promote the surface hardening. We are studying the near-surface mechanical properties by a depth-sensing nanoindentation technique. The improved bonding at the interface of the film/substrate by implantation is measured by the scratch test.

We have carried out Ion implantation and sputtering related activities to modify materials properties like ion beam mixing and pattern formation on surfaces. We have shown that an initially rough surface has a profound influence on the ion-beam induced pattern formation. We are investigating the pattern formation with different degrees of pristine surface roughness as a function of ion fluence, angle of ion incidence, substrate rotation and temperature. The data will improve the continuum theories for better understanding of the underlying mechanisms. Nanopatterned structures are thought to provide functional architectures for future opto-electronic devices. With this view in mind, our study concerns the study of luminescence and surface plasmon from nanostructured patterned semiconducting and metallic films/particles grown on such patterned substrate. At present, employing a high resolution scanning electron microscope coupled with a cathodoluminescence (HRSEM-CL) system that allows simultaneous recording of spectroscopic and imaging information with sub micron spatial resolution, the role of nanostructured amorphous silicon phase on the fast electron excitation induced luminescence from ion patterned silicon surface ripples is being investigated. We have also initiated a new program for the production, characterization and investigation of novel properties of deposited nanocluster films.

Another area of research is ‘metal quantum dots in glasses’ for synthesizing novel photonic materials for switching applications. Various metal nanocluster-glass composites that we synthesized by ion implantations have provided significant third-order dielectric susceptibility ($\chi^{(3)}$) in the picosecond time domains. We are employing Z-scan and ARINS techniques for nonlinear optical measurements. Optical nonlinearity has been explained to be due to two-photon absorption in the nanocomposite glasses.

Secondary Ion Mass Spectrometry (SIMS)

MCs_n^+ molecular ions (n = 2,3,. . .) in SIMS offers a significantly higher detection sensitivity compared to MCS^+ ions and has a potential relevance in quantification without the aid of ‘standards’. We have recently explored the formation mechanisms of these molecular ion complexes through their emission kinematics and measurement of instantaneous local surface work function changes of the sputter-emission sites. The MCs_n^+-SIMS method has been successfully used for direct compositional analysis of surfaces and interfaces of low-dimensional structures including MBE grown Si/Ge multilayer and Si1-xGex alloy structures.

Electrical and magnetic properties of nano-materials

We have found novel electronic transport properties in conducting polymer (Polypyrrole) nanowires. Low temperature transport study of these nanowires having low electron densities have exhibited characteristics of charge density waves observed in structurally ordered materials. A switching transition to highly conducting state has been observed above a threshold voltage, which can be tuned by changing the diameters of the nanowires and the temperature. Negative differential resistance and enhancement of noise have been observed above the threshold.

Magnetization measurements with conventional low temperature magnetometry and with polarized neutron scattering have been performed on a multilayer stack of noninteracting monolayers of gadolinium ions formed by the LB technique. This system is showing clear signature of twodimensional ordering of spins.

Structure – property correlations at the surfaces of strongly correlated materials

Since 2005, we have initiated a program on the structure-property correlations at the surfaces of strongly correlated materials. Our studies have been focused on the surfaces of oxide materials in the form of single crystals, micro/nano particles and on the epitaxially grown thin films, as well as on low dimensional surfaces and metal/semiconductor surfaces and overlayers. We are interested in studying the surface structure and morphologies, electronic structure and magnetism at the surfaces. We have been employing various tools for studying the surface properties including electron and x-ray spectroscopic techniques, scattering techniques as well as spectro-microscopic techniques. We have been successful in elucidating the electronic structure and magnetic structures and their structural and morphological origins at some of the strongly correlated material surfaces. Interesting new results in the antiferromagnetic domain structures at the surface of Nickel Oxide (NiO) were obtained in a study with the help of x-ray magnetic linear dichroism (XMLD) technique using a Photoemission Electron Microscopy (PEEM) system. The surface electronic structures of low dimensional materials such as Graphite, MoS2 etc are being explored using Angle-resolved Photoemission Spectroscopy (ARPES) along with their surface structural studies.

Electron spectroscopy of novel materials

As surface properties are strongly dependent on the nature of the interaction, understanding of the nature of interaction between the substrate and the polymer chains becomes a key issue. We have developed a state of the art XPS/UPS facility in our lab during 2004 in this direction. Problem comes with the fact that these polymers are insulators and gets charged when exposed to the X-rays. We have developed a novel method namely controlled neutralization technique (CNT) to understand charging and neutralization in polymers. Later we have developed another technique to use this charging to understand structure of organic multi layers. Orientation of polymer chains on a substrate is a direct outcome of polymer substrate interaction. Near Edge X-ray Absorption Fine Structure (NEXAFS) which is a synchrotron based technique is one of the best tools to study the interaction and the orientation of the molecules simultaneously. We are using this technique along with XPS to understand chemical nature of the substrate and the polymer molecules with their mutual interaction.

Growth of compound semiconductor nanostructures

We have recently initiated a research program in the areas of semiconductor materials and devices, especially in the area of III-V and II-VI compounds. Particularly, we are interested in epitaxial growth of such compounds and different low dimensional nanostructures using Metalorganic Vapor Phase Epitaxy (MOVPE) system and chemical vapor deposition (CVD) methods, and characterization of these materials using optical and electrical methods. A MOVPE system, aimed at growing Ga-In-Al-As-P system is at its last phase of installation to pursue this research interest. We have also built a CVD system for growing ZnO thin films, nanowires and other type of self organized hierarchical nanostructures. Vertically aligned as well as randomly oriented nanowires of ZnO have been successfully grown by varying the controlling parameters in the CVD process.

Theoretical Condensed Matter Physics

The activity of Theoretical Condensed Matter Physics (TCMP) Division can be broadly classified under the categories (a) Physics of Strongly Correlated Systems and (b) Statistical Physics. The division has seven faculty members at present and each of them leads their respective group of students and post-doctoral fellows. The divisional activity also includes a centre for interdisciplinary research, namely the **Centre for Applied Mathematics and Computational Sciences** (CAMCS).

For a brief introduction to the present activities of the TCMP division and of the CAMCS,we give below a summary of the investigations carried out by the TCMP faculty essentially in the ongoing plan period (last few years).

Physics of Strongly Correlated Systems

Bose-Einstein condensation is being studied in an optical lattice to obtain interaction-induced depletion of bose condensate. At strong interaction, the condensation temperature decreases with filling for n 0.5, where n is the number of bosons per site, and it becomes zero at n = 1 [PRB **72**, 094301 (2005)]. They studied the condensation of bosons in optical lattices under harmonic and quartic traps in different dimensions [EPJD **42**, 309 (2007); ibid **47**, 203 (2008)], as well as for anisotropic harmonic traps. Next, study of polaronic properties showed that site-diagonal disorder reduces the kinetic energy, Drude weight and spatial extent of the polarons. Increasing temperature also reduces the preceding quantities for weak and intermediate coupling. For strong coupling the effect of temperature is small but opposite [JPCM **20**, 345222 (2008)].

The effects of electron-electron interaction and disorder on persistent current in mesoscopic normal rings have been studied. It has been shown that the long-standing anomaly between theory and experiment regarding the amplitudes of persistent currents in the mesoscopic rings can be resolved by including second-nearest-neighbor hopping integrals in the usual nearest-neighbor tight-binding Hamiltonian [J. Phys.: Condens. Matter, **18**, 5349 (2006)]. Exact numerical calculations revealed that electron-electron interactions produce anomalous Aharonov-Bohm oscillations in the persistent currents which corroborate the experimental findings [Phys. Lett. A, **332**, 497 (2004)]. Studies have been made to understand the behavior of magnetic multilayers, obtained the ground state phase diagram and magnetoconductance of such superlattices using Hubbard model [Phys. Rev. B, **75**, 235117 (2007)]. In a recent work a magnetic quantum device has been proposed which acts as a spin filter [Phys. Lett. A, **374**, 1522 (2010)].

Solution (using novel approaches) of the the long-standing problem of analytically obtaining the Peierls instability condition in the Holstein model has been obtained [PRB, **75** 035124 (2007) and PRB, **71**, 235118 (2005)] by considering quantum phonons and predicted the phase diagram away from half-filling. We were the first to show, using the Peierls instability framework, that the ground state orbital ordering of $LaMnO_3$ can be explained using even weak electron-phonon coupling [PRB **80**, 235123 (2009)]. Next, a new model was proposed to understand cooperative Jahn-Teller effect for quantum phonons. The model involves an enhanced next-nearest-neighbor (NNN) hopping and nearest-neighbor (NN) repulsion and predicts a dramatic first-order transition at a critical repulsion. Sudhakar's group also derived an effective d-dimensional Hamiltonian for a system of hard-core-bosons coupled to optical phonons in a lattice. We demonstrated that the presence of NNN hopping and NN repulsion leads to supersolidity.

Statistical Physics

We have completed some major work and reviewed thoroughly their contributions in Quantum Annealing and Failure Dynamics in Fiber Bundles in two papers in Rev. Mod. Phys. (in 2008 and 2010). Two more reviews in Rev. Mod. Phys. have recently been commissioned; one on Quantum Critical Phenomena in Transverse Ising and XY models and the other one is on Statistical Physics of Fracture, Friction and Earthquakes. We have introduced the Kinetic Exchange Models of Markets; published a textbook on Econophysics (2010, Wiley-VCH) and have been invited for a Monograph on Econophysics from Cambridge Univ. Press, Cambridge.

Studies on semi-classical RRTN (Random Resistor cum Tunneling-bond Network, proposed in 1993-94) model continued [EPL 71, 797 (2005)]. These studies include (i) nonlinear response, (ii) breakdown, (iii) two early power-law dynamics (e.g., in many natural phenomena like earthquakes, some protein-folding dynamics); and (iv) very strong memory (associated hysteresis), useful for cryptography and natural computation (CFS, IEEE Comp Soc, Los Alamitos, CA 2008). An extensive pedagogical review on the RRTN, with many open problems, has recently been written in Quantum and Semi-classical Percolation and Breakdown in Disordered Solids, Lect. Notes in Phys., Vol-762 (Springer, Berlin, 2009).

We have, inspired by the physics of magnetohydrodynamics (MHD), proposed a simplified coupled Burgers-like model in one dimension (1d) to describe 1dMHD. In addition to MHD, this model serves as a 1d reduced model for driven binary fluid mixtures. In particular, we have determined the scaling exponents and the amplitude-ratios of the relevant correlation functions. [J. Stat. Mech. (2009) P08013]. At present, we are investigating the statistical properties of homogeneous and isotropic three-dimensional binary fluid turbulence and the role of topological defects in determining the statistical properties of two-dimensional nonequilibrium systems. We are also looking at the macroscopic effects of coupling driven directed motion (simple nonequilibrium dynamics) with diffusive motion in a 1d model proposed by them. In another work, beginning with biophysical motivations, they proposed two-dimensional coarse-grained equations for active gel systems as generic models for cytoplasmic dynamics in cells.

We have developed a method [J. Stat. Phys. Lett. 2009] to solve a class of non-equilibrium lattice models. The method has been used successfully in Extended Katz Lebowitz Spoon model, Restricted Asymmetric Exclusion Process [PRE, 2008], exclusion process with internal degrees of freedom [arXiv:2010], Tonks gas and DNA denaturation transition (working) to reveal novel spatial correlations. The group is trying to understand absorbing state phase transitions which do not belong to the generic Directed Percolation universality class. In another recent work they showed that random walk in a bounded domain can produce regular patterns, and the non-trivial distribution of returning walkers on the repeated pattern is caused by hidden non-linearity [EPL 2009]. Recently we have studied [OJB, 2009] the micro RNA (miRNA) co-target network and claim that miRNAs deregulate gene expression group-wise (contrary to the current view, i.e., individual regulation). This would help biologists to predict miRNAs those are possibly involved in any specific phenotype. The group is planning to set up a miRNA cluster data base at SINP.

Applied Material Science

This Division has been created in May 2010 from the Microelectronics Division, with the following research areas 1. Micro-electronics and ultrasonic device, 2. Image processing and hardware development, 3. Studies on nanomaterials and 4. Soft materials and nano-bio interfaces.

Research Activities

NMR study of a magnetic phase transition in $Ca_3CuNi_2(PO_4)_4$: A spin trimer compound

^{31}P nuclear-magnetic-resonance (NMR) studies have been performed in trimer spin chain compound $Ca_3CuNi_2(PO_4)_4$, in the temperature range 4–300 K. In the range 16–300 K, the spectrum corresponds to a typical overlap of two powder patterns, consistent with two inequivalent phosphorous sites, having different shift parameters. A comparison of the isotropic hyperfine field (H_{hf}^{iso}) and the axial part (H_{hf}^{ax}) obtained in the paramagnetic phase of $Ca_3CuNi_2(PO_4)_4$, with those obtained in $Ca_3Cu_3(PO_4)_4$, suggest a stronger interchain exchange interaction in $Ca_3CuNi_2(PO_4)_4$, which is possibly the reason for the higher antiferromagnetic transition temperature in $Ca_3CuNi_2(PO_4)_4$. The temperature dependence of the spin-lattice relaxation rate ($1/T_1$) shows a clear signature of long-range magnetic order in $Ca_3CuNi_2(PO_4)_4$ below 16 K (T_N). T_N agrees quite satisfactorily with that obtained from the derivative of the molar susceptibility versus T plot. The NMR line shape below T_N shows the signature of a considerable distribution of the internal magnetic field in the ordered state with the existence of two magnetic sublattices with opposite direction of polarization with respect to the direction of the external magnetic field. A comparison of the behavior of the $1/T_1$ data in $Ca_3CuNi_2(PO_4)_4$ with those in $Sr_3Cu_3(PO_4)_4$

clearly suggests that the mechanism of the relaxation changes from a two magnon-mediated Raman process in the former to a three magnon-mediated process in the latter.

Ghosh, M; Ghoshray, K; Majumder, M; Bandyopadhyay, B; Ghoshray, A

^{11}B and ^{195}Pt NMR study of heavy-fermion compound $CePt_2B_2C$

We report ^{11}B and ^{195}Pt NMR Knight shift K and spin–lattice relaxation rate $1/T_1$ in $CePt_2B_2C$ in the range 4–315 K. The quadrupolar coupling constant, ν_Q for boron nuclei is 790 ± 10 kHz. The change of hyperfine field, H_{hf}, is observed below 30 K in the K versus susceptibility, x, plot. The calculated value of H_{hf} at the ^{11}B (^{195}Pt) is 0.156 (6.86) kOe/μ_B in the range 30–300 K and ~0 (0.22) kOe/ì$_B$ below 30 K. The $1/T_1$ versus T curve shows some exotic behavior. The Ce 4f spin contribution to the nuclear relaxation rate ($1/T_{1f}$) in each case is obtained by subtracting the T_{1K}"^{1} estimated from its La analog, i.e. $LaPt_2B_2C$. In the case of ^{11}B resonance, in the temperature range of 300–100 K, ($1/T_{1f}$) is independent of T, suggesting a Curie–Weiss behavior of the imaginary part of the dynamic susceptibility. It then shows a slow but continuous increment in the range 100–70 K, indicating a signature of the development of short-range magnetic correlation among the Ce 4f spins. Below 70 K, this enhancement of $1/T_{1f}$ is completely suppressed and it decreases sharply, indicating a suppression of the effect of magnetic correlation, due to the dominance of the Kondo effect over the RKKY interaction. $1/T_{1f}$, follows ~T^{ã}, with an exponent α~0.7 in the range 4–30 K for ^{195}Pt and in the range 8–30 K for ^{11}B resonance. This is a characteristic of a non-Fermi-liquid like behavior. However, in the case of ^{11}B, there is again a clear change in the slope of the $1/T_{1f}$ versus T curve below 8 K, with the value of α = 1.0, as if the behavior of the conduction electrons approaches towards a Fermi liquid, when probed near the ^{11}B site.

Sarkar, R; Ghoshray, A; Pahari, B; Ghosh, M; Ghoshray, K; Bandyopadhyay, B; Majumder, M; Anand, VK†; Hossain, Z†

^{75}As NMR study of oriented CeFeAsO and $CeFeAsO_{0.84}F_{0.16}$

We report the resistivity and ^{75}As nuclear magnetic resonance (NMR) results of superconducting $CeFeAsO_{0.84}F_{0.16}$ and its parent compound CeFeAsO. The derivative of the resistivity with temperature and ^{75}As NMR in CeFeAsO clearly show a signature of the onset of the long-range magnetic ordering. The resistivity in $CeFeAsO_{0.84}F_{0.16}$ drops sharply at 41 K and becomes zero at 38 K. Analyzing the ^{75}As NMR spectra in $CeFeAsO_{0.84}F_{0.16}$ and CeFeAsO, we obtained the value of quadrupolar splitting frequency $í_i$=11.0 and MHz 9.9(±0.2) and asymmetry parameter *ç*=0.09 and 0.02, respectively. The shift (K_{ab}) in the oriented (H||"ab) $CeFeAsO_{0.84}F_{0.16}$ sample starts to decrease from 60 K (above T_c). Below 30 K, the NMR line broadens asymmetrically due to the formation of vortex lattice and the observed NMR spectra at 4–10 K clearly resemble the Redfield pattern.

Ghoshray, A; Pahari, B; Majumder, M; Ghosh, M; Ghoshray, K; Bandyopadhyay, B; Dasgupta, P; Poddar, A; Mazumdar, C

^{93}Nb NMR study of the charge density wave state in $NbSe_2$

^{93}Nb NMR studies were carried out for a single crystal of $NbSe_2$ at 73.328 MHz in the temperature range 9–300 K to investigate the normal and charge density wave (CDW) states. Detailed analysis of the NMR line shape of the central transition using a classical incommensurate model reveals the change in the conduction electron spin dynamics from above T_{CDW}. An increase of the Knight shift below T_{CDW} reflects modification to the uniform part of the conduction electron density of states. As suggested theoretically, the Knight shift distribution is found to be directly proportional to the square of the amplitude of the CDW. The results further indicate an in commensurate CDW state in 2H-$NbSe_2$. Analysis of the NMR spectra using the McMillan in commensurate model suggests a large value of the discommensuration parameter (γ) which is almost temperature independent, in contrast to the much smaller value previously reported in the case of 2H-$TaSe_2$.

Ghoshray, K; Pahari, B; Ghoshray, A; Eremenko, VV†; Sirenko, VA†; Suits, BH†

NMR study of the impurity induced ordered state in the doped Haldane chain compound $SrNi_{1.93}Mg_{0.07}V_2O_8$

We report the effect of Mg (S=0) substitution at the Ni site of S=1 Haldane chain compound $SrNi_2V_2O_8$ from magnetic susceptibility and ^{51}V NMR studies. The magnetic-susceptibility results in presence of different external fields (H=0.1, 1.198, 3, and 7 T) in $SrNi_{1.93}Mg_{0.07}V_2O_8$ indicate a strongly field dependent nature of the antiferromagnetic (AF) ordering in this compound, with the ordering being suppressed at HT ≥ 3. A comparison of these results with those reported in isostructural compound $PbNi_{1.76}Mg_{0.24}V_2O_8$ indicates a stronger interchain exchange in the Sr compound. In order to probe the local magnetic properties of $SrNi_{1.93}Mg_{0.07}V_2O_8$ both in the AF ordered state and also when the ordering is suppressed, the ^{51}V NMR studies were performed in presence of the magnetic fields of H=1.198 and 7.04 T. The resonance line shape in presence of both the fields remains almost unaltered in the temperature range of 50–300 K, as was reported in the pure system. However, the linewidth increased appreciably in the range 4 ≤ TK ≤ 20 in presence of both the fields. The temperature dependence of the first moment (M_1) and the second moment (M_2) of the NMR spectra indicates the effect of the development of three-dimensional (3D) correlations among the staggered spins below 20 K when HT =1.198. Whereas, the behavior at HT =7.04 indicates the more dominance of the short-range correlations among the staggered spins within the chain in the same temperature range. The behavior of the spin-lattice relaxation rate and the dynamic susceptibility in the same temperature range further support these findings. Moreover it is seen that the intrachain exchange (JK) =106 and the spin gap (ΔK) =25 for the uninterrupted chain remain almost unchanged after Mg substitution. Finally the present results suggest the coexistence of spin gapped phase of the uninterrupted chain together with the 3D correlated impurity induced staggered spins at HT =1.198 in $SrNi_{1.93}Mg_{0.07}V_2O_8$.

Pahari, B; Ghoshray, K; Sarkar, R; Ghoshray, A

^{31}P NMR of trimer cluster compound $Sr_3Cu_3(PO_4)_4$

^{31}P NMR in S = 1/2 cluster compound $Sr_3Cu_3(PO_4)(4)$ was investigated. At any temperature, the spectrum corresponds to a typical 2 overlap of two powder patterns, consistent with two inequivalent phosporous sites, having different components of the shift parameters. Intra-trimer exchange (J(1) = 110 +/- 15 K) and hyperfine field (H-hf) were directly obtained from temperature dependence of K-iso, considering S = 1/2, Heisenberg linear trimer. The behavior of the H-hf for the two sites is quite different and reflects the formation of 2 trimers below 100 K. The relaxation rate, 1/T-1 in the range 100-210 K, shows an activation (Delta/k(B) = 43 K) dependence of the spin excitation.

Ghosh, M; Ghoshray, K; Pahari, B; Sarkar, R; Ghoshray, A

^{27}Al NMR studies in grain-aligned $PrNi_2Al_5$

^{27}Al Knight shift (K) in grain aligned $PrNi_2Al_5$ has been measured, in the temperature range 3.5–320 K, for two crystallographic non-equivalent Al sites. K becomes independent of temperature below in each case. $\chi_f(T)$ for a Pr^{3+} ion in the orthorhombic crystal-field has been calculated to estimate the crystalline-electric-field (CEF) coefficients using K. The over-all crystal-field splitting (Δ) is and CEF energy from the ground state to the first excited state is .

Ghoshray, A; Sarkar, R; Pahari, B; Ghoshray, K; Bandyopadhyay, B

Impurity induced antiferromagnetic order in Haldane gap compound $SrNi_{2-x}Mg_xV_2O_8$

The effect of nonmagnetic Mg^{2+} doping in $SrNi_2V_2O_8$, a Haldane gap system with a disordered ground state, was investigated using DC magnetic susceptibility and heat capacity measurements in polycrystalline samples of $SrNi_{2-x}Mg_xV_2O_8$ with x=0.03, 0.05, 0.07, 0.1 and 0.14. The results clearly reveal that the substitution of Ni^{2+} (S=1) ion by Mg^{2+} (S=0) ion induces a magnetic phase transition with the ordering temperatures lying in the range 3.4–4.3 K, for the samples with lowest and highest value of x. The intrachain exchange constant (J/k_B) and the Haldane gap (Δ) for all the compounds were estimated to be ~98±2 and 25 K, respectively, which are close to that of the undoped compound. The magnetization data further suggest that the compounds exhibit metamagnetic behavior below T_N, supporting a picture of antiferromagnet with significant magnetic anisotropy and competing intrachain and interchain interactions.

Pahari, B; Ghoshray, K; Ghoshray, A; Samanta, T; Das, I

A comparative study of the magnetic properties and phase separation behavior of the rare earth cobaltates, Ln(0.5)Sr(0.5)CoO(3) (Ln = rare earth)

A comparative study of the magnetic properties of a few members of the Ln(0.5)Sr(0.5)CoO(3) family with different radii of the A-site cations, < r(A) >, in the range 1.19-1.40 A has been carried out. The apparent Tc (where the magnetization undergoes an abrupt increase) decreases markedly with < r(A) > as well as the size-disorder arising from the mismatch in the size of the A-site cations. The value of the magnetization at low temperatures decreases markedly with decrease in < r(A) > or increase in size-disorder, suggesting that the relative proportion of the ferromagnetic (FM) species decreases relative to that of the paramagnetic (PM) species. Such a variation of the FM/ PM ratio with composition and temperature is evidenced from the Mossbauer spectra of La0.5Sr0.5CoO3 as well. The variation of the FM/PM ratio with < rA > and size-disorder, as well as a local-probe study using Co-59 Nuclear magnetic resonance spectroscopy suggest that electronic phase separation is an inherent feature of the Ln(0.5)Sr(0.5)CoO(3) type cobaltates, with the nature of the different magnetic species in the phase-separated system varying with < r(A) > and size disorder.

Kundu, Asish; Sarkar, R; Pahari, B; Ghoshray, A; Rao, CNR†

Thermoelectric power of RFeAsO (R = Ce, Pr, Nd, Sm and Gd)

Thermoelectric powers of a series of compounds RFeAsO (R = Ce, Pr, Nd, Sm and Gd) have been reported for temperatures ranging from 77 K up to room temperature. The behavior of S(T) in this temperature range can be divided into three regions. Every region has been fitted with mathematical functions of T. The physical significance of separate terms in the mathematical functions has been discussed. Some kind of universality has been observed between different members of the series.

Poddar, Asok; Mukherjee, Sanjoy; Samanta, Tanmay; Saha, Rajat S; Mukherjee, Rajarshi; Dasgupta, Papri; Mazumdar, Chandan; Ranganathan, R

Magnetism of crystalline and amorphous $La_{0.67}Ca_{0.33}MnO_3$ nanoparticles

We report the ferromagnetism of $La_{0.67}Ca_{0.33}MnO_3$ in bulk polycrystalline, nanocrystalline, and amorphous phases. The structural change from crystalline phase to amorphous phase exhibited a systematic decrease in T_C (paramagnetic to ferromagnetic transition temperature) and spontaneous magnetization (M_S). The experimental results suggested few more interesting features, e.g., appearance of large magnetic irreversibility in the temperature dependence of magnetization, lack of magnetic saturation at high magnetic field, blocking of magnetization below T_B, and enhancement of coercivity. In addition, the magnetic phase transition near to T_C changes from first order character in bulk sample to second order character in nanocrystalline and amorphous samples. We understand the observed magnetic features as the effects of decreasing particle size and increasing magnetic (spin-lattice) disorder. The magnetic dynamics of amorphous samples is distinctly different from the nanocrystalline samples and also found to be comparable with the properties of reported amorphous ferromagnetic nanoparticles.

Bhowmik, RN; Poddar, Asok; Ranganathan, R; Mazumdar, Chandan

Magnetic behavior of binary intermetallic compound YPd_3

We report the results of detailed magnetic studies on binary rare-earth-transition metal compound YPd_3. The results of temperature and magnetic field dependent DC-magnetic measurements along with the results of powder X-ray diffraction measurement and electrical transport have been discussed. The X-ray data suggest a well-defined ordered crystal lattice, free from any detectable impurity phase. Magnetization data exhibits predominant diamagnetic character at higher fields. However, the compound exhibits anomalous behavior at low fields.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R

Magnetism in ordered metallic perovskite compound $GdPd_3B_xC_{1-x}$

We report results of dc-magnetization, ac-susceptibility and magnetoresistance measurements on crystalline metallic-perovskite compounds $GdPd_3B_xC_{1-x}$ (x=0.25, 0.50, 0.75 and 1.00) and the parent cubic compound $GdPd_3$. The interest in these materials stems from the observation of negative temperature coefficient of resistance and negative thermal expansion in some of the members of this series. In the present study, we show that by substitution of non-magnetic elements, boron and carbon, the nature of the magnetic interaction can be varied from dominating ferromagnetic to antiferromagnetic and finally to a canted magnetic structure without altering the crystal symmetry of the compounds. The variation of magnetic interaction by modifying the lattice parameter resembles Ruderman–Kittel–Kasuya–Yosida (RKKY) oscillations.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R; Dattagupta, S[†]

Observation of giant magnetoresistance and reversal of its sign upon boron filling in cubic $TbPd_3$

We report the observation of negative giant magnetoresistance (GMR) in the cubic intermetallic compound $TbPd_3$, which is largest (–30%) among the RPd_3 series of compounds. On introducing the nonmagnetic element boron in the lattice of $TbPd_3$, the GMR (+18%) changes sign from negative to positive in the resultant metallic perovskite compound $TbPd_3B$. Addition of boron also significantly modifies the magnetic and electrical transport properties of the compound. The sign of the observed magnetoresistance can be interrelated with the sign of paramagnetic Curie temperature, suggesting close correlation between the magnetotransport behavior and the nature of the magnetic exchange interaction.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R

Intermediate valency of Eu in a cubic intermetallic compound $Ce_{0.5}Eu_{0.5}Pd_3$

We report on a change in the valency of the Eu ions in cubic $EuPd_3$ upon Ce substitution. The resultant compound $Ce_{0.5}Eu_{0.5}Pd_3$ exhibits a mixed-valent state of Eu, where the valency differs from +3 observed in the case of $EuPd_3$. This change in the valency also manifests in significant modifications of magnetic properties of $Ce_{0.5}Eu_{0.5}Pd_3$ in comparison to that of $EuPd_3$ and $CePd_3$. In contrast to the usually observed expansion of the lattice accompanied with such valence transitions, our results suggest that the lattice volume in the present case remains essentially constant with respect to $EuPd_3$.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R; Reddy, V. Raghavendra†; Gupta, Ajay†

Negative pressure driven valence instability of Eu in cubic $Eu_{0.4}La_{0.6}Pd_3$

We report the change in the valency of Eu-ions in the binary intermetallic cubic compound $EuPd_3$ induced by La doping at rare-earth sites. Doping of La generates negative chemical pressure in the lattice, resulting in a significant increase of the lattice parameter without altering the simple-cubic structure of the compound. Results of dc-magnetic measurements suggest that this increase in the lattice parameter is associated with the valence transition of Eu-ions from Eu^{3+} to a mixed-valent state. As Eu^{2+}-ions possess a large magnetic moment, this valence transition significantly modifies the magnetic behavior of the compound. In contrast to introducing boron at the vacant body center site of the unit cell to change the valency of Eu-ions, as in the case of $EuPd_3B$, our results suggest it can also be altered by doping a rare-earth ion of larger size at the lattice site of Eu in $EuPd_3$.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R

Negative temperature coefficient of resistance in a crystalline compound

Resistivity measurements and temperature-dependent X-ray structural analyses are reported for the crystalline compounds $GdPd_3B_xC_{1-x}$. We show that a controlled tuning of the temperature coefficient of resistance (TCR) can be done by modifying the structural parameters and chemical environment of the compounds. We have achieved the result of negative TCR in an ordered, non-Kondo crystalline compound. Electronic-structure calculations have been carried out to elucidate some of our observations.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R; De Raychaudhury, Molly†; Saha-Dasgupta, T†; Tripathi, Saurabh†; Pandey, Dhananjai†; Dattagupta, S†

Transverse vibrations driven negative thermal expansion in a metallic compound $GdPd_3B_{0.25}C_{0.75}$

We have observed negative thermal expansion (NTE) in a metallic, polycrystalline, and structurally ordered cubic compound $GdPd_3B_{0.25}C_{0.75}$. Our analysis suggest that the NTE observed in this compound does not stems from valence or magnetic instability of lattice ions, which is in general the case of metallic compounds exhibiting such an anomaly. We propose a possible alternative mechanism, namely, the transverse vibrations at low temperatures arising from site anisotropy, that induce the lattice contraction thereby resulting in isotropic NTE. The observed NTE also reflects its effect on the electrical transport properties of this compounds.

Pandey, Abhishek; Mazumdar, Chandan; Ranganathan, R; Tripathi, S†; Pandey, D†; Dattagupta, S†

Magnetic ordering and electrical resistivity in $Co_{0.2}Zn_{0.8}Fe_2O_4$ spinel oxide

We report the magnetic, Mossbauer spectroscopy and resistivity measurements in order to understand the electronic behaviour of bulk $Co_{0.2}Zn_{0.8}Fe_2O_4$ spinel oxide. The effect of magnetic order on electrical behaviour is observed from the resistivity measurements in the absence and presence of magnetic field. The analysis of Mossbauer spectra suggests the absence of Fe_{2+} ions in the system, which implies that complete hopping of charge carriers between localized Fe_{3+}/Co_{2+} and Fe_{2+}/Co_{3+} pair of ions in B sublattice is not the favourable mechanism in $Co_{0.2}Zn_{0.8}Fe_2O_4$. We suggest that electrical behaviour of the present sample may be consistent with a model of fractional charge transfer via $Fe\text{-}B^{3+}O^{2-}$—$Co\text{-}B^{2+}$ superexchange path.

Bhowmik, RN; Ranganathan, R; Ghosh, B†; Kumar, S†; Chattopadhyay, S†

Microstructure, magnetic and Mossbauer studies on spark-plasma sintered Sm-Co-Fe/Fe(Co) nanocomposite magnets

Nanocomposite powders comprising Sm–Co–Fe intermetallic phases and Fe(Co) were synthesized by high-energy ball milling and were consolidated into bulk magnets by the spark-plasma sintering (SPS) technique. While the microstructure of the SPS samples was characterized by transmission electron microscopy (TEM), the solubility of Fe in different phases was investigated using Mössbauer spectroscopy. TEM studies revealed that the spark-plasma sintered sample has $Sm(Co,Fe)_5$ as a major phase with $Sm_2(Co,Fe)_{17}$, $Sm(Co,Fe)_2$ and Fe(Co) as secondary phases. The size of the nanocrystalline grains of all these phases was found to be in the range 50–100 nm. The Mössbauer spectra of the as-milled powders exhibited two different subspectra: a sextet corresponding to the Fe phase and a broad sextet associated with the Fe(Co) phase; while that of the SPS sample showed four different subspectra: a sextet corresponding to Fe and other three sextets corresponding to the Fe(Co), $Sm(Co,Fe)_5$ and $Sm_2(Co,Fe)_{17}$ phases; these results are in accordance with the TEM observation. Recoil magnetization and reversible susceptibility measurements revealed magnetically single phase behaviour of the SPS magnets.

Rao, NVR†; Saravanan, P†; Gopalan, R†; Raja, M Manivel†; Rao, DVSreedhara†; Sivaprahasam, D†; Ranganathan, R; Chandrasekaran, V†

Silica encapsulated Ni nanoparticles: Variation of optical and magnetic properties with particle size

Ni nanoparticles embedded in SiO_2 matrix were prepared by sol-gel process. The molar percentages of Ni were varied from 2 to 20% of total SiO_2 present in the matrix. Transmission electron microscope (TEM) images revealed that particle sizes varied from 8.0-15.7 nm at an annealing temperature of 773 K with variation of concentration. The optical absorption spectra revealed that the surface plasmon resonance (SPR) peak in the UV region of the spectrum shifted with the particle diameter (D) from that at 247.3 nm for D = 8.0 nm to 250.7 nm for D = 15.7 nm. In hysteresis loop measurements the magnetizations (M) of the nanocomposites also increased with higher Ni content in the matrix and did not saturate in the measuring limit of the magnetic filed (H) of 4 KOe. The anhysteric curves for different samples were analyzed with the law of approach to saturation (LAS). The zero field cooled (ZFC) and field cooled (FC) magnetization measurements at 50 Oe showed increasing broadening of the ZFC curve with the higher Ni content. To calculate the average blocking temperature ($< T_B >$) a distribution of the blocking temperatures $< T_B >$ was assumed to initiate theoretical fittings and it was found to be increasing with the Ni concentration in the matrix.

Das, Soumen†; Panda, Subhendu K†; Nandi, Prithiwish†; Chaudhuri, Subhadra†; Pandey, Abhishek; Ranganathan, R

Mossbauer spectroscopy: An essential tool for nanoparticle magnetism in $Co_{0.2}Zn_{0.8}Fe_2O_4$ ferrite

Magnetism ill $Co_{0.2}Zn_{0.8}Fe_2O_4$ nanoparticles, prepared by mechanical activated process and chemical (co-precipitation) process have been reported. Experimental data showed that magnetic behaviour in mechanical activated nanoparticles (MANP) is drastically different in comparison with the nanoparticles (CPNP) prepared by chemical route. For example, MANP exhibited enhancement in both magnetization and ferrimagnetic order, whereas CPNP shows the reduction in both magnetization and magnetic order. The magnetic evolution during thermal activated grain growth process is also different for samples with smaller particle size, whereas magnetic behaviour for larger particle size is similar for both nano particles and approaching to the properties of bulk system. We have understood the co-existence of various competitive effects during, grain growth process employing Mossbauer spectroscopy, dc magnetization and ac susceptibility measurements.

Bhowmik, RN; Ranganathan, R

Structural and magnetic studies on spark plasma sintered SMCo5/Fe bulk nanocomposite magnets

SmCo5 + x wt% Fe (x = 0, 5 and 10) nanocomposite powders were synthesized by mechanical milling and were consolidated into bulk shape by spark plasma sintering (SPS) technique. The evolution of structure and magnetic properties were systematically investigated in milled powders as well as in SPS samples. A maximum coercivity of 8.9 kOe was achieved in spark plasma sintered SMCo5 + 5 wt% Fe sample. The exchange spring interaction between the hard and soft magnetic phases was evaluated using delta M-H measurements and the analysis revealed that the SPS sample containing 5 wt% Fe had a stronger exchange coupling between the magnetic phases than that of the sample with 10 wt% Fe.

Rao, N. V. Rama†; Gopalan, R†; Raja, M Manivel†; Chandrasekaran, V†; Chakravarty, D†; Sundaresan, R†; Ranganathan, R; Hono, K†

Positron annihilation spectroscopic studies of the influence of heat treatment on defect evolution in hybrid MWCNT-polyacrylonitrile-based carbon fibers

Polyacrylonitrile-based carbon fibers, embedded with multi-wall carbon nanotubes (MWCNTs) in different concentrations, have been prepared by an electrospinning technique. The samples were subjected to oxidative stabilization followed by carbonization and graphitization at temperatures from 1000 to 3000 degrees C. Scanning electron microscopy, X-ray diffraction, and positron annihilation spectroscopy were used to investigate the samples. Positron annihilation studies, viz. analysis of positron lifetime and Doppler broadened spectrum line shape, provide deeper insight on defect specific aspects of the material as a function of temperature. Positron lifetime spectra for all the samples give a best fit for two-lifetime components. The trapping of positrons at specific sites in the nanotubes embedded in the fibers indicates the exact regions of open volume defects in the samples. Carbonization and graphitization are enhanced by embedding nanotubes in the fibers and could be an effective way of tailoring the properties of this system.

Chakrabarti, K; Nambissan, PMG; Mukherjee, CD; Bardhan, KK; Kim, C[†]; Yang, KS[†]

Magnetic cluster glass behavior and grain boundary effect in $Nd_{0.7}Ba_{0.3}MnO_3$ nanoparticles

The magnetic and transport properties of $Nd_{0.7}Ba_{0.3}MnO_3$ nanoparticles were explored by transmission electron microscopy, x-ray powder diffraction, resistivity, magnetoresistance, thermopower (S), and magnetic measurements. The metal-insulator transition behavior of the temperature dependence of resistivity for the sample with the largest particle size change to insulating nature with the decrease in the particle size due to the enhancement of the grain boundary effect. The magnetoresistance of the nanoparticles is analyzed in the light of a phenomenological model based on the spin polarized tunneling at the grain boundaries. The thermopower of the samples shows a crossover from negative to positive values and at high temperatures S follows adiabatic small polaron hopping theory. The zero field cooled and field cooled (FC) magnetizations display broad ferromagnetic transition. The Curie temperature (T_C) and the irreversibility temperature (T_{irr}) decrease considerably with the decrease in the particle size. During cooling the ac susceptibility of the nanoparticles exhibits two magnetic phase transitions with paramagnetic, ferromagnetic, and glassy phases. The frequency dependent peak in the out of phase part (÷’’) of the ac susceptibility is the signature of cluster glass behavior. Large thermomagnetic irreversibility, monotonic increase in the FC magnetization, nonsaturation of the magnetization, and the observation of two distinct magnetic transitions in ac susceptibility give evidence for the cluster glass nature of the nanoparticles.

Roy, B; Das, S

Size-induced metal insulator transition and glassy magnetic behavior in $La_{0.5}Sr_{0.5}CoO_3$ nanoparticles

Structural, electrical, and magnetic properties of $La_{0.5}Sr_{0.5}CoO_3$ nanoparticles prepared by sol-gel technique are investigated and the results reveal a size-induced metal insulator transition in the electrotransport behavior. The field cooled and zero field cooled magnetizations display a broad paramagnetic to ferromagnetic transition at T_C with a large magnetic irreversibility. Attempts are made to get an idea about the spin states in the nanoparticles. The observed frequency dependent shoulder in the in-phase (÷') component and the peak in the out of phase (÷'') component of the ac susceptibility in the low temperature region indicate the glassy nature of the samples.

Roy, B; Das, S

Magnetic properties of the spin trimer compound $Ca_3Cu_2Mg(PO4)_4$ from susceptibility measurements

The effect of the substitution of one Cu2+ ion (S = 1/2) by Mg2+ ion (S = 0) on the magnetic property of the linear-chain spin trimer compound Ca3Cu3(PO4)(4) was studied using dc magnetic susceptibility in Ca3Cu2Mg(PO4)(4) together with those in Ca3Cu3(PO4)(4) and Ca3Cu2Ni(PO4)(4) for comparison. A remarkable difference is observed among the results obtained in the Mg and the Ni substituted compounds. A clear signature of the reduction in the net spin of the trimers in Ca3Cu2Mg(PO4)(4) was found below 65 K, which is compatible with the presence of the Cu2-Cu1-Mg trimers in the singlet ground state, together with those of the type Cu2-Cu1-Cu2 and Mg-Cu1-Mg in the doublet state. However, no signature of the reduction in the net spin of the trimers was observed in Ca3Cu2Ni(PO4)(4). This finding suggests that the type of trimers present in Ca3Cu2Mg(PO4)(4) and Ca3Cu2Ni(PO4)(4) are different. Furthermore, a singlet ground state is partially realized in a quantum spin trimer system Ca3Cu2Mg(PO4)(4).

Ghosh, M; Majumder, M; Ghoshray, K; Banerjee, S

Effect of Interfacial Hydrogen Bonding on the Freezing/Melting Behavior of Nanoconfined Liquids

The effect of interfacial hydrogen bonding on the behavior of the freezing/melting processes in two organic liquids, namely, ethylene glycol [(CH2OH)(2)] and isopropanol [CH3CH(OH)CH3], confined in nanopores of ZSM-5 zeolite has been investigated using the positron annihilation spectroscopy (PAS) and nuclear magnetic resonance (NMR) techniques. Both liquids have intermolecular hydrogen bonding and feel attractive interaction toward the surface of the confining wall, resulting in all increase in the freezing/melting temperature while confined in nanopores. This observation differs front our earlier report on the behavior of benzene confined in ZSM-5 as well as in silica pores wherein a depression in freezing temperature was seen due to a weakly attractive/repulsive interaction between benzene and the pore Surface. the measured S parameter, o-Ps lifetime, and intensity profiles across the freezing point of ethylene glycol confined in ZSM-5 are seen to be different from those of isopropanol, signifying the difference in the behavior of phase transition in these two liquids Under confinement. It is to be noted that, Unlike isopropanol, ethylene glycol has strong intramolecular hydrogen bonding. This causes the difference in the fluid-wall interfacial interaction between ethylene glycol and isopropanol within the confinement. The phase-transition behavior of these two confined liquids Was also investigated using the NMR technique by studying the Spill-Spill relaxation time (T-2). The T-2 process in ethylene glycol is expressed as a sum of at least two distinct components exhibiting Gaussian decay, whereas in isopropanol, T-2 is expressed as a sum of three components showing Lorentzian decay. The transitions from one component to another were seen to be consistent with the positron annihilation spectroscopic observation.

Maheshwari, P†; Dutta, D†; Sharma, SK†; Sudarshan, K†; Pujari, PK†; Majumder, M; Pahari, B; Bandyopadhyay, B; Ghoshray, K; Ghoshray, A

Dielectric relaxation and electronic structure of BaAl1/2Nb1/2O3: x-ray photoemission and nuclear magnetic resonance studies

The frequency-dependent dielectric relaxation in barium-aluminium-niobate, BaAl1/2Nb1/2O3 (BAN), at low temperatures (103-443 K) is investigated by alternating-current impedance spectroscopy in the framework of conductivity and electric modulus formalisms. The Havriliak-Negami expression is used to analyse the electric modulus data. The scaling behaviour of the imaginary part of the electric modulus suggests that the relaxation describes the same mechanism at various temperatures. The frequency-dependent conductivity spectra follow the power law. The electronic structure of BAN is studied using x-ray photoemission spectroscopy (XPS). The XPS data are analysed by the first-principles full potential linearized augmented-plane-wave method using density functional theory under the generalized gradient approximation. The electronic structure calculation reveals that the electrical properties of BAN are dominated by the interaction between niobium d-states and oxygen p-states. The Al-27 and Nb-93 nuclear magnetic resonance (NMR) studies of the sample are performed at 78 and 73 MHz, respectively, in the temperature range 4-295 K to understand the transport properties of charge carriers in terms of their dynamics on a microscopic level. The description of the NMR lineshape is given on the basis of analytical formulae. The NMR investigation confirms the chemical ordering of 1:1 Al/Nb in BAN.

Dutta, Alo[†]; Sinha, TP[†]; Pahari, B; Sarkar, R; Ghoshray, K; Shannigrahi, Santiranjan[†]

Magnetization and Cu-63 NMR studies on granular FeCu alloys

Nanostructured FeCu granular alloys (Fe similar to 1%-20%) have been prepared by borohydride reduction and characterized by energy dispersive spectroscopy, x-ray, and transmission electron microscopy studies. Study of zero-field-cooling-field-cooling magnetization yields blocking temperature distribution of magnetic fine particles system in all samples. At low Fe concentration, the magnetizations of the samples combine superparamagnetism and paramagnetism near room temperature and small hystereses at 5 K. High Fe content alloys are almost entirely ferromagnetic even at 300 K. However, in all these samples, the observation of the Cu-63 NMR signal at all temperatures 4-300 K confirms the existence of a paramagnetic component having similar to 0.02-0.04 at. % Fe in Cu. The temperature dependence behavior of Fe contribution to Cu-63 NMR linewidth and the Knight shift indicate that the paramagnetic component might exhibit a Kondo temperature of similar to 24 K that is significantly higher than that obtained in bulk dilute FeCu alloys.

Bandyopadhyay, B; Pahari, B; Ghoshray, K

Millimeterwave spectrum of DC discharge produced ICN in excited vibrational states

An indigenously built 50 kHz source-modulated millimeter-wave spectrometer was used to produce cyanogen iodide (ICN) in the excited vibrational states (01(1)0), (03(3)0), (10(0)0), (20(0)0) and (02(0)0) and record their corresponding rotational spectra. The analysis of the recorded spectra was carried out in the frequency range of 57.0 - 98.0 GHz. ICN was produced using a DC glow discharge through a mixture of methyl iodide (CH3I) and benzyl cyanide (C6H5CH2CN) vapor at low pressure. I-127 nuclear quadrupole hyperfine structure and the I-type doublet spectra of (01(1)0) state have been resolved. The observed and assigned rotational transition frequencies were used in a least-square fit to determine more accurate values of molecular constants. The agreement between the derived parameters and those reported earlier clearly indicate that the reported spectral lines belong to ICN in the excited vibrational states. It also indicates that ICN could be produced in selective excited vibrational states by DC glow discharge technique.

Varadwaj, PR; Jaman, AI

Millimeter-wave spectrum and ab initio DFT calculation of the C-gauche conformer of allyl isocyanate

The analysis of the ground state rotational spectrum of the C-gauche conformer of allyl isocyanate has been extended up to the frequency range of 100.0 GHz. A detailed centrifugal distortion analysis has been carried out using previously reported and newly measured transition frequencies. More accurate values of the rotational and centrifugal distortion constants are presented. Quantum chemical calculations at DFT levels of theory using large basis sets b3lyp/6-311G(d, p), have also been made to compute rotational constants, dipole moments and potential energies for different conformers of this molecule. Finally, different bond lengths and centrifugal distortion constants for the C-gauche conformer have been computed.

Jaman, AI; Bangal, PR

Time-resolved Fourier transform infrared emission spectroscopy of laser ablation products

Time-resolved Fourier transform infrared spectroscopy was applied for observations of emission spectra from ablation products induced by a Nd:YLF laser with a 2.5 kHz repletion rate. The infrared emission spectra from Fe, Cu, Zn, and Al atoms were observed in the 2.5-5 mu m region. The observed emission spectrum from iron ablation in the 2500 cm (1) region agrees very well with solar absorption spectrum, where new lines have been detected in the present experiment in addition to the lines observed from a hollow cathode discharge. When O-2 was added to the carbon ablation, emissions from vibrationally excited CO were observed with non-equilibrium vibrational distribution.

Kawaguchi, K[†]; Sanechika, N[†]; Nishimura, Y[†]; Fujimori, R[†]; Oka, TN[†]; Hirahara, Y[†]; Jaman, AI; Civis, S[†]

Microwave spectrum of trans 3-fluorophenol in excited torsional states

The microwave rotational spectra of the trans conformer of 3-fluorophenol have been observed in excited torsional states and analyzed in the frequency range 12.0-43.0 GHz using conventional microwave and Radio-Frequency Microwave Double Resonance (RFMWDR) techniques. Analysis of the ground torsional state spectrum has been extended to higher rotational states. Least-squares analysis of three sets of rotational transitions yield rotational and centrifugal distortion constants for the ground and first two excited torsional states. A nonlinear behavior of the variation of inertial defect with the torsional quantum number was observed.

Jaman, AI

Crossover of the dimensionality of 3d spin fluctuations in LaCoPO

dc magnetization and P-31 spin-lattice relaxation rate in the polycrystalline sample of LaCoPO suggest a spin-fluctuation dominated ferromagnetically ordered state. Moreover, NMR data clearly indicate a crossover from two-dimensional to three-dimensional spin fluctuations across T-C. In contrast to isotropic hyperfine field, H-hf at the P-31 site in LaFePO, H-hf is anisotropic in LaCoPO. The data of spin-lattice relaxation rate also exhibit anisotropic spin fluctuation. The anisotropy vanishes near T-C.

Majumder, M; Ghoshray, K; Ghoshray, A; Bandyopadhyay, B; Pahari, B; Banerjee, S

Inverse magnetocaloric effect in polycrystalline La0.125Ca0.875MnO3

Recently the inverse magnetocaloric effect has been observed in different compounds. However, it is very rare for any manifestation of the effect to be seen in manganites. We have found the inverse magnetocaloric effect in the case of polycrystalline La0.125Ca0.875MnO3. Such a phenomenon is attributed to the stabilization of the antiferromagnetic state associated with inherent magnetic inhomogeneous phases for this compound.

Biswas, Anis; Samanta, Tapas; Banerjee, S; Das, I

Magnetoresistance studies on RPd2Si (R = Tb, Dy, Lu) compounds

Magnetoresistance studies on RPd2Si (R = Tb, Dy and Lu) compounds show large negative magnetoresistance (MR) in TbPd2Si and DyPd2Si near the magnetic ordering temperature. Positive MR at low temperature in the ferromagnetic Dy compound is shown to arise from the orbital contribution (the Lorentz force effect). As a consequence, a deviation from the linear relation between MR and isothermal entropy change (i.e. the magnetocaloric effect) is observed. In the case of the Tb compound, anomalous magnetoresistance behavior is observed at 3 K, where the resistivity is found to be different before and after magnetic field cycling. These results suggest complex magnetic behavior in TbPd2Si.

Rawat, R†; Kushwaha, Pallavi†; Das, I

Magnetocaloric properties of nanocrystalline La0.125Ca0.875MnO3

Some recent experimental studies show the invisibility of antiferromagnetic transition in the cases of manganites when their particle size is reduced to nanometer scale. In complete contrast to these cases, we have observed the signature of antiferromagnetic transition in the magnetocaloric properties of nanocrystalline La0.125Ca0.875MnO3 of average particle sizes 70 and 60 nm similar to its polycrystalline bulk form. The system exhibits inverse magnetocaloric effect in its polycrystalline and nanocrystalline forms. An extra ferromagnetic phase is stabilized at low temperature for the sample with particle size similar to 60 nm.

Biswas, Anis; Samanta, Tapas; Banerjee, S; Das, I

Low temperature conductivity in ferromagnetic manganite thin films: quantum corrections and inter-granular transport

The interplay between inter-granular transport and quantum corrections to low temperature transport properties of La0.67Sr0.33MnO3 (LSMO) and Nd0.67Sr0.33MnO3 (NSMO) thin films has been discussed. All the samples exhibit characteristics of renormalized electron-electron interaction in two dimensions. The contrasting response of the low temperature transport to magnetic field in the LSMO and NSMO films is attributed to the strikingly different magnetic field sensitivity of the inter-granular transport.

Mukhopadhyay, Soumik; Das, I

Comparative studies of magnetocaloric effect and magnetotransport behavior in GdRu2Si2 compound

Studies on magnetocaloric effect (change in magnetic entropy Delta S) and magnetotransport (difference in resistivity due to magnetic field Delta rho) have been performed on polycrystalline GdRu2Si2. Due to the presence of several field-induced metamagnetic transitions and superzone energy gap effect below the antiferromagnetic transition temperature (similar to 45 K), the system exhibits complex magnetotransport behavior. Such a complicated magnetotransport behavior has been analyzed by the comparative studies on Delta rho and Delta S. The anomalous regions of Delta rho, where it is not dominated by the change in the orientation of magnetic moments, have been highlighted by showing the difference in the variation in Delta S and Delta rho. The origin of similar and dissimilar behaviors of Delta S and Delta rho at different regions of temperature and magnetic field has been discussed. The comparative study of Delta S and Delta rho indicates that it is a powerful technique to understand the complex magnetotransport behavior of the magnetic materials. Interestingly, the intricate magnetic phase diagram of GdRu2Si2 generated by taking magnetization, magnetotransport, or magnetocaloric data appeared to be identical, indicating the usefulness of these physical quantities to generate magnetic phase diagram.

Samanta, Tapas; Das, I; Banerjee, S

Contribution of energy-gap in the ferromagnetic spin-wave spectrum on magnetocaloric parameters of CeRu2Ge2

A study of the magnetocaloric effect has been performed on a polycrystalline CeRu2Ge2 compound, which exhibits an antiferromagnetic ordering below T-N = 8.3 K and enters into a ferromagnetic ground state at T-C = 7.4 K. The origins of the magnetocaloric parameters (the isothermal entropy change: -Delta S and the adiabatic temperature change: Delta T-ad) of the CeRu2Ge2 compound below TC have been analyzed. A sharp decrease in -Delta S has been observed below TC. However, the Delta T-ad does not fall as sharply as -Delta S with decreasing temperature in the corresponding temperature region. This behavior results in an additional value of Delta T-ad at low temperature, which originates from the exponential decrease of the magnetic contribution of specific heat associated with an increase of energy-gap in the ferromagnetic spin-wave spectrum with the application of magnetic field.

Samanta, Tapas; Das, I; Banerjee, S

Colossal enhancement of magnetoresistance in La0.67Sr0.33MnO3 thin films: possible evidence of electronic phase separation

A gigantic three orders of magnitude change of resistivity in La0.67Sr0.33MnO3 (LSMO) thin film, on application of magnetic field, has been observed. The transport and magnetic properties are characteristic of electronic phase separation between ferromagnetic metallic and antiferromagnetic charge-ordered insulating regions, unusual for a canonical double exchange system such as LSMO.

Mukhopadhyay, Soumik; Das, I; Banerjee, S

Colossal enhancement of magnetoresistance in La0.67Sr0.33MnO3/Pr0.67Ca0.33MnO3 multilayers: Reproducing the phase separation scenario

Colossal enhancement of magnetoresistance has been achieved over a broad temperature range which extends up to the room temperature, in ferromagnetic metal-charge-ordered insulator manganite multilayers. The artificially created phase coexistence in the multlayers reproduces the characteristic signatures of metastability in the magnetotransport properties commonly observed in electronically phase-separated manganites.

Mukhopadhyay, Soumik; Das, I

Influence of charge ordering on magnetocaloric properties of nanocrystalline Pr-0.65(Ca0.7Sr0.3)(0.35)MnO3

Nanocrystalline Pr-0.65(Ca0.7Sr0.3)MnO3 show large magnetocaloric effect at their charge order transition temperature (T-CO) as well as at the temperature at which the spontaneous destabilization of charge ordered state occurs (T-M). In comparison to their polycrystalline bulk form, T-M's are substantially enhanced in the cases of nanocrystalline samples, whereas their T-CO's remain almost unchanged. Although there is no clear signature of charge order transition in the temperature dependence of magnetic susceptibility and resistivity for the sample with the lower particle size, a clear maxima due to charge order transition is visible in its temperature dependence of change in magnetic entropy.

Biswas, Anis; Samanta, Tapas; Banerjee, S; Das, I

Magnetocaloric properties of nanocrystalline Pr-0.65(Ca0.6Sr0.4)(0.35)MnO3

The coexistence of the charge-ordered phase and the ferromagnetic phase has a strong effect on the magnetocaloric property of the nanocrystalline Pr-0.65(Ca0.6Sr0.4)(0.35)MnO3 of average particle size 36 and 78 nm. The temperature dependence of the magnetic entropy change shows a tablelike behavior for the sample with a lower average particle size, for which the refrigerant capacity is significantly enhanced in comparison with the other.

Biswas, Anis; Samanta, Tapas; Banerjee, S; Das, I

Observation of large low field magnetoresistance and large magnetocaloric effects in polycrystalline Pr-0.65(Ca0.7Sr0.3)(0.35)MnO3

Magnetotransport and magnetocaloric properties of polycrystalline Pr-0.65(Ca0.7Sr0.3)MnO3 have been studied. Large low field magnetoresistance (similar to 100% at 75 K for 1 T field) with high magnetic field sensitivity (similar to 5000% T-1) has been observed due to the melting of charge ordered state. The system also shows large magnetocaloric effect at similar to 215 and 90 K. The magnetic entropy change is similar to 8 and 5.5 J/kg K, respectively, around these temperatures for a field change from 0 to 7 T. Such huge low field magnetoresistance along with large magnetocaloric effect exhibited by the material is interesting from the application point of view.

Biswas, Anis; Samanta, Tapas; Banerjee, S; Das, I

Low-temperature magnetotransport properties in granular ferromagnetic manganites

The magnetotransport properties at low temperature in La0.67Sr0.33MnO3 nanoparticles, La0.67Sr0.33MnO3/Al2O3 nanocomposites and ferromagnetic-manganite thick films have been studied. All the samples exhibit low-temperature upturn in resistivity and enhanced low-field magnetoresistance of varying magnitude below the resistivity minima. The voltage dependence of conductance at low temperature for all the samples can be described by a universal scaling function G=G(0) exp (V/V-0)(1/2), where the scaling parameter V-0 is sensitive to the magnetic field. The observed magnetotransport properties are explained in a unified treatment incorporating both inter-grain tunneling conduction and thermal activation over the inter-grain potential barrier lowered by the electric field.

Mukhopadhyay, Soumik; Das, I

Giant magnetocaloric effect in antiferromagnetic ErRu2Si2 compound

Giant magnetocaloric effect has been observed in ErRu2Si2, which is associated with field-induced metamagnetic transition from antiferromagnetic to ferromagnetic state. The maximum values of magnetic entropy change (-Delta S-M(max)) and adiabatic temperature change (Delta T-ad(max)) for a field change of 7 T are evaluated to be 19.3 J/kg K and 15.9 K, respectively, around 5.5 K within the temperature range of 4-25 K. The value of Delta T-ad(max) is even larger than other potential magnetic refrigerant materials reported in the same temperature range and also comparable to room temperature giant magnetocaloric materials exhibiting first-order magnetic transition from paramagnetic to ferromagnetic state.

Samanta, Tapas; Das, I; Banerjee, S

Unified description of spin-dependent transport in granular ferromagnetic manganites

We have presented direct experimental evidence that the description of spin-dependent transport in granular ferromagnets at low temperature is incomplete unless both intergrain tunneling and nontunneling transport are incorporated in a unified treatment. Depending on the microstructure of the system, charge-carrier localization inside the grain and the lowering of intergrain potential barrier by electric field will play a crucial role behind the magnetoresistive properties in granular ferromagnets.

Mukhopadhyay, Soumik; Das, I

Magnetic and transport properties of nanocrystalline Nd0.5Sr0.5MnO3

Nanocrystalline Nd0.5Sr0.5MnO3 of average particle size 30 and 55 nm are prepared by the sol-gel technique. Transport, magnetotransport, magnetization, specific heat, and current-voltage characteristics studies have been performed on the samples. Our experimental results indicate that the ferromagnetic transition temperatures of the nanocrystalline samples decrease in comparison with the bulk form of the sample. However, the ferromagnetic to charge ordered antiferromagnetic transition does not occur down to 2 K. The properties of the nanoparticles are discussed in detail which will provide a deeper insight into the physics of charge ordering and related phenomena in the rare-earth based manganites especially in their nanocrystalline form.

Biswas, Anis; Das, I

Magnetocaloric effect in Ho5Pd2: Evidence of large cooling power

The study of magnetocaloric effect has been performed on polycrystalline Ho5Pd2 compound, which undergoes magnetic field-induced first order metamagnetic transition from antiferromagnetic to ferromagnetic state below antiferromagnetic transition temperature. A large magnetic entropy change associated with the field-induced metamagnetic transition has been observed over a wide temperature range. The evaluated value of relative cooling power is 6.32 J/cm(3) for a magnetic field change of 5 T, which is even larger than that for reported best known magnetic refrigerant materials irrespective of the temperature range.

Samanta, Tapas; Das, I; Banerjee, S

Magnetotransport properties of nanocrystalline Pr-0.65(Ca1-ySry)(0.35)MnO3 (y similar to 0.4,0.3): Influence of phase coexistence

The influence of the coexistence of charge ordered insulating and ferromagnetic metallic phases on magnetotransport properties of nanocrystalline Pr-0.65(Ca1-ySry)(0.35)MnO3 (y similar to 0.4,0.3) has been studied. Large magnetoresistance at low magnetic field has been observed. The sharp increase of low field magnetoresistance with increase of temperature below the insulator to metal transition temperature is in complete contrast to the magnetoresistive properties of ferromagnetic manganite nanoparticles. The anomalous magnetoresistive behavior is attributed to the destabilization of the charge ordered insulating state by the magnetic field.

Biswas, Anis; Das, I

Effect of hydrostatic pressure on magnetic phase transition and magnetocaloric properties of $(Sm_{0.8}Nd_{0.2})_{0.52}Sr_{0.48}MnO_3$

We have investigated the effect of hydrostatic pressure (P) on ferromagnetic (FM) phase transition and magnetocaloric properties of $(Sm_{0.8}Nd_{0.2})_{0.52}Sr_{0.48}MnO_3$ single crystal. At ambient pressure, the system undergoes a first order FM transition associated with large magnetic entropy change (ΔS_M). The temperature distribution of ΔS_M exhibits an asymmetric behavior with respect to T_C. The application of pressure increases magnetization, shifts the FM transition to higher temperature, and weakens the metamagnetism. As a result, vertical bar ΔS_M vertical bar decreases and its thermal distribution becomes more symmetric as compared to P=0.

Arumugam, S†; Sarkar, P; Mandal, P; Murugeswari, A†; Matsubayashi, K†; Ganguli, C†; Uwatoko, Y†

Magnetocaloric effect in $HoMnO_3$ crystal

We have investigated the magnetic and magnetocaloric properties of $HoMnO_3$ single crystal. $HoMnO_3$ displays a series of complicated phase transitions due to the long range ordering of Mn^{3+} and Ho^{3+} moments. Field variation in magnetization generates a metamagnetic transition and produces an entropy change of 13.1 J/kg K at 7 T in the vicinity of antiferromagnetic ordering temperature of Ho^{3+}. The values of adiabatic temperature change (similar to 6.5 K) and relative cooling power (similar to 320 J/kg) for a field change of 7 T are also appreciable to consider $HoMnO_3$ as a magnetic refrigerant at low temperature.

Midya, A; Mandal, P; Das, S; Banerjee, S; Chandra, L S Sharath†; Ganesan, V†; Roy Barman, S†

Pressure-induced spin reorientation in $La_{1.2}Sr_{1.8}(Mn_{1-y}Ru_y)_2O_7$ (y=0 and 0.075) single crystals

The effect of hydrostatic pressure (P) and external magnetic field on the c-axis resistivity (ñ$_c$) and in-plane ac susceptibility (÷$_{ab}$) of $La_{1.2}Sr_{1.8}(Mn_{1-y}Ru_y)_2O_7$ (y=0 and 0.075) single crystals have been investigated. The ferromagnetic transition temperature (T_C) increases, while the conductivity decreases, with Ru doping. The application of pressure strongly decreases ñ$_c$ and shifts T_C to higher temperature for both the samples. For the undoped (y=0) sample, T_C increases almost linearly with P up to 2 GPa, while T_C for the Ru-doped sample starts to saturate above 1.0 GPa. In the ferromagnetic state, the nature of P dependence of ÷$_{ab}$ of Ru-doped sample changes dramatically around 1.5 GPa. These results are explained by the pressure-induced spin reorientation from the basal plane to along the c-axis.

Mydeen, K†; Arumugam, S†; Mandal, P; Murugeswari, A†; Sekar, C†; Krabbes, G†; Jin, C Q†

The magnetoresistance of a $PrFeAsO_{1-x}F_y$ superconductor

We have measured the temperature and magnetic field dependence of resistivity of polycrystalline $PrFeAsO_{0.60}F_{0.12}$ samples in the normal and superconducting state. The superconducting onset transition temperature T^{on}_c shifts by similar to 4 K as H is increased from 0 to 14 T. The zero-temperature upper critical field $H_{c2}(0)$ estimated by using the Ginzburg-Landau theory and the Werthamer-Helfand-Hohenberg equation exceeds 100 T. The resistivity below T^{on}_c exhibits Arrhenius behavior due to thermally activated flux flow of vortices. The activation energy U_0, determined from the Arrhenius plot of the resistivity, shows a power-law decrease (U_0 alpha H^{á}) with magnetic field. The normal-state magnetoresistance varies quasilinearly with magnetic field and does not obey Kohler's rule, suggesting a multiband feature of the material.

Bhoi, D†; Chandra, L S Sharath†; Choudhury, P†; Ganesan, V†; Mandal, P

90 MeV O-16 heavy-ion irradiation effects on $La_{0.9}Pb_{0.1}MnO_3$ single crystals

Effect of 90 MeV heavy-ion irradiation on the surface morphology, transport and magnetic properties of $La_{0.9}Pb_{0.1}MnO_3$ (LPMO) single crystals has been reported. It was found that at low ion-fluence the metal-insulator transition temperature (T_{MI}) increases by similar to 3 K and the Curie temperature (T_c) increases similar to 4 K, and the resistivity decreases as the irradiation increases up to 1×10^{12}. However, we have observed that the T_{MI} reduces with an increase in resistivity for the fluence of 1×10^{13}. These results correlate well with the irradiation induced strain, creation of point defect and grain boundaries in the crystals.

Babu, M Ramesh[†]; Han, X F[†]; Mandal, P; Kumar, Ravi[†]; Asokan, K[†]; Jayavel, R[†]

Pressure Induced Critical Behavior of Ferromagnetic Phase Transition in Sm-Nd-Sr Manganites

We report on the hydrostatic pressure dependence of the order of ferromagnetic (FM) to paramagnetic (PM) phase transition in a $(Sm_{0.7}Nd_{0.3})_{0.52}Sr_{0.48}MnO_3$ single crystal. At ambient pressure, the system undergoes a first-order FM-PM phase transition at 146 K. The application of pressure increases the T_C, suppresses the hysteresis width, and thus makes the transition second order. We have analyzed the critical behavior associated with the second-order FM-PM transition in the presence of an external pressure (12.1 kbar) and obtained the critical exponents â = 0.358, ã = 1.297, and ä = 4.536, which are close to those predicted for the three-dimensional Heisenberg system. Using these values of â, ã, ä and T_C (similar to 176 K), one can scale the magnetization data below and above T_C following a single equation of state.

Sarkar, P; Arumugam, S[†]; Mandal, P; Murugeswari, A[†]; Thiyagarajan, R[†]; Muthu, S Esaki[†]; Radheep, D Mohan[†]; Ganguli, Chandryee[†]; Matsubayshi, K[†]; Uwatoko, Y[†]

Pressure- and temperature-induced spin-state transition in single-crystalline $La_{1-x}Sr_xCoO_3$ (x=0.10 and 0.33)

We report on the temperature dependence of magnetization (M) and resistivity (ñ) of $La_{1-x}Sr_xCoO_3$ (x=0.10 and 0.33) single crystals. For x=0.10, the temperature dependence of field-cooled magnetization (M-FC) and zero-field-cooled magnetization (M-ZFC) are similar to that expected for a canonical spin-glass system. The thermal response of M-ZFC for x=0.33 indicates a glassy ferromagnetic state. We observe that the ferromagnetic transition temperature T_C decreases and ñ increases rapidly with increasing pressure (P) for the metallic sample (x=0.33) while the dependence of ñ on P for the insulating sample (x=0.10) is quite complicated; the pressure coefficient of resistivity (dñ/dT) is sensitive to temperature and applied pressure due to the strong interplay between the pressure-induced band broadening and spin-state transition phenomenon. dñ/dT is large and negative at low-pressure and low-temperature regimes while small and positive at high pressures (P >5.4 GPa) and high temperatures (T >110 K).

Mydeen, K[†]; Mandal, P; Prabhakaran, D[†]; Jin, C Q[†]

Effect of uniaxial pressure on metal-insulator transition in $(Sm_{1-y}Nd_y)_{0.52}Sr_{0.48}MnO_3$ single crystals

We have investigated the effect of uniaxial pressure (P) on resistivity along the ab plane and c-axis in single crystals of $(Sm_{1-y}Nd_y)_{0.52}Sr_{0.48}MnO_3$ with y=0, 0.05, and 0.3. The application of pressure along the c-axis shifts the metal-insulator transition (MIT) to higher temperature, while MIT temperature decreases with P when it is applied perpendicular to the c-axis. This behavior is quite different from that observed in hydrostatic pressure and can be explained by considering the P dependence change in equatorial and apical Mn-O-Mn bond angles.

Murugeswari, A†; Sarkar, P; Arumugam, S†; Manivannan, N†; Mandal, P; Ishida, T†; Noguchi, S†

Role of external and internal perturbations on the ferromagnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$

We report on the magnetic field (H), hydrostatic pressure (P), and doping dependence of the order of the ferromagnetic (FM) to paramagnetic (PM) phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal. It has been shown that (H_{cr} approximate to 4 T, T_{cr} approximate to 160 K) is a critical point below which FM to PM phase transition is first order in nature accompanied by a sharp drop in resistivity and magnetization with thermal hysteresis. Below the critical point, these parameters also show field-induced metamagnetic transition along with hysteresis between the increasing and decreasing fields. All these signatures of first-order FM transition disappear above the critical point and the transition becomes a crossover. The effect of P on the nature of FM-PM transition is quite similar to that of H and the corresponding critical point, where the character of FM transition that changes from first to second order is (P_{cr} approximate to 2.5 GPa, T_{cr} approximate to 160 K). We have also determined the location of critical point expressed in terms of Nd concentration (y) of $(Sm_{1-y}Nd_y)_{0.52}Sr_{0.48}MnO_3$ and found that the transition changes to second order at (y_{cr} approximate to 0.4, T_{cr} approximate to 175 K). The change in the character of FM transition with the application of external (H and P) and internal (Nd concentration) perturbations has been explained within the framework of the formation of polarons.

Sarkar, P; Mandal, P; Mydeen, K†; Bera, A K†; Yusuf, S M†; Arumugam, S†; Jin, C Q†; Ishida, T†; Noguchi, S†

Resistivity saturation in $PrFeAsO_{1-x}F_y$ superconductor: evidence of strong electron-phonon coupling

We have measured the resistivity of $PrFeAsO_{1-x}F_y$ samples over a wide range of temperature in order to elucidate the role of electron-phonon interaction on normal- and superconducting-state properties. The linear T dependence of ñ above 170 K followed by a saturation-like behavior at higher temperature is a clear signature of strong electron-phonon coupling. From the analysis of the T dependence of ñ, we have estimated several normal- state parameters that are useful for understanding the origin of superconductivity in this system. Our results suggest that Fe-based oxypnictides are phonon-mediated BCS superconductors like Chevrel phases and A15 compounds.

Bhoi, D†; Mandal, P; Choudhury, P†

Normal-state transport properties of $PrFeAsO_{1-x}F_y$ superconductor

We have synthesized oxygen-deficient fluorine-doped samples of nominal composition $PrFeAsO_{1-x}F_y$ to study the normal- and superconducting-state properties. Resistivity of undoped PrFeAsO exhibits a strong anomaly at around 155K due to the spin-density-wave instability. Fluorine-doping (x=0.4, y = 0.12) suppresses this magnetic instability and drives the system to the superconducting ground state with superconducting onset temperature 50 K. The behavior of normal-state resistivity changes from T^2-like to T-linear to sublinear in T with increasing temperature indicating that both electron-electron interaction and electron-phonon interaction are strong. From the analysis of T dependence of ñ, we have estimated the electron-phonon coupling strength ë to be quite large (1.3).

Bhoi, D†; Mandal, P; Choudhury, P †

Anomalous transport properties of Co-site impurity doped Na_xCoO_2

The effect of substitution of Cu, Zn, Ga, Mn, and Ni for Co in layered Na_xCoO_2 (x ~ 0.85) on its resistivity (ñ), magnetization (M), and thermopower (S) has been investigated. At low temperature, ñ remains metallic (dp/dT>0) for Cu. Zn, and Ga impurities up to a maximum doping of 15%, while for Mn and Ni a metal-insulator transition occurs at 3% and 6% doping, respectively. For the Cu-doped samples, ñ(T) shows a strong anomaly and a hysteresis around 280 K where a first-order structural phase transition occurs due to long-range ordering of the Na-vacancy clusters. Well above the antiferromagnetic transition temperature, the magnetic susceptibility exhibits the Curie-Weiss law. The Neel temperature is insensitive to impurity while both the Curie constant and Weiss constant (è) depend on the nature of impurity. A small enhancement in magnetization above 280 K and an increase of theta with Cu doping are the signatures of superior Na-vacancy ordering in the Cu-doped samples. In contrast to ñ and M, S changes systematically with doping and temperature, and does not show any anomalous behavior around 280 K.

Mandal, P

Field-induced first-order to second-order magnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$

We report on the magnetic field (H) dependence of the order of the ferromagnetic (FM) to paramagnetic (PM) phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal. For H < 4 T, magnetization and specific-heat data show a first-order phase transition, with sharp drop of magnetization along with hysteresis, and large, symmetric, and narrow specific-heat peak with finite amount of entropy change at T_C. By contrast, for H > 4 T, the phase transition becomes essentially second-order with tricritical point exponents beta similar to 0.32 and gamma similar to 1.31. The tricritical point separates first-order (H < 4 T) from second-order (H > 4 T) transition.

Sarkar, P; Mandal, P; Bera, A K†; Yusuf, S M†; Chandra, L S Sharath†; Ganesan, V†

Large magnetocaloric effect in $Sm_{0.52}Sr_{0.48}MnO_3$ in low magnetic field

This letter reports on the magnetocaloric properties Of $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal. A magnetic field of only 1 T yields a change in the magnetic entropy by 5.9 J/(kg K) at T_C (= 124 K), which is higher than those observed in several other perovskite manganites and rare earth alloys of comparable T_C. This change originates from a sharp magnetization jump, associated with a first-order metamagnetic transition. Such a large change in entropy at a low magnetic field makes this material useful for magnetic refrigeration.

Sarkar, P; Mandal, P; Choudhury, P†

Hydrostatic pressure effect on archetypal $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal

The effect of hydrostatic pressure (P) on the c-axis electrical resistivity ($ñ_c$) and ferromagnetic (FM) transition temperature (T_C) of $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal has been investigated. At P=0, the strong hysteretic nature of metal-insulator transition (MIT) and the abrupt decrease of $ñ_c$ by several orders just below T_C suggest that the FM transition is discontinuous in nature. The application of pressure strongly decreases $ñ_c$, shifts MIT to higher temperature at the rate of 19 K/GPa, and suppresses the hysteresis width. The nature of the FM phase transition would change from discontinuous to continuous at around P=2.5 GPa.

Mydeen, K†; Sarkar, P; Mandal, P; Murugeswari, A†; Jin, C Q†; Arumugam, S †

Modification of the spin state in $Sm_{0.52}Sr_{0.48}MnO_3$ by external magnetic field

The effect of applied magnetic field (H) on the magnetic properties of $Sm_{0.52}Sr_{0.48}MnO_3$ single crystal in the paramagnetic (PM) state has been investigated. We observe a field induced steplike jump in magnetization (M) above T_C (110 K). The temperature and magnetic field dependence of susceptibility reveal that the PM phase of this system is quite complicated due to the coexistence of ferromagnetic (FM) and antiferromagnetic (AFM) interactions. The nature of magnetic interaction changes abruptly from AFM to FM at around 3.5 T, above which M ceases the steplike jump.

Sarkar, P; Mandal, P

Correlation between structural, transport, and magnetic properties in $Sm_{1-x}A_xMnO_3$ (A=Sr, Ca)

Transport, magnetic, and structural properties of $Sm_{1-x}A_xMnO_3$, where A is Ca and Sr, have been investigated systematically over the range of doping $0 \le x \le 0.52$. For x < 0.30, both systems are ferromagnetic (FM) insulator, and the resistivity ñ can be described well by polaron hopping model. Above x=0.30, Sr-doped compounds exhibit large negative magnetoresistance (MR) in the FM metallic state and charge/orbital ordering over a narrow doping range around x = 0.50. On the other hand, Ca-doped system does not show any insulator to metal transition and MR, possibly due to the smaller average A-site cationic radius $\langle r \rangle$ than that for Sr-doped one. The magnetic ground state of Ca-doped system changes from FM to canted antiferromagnetic above x = 0.30. A strong coupling between transport, magnetic, and structural properties has been established from this study. The results are summarized in (x-T) phase diagrams.

Hassen, A; Mandal, P

Relaxation dynamics in small clusters: A modified Monte Carlo approach

Relaxation dynamics in two-dimensional atomic clusters consisting of mono-atomic particles interacting through Lennard-Jones (L-J) potential has been investigated using Monte Carlo simulation. A modification of the conventional Metropolis algorithm is proposed to introduce realistic thermal motion of the particles moving in the interacting L–J potential field. The proposed algorithm leads to a quick equilibration from the nonequilibrium cluster configuration in a certain temperature regime, where the relaxation time (τ), measured in terms of Monte Carlo Steps (MCS) per particle, vary inversely with the square root of system temperature (T) and pressure (P); $\tau \propto (PT)^{-1}$. From this a realistic correlation between MCS and time has been predicted.

Barnana Pal

Dielectric anomaly at T_N in $LaMnO_3$ as a signature of coupling between spin and orbital degrees of freedom

We observe a distinct anomaly in dielectric permittivity ($\acute{\alpha}^{2}$) as well as relaxation time ($\hat{o}_0$) versus temperature (T) pattern at the antiferromagnetic transition point T_N in a single crystal of $LaMnO_3$. The equivalent circuit analysis of the impedance spectra across T_N reveals a clear anomaly in the capacitive component C_0 at T_N. Since no structural transition takes place across T_N, the anomaly in $\hat{o}_0$ and C_0 at T_N possibly signifies multiferroicity stemming from coupling between orbital and spin order in $LaMnO_3$.

Parthasarathi Mondal[†], *Dipten Bhattacharya*[†], *Pranab Choudhury*[†] *and Prabhat Mandal*

Magnetic frustration effect in Mn-rich $Sr_2Mn_{1-x}Fe_xMoO_6$ system

Variation in lattice parameters and magnetic properties of $Sr_2Mn_{1-x}Fe_xMoO_6$ (0 <= x <= 0.4) has been studied in the present work. Our findings suggest that the crystal structures at room temperature for all the compositions Studied here are pseudocubic in nature Substitution of as small as 10% Fe in place of Mn destroys the long range anti ferromagnetic ordering observed in Sr_2MnMoO_6 and introduces local magnetic frustration, i.e., short range ferromagnetic interactions centered around the substituted Fe atoms, although the shape of the magnetic susceptibility creates an illusion of antiferromagnetic ordering. Different local structural environments around Mn and Fe atoms are thought to be responsible for the presence of such magnetic frustration. The results have been compared with those observed previously in $SrLaMnMoO_6$ Our detailed measurements and interpretations are clearly at variance with the magnetic phase diagrams of Mn-rich phases of $Sr_2Mn_{1-x}Fe_xMoO_6$ compounds reported earlier, although the experimental results appear to be similar in both cases.

Poddar, Asok; Mazumdar, Chandan

Effect of Pt on the superconducting and magnetic properties of $ErNi_2B_2C$

We show that the variation of T-c in $Er(Ni_{1-x}Pt_x)_2B_2C$ (T_c ~10.6 K and T_N ~ 5.7 K for x = 0) as a function of x proceeds in two steps: strong decrease of T_c for initial values of x (0 d” x < 0.10, T_c = 7.3 K at x = 0.1) and, thereafter, a relatively much weaker drop (almost a plateau) of T_c with further increase of x. TN exhibits a slight, almost linear, decrease over the entire range ofx studied here: T-N = 4.7 K for x = 0.2. Our results for x = 0.10 are in sharp disagreement with the results, namely, $T_c < T_N$, as reported by Felner et al. [I. Felner, D. Schmitt, B. Barbara, C. Godart, E. Alleno, J Solid State Chem. 133 (1997), 5].

Mazumdar, Chandan; Gupta, LC[†]*; Nenkov, K*[†]*; Behr, G*[†]*; Fuchs, G*[†]

Crystalline electric field effects in $PrNi_2B_2C$: Inelastic neutron scattering

$PrNi_2B_2C$ as a member of the borocarbide series is characterized by antiferromagnetic order below T-N=4 K and the absence of superconductivity (at least down to 100 mK). There are two effects responsible for the absence of superconductivity in $PrNi_2B_2C$. These are the strong conduction electron-Pr moment interaction and a comparatively lower density of states. We studied the crystalline electric field (CEF) excitations and excitons in this compound by inelastic neutron scattering. The CEF level scheme obtained from these data comprises a singlet ground state, a doublet at 1 meV, and further higher levels at 5.2, 24.3 (doublet), 25.1, 29.4, and 31.5 meV. Large dispersion was found for the 1 meV excitation and explained theoretically taking into account magnetic exchange interactions. The calculated crystal-field parameters explain satisfactorily the neutron spectra as well as the heat-capacity and magnetic-susceptibility data. This leads to the conclusion that $PrNi_2B_2C$ can be described by the standard model of rare-earth magnetism. Thus the heavy-fermion concept, suggested by some groups earlier in literature, is not the cause of the suppression of superconductivity. Excitation spectra of the diluted series $PrNi_2B_2C$ were also investigated. No drastic changes in the CEF level scheme have been observed in these compounds. Hence the CEF level scheme of the full compound, i.e., $PrNi_2B_2C$, is reasonably valid for these samples too. The superconducting-transition temperature T_C similar to 15.5 K for YNi_2B_2C decreases linearly with decreasing Y concentration x. Samples with x d” 0.65 do not exhibit superconductivity down to 2 K.

Mazumdar, Chandan; Rotter, M†; Frontzek, M†; Michor, H†; Doerr, M†; Kreyssig, A†; Koza, M†; Hiess, A†; Voigt, J†; Behr, G†; Gupta, LC†; Prager, M†; Loewenhaupt, M†

Study of disorder effects in La substituted Ca_2FeMoO_6 ferrimagnet using magnetic and transport measurements

We have substituted non-magnetic La in ferrimagnetic $Ca_{2-x}La_xFeMoO_6$ double perovskite. The cell volume showed expansion with the increase of La substitution in monoclinic crystal structure and space group $P2_1/n$. Analysis of XRD spectrum indicated the increase of disorder in lattice structure. Surface structure of the material is modified from adhesive type for x = 0 sample to brittle type in La doped samples, suggesting the increase of grain boundary contributions. DC magnetization and ac susceptibility measurements showed reduction of magnetic moment, enhancement of T_c, and cluster spin-glass phase in the ferromagnetic matrix. These experimental results confirmed the enhancement of magnetic disorder in 12 doped samples. The reduction of metallic nature in the compound provided additional support of enhanced disorder upon La doping in double perovskite structure.

Muthuselvam, I Panneer†; Poddar, Asok; Bhowmik, RN

Evidence of disorder induced magnetic spin glass phase in Sr_2FeMoO_6 double perovskite

The present work described the disorder induced magnetic properties of Sr_2FeMoO_6 (SFMO) samples. The crystal structure and magnetic order of SFMO samples with nanosized grains were studied using x-ray diffraction spectrum, scanning electron microscope morphology, and magnetic measurements. Thermal annealing of as prepared chemical routed materials showed an increase in grain size and in the magnetic moment per formula unit. A small decrease in magnetic moment was noted at higher annealing temperature. At the same time, the ac susceptibility measurement indicated the presence of a magnetic spin glass phase in the material, coexisting with the ferromagnetic matrix. The observation of the magnetic glassy phase confirmed the presence of intrinsic disorder in the lattice structure of SFMO. The signature of intrinsic disorder in the samples, irrespective of annealing temperatures, is also realized from the splitting of temperature dependent field cooled and zero field cooled magnetization curves. Such magnetic splitting in the temperature dependence of magnetization curves is suppressed at a higher magnetic field. A careful analysis of the temperature and field dependent magnetization data provided more insight on the grain size dependent disorder in the double perovskite structure.

Poddar, Asok; Bhowmik, RN; Muthuselvam, I Panneer[†]; Das, Nilanjan[†]

Failure processes in elastic fiber bundles

The fiber bundle model describes a collection of elastic fibers under load. The fibers fail successively and, for each failure, the load distribution among the surviving fibers changes. Even though very simple, this model captures the essentials of failure processes in a large number of materials and settings. A review of the fiber bundle model is presented with different load redistribution mechanisms from the point of view of statistics and statistical physics rather than materials science, with a focus on concepts such as criticality, universality, and fluctuations. The fiber bundle model is discussed as a tool for understanding phenomena such as creep and fatigue and how it is used to describe the behavior of fiber-reinforced composites as well as modeling, e. g., network failure, traffic jams, and earthquake dynamics.

Pradhan, Srutarshi[†]; Hansen, Alex[†]; Chakrabarti, Bikas K

Quantum phase transition in a disordered long-range transverse Ising antiferromagnet

We consider a long-range Ising antiferromagnet put in a transverse field (LRTIAF) with disorder. We have obtained the phase diagrams for both the classical and quantum cases. For the pure case applying quantum Monte Carlo method, we study the variation in order parameter (spin correlation in the Trotter direction), susceptibility, and average energy of the system for various values of the transverse field at different temperatures. The antiferromagnetic order is seen to get immediately broken as soon as the thermal or quantum fluctuations are added. We discuss generally the phase diagram for the same LRTIAF model with perturbative Sherrington-Kirkpatrick-type disorder. We find that while the antiferromagnetic order is immediately broken as one adds an infinitesimal transverse field or thermal fluctuation to the pure LRTIAF system, an infinitesimal SK spin-glass disorder is enough to induce a stable glass order in the LRTIAF. This glass order eventually gets destroyed as the thermal or quantum fluctuations are increased beyond their threshold values and the transition to paramagnetic phase occurs. Analytical studies for the phase transitions are discussed in details in each case. These transitions have been confirmed by applying classical and quantum Monte Carlo methods. We show here that the disordered LRTIAF has a surrogate incubation property of the SK spin glass phase.

Chandra, Anjan Kumar; Inoue, Jun-ichi[†]; Chakrabarti, Bikas K

Scaling theory of quantum breakdown in solids

We propose a notable scaling theory for general quantum breakdown phenomena. We show, taking Landau-Zener-type breakdown as a particular example that the breakdown phenomena can be viewed as a quantum phase transition for which the scaling Ansatz is developed. Its application to Zener-type breakdown in Anderson insulators and quantum quenching has been discussed.

Chakrabarti, Bikas K; Samanta, Debashis

Microeconomics of the ideal gas like market models

We develop a framework based on microeconomic theory from which the ideal gas like market models call be addressed. A kinetic exchange model based on that framework is proposed and its distributional features have been Studied by considering its moments. Next, we derive the moments of the CC model (Eur. Phys. J. B 17 (2000) 167) as well. Some precise Solutions are obtained which conform with the solutions obtained earlier. Finally, an output market is introduced With global price determination in the model with some necessary modifications.

Chakrabarti, Anindya S; Chakrabarti, Bikas K

A Zero-Temperature quantum Monte Carlo Algorithm and Quantum Spin Glasses

This technique helps determine key properties of the quantum Hamiltonian’s ground state and tunes quantum fluctuations to help users find optimized solutions to computationally hard problems.

Das, Arnab; Chandra, Anjan K; Chakrabarti, Bikas K

The Kolkata Paise Restaurant problem and resource utilization

We Study the dynamics of the “Kolkata Paise Restaurant problem”. The problem is the following: In each period, N agents have to choose between N restaurants. Agents have a common ranking of the restaurants. Restaurants can only serve one customer. When more than one customer arrives at the same restaurant, one Customer is chosen at random and is served; the others do not get the service. We first introduce the one-shot versions of the Kolkata Paise Restaurant problem which we call one-shot KPR games. We then study the dynamics of the Kolkata Paise Restaurant problem (which is a repeated game version of any given one shot KPR game) for large N. For statistical analysis, we explore the long time steady state behavior. In many Such models with myopic agents we get under-utilization of resources, that is, we get a lower aggregate payoff compared to the Social Optimum. We Study a number of myopic strategies, focusing on the average occupation fraction of restaurants.

Chakrabarti, Anindya Sundar[†]*; Chakrabarti, Bikas K; Chatterjee, Arnab; Mitra, Manipushpak*[†]

Reaching the ground state of a quantum spin glass using a zero-temperature quantum Monte Carlo method

Here we discuss the annealing behavior of an infinite-range +/- J Ising spin glass in the presence of a transverse field using a zero-temperature quantum Monte Carlo method. Within the simulation scheme, we demonstrate that quantum annealing not only helps finding the ground state of a classical spin glass, but can also help simulating the ground state of a quantum spin glass, in particular, when the transverse field is low, much more efficiently.

Das, Arnab; Chakrabarti, Bikas K

Quantum annealing and analog quantum computation

The recent success in quantum annealing, i.e., optimization of the cost or energy functions of complex systems utilizing quantum fluctuations is reviewed here. The concept is introduced in successive steps through studying the mapping of such computationally hard problems to classical spin-glass problems, quantum spin-glass problems arising with the introduction of quantum fluctuations, and the annealing behavior of the systems as these fluctuations are reduced slowly to zero. This provides a general framework for realizing analog quantum computation.

Das, Amab; Chakrabarti, Bikas K

Two-fractal overlap time series: Earthquakes and market crashes

We find prominent similarities in the features of the time series for the (model earthquakes or) overlap of two Cantor sets when one set moves with uniform relative velocity over the other and time series of stock prices. An anticipation method for some of the crashes has been proposed here, based on these observations.

Chakrabarti, Bikas K; Chatterjee, Arnab; Bhattacharyya, Pratip

Neural network modeling

Some of the (comparatively older) numerical results on neural network models obtained by our group are reviewed. These models incorporate synaptic connections constructed by using the Hebb's rule. The dynamics is determined by the internal field which has a weighted contribution from the time delayed signals. Studies on relaxation and the growth of correlations in the Hopfield model are discussed here. The memory capacity of such networks have been investigated also for some asymmetric synaptic interactions. In some cases both the asynchronous (or Glauber; Hopfield) and synchronous (Little) dynamics are used. At the end, in the appendix, we discuss the effects of asymmetric interactions on the statistical properties in a related model of spin glass (new results).

Chakrabarti, Bikas K; Basu, Abhik

The mean distance to the nth neighbour in a uniform distribution of random points: an application of probability theory

We study different ways of determining the mean distance < r(n)> between a reference point and its nth neighbour among random points distributed with uniform density in a D-dimensional Euclidean space. First, we present a heuristic method; though this method provides only a crude mathematical result, it shows a simple way of estimating < r(n >). Next, we describe two alternative means of deriving the exact expression of < r(n)>: we review the method using absolute probability and develop an alternative method using conditional probability. Finally, we obtain an approximation to < r(n)> from the mean volume between the reference point and its nth neighbour and compare it with the heuristic and exact results.

Bhattacharyya, Pratip; Chakrabarti, Bikas K

Kinetic exchange models for income and wealth distributions

Increasingly, a huge amount of statistics have been gathered which clearly indicates that income and wealth distributions in various countries or societies follow a robust pattern, close to the Gibbs distribution of energy in an ideal gas in equilibrium. However, it also deviates in the low income and more significantly for the high income ranges. Application of physics models provides illuminating ideas and understanding, complementing the observations.

Chatterjee, A; Chakrabarti, BK

Kolmogorov dispersion for turbulence in porous media: A conjecture

We will utilise the self-avoiding walk (SAW) mapping of the vortex line conformations in turbulence to get the Kolmogorov scale dependence of energy dispersion from SAW statistics, and the knowledge of the effects of disordered fractal geometries on the SAW statistics. These will give us the Kolmogorov energy dispersion exponent value for turbulence in porous media in terms of the size exponent for polymers in the same. We argue that the exponent value will be somewhat less than I for turbulence in porous media.

Chakrabarti, Bikas K

Economic inequality: Is it natural?

Mounting evidences are being gathered suggesting that income and wealth distribution in various countries or societies follows a robust pattern, close to the Gibbs distribution of energy in an ideal gas in equilibrium, but also deviating significantly for high-income groups. Application of physical models seems to provide illuminating ideas and understanding, complementing the observations.

Chatterjee, Arnab; Sinha, Sitabhra; Chakrabarti, Bikas K

Ideal-gas-like market models with savings: Quenched and annealed cases

We analyze the ideal-gas-like models of markets and review the different cases where a ‘savings’ factor changes the nature and shape of the distribution of wealth. These models can produce similar distribution of wealth as observed across varied economies. We present a more realistic model where the saving factor can vary over time (annealed savings) and yet produce Pareto distribution of wealth in certain cases. We discuss the relevance of such models in the context of wealth distribution, and address some recent issues in the context of these models.

Chatterjee, Arnab; Chakrabarti, Bikas K

A common mode of origin of power laws in models of market and earthquake

We show that there is a common mode of origin for the power laws observed in two different models: (i) the Pareto law for the distribution of money among the agents with random-saving propensities in an ideal gas-like market model and (ii) the Gutenberg-Richter law for the distribution of overlaps in a fractal-overlap model for earthquakes. We find that the power laws appear as the asymptotic forms of ever-widening log-normal distributions for the agents' money and the overlap magnitude, respectively. The identification of the generic origin of the power laws helps in better understanding and in developing generalized views of phenomena in such diverse areas as economics and geophysics.

Bhattacharyya, Pratip; Chatterjee, Arnab; Chakrabarti, Bikas K

Dynamics of breakdown in the RRTN model for nonlinear complex systems

We study the dynamics of reversible breakdown in a driven Random Resistor cum Tunnelling-bond Network (RRTN). Historically, we used the paradigm of dielectric breakdown of a classical insulator between a pair of next nearest neighbour metallic bonds (via semi-classical tunnelling above a microscopic threshold voltage), to model a generalised microscopic failure/breakdown of any driven non-electrical system, as well. This paradigm shift may be clear with some examples. To wit, the threshold field for tunnelling may stand for the minimum field for the onset of classical fluid motion against the capillary (surface tension) forces in a disordered porous media, or that for the onset of classical mechanical motion on a rigid surface due to the frictional forces, etc. The cascade of such microscopic failures propagates from the active end (where the external field is imposed) towards the free (neutral) end, if sufficient external force exists to cause a macroscopic failure/breakdown. In the electrical paradigm, the first-passage time of electrical charge through the whole system (i.e., onset time of the macroscopic dielectric breakdown) is the general fracture/breakdown time. Using the local (general enough) equation of continuity at each node to reach the global continuity, we find an important and practically useful result that in large disordered systems, the breakdown time bears a constant ratio to the sample-dependent macroscopic relaxation time of the whole system (i.e., the breakdown time is predictable on an average). Some early results were presented as an invited talk at the 11th International Conference on Continuum Models and Discrete Systems (CMDS11), and published in the refereed proceedings as "Dynamics of breakdown in the RRTN model for nonlinear systems, Eds. D. Jeulin and S. Forest, pp.251-256 (Ecole des Mines de Paris, Paris 2008).

Asok K Sen; Shubhankar Mozumdar†

Strong Memory and Recognition in the RRTN Model

For studying nonlinear response of complex systems, we developed a Random Resistor cum Tunnelling (t) bond Network (RRTN) model. We study the memory (or the lack of it) of the final macroscopic state, by imparting this complex system, an arbitrary initial configuration of voltages at each of its nodes. Our earlier results show that the early dynamics is scale-free with two power-law regimes, as observed in many complex (many of them being non-electrical) systems of Nature with statistically correlated randomness (including earthquakes). Eventually, the dynamics becomes exponentially fast, i.e., acquires a time-scale, as it approaches a steady state which is very robust against arbitrarily chosen initial field distributions. This strong memory attribute of the steady state, in spite of its intrinsic disorder, should be very useful in the field of cognitive processes, learning, fault-tolerant coding etc. Some early results are quite exciting. Such fundamental results could be useful to the computer-science community and, as such, were presented as an invited talk at the 4th International Conference on Natural Computation (ICNC2008), and published in the refereed proceedings as "Strong memory and recognition in the RRTN model", Eds. M. Guo, L. Zhao and L. Wong, ICNC2008 vol. 3, pp.339-343 (CPS, IEEE Computer Society, Los Alamitos, CA, USA, 2008).

Asok K Sen

Effect of disorder and isotope on the properties of a two orbital double exchange system

A two-site single electron double exchange model incorporating orbital degeneracy, superexchange and electron-phonon (e-ph) interaction is studied using exact diagonalization method. The core spins are treated quantum mechanically. We study the ground state phase diagram as well as the magnetic susceptibility and the kinetic energy of the system as a function of temperature. Effect of difference in site energies, which mimics the role of site-diagonal disorder, is investigated. The susceptibility shows a peak at a characteristic temperature which we have referred to as T-0. The variation of T-0 with e-ph coupling and that of the isotope-shift exponent (alpha) with T-0 are obtained. We also investigate the field-induced change in the kinetic energy, which is related to the colossal magnetoresistance (CMR) of the system, and find that the disorder enhances the CMR even for the two-site system.

Das, AN; Mitra, Manidipa

Thermodynamic properties of Holstein polarons and the effects of disorder

The ground state and finite-temperature properties of polarons are studied considering a two-site and a four-site Holstein model by exact diagonalization of the Hamiltonian. The kinetic energy, Drude weight, correlation functions involving charge and lattice deformations, and the specific heat have been evaluated as a function of electron-phonon (e-ph) coupling strength and temperature. The effects of site diagonal disorder on the above properties have been investigated. The disorder is found to suppress the kinetic energy and the Drude weight, and reduces the spatial extension of the polaron. Increasing temperature also reduces the kinetic energy, Drude weight and the polaron size when the e-ph interaction is weak or intermediate. For strong coupling the effect of temperature is small but opposite. For sufficiently strong coupling the kinetic energy arises mainly from the incoherent hopping processes owing to the motion of electrons within the polaron and is almost independent of the disorder strength. The specific heat shows a peak in the intermediate range of coupling, and the peak is suppressed in the presence of disorder. From the coherent and incoherent contributions to the kinetic energy, the temperature above which the incoherent part dominates is determined as a function of e-ph coupling strength.

Das, AN; Sil, S[†]

Lattice bosons in quartic confinement

We present a theoretical study of bose condensation of non-interacting bosons in finite lattices in quartic potentials in one, two, and three dimensions. We investigate dimensionality effects and quartic potential effects on single boson density of energy states, condensation temperature, condensate fraction, and specific heat. The results obtained are compared with corresponding results for lattice bosons in harmonic traps.

Ramakumar, R[†]*; Das, AN*

Studies of bosons in optical lattices in a harmonic potential

We present a theoretical study of Bose condensation and specific heat of non-interacting bosons in finite lattices in harmonic potentials in one, two, and three dimensions. We numerically diagonalize the Hamiltonian to obtain the energy levels of the systems. Using the energy levels thus obtained, we investigate the temperature dependence, dimensionality effects, lattice size dependence, and evolution to the bulk limit of the condensate fraction and the specific heat. Some preliminary results on the specific heat of fermions in optical lattices are also presented. The results obtained are contextualized within the current experimental and theoretical scenario.

Ramakumar, R[†]*; Das, AN; Sil, S*[†]

Magnetic quantum wire as a spin filter: An exact study

We propose that a magnetic quantum wire composed of magnetic and non-magnetic atomic sites can be used as a spin filter for a wide range of applied bias voltage. We adopt a simple tight-binding Hamiltonian to describe the model where the quantum wire is attached to two semi-infinite one-dimensional non-magnetic electrodes. Based on single particle Green's function formalism all the calculations which describe two-terminal conductance and current through the wire are performed numerically. Our exact results may be helpful in fabricating mesoscopic or nano-scale spin filter.

Dey, Moumita; Maiti, Santanu K; Karmakar, SN

Quantum Transport Through Terocyclic Molecules

We explore electron transport properties in molecular wires made of heterocyclic molecules (pyrrole, furan and thiophene) by using the Green's function technique. Parametric calculations are given based on the tight-binding model to describe the electron transport in these wires. It is observed that the transport properties are significantly influenced by (a) the heteroatoms in the heterocyclic molecules and (b) the molecule-to-electrodes coupling strength. Conductance (g) shows sharp resonance peaks associated with the molecular energy levels in the limit of weak molecular coupling, while they get broadened in the strong molecular coupling limit. These resonances get shifted with the change of the heteroatoms in these heterocyclic molecules. All the essential features of the electron transfer through these molecular wires become much more clearly visible from the study of our current-voltage (I-V) characteristics, and they provide several key information in the study of molecular transport.

Maiti, Santanu K; Karmakar, SN

Effect of external electric field on the charge density waves in one-dimensional Hubbard superlattices

We have studied the ground state of one-dimensional Hubbard superlattice structures with different unit-cell sizes in the presence of an electric field. A self-consistent Hartree-Fock approximation calculation is done in the weak- to intermediate-interaction regime. Studying the charge gap at the

Fermi level and the charge density structure factor, we get an idea of how the charge modulation on the superlattice is governed by the competition between the electronic correlation and the external electric field.

Chowdhury, Jayeeta; Karmakar, SN; Bhattacharyya, Bibhas

Ground-state phase diagram and magnetoconductance of a one-dimensional Hubbard superlattice at half filling

We have studied a one-dimensional Hubbard superlattice with different Coulomb correlations at alternating sites for a half-filled band. Mean field calculations based on the Hartree-Fock approximation together with a real space renormalization group technique were used to study the ground state of the system. The phase diagrams obtained in these approaches agree with each other from the weak to the intermediate coupling regime. The mean field results show very quick convergence with system size. The renormalization group results indicate a spatial modulation of local moments that was identified in some previous work. Also we have studied the magnetoconductance of such superlattices which reveals several interesting points.

Chowdhury, Jayeeta; Karmakar, SN; Bhattacharyya, Bibhas

Orbital ordering in undoped manganites via a generalized Peierls instability

We study the ground-state orbital ordering of LaMnO3, at weak electron-phonon coupling, when the spin state is A-type antiferromagnet. We determine the orbital ordering by extending to our Jahn-Teller system a recently developed Peierls instability framework for the Holstein model [S. Datta and S. Yarlagadda, Phys. Rev. B 75, 035124 (2007)]. By using two-dimensional dynamic response functions corresponding to a mixed Jahn-Teller mode, we establish that the Q(2) mode determines the orbital order.

Yarlagadda, S; Littlewood, PB†; Mitra, M; Monu, RK† *TCMP*

Phase transition and phase diagram at a general filling in the spinless one-dimensional Holstein model

We derive the Luttinger liquid to charge density wave (CDW) transition condition, exact to second order in a blocked perturbative approach, for the spinless one-dimensional Holstein model in the adiabatic regime. The small parameter is the ratio of the electron-phonon coupling g and the adiabaticity parameter t/omega(0). Here we correct the mean-field criterion for Peierls instability, by replacing the static noninteracting susceptibility at twice the Fermi momentum chi(0)(2k(F),0) with the dynamic one, and get 1+2g(2)omega(0)chi(0)(2k(F),omega(0))=0. At non-half-filling, we present the phase diagram showing the surprising result that the CDW occurs in a more restricted region of the two-parameter (g(2)omega(0)/t and t/omega(0)) space than at half-filling.

Datta, Sanjoy; Yarlagadda, Sudhakar

Spatial correlations in exclusion models corresponding to the zero-range process

We show that the steady state weights of all one-dimensional exclusion models which are mapped to the zero-range process (ZRP) can be written in a matrix product form, where the required matrices depend only on the steady state weights of the ZRP. An infinite-dimensional representation of these matrices which works for generic systems has also been provided. This is in contrast to the case for the usual matrix product ansatz which does not always guarantee a solution for the dynamics dependent algebra that the matrices need to satisfy. The formulation helps us study the spatial correlations of these exclusion processes which are unfeasibly difficult to obtain directly from their ZRP correspondence. To illustrate this method we reproduce certain known results, and then investigate unexplored correlations in some other model systems.

Basu, Urna; Mohanty, PK

Phase Diagram of the ABC Model on an Interval

The three species asymmetric ABC model was initially defined on a ring by Evans, Kafri, Koduvely, and Mukamel, and the weakly asymmetric version was later studied by Clincy, Derrida, and Evans. Here the latter model is studied on a one-dimensional lattice of N sites with closed (zero flux) boundaries. In this geometry the local particle conserving dynamics satisfies detailed balance with respect to a canonical Gibbs measure with long range asymmetric pair interactions. This generalizes results for the ring case, where detailed balance holds, and in fact the steady state measure is known, only for the case of equal densities of the different species: in the latter case the stationary states of the system on a ring and on an interval are the same. We prove that in the limit N -> a the scaled density profiles are given by (pieces of) the periodic trajectory of a particle moving in a quartic confining potential. We further prove uniqueness of the profiles, i.e., the existence of a single phase, in all regions of the parameter space (of average densities and temperature) except at low temperature with all densities equal; in this case a continuum of phases, differing by translation, coexist. The results for the equal density case apply also to the system on the ring, and there extend results of Clincy et al.

Ayyer, A[†]; Carlen, EA[†]; Lebowitz, JL[†]; Mohanty, PK; Mukamel, D[†]; Speer, ER [†]

Dynamics of path aggregation in the presence of turnover

We investigate the slow time scales that arise from aging of the paths during the process of path aggregation. This is studied using Monte Carlo simulations of a model aiming to describe the formation of fascicles of axons mediated by contact axon-axon interactions. The growing axons are represented as interacting directed random walks in two spatial dimensions. To mimic axonal turnover, random walkers are injected and whole paths of individual walkers are removed at specified rates. We identify several distinct time scales that emerge from the system dynamics and can exceed the average axonal lifetime by orders of magnitude. In the dynamical steady state, the position-dependent distribution of fascicle sizes obeys a scaling law. We discuss our findings in terms of an analytically tractable, effective model of fascicle dynamics.

Chaudhuri, Debasish[†]; Borowski, Peter[†]; Mohanty, PK; Zapotocky, Martin[†]

Active-absorbing-state phase transition beyond directed percolation: A class of exactly solvable models

We introduce and solve a model of hardcore particles on a one-dimensional periodic lattice which undergoes an active-absorbing-state phase transition at finite density. In this model, an occupied site is defined to be active if its left neighbor is occupied and the right neighbor is vacant. Particles from such active sites hop stochastically to their right. We show that both the density of active sites and the survival probability vanish as the particle density is decreased below half. The critical exponents and spatial correlations of the model are calculated exactly using the matrix product ansatz. Exact analytical study of several variations of the model reveals that these nonequilibrium phase transitions belong to a new universality class different from the generic active-absorbing-state phase transition, namely, directed percolation.

Basu, Urna; Mohanty, PK

Modeling wealth distribution in growing markets

We introduce an auto-regressive model which captures the growing nature of realistic markets. In our model agents do not trade with other agents, they interact indirectly only through a market. Change of their wealth depends, linearly on how much they invest, and stochastically on how much they gain from the noisy market. The average wealth of the market could be fixed or growing. We show that in a market where investment capacity of agents differ, average wealth of agents generically follow the Pareto-law. In few cases, the individual distribution of wealth of every agentcould also be obtained exactly. We also show that the underlying dynamics of other well studied kinetic models of markets can be mapped to the dynamics of our auto-regressive model.

Basu, Urna; Mohanty, PK

Analytical results for stochastically growing networks: Connection to the zero-range process

We introduce a stochastic model of growing networks where both the number of new nodes which join the network and the number of connections vary stochastically. We provide an exact mapping between this model and the zero-range process, and calculate analytically the degree distribution for any given evolution rule. We argue that this mapping can be used to infer a possible evolution rule for any given network. This is being demonstrated for a protein-protein interaction network of Saccharomyces cerevisiae.

Mohanty, PK; Jalan, Sarika†

Critical behavior of sandpile models with sticky grains

We revisit the question whether the critical behavior of sandpile models with sticky grains is in the directed percolation universality class. Our earlier theoretical arguments in favor, supported by evidence from numerical simulations [P.K. Mohanty, D. Dhar, Phys. Rev. Lett. 89 (2002) 1043031, have been disputed by Bonachela et a]. [Phys. Rev. E 74 (2006) 050102] for sandpiles with no preferred direction.

We discuss possible reasons for the discrepancy. Our new results of longer simulations of the one-dimensional undirected model fully support our earlier conclusions.

Mohanty, PK; Dhar, Deepak†

Why only few are so successful?

In many professions employees are rewarded according to their relative performance. Corresponding economy can be modeled by taking N independent agents who gain from the market with a rate which depends on their current gain. We argue that this simple realistic rate generates a scale-free distribution even though intrinsic ability of agents are marginally different from each other. As an evidence we provide distribution of scores for two different systems (a) the global stock game where players invest in real stock market and (b) the international cricket.

Mohanty, PK

Energy diffusion in hard-point systems

We investigate the diffusive properties of energy fluctuations in a one- dimensional diatomic chain of hard- point particles interacting through a square- well potential. The evolution of initially localized infinitesimal and finite perturbations is numerically investigated for different density values. All cases belong to the same universality class which can be also interpreted as a Levy walk of the energy with scaling exponent gamma= 3/5. The zero- pressure limit is nevertheless exceptional in that normal diffusion is found in tangent space and yet anomalous diffusion with a different rate for perturbations of finite amplitude. The different behaviour of the two classes of perturbations is traced back to the "stable chaos" type of dynamics exhibited by this model. Finally, the effect of an additional internal degree of freedom is investigated, finding that it does not modify the overall scenario.

Delfini, L†; Denisov, S†; Lepri, S†; Livi, R†; Mohanty, PK; Politi, A†

Driven diffusive systems of active filament bundles

The cytoskeleton is an important subsystem of cells that is involved for example in cell division and locomotion. It consists of filaments that are cross-linked by molecular motors that can induce relative sliding between filaments and generate stresses in the network. In order to study the effects of fluctuations on the dynamics of such a system we introduce here a new class of driven diffusive systems mimicking the dynamics of active filament bundles where the filaments are aligned with respect to a common axis. After introducing the model class we first analyze an exactly solvable case and find condensation. For the general case we perform a mean-field analysis and study the behavior on large length scales by coarse-graining. We determine conditions for condensation and establish a relation between the hopping rates and the tension generated in the bundle.

Mohanty, PK; Kruse, K†

Scaling and universality in coupled driven diffusive models

Inspired by the physics of magnetohydrodynamics (MHD) a simplified coupled Burgers-like model in one dimension (1d), a generalization of the Burgers model to coupled degrees of freedom, is proposed to describe 1dMHD. In addition to MHD, this model serves as a 1d reduced model for driven binary fluid mixtures. Here we have performed a comprehensive study of the universal properties of the generalized d-dimensional version of the reduced model. We employ both analytical and numerical approaches. In particular, we determine the scaling exponents and the amplitude ratios of the relevant two-point time-dependent correlation functions in the model. We demonstrate that these quantities vary continuously with the amplitude of the noise cross-correlation. Further our numerical studies corroborate the continuous dependence of long wavelength and long timescale physics of the model on the amplitude of the noise cross-correlations, as found in our analytical studies. We construct and simulate lattice-gas models of coupled degrees of freedom in 1d, belonging to the universality class of our coupled Burgers-like model, which display similar behavior. We use a variety of numerical (Monte Carlo and Pseudo-spectral methods) and analytical (dynamic renormalization group, self-consistent mode coupling theory and functional renormalization group) approaches for our work. The results from our different approaches complement one another. Possible realizations of our results in various non-equilibrium models are discussed.

Basu, Abhik; Frey, Erwin†

Thermal and non-thermal fluctuations in active polar gels

We discuss general features of noise and fluctuations in active polar gels close to and away from equilibrium. We use the single-component hydrodynamic theory of active polar gels built by Kruse and coworkers to describe the cytoskeleton in cells. Close to equilibrium, we calculate the response function of the gel to external fields and introduce Langevin forces in the constitutive equations with correlation functions respecting the fluctuation-dissipation theorem. We then discuss the breakage of the fluctuation-dissipation theorem due to an external field such as the activity of the motors. Active gels away from equilibrium are considered at the scaling level. As an example of application of the theory, we calculate the density correlation function (the dynamic structure factor) of a compressible active polar gel and discuss possible instabilities.

Basu, A; Joanny, JF; Julicher, F†*; Prost, J*†

Perspectives on the mode-coupling approximation for the dynamics of interacting Brownian particles

We analyse the field theory for the dissipative dynamics of interacting inertialess particles, using a dynamic density-wave model (Bagchi 1987 Physica A 145 273), including thermal fluctuations (Dean 1996 J. Phys. A: Math. Gen. 29 L619; Fuchizaki and Kawasaki 1999 Physica A 266 400). The symmetries of the problem lead to Ward identities relating vertex functions of different orders. We show that in this theory self-consistent one-loop expansions must involve three-point functions in addition to two-point functions. We obtain correlation and response functions in a one-loop self-consistent approximation similar to, but distinct from, standard mode-coupling theories, and discuss the role of vertex renormalizations. We present a resolution of the conflict between the one-loop approximation and the fluctuation-dissipation theorem, compare our results with those of other approaches, and obtain a modified equation for the non-ergodicity parameter for this model.

Basu, Abhik; Ramaswamy, Sriram†

Small-angle x-ray scattering study of the aggregation of gold nanoparticles during formation at the toluene-water interface

We report the results of an in situ small-angle x-ray scattering (SAXS) study of the aggregation of gold nanoparticles formed by an interfacial reaction at the toluene-water interface. The SAXS data provide a direct evidence for aggregate formation of nanoparticles having 1.3 nm gold core and an organic shell that gives a core-core separation of about 2.5 nm. Furthermore, the nanoparticles do not occupy all cites of 13-member cluster. This occupancy decreases with reaction time and indicate reorganization of the clusters that generates planner disklike structures. A gradual increase in fractal dimension from 1.82 to 2.05 also indicates compactification of cluster aggregation with reaction time, the final exponent being close to 2 expected for disklike aggregates.

Bera, MK; Sanyal, MK; Yang, L†*; Biswas, K; Gibaud, A*†*; Rao, CNR* †

Anomalous effect of biased oscillating field on the switching behaviour: Modulating friction of charge carriers in nanowires

Ultra-low doped polypyrrole nanowires show characteristics of charge density waves (CDW) due to possible Wigner crystallization. The motion of CDW in these structurally discordered wires is expected to be different as CDW is not forming here due to underlying lattice. The results presented here show that the dc switching threshold voltage decreases rapidly with increasing ac bias, but the threshold current remains same. The ac component acts as an effective dc bias having value proportional to (ac amplitude) (1.5). Near the switching transition, the voltage fluctuates and shows repetitive downward spikes. The results show several similarities with the "stick-slip" motion and aging-rejuvenation competition observed in jamming near the sliding motion in mechanical friction. The results also suggest an increase of dynamic correlation length in the presence of ac bias.

Rahman, A; Sanyal, MK

Nanopattern formation in self-assembled monolayers of thiol-capped Au nanocrystals

The structure and the stability of the transferred monolayers of gold-thiol nanoparticles, formed at air-water interface at different surface pressure, on to silicon surface have been studied using two complementary techniques, x-ray reflectivity and atomic force microscopy (AFM). Networklike nanopatterns, observed through AFM, of the in-plane aggregated nanoparticles can be attributed to the late stage drying of the liquid trapped in the islands formed by nanoparticles. During drying process the trapped liquid leaves pinholes in the islands which by the process of nucleation and growth carry the mobile nanoparticles on their advancing fronts such that the nanoparticles are trapped at the boundaries of similar adjacent holes. This process continues bringing about in-plane as well as out-of-plane restructuring in the monolayer until the liquid evaporates completely rendering a patterned structure to the islands and instability in the monolayer is then stabilized.

Banerjee, R; Hazra, S; Banerjee, S; Sanyal, MK

Surface and interfacial structural characterization of MBE grown Si/Ge multilayers

Si/Ge multilayer structures have been grown by solid sourcemolecular beamepitaxy (MBE) on Si (1 1 1) and (1 0 0) substrates and were characterized by high-resolution X-ray diffraction (XRD), atomic force microscopy (AFM), high-depth-resolution secondary ion mass spectroscopy (SIMS) and cross-section high-resolution transmission electron microscopy (HRTEM). A reasonably good agreement has been obtained for layer thickness, interfacial structure and diffusion between SIMS and HRTEM measurements. Epitaxial growth and crystalline nature of the individual layer have been probed using cross-sectional HRTEM and XRD measurements. Surface and interface morphological studies by AFM and HRTEM show island-like growth of both Si and Ge nanostructures.

Saha, Biswajit; Sharma, Manjula; Sarma, Abhisakh; Rath, Ashutosh[†]; Satyam, PV[†]; Chakraborty, Purushottam; Sanyal, Milan K

Negative capacitance in Wigner crystal forming polymer nanowires

Negative capacitance has been observed in conducting polymer nanowires. These nanowires exhibit features of one-dimensional Wigner crystals, such as switching transition that reduces resistance by several orders of magnitude, negative differential resistance, and enhancement of noise in the switched state. Negative capacitance is theoretically predicted characteristic feature of a Wigner crystal. The magnitude of negative capacitance increases with increasing bias voltage below the switching transition. Above switching transition the magnitude decreases with increasing current bias. The capacitance goes from negative to positive value as the features of Wigner crystal state disappear with increasing temperature.

Rahman, Atikur; Sanyal, Milan K

The use of grazing incidence X-ray scattering techniques to probe chemical reactions at the liquid-liquid interface: the formation and ordering of gold nanoparticles

In this short feature article we shall highlight the merits of grazing incidence X-ray scattering (GIXS) techniques to investigate enigmatic chemical reactions at liquid-liquid interfaces. We shall illustrate the techniques by using the results of a recent GIXS study that helped to understand the formation and ordering of gold nanoparticles in an interfacial reaction at the water-toluene interface. The applicability of the presented techniques is far-reaching as transfer of charge/ion across a liquid-liquid interface is important in various fields like biochemistry, biophysics and catalysis. Moreover these techniques may become useful to improve our understanding of chemical processes at any asymmetric environments.

Sanyal, Milan K

Suppression of Mn photoluminescence in ferromagnetic state of Mn-doped ZnS nanocrystals

Magnetic ordering can tune optical properties of photoluminescent dilute magnetic semiconductors. The results of a magnetic field dependent photoluminescence (PL) up to 50 T above and below ferromagnetic transition temperature T-C in Mn-doped ZnS nanocrystals have been reported here. The PL intensity corresponding to internal transition between states of Mn significantly decreases with application of magnetic field below T-C but no such suppression was observed above T-C even at 50 T. The zero-field PL intensity also exhibits continuous suppression with decreasing temperature in the ferromagnetic state. The PL intensity profiles could be fitted consistently using a model of magnetic-ordering-induced spin-sensitive energy transfer to Mn states below T-C.

Sarkar, I; Sanyal, MK; Takeyama, S[†]; Kar, S; Hirayama, H[†]; Mino, H[†]; Komori, F[†]; Biswas, S

Gold Nanoparticles at the Liquid-Liquid Interface: X-ray Study and Monte Carlo Simulation

Abstract: The behavior of mixed-ligand-coated gold nanoparticles at a liquid-liquid interface during compression has been investigated. The system was characterized by measuring pressure-area isotherms and by simultaneously performing in situ X-ray studies. Additionally, Monte Carlo (MC) simulations were carried out in order to interpret the experimental findings. With this dual approach it was possible to characterize and identify the different stages of compression and understand what happens microscopically: first, a compression purely in-plane, and, second, the formation of a second layer when the in-plane pressure pushes the particles out of the plane. The first stage is accompanied by the emergence of an in-plane correlation peak in the scattering signal and a strong increase of the pressure in the isotherm. The second stage is characterized by the weakening of the correlation peak and a slower increase in pressure.

Kubowicz, Stephan[†]; Hartmann, Markus A[†]; Daillant, Jean[†]; Sanyal, Milan K; Agrawal, Ved V[†]; Blot, Christian[†]; Konovalov, Oleg[†]; Moehwald, Helmuth[†]

The tunable bistable and multistable memory effect in polymer nanowires

Tunable bistable and multistable resistance switching in conducting polymer nanowires has been reported. These wires show reproducible switching transition under several READ-WRITE-ERASE cycles. The switching is observed at low temperature and the ON/OFF resistance ratio for the voltage biased switching transition was found to be more than 10(3). Current biased measurements show lower ON/OFF ratio and some of the nanowires exhibit a multistable switching transition in current biased measurements. The threshold voltage for switching and the ON/OFF resistance ratio can be tuned by changing doping concentration of the nanowires.

Rahman, Atikur; Sanyal, Milan K

Effect of vibrations on the formation of gold nanoparticle aggregates at the toluene-water interface

We report on the profound effect of vibrations on the formation and ordering of aggregates of gold nanoparticles formed at the toluene-water interface using high-resolution atomic force microscopy. We obtain 2.3 nm thick monolayer films composed of gold nanoparticles of 1.2 nm diameter, with an organic capping of 1.1 nm, at the early stages of the reaction carried out on an anti-vibration table. Reaction carried out on a table without anti-vibration fixtures produces thicker films composed of 1.2 nm nanoparticles. The results demonstrate that the reduction reaction carried out at the toluene-water interface on an anti-vibration table provides a suitable means for large scale synthesis of Au-55 like nanoparticles.

Bera, MK; Sanyal, MK; Banerjee, R; Kalyanikutty, KP†; Rao, CNR†

Enhanced surface diffusion in forming ion-beam-induced nanopatterns on Si (001)

The diffusion process on Si (001) in the presence of a 5 keV Ar+ ion beam has been investigated by monitoring initiation of ripple-pattern formation. The morphology of the surface obtained by scanning tunnelling microscopy measurements in ultrahigh vacuum were characterized using the height-difference correlation function. These measurements clearly show formation of nanostructured ripple patterns having wavelength similar to 60 nm and height similar to 0.32 nm at 200 degrees C. The results demonstrate that ion beam induced and thermal diffusions cannot be treated as additive processes and the observed enhancement of surface diffusion requires lowering of activation energy that arises due to creation of ion-beam induced vacant regions.

Banerjee, R; Hazra, S; Sanyal, MK

Formation and ordering of gold nanoparticles at the toluene-water interface

Microscopic measurements that provide direct information in nanometer length scales are essential to obtain a proper understanding of the interfacial reactions that form nanostructured materials. We present here the results of a synchrotron X-ray scattering study of the formation and ordering of gold nanoparticles at the toluene-water interface through a reduction reaction. The observed X-ray reflectivity and diffuse scattering data show the formation of a monolayer of “magic clusters” at the water-toluene interface. Each cluster consists of 13 nanoparticles with about 12 angstrom diameter, similar to Au-55 nanoparticles, with about an 11 angstrom organic layer and an in-plane cluster-cluster separation of 180 angstrom. The electron density profile of the monolayer of these clusters exhibits three layers of nanoparticles as a function of depth that evolves with time.

Sanyal, Milan K; Agrawal, Ved V†; Bera, Mrinal K; Kalyanikutty, KP†; Daillant, Jean†; Blot, Christian†; Kubowicz, S†; Konovalov, Oleg†; Rao, CNR†

Novel switching transition of resistance observed in conducting polymer nanowires

A novel switching property of conducting polymer nanowires is observed. The change in resistance was found to be more than three orders of magnitude (see figure) and the threshold voltage (current) can be tuned by playing with switching mechanism observed in this structurally disordered material is found to be similar to that of charge-density-wave systems observed in nanowires of crystalline substances.

Rahman, Atikur; Sanyal, Milan K

Enhancement of electron-electron interactions in chemically synthesized polymer nanowires

We report here a comparison of electronic transport properties of conducting polymer nanowires synthesized by chemical and electrochemical methods inside nanopores. Electronic transport properties of these nanowires show a power-law behavior (I proportional to V1+beta) at low temperature. Chemically synthesized nanowires exhibit higher values of beta and these values increase further with the diameter of nanowires. Zero bias differential conductance of all the nanowires increase with increasing diameter and temperature but the obtained values of chemically synthesized nanowires were always found to be much lower. These results indicate enhancement of electron-electron interactions in chemically synthesized nanowires.

Rahman, Atikur; Sanyal, Milan K; Gangopadhayy, Rupali[†]; De, Amitabha

High-temperature induced nano-crystal formation in ion beam-induced amorphous silicon ripples

We report on in-situ investigations of a recrystallization process of amorphous and damaged crystalline parts generated during ion-beam induced rippling on a Si(100) surface. The ripple structure was created by 60 keV At-40(+) irradiation with a dose of (similar to)5 x 10(17) ions/cm(2) at ion incident angle of 60 degrees with respect to the surface normal. At this dose the ripples have an average spatial periodicity of about 715 nm and surface undulations with an amplitude of about 40 nm. Structure and morphology of ripples were studied by two types of X-ray scattering (grazing incidence diffraction and amorphous scattering) methods, transmission electron microscopy and atomic force microscopy. X-ray grazing-incidence amorphous scattering pattern were recorded in-situ for a temperature range from 250 to 750 degrees C. Up to about 500 degrees C mainly we found a single broad scattering maximum corresponding to the Si(I 11) inter-planar distances. At higher temperature these peaks become sharp and intense indicating the onset of a re-crystallization process in the amorphous top layer. Two processes were found, a formation of crystalline islands on top of the former amorphous surface ripples and a growth of polycrystalline twins close to the former amorphous-crystalline interface.

Grenzer, J[†]; Mucklich, A[†]; Grigorian, S[†]; Pietsch, U[†]; Datta, DP; Chini, TK; Hazra, S; Sanyal, MK

Observation of charge density wave characteristics in conducting polymer nanowires: Possibility of Wigner crystallization

We have presented here results of a low temperature transport study of polypyrrole nanowires having low electron densities, which shows characteristics of charge density waves observed in structurally ordered materials. The current-voltage characteristics of all these nanowires show a power-law dependence on voltage and temperature and a “gap” that decreases rapidly as the temperature is increased, confirming the existence of a long-range electron-electron interaction in the nanowires. A switching transition to highly conducting state has been observed above a threshold voltage, which can be tuned by changing the diameters of the nanowires and the temperature. Negative differential resistance and enhancement of noise have been observed above the threshold. These experimental results give evidence in favor of Wigner crystallization in these nanowires.

Rahman, Atikur; Sanyal, Milan K

Ferromagnetism in zinc sulfide nanocrystals: Dependence on manganese concentration

Ferromagnetic ordering in nanocrystallites of dilute magnetic semiconductors arises due to a fascinating interplay of carrier concentration, randomness of magnetic impurity sites, and size-induced quantum confinement. We here report results of a magnetization study on ZnS nanoparticles (similar to 2.5 nm) carried out by varying the doping concentration of substitutional Mn ions that occupy cationic sites without altering the carrier concentration. Ferromagnetic ordering and giant Zeeman splitting are observed below 30 K in these nanoparticles for doping above 1.5%. The change in coercive field Delta H-C exhibited root T temperature dependence expected for noninteracting nanoparticles. The values of blocking temperature T-B and H-C are found to be maximized for a doping level of 2.5% that corresponds to around five Mn atoms per ZnS nanocrystal.

Sarkar, I; Sanyal, MK; Kar, S; Biswas, S; Banerjee, S; Chaudhuri, S†; Takeyama, S†; Mino, H†; Komori, F†

Reversible buckling in monolayer of gold nanoparticles on water surface

Formation of condensed films of nanoparticles having small ratio of metal-core-diameter to organic-shell-thickness is desired for several applications in nanotechnology. We report here results of a X-ray scattering study carried out to understand structure and morphology of monolayer of such nanoparticles having gold-core and thiol-shell directly on the water surface before the monolayer undergoes a continuous transition to a bilayer. Our results demonstrate buckling of the monolayer over a large surface pressure range (1 to 15 mN/m). The buckled state exhibits reversibility on decompression and can be annealed with temperature. We also show that condensed monolayer films of nanoparticles can be formed by annealing the buckled monolayer before transferring to solid substrates.

Bera, MK; Sanyal, MK; Pal, S; Daillant, J†; Datta, A; Kulkarni, GU†; Luzet, D†; Konovalov, O†

Structure, Electronic Structure, Optical, and Dehydrogenation Catalytic Study of (Zn1-zInz)(O1-xNx) Solid Solution

Indium and nitrogen codoping in ZnO leads to a solid solution of InN in ZnO with I composition of(Zn1-zInz)(O1-xNx). A simple solution combustion method has been adopted to prepare the above materials in less than 10 min with metal nitrates as the metal loll source and urea as fuel. With reference to ZnO, significant increase in lattice parameters was observed with increasing In-content. However, the In2O3 phase was Observed along with InN for]it content >= 10%. Optical absorption extended into the Visible region, at least LIP to 550 nm, demonstrates an effective reduction of optical band gap due to the formation of solid Solution. A new feature observed just above O2p valence band in X-ray photoelectron spectroscopy (XPS) suggests the creation of N 2p states from InN; the N Is core level XPS result too confirms nitride contribution. Raman spectroscopy and secondary ion mass spectrometry results show direct In-N, Zn-N. and In-N-Zn fragments in (Zn1-zInz)(O1-x,N-x). Catalytic activity explored for Oxidation of 2-butanol to ethyl methyl ketone demonstrates a high selectivity at 350 and 400 degrees C. All of the above characteristics suggest the multifunctional nature of (Zn1-zInz)(O1-xNx) and its potential for other applications.

Mapa, Maitri†; Sivaranjani, Kumarsrinivasan†; Bhange, Deu S†; Saha, Biswajit; Chakraborty, Purushottam; Viswanath, Annamraju Kasi†; Gopinath, Chinnakonda S†

Enhanced nonlinear optical responses in metal-glass nanocomposites

The “engineered” nonlinear nanocomposite materials with extremely large values of optical Kerr susceptibility and fast temporal responses that can be precisely tuned to satisfy the requirements of switching applications is of current interest in photonics. Metal quantum-dot composite glasses can exhibit enhanced optical susceptibility, chi(3), whose real and imaginary parts are related to the intensity-dependent refractive index and two-photon absorption coefficient, respectively. Classical (dielectric) and quantum confinement effects come into play in the nonlinear optical responses of these nanocomposites. Metal nanocluster-glass composites have been synthesized by 200 keV Cu+ and 1.5 MeV Au+ ion implantations in fused silica glasses at a dose of 3 x 10(16) ions/cm(2), followed by thermal annealing in reducing atmosphere to promote cluster growth. UV-Visible spectroscopy has revealed prominent linear absorption bands at characteristic surface plasmon resonance (SPR) frequencies signifying appreciable formation of copper and gold colloids in glass matrices. Third-order optical properties of the composite materials have been studied by Z-Scan and Anti-Resonant Interferometric Nonlinear Spectroscopy (ARINS) measurements. The sign of nonlinear refraction is readily obtained from the Z-Scan signatures. The ARINS technique utilizes the dressing of two unequal-intensity counter-propagating pulsed light beams with differential nonlinear phases, which occur upon traversing the sample if it exhibits nonlinear optical response. This difference in phase manifests itself in the intensity-dependent transmission. The nonlinear refractive index, nonlinear absorption coefficient, the real and imaginary parts of the third-order optical susceptibility have been extracted.

Ghosh, Binita; Chakraborty, Purushottam; Singh, BP[†]; Kundu, T [†]

Electronic Structure and Catalytic Study of Solid Solution of GaN in ZnO

Solid solutions of GaN in ZnO (Zn1-zGaz)(O1-xNx) (x and z <= 0.15) have been prepared by simple solution combustion method, Except for minor changes in the lattice contraction, no significant change in the Wurtzite structure was observed. Raman and secondary ion mass spectrometry results show the direct Zn-N and Ga-N bonds in (Zn1-zGaz)(O1-xNx). Visible light absorption and XPS results demonstrate that N 2p states of nitride occupy the states above the O 2p valence band, and hence a change in optical band gap reduction occurs to similar to 2.5 eV from 3.37 eV for ZnO. Significant nitrogen fixation catalytic activity through NH3 formation has been observed at ambient pressure oil virgin (Zn1-zGaz)(O1-xNx) material, indicating its potential as a catalyst.

Mapa, Maitri[†]; Thushara, KS[†]; Saha, Biswajit; Chakraborty, Purushottam; Janet, CM[†]; Viswanath, RP[†]; Nair, C Madhavan[†]; Murty, KVGK[†]; Gopinath, Chinnakonda S[†]

Photoacoustic spectroscopy of Ni+-implanted quartz

Quartz were implanted with Ni+ ions of various doses with energy 100 KeV. The technique of photoacoustic spectroscopy is used in the present work to investigate the optical properties of the metal implanted glass substrates. The photoacoustic technique is an absolute method, which provides a direct measurement of the energy absorbed by the sample. Here we have used a very simple technique to obtain the normalized photoacoustic spectra corrected for the spectral variation of the source in a single scan. The observed features in the photoacoustic spectrum were compared with the optical absorption data obtained from UV-Vis spectroscopy. A correlative study of the optical absorption as well as the photoacoustic spectroscopy helps to get a detailed information of the interesting physical properties of Ni+ nanoclusters in glass.

Ghosh, Binita; Chakraborty, Purushottam; Kumar, P[†]; Kanjilal, D[†]; Vijayan, C[†]

Saturable absorption in gold implanted fused silica

Metal nanocluster composite glasses (MNCGs) have been the subject of both experimental and theoretical investigation because of their peculiar optical properties. in particular, the enhanced third order optical nonlinearity could be exploited in the all-optical switching device technology. In the present work, we present some results on MNCG films prepared by ion implantation. Fused silica were implanted with Au+ of fluences 3 x 10(16) and 1 x 10(17) ions/cm(2) using an energy of 1.5 MeV. Optical absorption spectra of these samples have revealed prominent linear absorption bands at characteristic surface plasmon resonance (SPR) wavelength at and around 490 nm. Rutherford backscattering spectrometry (RBS) measurements reveal a Gaussian spatial distribution of Au ions. Third order optical nonlinear properties were studied by the Z-scan technique using a nanosecond laser. Z-scan measurements on the metal nanoclusters glass composites have revealed saturable absorption signifying the nonlinear responses.

Ghosh, Binita; Chakraborty, Purushottam; Sundaravel, B[†]; Vijayan, C[†]

On the emission of MoCs+ molecular ions from Cs+ irradiated molybdenum surface

The present paper deals with the emission of atomic and molecular ions from elemental molybdenum surface under Cs+ bombardment to explore the MCs+ formation mechanism with changing Cs surface coverage. Integrated count of MoCs+ shows a monotonic increase with increasing primary ion energy (1-5 keV). Change in MoCs+ intensity is attributed to the variation of surface work function phi and cesium surface concentration c(Cs) due to varying impact energies. Variation of c(Cs) has been obtained from the expression, c(Cs) alpha 1/(1 + Y) where Y is the elemental sputtering yield estimated from TRIM calculations. Systematic study of the energy distributions of all species emerging from Mo target has been done to measure the changes in surface work function. Changing slopes of the leading parts of Cs+ energy distributions suggest a substantial depletion in surface work function 0 with decreasing primary ion energies. Delta phi shows a linear dependence on c(Cs). The maximum reduction in surface work function A phi(max) = 0.69 eV corresponds to the highest value of c(Cs) = 0.5. A phenomenological model, based on the linear dependence of phi on c(Cs), has been employed to explain the MoCs+ data.

Saha, Biswajit; Chakraborty, Purushottam

Ultra-high depth resolution SIMS for the interface analysis of complex low-dimensional structures

The flexibility of sputter sectioning, in combination with the principal advantages of the mass spectrometric techniques, such as large dynamic ranges both in the mass separation and detection systems, has enabled the dynamic secondary ion mass spectrometry (SIMS) to be an extremely sensitive technique for the analysis of solid surfaces and thin films. SIMS depth profiling is now possible at depth resolutions down to similar to 2 nm with quantification data obtainable from the topmost atomic layer onwards into the depth. With optimized experimental conditions, like extremely low primary beam current (down to similar to 10 nA) and low impact energy (below 1 keV), appropriate impact angle and with effective profile reconstruction approaches, ultra-high resolution SIMS depth profiling has enabled interfacial composition analysis of ultra-thin films, Bragg mirrors, quantum wells, hetero-structures, etc. and interfacial alloys in metallic multilayer with high precision and repeatability. The paper addresses some of our recent studies on high depth resolution SIMS analysis of such low-dimensional structures and their interfaces.

Chakraborty, Purushottam

Secondary emission of MCsn+ molecular ions under the joint influence of electropositive and electronegative elements

Emission of MCsn+ (n = 1, 2,... etc.) molecular ions has been studied under the joint influence of electropositive (cesium) and electronegative (oxygen) elements in the secondary ion mass spectrometry (SIMS) process. The kinetic energy distributions, measured for Cs+, Cs-2(+), AgCs+ and AgCs2+ ions at different oxygen pressures exhibited changing slopes in their leading parts that hinted at appreciable change in the surface work function. The maximum observed change in the surface work function Delta phi(max) was similar to 0.44 eV. The measured integrated counts of all ionic species showed a strong variation with the changing oxygen environment. The observations are explained in the light of surface work function changes at the sputtering site. Formation mechanisms of Cs-2(+), AgCs+ and AgCs2+ ions are explained in the framework of sputter-ion emission models.

Saha, Biswajit; Sarkar, Subhendu; Chakraborty, Purushottam; Gnaser, Hubert[†]

Linear and nonlinear optical absorption in copper nanocluster-glass composites

Copper nanoclusters have been formed in fused silica glasses under 100 keV and 200 keV Cu+ ion implantations. UV-Vis spectroscopy measurements have revealed prominent linear absorption bands at characteristic surface plasmon resonance (SPR) frequency signifying the appreciable formation of copper colloids in glass matrices even without thermal treatments. Ion-induced colloid formation in glasses without thermal treatments is probably the first time observation in the present study. Subsequent annealing of the implanted samples has resulted in the further enhancement of the absorption bands. Formation of copper nanoclusters without thermal annealing can be attributed to the relatively high mobility of copper atoms even at ambient conditions. The transmittance measurements made by Z-scan technique have revealed saturable absorption signifying the nonlinear optical responses of the metal nanocluster-glass composites.

Ghosh, Binita; Chakraborty, Purushottam; Mohapatra, Satyabrata[†]*; Kurian, Pushpa Ann*[†]*; Vijayan, C*[†]*; Deshmukh, PC*[†]*; Mazzoldi, Paolo*[†]

Secondary ion mass spectrometry of MCsn+ molecular ion complexes

Excellent detection sensitivity, high dynamic range and good depth resolution make the SIMS technique extremely powerful for the analysis of surfaces and interfaces. However, a serious problem in SIMS analysis is its “matrix effect” that hinders the quantification of a certain species in a sample and consequently, probing the composition of surfaces or interfaces by SIMS is greatly hindered. Appropriate corrective measures are therefore, needed to calibrate the secondary ion currents into respective concentrations for accurate compositional analysis. Working in the MCs+-SIMS mode (M - element to be analyzed, Cs+ - bombarding ions) can circumvent the matrix effect. The quantitative potential of the MCs+-SIMS method is understood by assuming that an MCs+ ion is generated by the combination of a secondary neutral M-0 atom with a re-sputtered Cs+ ion in the near-surface region. The emission process for the species M-0 is thus decoupled from the subsequent MCs+ ion formation process, in analogy with the ion formation in secondary neutral mass spectrometry (SNMS), resulting in a drastic decrease in matrix effect. Although this technique has found its applicability in direct quantification, it generally suffers from a low useful yield. In such cases, detection of MCsn+ (n = 2,3....) molecular ions offers a better sensitivity as the yields of such molecular ion complexes have often been found higher than that of MCs+ ions. This is true in most of the cases where the elements are strongly electronegative with respect to cesium. Several works have been reported on the emission of MCsn+ molecular ions in the SIMS process, but a complete understanding on the formation mechanism of these ion complexes is still lacking. The kinetic energy distributions of secondary MCsn+ molecular ion complexes has been found to be an effective approach to estimate the local instantaneous surface work function changes under various surface exposure conditions, thereby enabling one to elucidate on the probable formation mechanisms of these molecular complexes from their emission dynamics. The present paper addresses a brief review on the MCsn+ molecular ion complexes that are emitted in the SIMS process, including various phenomenological approaches on the subject.

Saha, Biswajit; Chakraborty, Purushottam

On the formation mechanism of MCs2+ molecular ions under varying oxygen environment

Formation of MCs2+ molecular ions under Cs+ bombardment of silver surface has been investigated in the SIMS process under vary ing oxygen environments. Energy distributions of MCs+ and MCs2+ ions have shown a remarkable dependence on the changing oxygen environment. The changes in the intensities of the above molecular species are attributed to the changes in the resputtered Cs+ intensity due to the decrease in the local surface work function. The MCs+ molecular ion has been found to form via the recombination of a neutral Mo atom with a Cs+ ion and its formation probability remains unaffected by changing oxygen environment. A systematic study on the kinetic energy distributions of secondary Cs+, Cs-2(+), MCs+ and MCs2+ ions and the estimation of the mean emission energies of various constituents participating in the respective formation processes confirm that the MCs2+ molecular ion formation via recombination of a neutral MCs0 molecule with a Cs+ ion is the most probable one.

Saha, Biswajit; Chakraborty, Purushottam

Formation and characterization of perpendicular mode Si ripples by glancing angle O_2^+ sputtering at room temperature

Off-normal low energy ion beam sputtering of solid surfaces often leads to morphological instabilities resulting in the spontaneous formation of ripple structures in nanometer length scales. In the case of Si surfaces at. ambient temperature, ripple formation is found to take place normally at lower incident angles with the wave vector parallel to the ion beam direction. The absence of ripple pattern on Si surface at larger angles is due to the dominance of ion beam polishing effect. We have shown that a gentle chemical roughening of the starting surface morphology can initiate ripple pattern under grazing incidence ion beam sputtering (è>64º with respect to the surface normal), where the ripple wave vector is perpendicular to the ion beam direction. The characteristics of the perpendicular mode ripples are studied as a function of pristine surface roughness (2-30 nm) and projectile fluence 5×10^{16}-1.5×10^{18} O atoms cm^{-2}. The quality of the morphological structure is assessed from the analysis of ion induced topological defects.

Mollick, SA; Ghose, D

Production and deposition of energetic metal nanocluster ions of silver on Si substrates

In this study we report the growth, morphology, structures, and composition of silver nanocluster films on Si substrates. DC Magnetron discharge is used to generate the clusters inside a liquid nitrogen cooled aggregation tube. The morphology of the films was characterised by Scanning Electron Microscopy attached with Energy Dispersive X-ray Analysis (SEM/EDX) and the structural information of the films was investigated by X-ray Diffraction (XRD). X-ray Photoelectron Spectroscopy (XPS) was used to get the composition of the films developed. In order to understand the effect of ion irradiation for possible alterations in the morphology, one sample was irradiated by energetic argon ions. Apart from these studies, the Atomic Force Microscopy (AFM) was also carried out in order to get an idea about the height distribution profiles and scaling aspects of the surface morphology of Ag-nanocluster films. Comparing SEM and AFM results in a signature of cluster flattening has been confirmed.

Datta, D; Bhattacharyya, SR; Shyjumon, I[†]*; Ghose, D; Hippler, R*[†]

Morphological evolution of films composed of energetic and size-selected silver nanocluster ions

In this study, morphologies of as-deposited and rapid thermal annealed films of silver nanoclusters are studied using scanning electron microscope (SEM) and atomic force microscope (AFM). Size-selected silver nanoclusters, containing 5000 atoms in a cluster, produced by the gas condensation method are deposited on Si substrate for a period of 8 min. In order to get an idea about the melting of clusters, the film is treated by rapid thermal annealing at 200 and 400 degrees C. The remarkable changes of morphology due to annealing signify a lowering of melting temperature of silver in the form of nanoscale particles.

Bhattacharyya, SR; Datta, D; Chini, TK; Ghose, D; Shyjumon, I[†]*; Hippler, R*[†]

Ion beam sputtering induced nanostructuring of polycrystalline metal films

The development of fine scale nanostructures in polycrystalline metal films by off-normal ion beam sputtering (IBS) follows similar mechanisms to those in random targets, i.e. the pattern results from the interplay of curvature-dependent-roughening and various smoothing processes. By grazing angle IBS of the deposited metal films it is possible to fabricate metallic nanoripples, nanowires, and nanorods onto semiconductor or insulator substrates without using a template. It has been found that the rms roughness of the as-deposited film is substantially reduced under ion bombardment before the development of nanoscale patterns. The structural anisotropy of the sputtered morphology can have a great influence on the local physical properties of the underlying material. In this paper, we shall review the experimental results on the formation and characteristics of the IBS ripples on polycrystalline metal films prepared by the physical vapor deposition (PVD) technique.

Ghose, Debabrata

Effect of initial target surface roughness on the evolution of ripple topography induced by oxygen sputtering of Al films

The effect of pre-existing random roughness on the evolution of ripple structures in O_2^+ sputtered thin Al films has been investigated. The results show that there is a considerable reduction in initial roughness of the film surface at the early stages of sputtering. For large scale surface structures, angle-dependent first order sputtering is responsible for ion beam smoothening, while for smaller microscopic features, different relaxation mechanisms dominate for smoothing of the surface. At the later stages of sputtering, the curvature dependent erosion instability sets in leading to the development of either coherent ripples or faceted structures depending on the degree of virgin film roughness and bombarding angle. It is found that coating a flat Si surface with ultrathin Al film and subsequent removal of the Al layer by oblique O_2^+ sputtering leads to the formation of ripple pattern with moderate amplitude in the Si matrix at much lower effective fluence than that would be in bare Si without Al masking.

Mishra, P; Ghose, D

Growth and melting of silicon supported silver nanocluster films

Thin films of silver nanoclusters deposited on Si substrates are studied using scanning electron microscopy along with energy dispersive x-ray spectrometry. The nanoclusters are produced by dc magnetron sputtering followed by gas aggregation in a dense buffer gas. The film deposition is performed in a low impact energy regime with mass (size) selected clusters. These clusters were treated with rapid thermal annealing that gives an idea about the melting and evaporation mechanism of silver nanoclusters. Subsequent annealing of the grown silver film allows one to analyse the structure of the film and the character of its evolution. At room temperature, deposited clusters are distributed randomly, and annealing of the film leads to joining of clusters-monomers in non-compact clusters. At high temperatures, evaporation of clusters takes place. Parameters of the processes under consideration are estimated.

Bhattacharyya, SR; Datta, D; Shyjumon, I[†]; Smirnov, BM[†]; Chini, TK; Ghose, D; Hippler, R[†]

Surface morphology and composition of films grown by size-selected Cu nanoclusters

We report the investigation of morphology and composition of copper nanocluster films deposited on Si substrates. The nanoclusters are formed in an aggregation tube at room temperature and magnetron sputtering source is used to get negatively charged Cu-clusters' beam which is subsequently mass-filtered to get size-selected cluster on the substrates as soft-landing process of deposition. For composition of the films, X-ray photoelectron spectroscopy (XPS) technique is used. For morphological changes of the films both scanning electron microscopy (SEM) and atomic force microscopy (AFM) analyses are carried out Additionally, Energy Dispersive X-ray (EDX) spectra support the compositional and structural informations of the film. The analysis of Cu nanoclusters' films reveals that initial nucleation of Cu clusters takes place in the form of isolated islands and the arrival of subsequent Cu clusters onto Si substrates has preferential aggregation around the preceding clusters forming a mound structure.

Majumdar, Abhijit; Ganeva, Marina[†]; Koepp, Daniel[†]; Datta, Debasish; Mishra, Puneet; Bhattacharayya, Satyaranjan; Ghose, Debabrata; Hippler, Rainer[†]

The rotation of ripple pattern and the shape of the collision cascade in ion sputtered thin metal films

The sputter ripple formation in polycrystalline metal thin films of Al, Co, Cu, and Ag has been studied by 16.7 keV Ar^+ and O_2^+ ion bombardment as a function of angle of ion incidence. The experimental results show the existence of a critical angle of ion incidence è$_c$ beyond which the ripples of wave vectors perpendicular to the projected ion beam direction appear. Monte Carlo simulation (SRIM) is carried out to calculate the depth, longitudinal and lateral straggling widths of energy deposition as these values are crucial in determining the critical angle è$_c$. It is found that the radial energy distribution of the damage cascade has the maximum slightly away from the ion path in contradiction to the Gaussian distribution and the distribution is better characterized by an exponential function. The lower values of lateral straggling widths as those extracted from the measured critical angles using the Bradley and Harper theory indicate a highly anisotropic deposited-energy distribution.

Mishra, P; Ghose, D

Study of low energy Si_5^- and C_s^- implantation induced amorphization effects in Si(100)

The damage growth and surface modifications in Si(1 0 0), induced by 25 keV Si_5^- cluster ions, as a function of fluence, ö has been studied using atomic force microscopy (AFM) and channelling Rutherford backscattering spectrometry (RBS/C). RBS/C results indicate a nonlinear growth in damage from which it has been possible to get a threshold fluence, ö$_0$, for amorphization as 2.5 x 10^{13} ions cm^2. For ö below ö$_0$, a growth in damage as well as surface roughness has been observed. At a ö$_0$ of 1 x 10^{14} ions cm^2, damage saturation coupled with a much reduced surface roughness has been found. In this case a power spectrum analysis of AFM data showed a significant drop in spectral density, as compared with the same obtained for a fluence, ö < ö$_0$. This drop, together with damage saturation, can be correlated with a transition to a stress relaxed amorphous phase. Irradiation with similar mass Cs^- ions, at the same energy and fluence, has been found to result in a reduced accumulation of defects in the near surface region leading to reduced surface features.

Lenka, HP[†]; Joseph, B[†]; Kuiri, PK[†]; Sahu, G[†]; Mishra, P; Ghose, D; Mahapatra, DP[†]

Role of initial surface roughness on ion induced surface morphology

We report here the influence of initial surface roughness on the development of ion induced Si surface morphology. Surfaces of different initial roughness have been generated chemically and bombarded by 16.7 keV O_2^+ ions at an oblique angle. It is observed that surface roughness enhances the initial perturbation, which aids to form the ion induced regular nanostructures at an ion fluence typically one to two orders of magnitude less than that are required to produce the same structures on an initially flat surface. This observation also explores the role of initial surface perturbation on the initiation of curvature dependent sputtering.

Karmakar, P; Mollick, SA; Ghose, D; Chakrabarti, A[†]

Nanoindentation on single-crystal Si modified by 100 keV Cr^+ implantation

Ion implantation is known to be an effective method for improving the surface mechanical properties of materials, such as hardness, elastic modulus, wear and corrosion resistance. In the present work, we have modified Si(l 0 0) surface by 100 keV Cr^+ implantation at fluences 5 x 10^{15} and 1 x 10^{17} ions/cm^2. The near-surface hardness and elastic modulus have been examined by depth-sensing nanoindentation technique. About 15% decrease in hardness of the implanted samples has been observed. The nanoscratch test, on the other hand, shows very distinct increase of friction and wear for the implanted surface. The results are discussed with reference to the damage introduced by the bombarding ion.

Mishra, P; Bhattacharyya, SR; Ghose, D

The energy dependence of sputtering induced ripple topography in Al film

Sputtering by off-normal ion bombardment of solid targets frequently leads to the development of periodically modulated structures (ripples) on the eroded surface. The ripple topography provides insight about the nature of diffusion mechanisms in the topography evolution. In the present work, the wavelength and the amplitude of the ripples formed on O_2^+ and O^+ sputtered aluminum films at ambient temperature are measured as a function of bombarding energy in the range 5-24 keV per O atom. The results show that the wavelength varies weakly with energy. It is concluded that thermally activated diffusion is the probable relaxation mechanism for room temperature ripple formation in metals. The diffusion rate in Al is estimated to be ~ 10^{-28} cm^4 s^{-1}, which shows a slight energy dependence attributing to the increase of steady-state diffusing adatom yield as a function of projectile energy.

Mishra, P; Ghose, D

Microstructural and chemical evolution of -CH3-incorporated (Low-k) SiCO(H) films prepared by dielectric barrier discharge plasma

The present work focuses on the incorporation of -CH3 radicals in organic SiCO(H) films with low dielectric constant (k = 2.46). The SiCO(H) films were deposited by dielectric barrier discharge plasma method using a mixture of CH4 and Ar gases at different conditions (varying the frequency and pressure). The evolution of the film microstructure was investigated by means of X-ray photoelectron spectroscopy (XPS), Fourier transform infrared (FTIR) absorption spectroscopy, and atomic force microscopy (AFM). Various bonds, C-C, C-O, Si-O, and Si-CH3, were observed in XPS. In XPS analysis, it is observed that at higher frequency range (from 1 to 5 kHz), -CH3 radicals (in the form of Si-CH3) increase significantly. FTIR absorption spectra consist of several vibrational bands: namely, Si-O-Si asymmetric stretching at 1034 cm^{-1}, symmetric deformation of the -CH3 group in Si -CH3 configuration at 1270 cm-1, C-H stretching of -CHx (x = 2 and 3) groups in the region between 3050 and 2750 cm^{-1}, and -OH related vibrational bands in the range between 3700 and 3150 cm^{-1}. The change in various deposition parameters causes the change in different Si-O-Si vibrational band ratio, and the intensity of C-H-x and Si-CHx. The film roughness was verified by AFM measurement.

Majumdar, Abhijit†; Das, Gobind†; Patel, Nainesh†; Mishra, Puneet; Ghose, Debabrata; Hippler, Rainer†

Chemical composition and bond structure of carbon-nitride films deposited by CH4/N-2 dielectric barrier discharge

Carbon nitride films have been deposited by dielectric barrier discharge with a CH4/N-2 gas mixture at different conditions. Fourier Transform Infrared (FTIR) spectroscopy, X-ray photo electron spectroscopy (XPS), Raman spectroscopy, Atomic force microscopy (AFM) and ellipsometry were used to systematically study chemical composition, bond structure and surface morphology of deposited films. Various bonds between carbon, nitrogen, hydrogen, and also oxygen were observed.

Majumdar, Abhijit†; Schaefer, Jan†; Mishra, Puneet; Ghose, Debabrata; Meichsner, Juergen†; Hippler, Rainer†

The hardness study of oxygen implanted aluminum thin films

Effects of mass analyzed low energy O_2^+ ion implantation in Al thin films on the hardening and microstrucure have been studied by nanoindenting atomic force microscopy (AFM). The fluence range was 1 x 10^{17}-1 x 10^{18} O atoms/cm^2. A maximum increase of hardness about 90% of the implanted samples is observed. Apparently there is no significant variation in the hardness values within the range of ion fluences investigated here. Finally, the surface roughness is found to decrease considerably by oxygen irradiation.

Mishra, P; Ghose, D

Anomalous magnetic behavior of CuO nanoparticles

We report studies on temperature, field and time dependence of magnetization on cupric oxide nanoparticles of sizes 9 nm, 13 nm and 16 nm. The nanoparticles show unusual features in comparison to other antiferromagnetic nanoparticle systems. The field cooled (FC) and zero field cooled (ZFC) magnetization curves bifurcate well above the Neel temperature and the usual peak in the ZFC magnetization curve is absent. The system does not show any memory effects which is in sharp contrast to the usual behavior shown by other antiferromagnetic nanoparticles. It turns out that the non-equilibrium behavior of CuO nanoparticles is very strange and is neither superparamagnetic nor spin glass like.

Bisht, Vijay†; Rajeev, KP†; Banerjee, Sangam

Effect of self-affine fractal characteristics of surfaces on wetting

In this letter, we show experimentally that the wetting property of a solid surface crucially depends on the surface morphological parameters such as; (1) root mean square (rms) roughness sigma, (2) in-plane roughness correlation length xi, and (3) roughness exponent alpha of the self-affine surface. We have shown that the contact angle monotonically decreases with the increase in the rms local surface slope rho (proportional to sigma/xi(alpha)). We have shown that the same solid surface can be made hydrophobic or hydrophilic by merely tuning these self-affine surface morphological parameters.

Sarkar, S; Patra, S; Gayathri, N; Banerjee, S

Core-shell model of the vacancy concentration and magnetic behavior for antiferromagnetic nanoparticle

The local defect structure of NiO nanoparticles was determined by extended x-ray absorption fine structure method. By using the bulk and surface sensitive characterization techniques, we are able to show that the vacancies mostly reside on the surface of the particles and the distribution of vacancies can be considered within a core-shell model. We argue that these observations can give a suitable explanation for the venerable problem of observed magnetic behaviors of antiferromagnetic nanoparticles and other functional properties of the material. The observed magnetic moment has been attributed to the interacting vacancies inside the antiferromagnetic host and the distribution of vacancies over the particle volume determines behaviors such as size-dependent different nature of spin-glass freezing and exchange bias.

Mandal, Suman; Banerjee, S; Menon, Krishnakumar S R

Nanopattern formation in self-assembled monolayers of thiol-capped Au nanocrystals

The structure and the stability of the transferred monolayers of gold-thiol nanoparticles, formed at air-water interface at different surface pressure, on to silicon surface have been studied using two complementary techniques, x-ray reflectivity and atomic force microscopy (AFM). Networklike nanopatterns, observed through AFM, of the in-plane aggregated nanoparticles can be attributed to the late stage drying of the liquid trapped in the islands formed by nanoparticles. During drying process the trapped liquid leaves pinholes in the islands which by the process of nucleation and growth carry the mobile nanoparticles on their advancing fronts such that the nanoparticles are trapped at the boundaries of similar adjacent holes. This process continues bringing about in-plane as well as out-of-plane restructuring in the monolayer until the liquid evaporates completely rendering a patterned structure to the islands and instability in the monolayer is then stabilized.

Banerjee, R; Hazra, S; Banerjee, S; Sanyal, MK

Imaging elastic property of surfaces at nanoscale using atomic force microscope

We present a simple technique to characterize and image the distribution of local elastic property using ultrasonic atomic force microscope (UAFM). We interpret the UAFM images using simple arguments. We have demonstrated the capability of the UAFM technique to image the distribution of the local elastic property of the sample surface and semi-quantitatively map the local stiffness of the sample surface using a few selected samples. The local stiffness of the sample surface was obtained by measuring the changes in the frequency of contact resonance peak values and could verify the same using force distance measurement at the same regions on the sample surface.

Banerjee, S; Gayathri, N[†]; Dash, S[†]; Tyagi, AK[†]; Raj, Baldev[†]

Light-charged-particle emission from hot S-32* formed in Ne-20+C-12 reaction

Inclusive energy distributions for light charged particles (p, d, t and alpha) have been measured in the Ne-20 (158, 170, 180, 200MeV)+ C-12 reactions in the angular range 10 degrees-50 degrees. Exclusive light-charged-particle energy distribution measurements were also done for the same system at 158MeV bombarding energy by in-plane light charged particle - fragment coincidence. Pre-equilibrium components have been separated out from proton energy spectra using the moving source model considering two sources. The data have been compared with the predictions of the statistical model code CASCADE. It has been observed that significant deformation effects were needed to be introduced in the compound nucleus in order to explain the shape of the evaporated d, t energy spectra. For protons, evaporated energy spectra were rather insensitive to nuclear deformation, though angular distributions could not be explained without deformation. The decay sequence of the hot S-32 nucleus has been investigated through exclusive light-charged-particle measurements using the Ne-20 (158MeV)+ C-12 reaction. Information on the sequential decay chain has been extracted through a comparison of the experimental data with the predictions of the statistical model. It is observed from the present analysis that exclusive light-charged-particle data may be used as a powerful tool to probe the decay sequence of hot light compound systems.

Dey, Aparajita[†], Bhattacharya S, Bhattacharya C[†], Banerjee K[†], Rana TK[†], Kundu S, Banerjee SR[†], Mukhopadhyay S[†], Gupta D[†], Saha R[†]

Influence of Mn doping on the microstructure and optical property of ZnO

Undoped and Mn-doped ZnO samples with different percentage of Mn content (1, 2 and 3 mol%) were synthesized by a simple solvo-thermal method. We have studied the structural, chemical and optical properties of the samples by using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray (EDX) analysis, Fourier transform infrared (FTIR) spectroscopy and UV-VIS spectroscopy. The XRD spectra show that all the samples are hexagonal wurtzite structures. The lattice parameters calculated for the Mn-doped ZnO from the XRD pattern were found to be slightly larger than those of the undoped ZnO, which indicates substitution of Mn in ZnO lattice. SEM photograph shows that the grain size of undoped ZnO is bigger than the Mn-doped ZnOs, indicating hindrance of grain growth upon Mn doping. As the Mn doping increases the optical band gap decreases for the range of Mn doping reported here.

Senthilkumaar, S[†]; Rajendran, K[†]; Banerjee, S; Chini, TK; Sengodan, V[†]

Electronic properties of nano-graphene sheets calculated using quantum chemical DFT

Electronic properties of nano-graphene with hydrogen terminated edges arc significantly different from infinite graphene sheets without any defined edge. Structure of edges of 2D graphene sheets are either in trans (zig-zag) or cis (arm-chair) forms and these edges are known to spontaneously reduced by hydrogen to neutralize the valancies of all the carbons at the edges. Recent experiments revealed different electronic properties on these edges as measured by conducting tip atomic force microscope (AFM) and scanning tunneling microscopy (STM). We shall present here some theoretical understanding of these edges using molecular orbital calculations based on density functional theory with B3LYP functional. We have shown here that electron density around a mono-vacancy in a graphene sheet is high, which further leads to bending of the graphene sheet. This reduced vacancy can be considered equivalent to H-3 complex which may lead to magnetism. We also find that HOMO-LUMO gap of graphene sheet varies as a function of its size and spatial variation of the electron density across the nano-graphene sheet depends on the sheet separation.

Banerjee, Sangam; Bhattacharyya, Dhananjay

Change in the room temperature magnetic property of ZnO upon Mn doping

We present in this paper the changes in the room temperature magnetic property of ZnO on Mn doping prepared using solvothermal process. The zero field cooled (ZFC) and field cooled (FC) magnetization of undoped ZnO showed bifurcation and magnetic hysteresis at room temperature. Upon Mn doping the magnetic hysteresis at room temperature and the bifurcation in ZFC-FC magnetization vanish. The results seem to indicate that undoped ZnO is ferromagnetic while on the other hand the Mn doped ZnO is not a ferromagnetic system. We observe that on addition of Mn atoms the system shows antiferromagnetism with very giant magnetic moments.

Banerjee, S; Raiendran, K†; Gayathri, N†; Sardar, M†; Senthilkumar, S†; Sengodan, V†

Photoluminescence studies on porous silicon/polymer heterostructure

Hybrid devices formed by filling porous silicon with MEH-PPV or poly [2-methoxy-5(2-ethylhexyloxy-p-phenytenevinylene)] have been investigated in this work. Analyses of the structures by scanning electron microscopy (SEM) demonstrated that the porous silicon layer was filled by the polymer with no significant change of the structures except that the polymer was infiltrated in the pores. The photoluminescence (PL) of the structures at 300 K showed that the emission intensity was very high as compared with that of the MEH-PPV films on different substrates such as crystalline silicon (c-Si) and indium tin oxide (ITO). The PL peak in the MEH-PPV/porous silicon composite structure is found to be shifted towards higher energy in comparison with porous silicon PL. A number of possibilities are discussed to explain the observations.

Mishra, JK†; Bhunia, S; Banerjee, S; Banerji, P†

Enhancement of ferromagnetism upon thermal annealing in pure ZnO

We report here the enhancement of ferromagnetism in pure ZnO upon thermal annealing with the ferromagnetic transition temperature T-c above room temperature. We observe a finite coercive field up to 300 K and a finite thermoremanent magnetization up to 340 K for the annealed sample. We propose that magnetic moments can be formed at anionic vacancy clusters. Ferromagnetism can occur due to either superexchange between vacancy clusters via isolated F+ centers or through a limited electron delocalization between vacancy clusters. Isolated vacancy clusters or isolated F+ centers give rise to a strong paramagneticlike behavior below 10 K.

Banerjee, S; Mandal, M; Gayathri, N†; Sardar, M†

Structural, magnetic, and transport properties of nanoparticles of the manganite Pr0.5Ca0.5MnO3

In this paper we report the structural, magnetic, and transport properties of nanoparticles of Pr0.5Ca0.5MnO3(PCMO). On comparing our results with that of bulk PCMO, we find that there is a likely destabilization of charge ordering in nanoparticles of PCMO. The investigation has been done with particle sizes as small as 15 nm synthesized by polyol route. The size reduction (by keeping the chemical composition unchanged) reduces the orthorhombic c axis preferentially and thus reduces the orthorhombic distortion. The size reduction to 15 nm enhances the ferromagnetic moment at low temperatures and strongly suppresses the activated charge transport which is seen in the bulk samples of charge ordered PCMO.

Sarkar, Tapati†; Mukhopadhyay, PK†; Raychaudhuri, AK†; Banerjee, Sangam

Imaging distribution of local stiffness over surfaces using atomic force acoustic microscopy

We report a systematic study to determine local elastic properties of surfaces using atomic force acoustic microscopy (AFAM). AFAM is a combination of atomic force microscopy (AFM) and acoustic waves. We describe the technique and principle of AFAM in detail and interpret the obtained images using simple arguments. We have used (1) polished commercial piezoelectric PZT, Pb(Zr,Ti)O-3 ceramic, (2) thin film of PZT deposited by the sol-gel technique and (3) thin film of Au deposited on a Si(001) substrate to elucidate the capability of the AFAM technique to image the distribution of local stiffness over the sample surface. We have also used a complementary technique such as force-distance measurements using the AFM mode to support the interpretation of the AFAM images. We have determined semi-quantitatively the change in the local stiffness over the sample surface using both the force-distance measurement and the change in the contact resonance peak frequency at various regions. We have also shown that the AFAM technique can be used to get a better surface image contrast where contact mode AFM shows poor contrast.

Banerjee, S; Gayathri, N†; Shannigrahi, SR†; Dash, S†; Tyagi, AK†; Raj, Baldev†

Stability of a deposited liquid cluster

The fragmentation of silver liquid clusters deposited onto a silicon surface is observed after heating the clusters to 1073 K and subsequent annealing with the exposition time 3 min. This contradicts macroscopic models of a liquid drop deposited on a surface if we use critical parameters of bulk silver. Some versions are analyzed that are based on cluster properties and may explain the phenomenon of cluster fragmentation. An experiment is suggested for clarifying the nature of the cluster fragmentation phenomenon and cluster critical phenomena.

Kashtanov, PV†; Hippler, R†; Smirnov, BM†; Bhattacharyya, SR

Development of metal nanocluster ion source based on dc magnetron plasma sputtering at room temperature

A simple and cost effective nanocluster ion source for the deposition of size selected metal nanocluster has been developed based on the dc magnetron discharge (including pulsed dc discharge). The most important and interesting feature of this cluster source is that it is working at room temperature, cooled by chilled water during the experiment. There is no extraction unit in this device and the cluster streams flow only due to the pressure gradient from source chamber to substrate via quadrupole mass filter. It has provision of multiple substrate holders in the deposition chamber, which can be controlled manually. The facility consists of quadrupole mass filter (QMF 200), which can select masses in the range of 2-125 000 atoms depending on the target materials, with a constant mass resolution (M/Delta M similar to 25). The dc magnetron discharge at a power of about 130 W with Ar as feed/buffer gas was used to produce the Cu nanocluster in an aggregation tube and deposited on Si (100) wafer temperature.

Majumdar, Abhijit†; Koepp, Daniel†; Ganeva, Marina†; Datta, Debasish; Bhattacharyya, Satyaranjan; Hippler, Rainer†

Morphological evolution of films composed of energetic and size-selected silver nanocluster ions

In this study, morphologies of as-deposited and rapid thermal annealed films of silver nanoclusters are studied using scanning electron microscope (SEM) and atomic force microscope (AFM). Size-selected silver nanoclusters, containing 5000 atoms in a cluster, produced by the gas condensation method are deposited on Si substrate for a period of 8 min. In order to get an idea about the melting of clusters, the film is treated by rapid thermal annealing at 200 and 400 degrees C. The remarkable changes of morphology due to annealing signify a lowering of melting temperature of silver in the form of nanoscale particles.

Bhattacharyya, SR; Datta, D; Chini, TK; Ghose, D; Shyjumon, I†; Hippler, R†

Ripple formation on silicon by medium energy ion bombardment

The formation of a self-organized nanoscale ripple pattern after off-normally incident ion bombardment on the surface of amorphous materials, or on semiconductors like silicon that are easily amorphized by ion bombardment, has attracted much attention in recent years from the point of view of both theory and applications. As the energy of the impinging ions increases from low to medium, i.e. several hundred eV to a few tens of keV, the ratio of amplitude to wavelength of the generated ripple pattern becomes so large that inter-peak shadowing of the incident ion flux takes place. Morphologically, the sinusoidal surface profile starts to become distorted after prolonged ion bombardment under such conditions. Structural and compositional modifications of the ripple morphology generated under shadowing conditions include the formation of a thicker amorphous layer with high incorporation of argon atoms in the form of nanometer sized bubbles around the middle part of the front slope of the ripple facing the ion beam, as compared to the rear slope. The present paper reviews recent developments in the experimental study of morphological, structural and compositional aspects of ripple patterns generated on a silicon surface after medium keV (30-120 keV) argon bombardment mainly at an angle of ion incidence of 60 degrees.

Chini, Tapas Kumar; Datta, Debi Prasad; Bhattacharyya, Satya Ranjan

Processes Involved in the Formation of Silver Clusters on Silicon Surface

We analyze scanning electron microscopy measurements for structures formed in the deposition of solid silver clusters onto a silicon(100) substrate and consider theoretical models of cluster evolution onto a surface as a result of diffusion and formation of aggregates of merged clusters. Scanning electron microscopy (SEM) data are presented in addition to energy dispersive X-ray spectrometry (EDX) measurements of the these films. Solid silver clusters are produced by a DC magnetron sputtering source with a quadrupole filter for selection of cluster sizes (4.1 and 5.6 nm or 1900 and 5000 atoms per cluster in this experiment); the energy oh cluster deposition is 0.7 eV/atom. Rapid thermal annealing of the grown films allows analysis of their behavior at high temperatures. The results exhibit formation of cluster aggregates via the diffusion of deposited solid clusters along the surface an aggregate consists of up to hundreds of individual clusters. This process is essentially described by the diffusion-limited aggregation (DLA) model. and thus a grown porous film consists of cluster aggregates joined by bridges. Subsequent annealing of this film leads to its melting, at temperatures lower than to the melting point of bulk silver. Analysis of evaporation of this thin at higher temperature gives a binding energy in bulk silver of epsilon(0) = (2.74 +/- 0.03) eV/atom.

Bhattacharyya, SR; Chini, TK; Datta, D; Hippler, R†; Shyjumon, I†; Smirnov, BM †

Ion beam induced mixing of co-sputtered Au-Ni films analyzed by Rutherford backscattering spectrometry

Co-sputtered Au-Ni thin films having thickness of 30 nm were deposited on Si(1 0 0) substrates and irradiated with 160 keV Ar-40(+) under ambient condition at a number of fluences and analyzed using Rutherford backscattering spectrometry (RBS). The variation of Au signal counts in the RBS spectra with ion fluence has been investigated. The distribution of Au, Ni and Si atoms over various depths within the as deposited and irradiated samples has been computed using the backscattering data by means of a direct analytical method. Au and Si profiles have been fitted with error function and the relative changes in variance for various ion fluences compared to that of as deposited profiles have been studied. The spreading rates of different constituents across the interface due to Ar ion impact have also been discussed.

Datta, D; Bhattacharyya, SR

Binary beryllium-tungsten mixed materials

Both Be and W are planned as wall materials for ITER. Although these materials will dominate the ITER first wall, and despite the fact that their interaction during operation will be dominated by surface processes, mostly bulk material data on the Be-W binary system are available. This article describes investigations of thin films of Be deposited on W, the inverse system (W films on Be), as well as experiments where W surfaces are exposed to a Be-seeded deuterium plasma. The formed alloy phases Be2W and Be12W are identified by X-ray photoelectron spectroscopy (XPS) and depth profile data both from sputter-XPS and MeV ion beam analysis are presented.

Linsmeier, Ch†; Ertl, K; Roth†, J; Wiltner, A†; Schmid, K†; Kost, F†; Bhattacharyya, SR;
Baldwin, M†; Doerner, RP†

Vapor condensation growth and evolution mechanism of ZnO nanorod flower structures

ZnO flower-like nanostructures were grown on Ge (100) substrate, by a modified chemical vapor condensation technique of zinc acetate dihydrate at 300 degrees C, without using any catalyst. These self-organized three-dimensional nanostructures were composed of hierarchical arrangement of ZnO nanorods of diameter similar to 50 nm around a common nucleus and were distributed uniformly over the entire substrate surface. Evolution study of these structures indicates that the growth begins with a two-dimensional planar arrangement of (0001)oriented ZnO nanorods. With increasing growth time, the expanding adjacent two-dimensional growth fronts approach each other, followed by which, the formation of three-dimensional flower-like structures evolve. Surface diffusion mechanism seems to play an important role in forming these nanostructures, which has been discussed in detail. Elaborate electron microscopic (SEM, TEM) techniques have been used to investigate the growth characteristics of the flower structures. The photoluminescence measurements showed pure free excitonic transition centered at about 3.249 eV with full width at half-maximum of about 141 meV at 300 K, which blue shifted to 3.361 eV at 10 K with corresponding half width of 7 meV with no defect-related bandgap peak due to relatively low growth temperature. The optical emission area was imaged through a cathodoluminescence technique.

Haldar, SR; Nayak, A†; Chini, TK; Ray, SK†; Yamamoto, N†; Bhunia, S

Strong temperature and substrate effect on ZnO nanorod flower structures in modified chemical vapor condensation growth

We have reported low temperature growth (300 degrees C) of ZnO nanorod flower structures by depositing zinc acetate vapor on Ge (100) substrate in the form of a jet using chemical vapor condensation technique. The flowers were comprised of hierarchical arrangement of highly crystalline ZnO nanorods oriented isotropically around a common nucleus. The temperature window for stability of these structures was found to be very narrow and the formation of the flowers was highly depended on the type of the substrates used. The flower morphology changed to a different hemispherical shape when the growth temperature was increased by only 50 degrees C while decreasing the growth temperature of the same degrees resulted in an amorphous deposition of ZnO. The temperature and substrate effect has been explained on the basis of adatom kinetics during growth. X-ray diffraction and TEM study revealed wurtzite ZnO nanorods with lattice constants a and c of 3.2 and 5.19 angstrom, respectively. The flower structures showed strong room temperature photoluminescence having pure excitonic transition at around 3.298 eV.

Haldar, SR; Nayak, A†; Chini, TK; Bhunia, S

Formation of nanodots on oblique ion sputtered InP surfaces

Using a field emission gun based scanning electron microscopy, we report the formation of nanodots on the InP surfaces after bombardment by 100 keV Ar+ ions under off-normal ion incidence (30 degrees and 60 degrees with respect to the surface normal) condition in the fluence range of 1 x 10(16) to 1 x 10(18) ions cm (2). Nanodots start forming after a threshold fluence of about 1 x 10(17) ions cm (2). It is also seen that although the average dot diameter increases with fluence the average number of dots decreases with increasing. uence. Formation of such nanostructured features is attributed due to ion-beam sputtering. X-ray photoelectron spectroscopy analysis of the ion sputtered surface clearly shows In enrichment of the sputtered InP surface. The observation of growth of nanodots on the Ar+-ion sputtered InP surface under the present experimental condition matches well with the recent simulation results based on an atomistic model of sputter erosion.

Som, T†; Chini, TK; Katharia, YS†; Tripathy, S†; Kanjilal, D†

Photoluminescence from Si: Effect of ripple microstructures induced by argon ion irradiation

We performed photoluminescence (PL) measurements on Si surface irradiated with 60 keV Ar+ at a fixed ion fluence of 10(18) ions/cm(2) for two angles of ion incidence, namely 0 degrees (with respect to surface normal of the sample) and 60 degrees. Periodically modulated ripple morphology is observed for a 60 degrees angle of ion incidence. The ripple microstructure consists of amorphous structure on the rear slope and a comparatively thicker amorphous layer with Ar bubbles on the front slope, whereas a uniformly thick amorphous layer with relatively large bubbles is created tinder normal bombardment. Room temperature PL of the rippled Si shows a visible band with a peak at similar to 700 nm and a strong infrared (IR) band having a peak at similar to 1000 nm. However, the visible PL was very weak and no IR emission was observed for normally irradiated Si.

Chini, TK; Datta, DP; Luchhesi, U†; Mucklich, A†

Room temperature photoluminescence from the amorphous Si structure generated under keV Ar-ion-induced surface rippling condition

We observe room temperature (RT) visible and infrared (IR) photoluminescence (PL) bands peaked around 680 and 1020 nm, respectively, from a silicon (Si) surface amorphized and patterned with ripples by 60 keV Ar+ bombardment at 60 degrees angle of ion incidence. However, the Si surface amorphized but not patterned under normal bombardment (0 degrees angle of ion incidence) condition shows a drastic reduction in the intensity of the visible PL along with the complete suppression of IR emission. The present work demonstrates that Ar ion irradiation at rippling condition may yield a porouslike light emitting amorphous silicon (a-Si) nanostructure.

Chini, TK; Datta, DP; Facsko, S†; Mucklich, A†

Coarsening of ion-beam-induced surface ripple in Si: Nonlinear effect vs. geometrical shadowing

The temporal evolution of a periodic ripple pattern on a silicon surface undergoing erosion by 30 keV argon ion bombardment has been studied for two angles of ion incidence of 60 degrees and 70 degrees using ex situ atomic force microscopy (AFM) in ambient condition. The roughness amplitude (w) grows exponentially with sputtering time for both the angle of ion incidence followed by a slow growth process that saturates eventually with almost constant amplitude. Within the exponential growth regime of amplitude, however, ripple wavelength (l) remains constant initially and increases subsequently as a power law fashion l proportional to t(n), where n=0.47 +/- 0.02 for a 60 degrees angle of ion incidence followed by a saturation. Wavelength coarsening was also observed for 70 degrees but ordering in the periodic ripple pattern is destroyed quickly for 70 degrees as compared to 60 degrees. The ripple orientation, average ripple wavelength at the initial stage of ripple evolution, and the exponential growth of ripple amplitude can be described by a linear continuum model. While the wavelength coarsening could possibly be explained in the light of recent hydrodynamic model based continuum theory, the subsequent saturation of wavelength and amplitude was attributed to the effect of geometrical shadowing. This is an experimental result that probably gives a hint about the upper limit of the energy of ion beam rippling for applying the recently developed type of nonlinear continuum model.

Datta, Debi Prasad; Chini, Tapas Kumar

Growth and stability of Langmuir-Blodgett films on OH-, H-, or Br-terminated Si(001)

Growth of Langmuir-Blodgett (LB) films of nickel arachidate (NiA) on differently terminated (OH-, H-, or Br-terminated) Si (001) substrates and their structural evolution with time have been investigated by x-ray reflectivity technique, complemented by atomic force microscopy. Stable and strongly attached asymmetric monolayer (AML) of NiA is found to grow on freshly prepared oxide-covered Si substrate while unstable and weakly attached symmetric monolayer (SML) of NiA grows on H-terminated Si substrate, corresponding to stable hydrophilic and unstable hydrophobic natures of the substrates, respectively. The structure of LB film on Br-terminated Si substrate, however, shows intermediate behavior, namely, both AML and SML are present on the substrate, indicative of coexisting (hydrophilic and hydrophobic) nature of this terminated surface. Such coexisting nature of the substrate shows unusual growth behavior of LB films: (i) hydrophilic and hydrophobic attachments of NiA molecules in single up stroke of deposition and (ii) growth of few ring-shaped large-heights islands in subsequent deposition. These probably occur due to the presence of substrate-induced perturbation in the Langmuir monolayer and release of initially accumulated strain in the film structures near hydrophilic/hydrophobic interface, respectively, and provide the possibility to grow desired structures (AML or SML) of LB films by passivation-selective surface engineering.

Bal, JK; Kundu, S; Hazra, S

Atmospheric pressure induced atomic diffusion into solid crystal

Gaussian-shape diffused nanolayer, formed due to atomic diffusion of gold into silicon crystal, shows wave-front-like movement with time when the system is in ambient condition, while it remains almost static as long as it is in ultrahigh vacuum condition. This is clear evidence of simple atmospheric pressure induced diffusion of atomic gold into the silicon crystal and provides an interesting concept of inherent pressure inside a crystal structure. The atmospheric pressure at the surface and its gradual decreasing nature from the surface to inside crystal acts as driving and retarding forces, respectively, which can be used to control the formation and movement of the diffused layer in nanolevel. Such diffusion also depends on the crystal structure and freeness of the diffusing atoms. The latter increase as the thickness and/or coverage of the gold layer decreases.

Bal, JK; Hazra, S

Time-evolution growth of Ag nanolayers on differently-passivated Si(001) surfaces

The growth and evolution of Ag nanolayers on differently-passivated Si(001) substrates at ambient condition have been studied. Initial compactness and smoothness of Ag nanolayer on the H-passivated Si(001) surface are found better compared to those on the Br-passivated Si(001) surface, which can be understood considering surface free energy and surface mobility of the passivated surfaces. As the time passes, the growth of dewetted three-dimensional (3D) islandlike structures (Volmer-Weber-type mode) from comparatively wetted Ag nanolayer (Stranski-Krastanov-type mode) is evident at ambient conditions. Such evolution of growth is through dewetting (related to the change in the interfacial energy due to the oxide growth), migration, and coalesce of Ag, which can even produce large epitaxial

[Ag(001)/Si(001)] 3D islands on H-passivated Si(001) surface. The growth rate, size, number density, and epitaxy/nonepitaxy of 3D islands are different for different passivated surfaces. These differences can be realized considering the growth time of oxide (i.e., instability of passivated surface), in-plane inhomogeneity of interfacial energy (i.e., inhomogeneous nature of passivation), and in-plane diffusion of Ag on the passivated surfaces.

Bal, JK; Hazra, S

Role of ceramic matrix and Au fraction on the morphology and optical properties of cosputtered Au-ceramic thin films

Surface sensitive x-ray scattering studies were carried out to understand the morphology of cermet thin films prepared by cosputtering metallic gold and ceramic materials on float glass substrates. It has been observed that the morphology of Au clusters in cermet thin films depends strongly on the matrix during growth, even if, all other conditions are kept identical. In particular, nearly isotropic growth of Au clusters, to form nanoparticles, is found in silica and alumina matrices, while anisotropic columnar-like growth of Au clusters, to form a nanorod-like shape, is found in a titanium oxide matrix. Thickness of the films was also found very different, which is likely to be related to the different sputtering yields of the ceramic materials. The volume fraction of Au estimated from the electron density profile shows that the total volume or the amount of Au is different in films of different ceramic matrices. This suggests that even the sputtering yield of Au is very different in the presence of different ceramic atmosphere, which is likely to be responsible for having a different morphology of Au clusters in different matrices. Optical absorption spectra of the films, on the other hand, show linear dependence of the absorption peak position with the volume fraction of Au and independent of both the ceramic matrix and morphology of Au clusters.

Hazra, S; Gibaud, A[†]*; Sella, C* [†]

Interfacial role in room-temperature diffusion of Au into Si substrates

X-ray reflectivity is used in tracking the diffusion of Au into Si(001) substrates with time at room temperature. It has been observed that the diffusion of Au into Si substrates strongly depends on the initial pretreatment conditions of Si surface. In particular, there is very little diffusion for the untreated Si surface, while the Si surface pretreated with HF seems to be prone to strong diffusion and the surface further pretreated with Br shows diffusion in between. Such different diffusion and apparent non-Fickian-type time dependence in the diffusion can be quantitatively explained by Fickian diffusion of Au through changing unblocked interfacial layer. The growth of the blocking (oxide) layer with time essentially prevents further diffusion through those areas, and the growth of that layer is directly related to the surface stability due to the surface pretreatment and/or passivation conditions, which gives a control in the formation of diffusion-induced Au-Si nanolayer of different widths and compositions. The morphology and evolution of the top surface, mapped with atomic force microscopy and scanning electron microscopy, further helped to verify and understand such differences.

Bal, JK; Hazra, S

Preparation, characterization and performance of conducting polypyrrole composites based on polysulfone

The poor applicability of conducting polymers due to the limitations of processibility has motivated researchers to prepare their composites. Diffusive chemical oxidative polymerization technique of pyrrole is employed to prepare polypyrrole-polysulfone (PPy-Psf) composite membranes. FTIR, TGA and AFM studies have been carried out to provide evidence for incorporation of pyrrole moiety as well as to characterize the composites. The polysulfone-polypyrrole composite membranes show the potential of removing sodium chloride and magnesium sulfate from the solution to a certain extent. The study reveals that salt rejection performance of the composite membranes depends on the FeCl3 dopant concentration, and it follows the order R-MgSO4 > R-NaCl.

Bhattacharya, A[†]; Mukherjee, DC[†]; Gohil, JM[†]; Kumar, Y[†]; Kundu, S

Langmuir-Blodgett film from a bi-molecular layer at air-water interface

Langmuir-Blodgett (LB) films deposited on hydrophilic silicon (0 0 1) from a bi-molecular layer of preformed three-tailed fatty acid salt like ferric stearate (FeSt) have been studied by X-ray reflectivity technique and atomic force microscopy (AFM). Surface topography and electron density profiles (EDPs) show that only monomolecular layer is deposited for each up and down stroke of the substrate through this bi-molecular layer film. EDPs and surface topography analysis also indicate very less deposition of molecules after five strokes of the substrate in contradiction with standard LB deposition. The reason for such kind of deposition of three-tailed molecules has proposed.

Kundu, S

Study of neutralization kinetics in charged polymer-metal nanocomposite systems by photoemission spectroscopy

In case of photoelectron spectroscopy of an insulating material the data obtained from the charged surface are often distorted due to differentially charged surface domains. Recently we have developed a controlled surface neutralization technique to Study the kinetics of the surface charging. Here we demonstrate the application of the technique to study the neutralization kinetics of both thick and thin films of charged polymer-metal nanocomposite material using photoemission. Neutralization kinetics of grounded and floated pure polymer thin films was also studied. It was observed that for the thick sample the transition of positively charged domains to overcompensated ones occurs through percolation. In case of grounded thin films the growth of overcompensated domains exhibit a linear behavior followed by saturation. When electrons appear at both Surfaces of a floated thin film, the neutralization kinetics show a completely different behavior. Present investigation indicates that for thin films of insulating materials appearing to be neutral in presence of an electron source, controlled neutralization technique may be an important tool to distinguish between presence of multiple chemical species and differential charging.

Mukherjee, S; Mukherjee, M

Onset Kinetics of Thermal Degradation of Ultrathin Polyacrylamide Films

There are several pathways through which a polymer can degrade such as thermal, photoinduced, biological, chemical and mechanical. The thermal degradation process of polymers is widely studied because of both academic and industrial interest. Here we have investigated the kinetics of thermal degradation and structural modification of polyacrylamide ultrathin films as a result of heat treatment at the degradation onset temperature. The chemical analysis of the material was performed using X-ray photoelectron spectroscopy (XPS) and near-edge X-ray absorption Fine structure (NEXAFS) spectroscopy. The formation of imide functionalities was found to occur on the polymer chains with simultaneous breakdown of amide groups, The kinetics of the degradation products obtained from quantitative analysis of the XPS spectra shows that the thermal degradation of the major part of the polymer occurs within the First 30 min of heating at the onset temperature of 220 degrees C. The rate of degradation was found to saturate after similar to 3 h of heating. The structural aspects of the heated films were studied using X-ray reflectivity (XRR). Analysis of the reflectivity data shows that the thickness of the film decreases and the electron density increases after prolonged heating at 220 degrees C. From the amplitude of the reflectivity data, it was found that the interfacial morphology of the film stays almost unmodified and the film retains the polymeric property even after undergoing thermal degradation. The final onset degradation product obtained was ultrathin films of polymer containing 60% and 40% mono- and bicyclic imide functionalities, respectively.

Mukherjee, S; Mondal, MH; Mukherjee, M; Doyle, BP†; Nannarone, S †

Study of Thickness Dependent Density in Ultrathin Water Soluble Polymer Films

Density of the polyacrylamide ultrathin films has been studied using X-ray reflectivity technique. Two Sources (one powder and another aqueous solution) of polyacrylamide were used to prepare spin coated films on silicon substrate. Light scattering measurements show that the polymer chains were unentangled in a concentrated (4 mg/mL) as well as in a dilute (2 mg/mL) solution prepared from the powder, whereas the solution (4 mg/mL) prepared by diluting the solution source shows entangled chain morphology. Three sets of films of different thicknesses were prepared using the three solutions by spin coating on silicon substrates. Comparison of X-ray reflectivity data for as prepared and dry films reveals that the shrinkage of the films decreases with increasing thickness. Average electron densities of the films were found to follow a trend of higher density for thinner films with a maximum increase of about 12% compared to the bulk. The densities of all the films irrespective of the nature of entanglement and concentration of their source were found to increase with spin speed of coating and attain saturation at higher speed. Absence of correlation between shrinkage and density data and the fact that the densities of all the films follow a master curve irrespective of their origin suggest that the higher density of the films result from the higher orientation of chains as a consequence of an interplay between stretching and stronger attractive interactions of polar nature.

Mondal, Mojammel H; Mukherjee, M; Kawashima, K†; Nishida, K†; Kanaya, T†

Effect of Annealing Induced Polymer Substrate Attachment on Swelling Dynamics of Ultrathin Polymer Films

The effects of annealing on the dynamical behavior of swelling for ultrathin polyacrylamide films deposited on silicon substrates have been studied using X-ray reflectivity technique. The spin coated polyacrylamide films of similar thicknesses were annealed at various temperatures below and above the glass transition temperature of the polymer. The electron density of the films was found to increase systematically on annealing. The swelling dynamics of the annealed films were found to have systematic dependence on the temperature of annealing. The interaction between the substrate and the polymer molecules was found to play important role in the swelling dynamics of the annealed films unlike our earlier observation with as coated films. The chain segments attached directly to the substrate were believed to have restricted freedom of movements compared to the ones that are at a distance from the substrate and relatively free. Accordingly, the dynamical behavior of swelling was modeled in terms of the combination of a free and a restricted component and was found to be in excellent agreement with the data. The diffusion coefficients corresponding to the restricted polymer segments were an order of magnitude smaller than those of the free segments and the fraction. of the same was found to increase with annealing at higher temperatures. The overall reduction of swellability of the films was explained in terms of the increase of density of the films and the segmental attachment to the substrate on annealing.

Mondal, Mojammel H; Mukherjee, M

Interaction of chromium with resistant strain Aspergillus versicolor: Investigation with atomic force microscopy and other physical studies

The interaction of chromium and a chromate resistant Aspergillus versicolor strain has been studied by atomic force (AFM) and transmission electron (TEM) microscopies. The nanomechanical properties such as cell wall rigidity and elasticity were measured by force spectroscopy and found to be 0.6.1 +/- 0.08 N/m, and 20.5 +/- 2.1 MPa, respectively. On chromium binding, ultrastuctural changes of the cell wall along with the formation of layered structures on the cell wall were observed. TEM and AFM micrographs demonstrate the accumulation of chromium on the cell wall, which were rough and irregular compared with the smooth pristine mycelia. The surface roughness, cell wall rigidity and elasticity increased to 35.5 +/- 3.5 nm, 0.88 +/- 0.05 N/m, and 62.5 +/- 3.5 MPa, respectively, from the corresponding values of 5.2 +/- 0.68 nm, 0.61 +/- 0.02 N/m, and 20.5 +/- 2.1 MPa for the pristine mycelia. X-ray photoelectron spectroscopy and Fourier transform infrared studies suggest that bound chromium was reduced to its trivalent state by the cell wall components. The reduced chromium species on the cell surface further electrostatically bind chromate ions forming layered structure on the cell wall.

Das, Sujoy K[†]*; Mukherjee, Manabendra; Guha, Arun K*[†]

Characterization of Langmuir-Blodgett film using differential charging in X-ray photoelectron spectroscopy

Differential charging is often regarded as a problem in X-ray photoelectron spectroscopy (XPS) studies, especially for insulating or partially conducting samples. Neutralization techniques have been developed to circumvent this effect. Instead of neutralizing the positive charge, which is often the technique to obtain good quality data, it is possible to exploit this phenomenon to get useful information about the sample. An attempt is made here to use this differential charging to study the mono- and multilayer Langmuir-Blodgett (LB) films of cadmium arachidate on silicon substrate. The surface potential was probed by measuring XPS line shift with respect to their neutral position and was found to have correlation with the thickness of the films. No differential charging was observed in the monolayer LB film where there was only one layer of cadmium headgroup. Significant differential charging was observed for multilayer films, the total charging as well as the differential charging in these films increase with increasing number of layers. Angle-resolved XPS measurements were performed to obtain additional information about the structure of the films. Charging of the upper layer of the films close to the vacuum interface was found to be less compared to that of the interior. The discrete cadmium layers were found to be more differentially charged compared to the continuous hydrocarbon stacks in the multilayer LB films. Charging of the discrete cadmium layers has been utilized to obtain quantitative information of the multilayer LB films.

Islam, AKM Maidul; Mukherjee, M

Neutralization kinetics of charged polymer surface

In case of photoemission spectroscopy of an insulating material the data obtained from the charged surface are normally distorted due to differential charging. Recently, we have developed a controlled surface neutralization technique to study the kinetics of the surface charging. Using this technique and the associated data analysis scheme with an effective charging model, quantitative information from the apparently distorted photoemission data from PTFE surfaces were extracted. The surface charging was controlled by tuning the electron flood current as well as the X-ray intensity. The effective model was found to describe the charging consistently for both the cases. It was shown that the non-linear neutralization response of differential charging around a critical neutralizing electron flux or a critical X-ray emission current was due to percolation of equipotential surface domains. The obtained value of the critical percolation exponent gamma close to unity indicates a percolation similar to that of avalanche breakdown or chain reaction.

Mukherjee, S; Mukherjee, M

X-ray photoelectron spectroscopy studies on core-shell structured nanocomposites

Core-shell nanostructures were grown in silica-based glasses. Copper-copper oxide and iron-iron oxide structures had diameters in the range 3-6 nm, with shell thicknesses similar to 1-2 nm. Silver-lithium niobate core-shell nanostructures had diameters in the range 4.2-46 nm and thicknesses varying from 2.2 to 22 nm. X-ray photoelectron spectroscopy studies were carried out on all these specimens. The analyses of these results show the presence of Cu+/Cu2+, Fe2+/Fe3+ and Nb4+/Nb5+, valence states in the above three systems. Electrical resistivity data were fitted satisfactorily to the small polaron hopping model in the case of copper and iron-Contain -ing specimens. The presence of ions in the lithium niobate shell provides direct evidence of the formation of localized states between which variable range hopping conduction can be effected.

Mukherjee, M; Basu, S[†]; Ghosh, B[†]; Chakravorty, D[†]

Vapor condensation growth and evolution mechanism of ZnO nanorod flower structures

ZnO flower-like nanostructures were grown on Ge (100) substrate, by a modified chemical vapor condensation technique of zinc acetate dihydrate at 300 degrees C, without using any catalyst. These self-organized three-dimensional nanostructures were composed of hierarchical arrangement of ZnO nanorods of diameter similar to 50 nm around a common nucleus and were distributed uniformly over the entire substrate surface. Evolution study of these structures indicates that the growth begins with a two-dimensional planar arrangement of (0001)oriented ZnO nanorods. With increasing growth time, the expanding adjacent two-dimensional growth fronts approach each other, followed by which, the formation of three-dimensional flower-like structures evolve. Surface diffusion mechanism seems to play an important role in forming these nanostructures, which has been discussed in detail. Elaborate electron microscopic (SEM, TEM) techniques have been used to investigate the growth characteristics of the flower structures. The photoluminescence measurements showed pure free excitonic transition centered at about 3.249 eV with full width at half-maximum of about 141 meV at 300 K, which blue shifted to 3.361 eV at 10 K with corresponding half width of 7 meV with no defect-related bandgap peak due to relatively low growth temperature. The optical emission area was imaged through a cathodoluminescence technique.

Haldar, SR; Nayak, A; Chini, TK; Ray, SK[†]; Yamamoto, N[†]; Bhunia, S

Strain-induced nonequilibrium magnetoelastic domain structure and spin reorientation of NiO(100)

We report the observation of strain-induced antiferromagnetic domain structure on cleaved surface of NiO single crystal. This nonequilibrium domain structure undergoes various spin reorientations (from in plane to different in plane, out of plane to in plane) after mild annealing, indicating a direct correlation between the surface strain field and domain morphology. These reorientations are found to be driven by structural modification on the surface generated by cleaving process and buried dislocations, altering the surface magnetic anisotropy and their relaxation through mild annealing. These observations establish that the magnetoelastic effect plays a dominant role in determining antiferromagnetic domain structure.

Mandal, Suman; Menon, Krishnakumar S R

Enhanced ionic conductivity in Ce0.8Sm0.2O1.9: Unique effect of calcium co-doping

In order to identify new oxide ion-conducting materials in the ceria family of oxides, the unique effect of co-doping is explored and a novel series of Ce0.8Sm0.2-xCaxO2-delta Compositions is identified that have enhanced properties compared to the singledoped Ce0.8Sm0.2O1.9 and Ce0.8Ca0.2O1.9 cornpositions. Moreover, the superior characteristics of the co-doped Ce0.8Sm0.2-xCaxO2-delta powders prepared by the mixed-fuel process aid in obtaining 98 % dense ceramics upon sintering at 1.200 degrees C for 6 h. Though a linear increase in conductivity is observed by replacing Sm with Ca, the composition with the maximum amount of Ca and the minimum amount of Sm exhibits a significant improvement in properties compared to the rest in the series. The composition Ce0.80Sm0.05Ca0.15O2-delta exhibits a conductivity as high as 1.22 x 10(-1) S cm-l at 700 degrees C with minimum activation energy (0.56 eV) and a superior chemical stability to reduction compared to any of the hitherto known (CaSm) compositions. The absence of Ce-III, confirmed both from X-ray photoelectron spectroscopy and X-ray absorption spectroscopy, strongly suggests that the observed increase in conductivity is solely due to the oxide ion conductivity and not due to the partial electronic contribution arising from the presence of Ce-III and Ce-IV. To conclude, the experimental results on the Ce0.8Sm0.2-xCaxO2-delta series underscore the unique effect of calcium co-doping in identifying a cost-effective new composition, with a remarkably high conductivity and enhanced chemical stability to reduction, for technological applications.

Banerjee, Suparna; Devi, Parukuttyamma Sujatha†; Topwal, Dinesh†; Mandal, Suman; Menon, Krishnakumar

Relaxation of bimolecular layer films on water surfaces

Ferric stearate, a three-tailed amphiphile, forms bimolecular layers on water surfaces. Molecules in the lower layer are in an "asymmetric" configuration, Fe-containing heads touching water and three hydrocarbon tails in air, while molecules in the upper layer are in a "symmetric" configuration, in pairs of "Y and inverted Y" disposition of tails about the Fe-bearing head. Pressure relaxation at constant area (pi-t curves) and area relaxation at constant pressure (A-t curves) of this bimolecular layer can be modeled as a sum of three exponential decay terms with distinct time constants and weight factors. Relating the long-term decay with desorption of the total film thus indicates a remarkable long-term stability of the bimolecular layer film. An X-ray reflectivity study of the bimolecular films deposited horizontally on Si(001) at various conditions of relaxation shows no further growth along the vertical of any other layer. Under pressure relaxation molecules are transferred from the upper layer to the lower layer with a change from symmetric to asymmetric configuration, while under area relaxation the transfer is from the lower layer to the upper layer with a configurational change from symmetric to asymmetric.

Kundu, S; Datta, A; Hazra, S

A non-equilibrium quasistationary state in an ionic liquid caused by a focused laser

A radial pattern of polarization is observed in a Fe-based (but not in a Ga-based) room-temperature ionic liquid (RTIL) on irradiation by a focused laser. On switching the laser off, the pattern shows a fast (<1 s) change followed by a quasistationary structure for more than 100 s with decay exponents varying approximately from -0.2 to -0.02. Optical spectra of the RTILs indicate a band at 532 nm for the Fe-based RTIL and absence of this band in the Ga-based RTIL. A preliminary qualitative explanation based on the Hamiltonian Mean Field model of coupled rotators, where the rotators are charge transfer complex (CTC) dipoles created resonantly by the laser for the Fe-based RTIL, has been proposed.

Iguchi, Natsuki†; Datta, Alokmay; Yoshikawa, Kenichi†; Yoshida, Yukihiro†; Saito, Gunzi†

Dependence of mesoscopic growth on molecular configuration in Langmuir-Blodgett multilayers

Systematic studies by atomic force microscopy and X-ray reflectivity of three monolayer Langmuir-Blodgett films of M-Stearate (M = Cd, Zn, Mn) show change in surface morphology and growth mode with change in metal ions in the headgroup. Growth proceeds via Volmer Weber mode in CdSt, Stranski-

Krastanov mode in ZnSt and Frank Van der Merwe mode in MnSt, as ascertained from fractal dimensions and out-of-plane density profiles. This is closely related with increase in number of metal ions incorporated per headgroup with change in metal ions in the order Cd, Zn and Mn. A preliminary correlation with metal atomic number is noted.

Mukherjee, S; Datta, A

Morphology and Structural Evolution in Cobalt Stearate Langmuir-Blodgett Films

Structural evolution of cobalt stearate (CoSt) Langmuir-Blodgett (LB) films show 2D layer-by-layer or Frank van der Merwe type growth, with in-plane defect-free morphology and bidentate bridging metal ion headgroup coordination, observed from both Atomic Force Microscopy (AFM) and X-ray Reflectivity (XRR) studies. Difference in headgroup structure of first monolayer with that of subsequent bilayers is observed from XRR studies. However, AFM study of preformed cobalt stearate (CoStp) LB films did not show such defect-free growth in spite of having same metal ion coordination, as seen from its bulk Fourier Transform Infra-red (FTIR) spectra. Increased interaction between two methyl groups of adjacent hydrocarbon tails in case of CoSt deposition was indicated from the observed lengthening of C-H bonds in these. Along with metal ion headgroup coordination, supramolecular tail-tail interaction is proposed to play a key role in defect free multilayer formation.

Mukherjee, Smita; Datta, Alokmay

Nanoparticle-Virus Complex Shows Enhanced Immunological Effect Against Baculovirus

Insects protect themselves from majority of infections by a non-specific innate immune system (present in both vertebrates and invertebrates). *Bombyx mori* nuclear polyhedrosis virus (BmNPV), a baculovirus, causing the deadly grasserie disease is a scourge to silkworm industry and we report here the first success in combating this disease with the help of a nanosilica-virus complex. Hydrophobic aluminium silicate nanoparticles were mixed with live BmNPV *in vitro*. This mixture was injected into one day old 5th instar silkworm larvae (into the hemocoel at the third abdominal spiracle) before challenging the larvae with live BmNPV via a second injection. This led to substantial enhancement of longevity in the diseased silkworm larvae and 35±5.3% larvae completed their lifecycle (i.e., formed normal pupae and enclosed as moth). On the other hand, 100% larvae infected with BmNPV alone died within 36 hours. The larvae treated with nanoparticles before infection had a longer lifespan but all of them eventually succumbed, not a single larva metamorphosed to adult stage. Results suggest two pathways of host protective response—one mediated by nanoparticle-alone and the second, more important, via non-specific innate immunological mechanism. AFM and confocal studies show that nanoparticles alter 3-D molecular structure of the virus envelope. Possibly this exhibits novel potent epitope(s) which stimulate(s) anti-viral machinery in infected silkworm larvae. SDS-PAGE results suggest that 39 KDa viral protein is the major target of the nanoparticles.

Rahman, Ayesha[†]*; Biswas, Nupur; Ulrichs, Christian*[†]*; Buettner, Carmen*[†]*; Bramhachary, Ratan Lal*[†]*; Goswami, Arunava*[†]*; Datta, Alokmay*

Interaction of Oxicam NSAIDs with lipid monolayer: Anomalous dependence on drug concentration

Surface pressure (pi) versus specific molecular area (A) isotherms of Langmuir monolayers of climyristoylphosphatidylcholine ne (DMPC) lipid on pure water were studied in pristine form and in presence of three non-steroidal anti-inflammatory drugs, meloxicam (MX), piroxicann (PX) and tenoxicam (TX) in the subphase. Data were taken at three drug/lipid (D/L) ratios of 0.026, 0.05, and 0.1. Integration of drug to the lipid monolayer was measured by the increase in A (Delta A) of DMPC monolayer due to the presence of drugs. All three drugs could be integrated in the monolayer resulting in a positive value of Delta A for D/L ratio of 0.026. Above this D/L value, there is an anomalous, monotonic decrease in Delta A for MX and TX resulting, finally, in negative Delta A values. For PX, however, decrease in Delta A values at D/L of 0.05 is partially compensated at D/L of 0.1. We have tentatively explained these observations by invoking two competing forces in the overall drug-lipid interaction. One of these is an 'in-plane' force that tends to integrate the drug molecule to the plane formed by the lipid monolayer and the other is an 'out-of-plane' force that perturbs the drug and the lipid molecules such that the monolayer plane is no longer well defined.

Kundu, Sarathi; Chakraborty, Hirak; Sarkar, Munna; Datta, Alokmay

Chemistry at Air/Water Interface versus Reaction in a Flask: Tuning Molecular Conformation in Thin Films

Atomic force microscopy and X-ray reflectivity studies of cobalt stearate Langmuir-Blodgett (LB) films (CoStp) deposited from a preformed bulk sample on quartz substrates showed formation of a Volmer-Weber type monolayer but no multilayers as compared to the excellent multilayers of cobalt stearate films (CoStn) deposited at the air/water interface by the usual LB technique, in spite of both showing bidentate bridging type coordination of cobalt ions with the carboxylate group. The difference is attributed to existence of different headgroup conformers, observed from Fourier transform infrared (FTIR) studies. The CoStp films had a higher energy 'boat' conformation with linear O-Co-O linkage, whereas CoStn formed a low energy conformer with a bent O-Co-O configuration (bond angle of 105). Present results support the necessity of bidentate bridging coordination in multilayer deposition, but reject its sufficiency by bringing out the crucial role played by air/water interface. Differences in surface pressure-molecular area isotherms and hydrocarbon tail-tail interactions (evident from FTIR spectra) of the films support the above statement. Methyl-methyl interactions observed in CoStn samples suggest hierarchy of supramolecular chemistry at the air/water interface in tuning the C-O-Co bond angle essential to satisfy the wetting condition with the substrate and subsequently form LB multilayers.

Mukherjee, Smita; Datta, Alokmay; Giglia, Angelo[†]*; Mahne, Nicola*[†]*; Nannarone, Stefano*[†]

Self-Assembly of a Two-Dimensional Au-Nanocluster Superlattice and Its Photoluminescence Spectra

A solution of dodecanethiol-capped Au nanoparticles (diameter ≥ 2 nm), prepared through reduction of hydrogen tetrachloroaurate, was coated on a patterned cross-linked polydimethylsiloxane (*PDMS*) film (thickness ≥ 1 μm) comprising array of square pillars, by either spin- or dip coating. Drying in ambient conditions for about 5 days resulted in the self-assembly of a superlattice (300 nm × 300 nm × 90 nm) of monodisperse nanoparticle clusters for the dip-coated samples, the clusters occupying the interstitial locations between four adjacent pillars on the polymer surface. Initial patterning of the PDMS is found to give rise to new photoluminescence bands in the near ultraviolet and visible regions, which the nanoclusters quench.

Chattopadhyay, Sudeshna†; Mukherjee, Rabibrata†; Datta, Alokmay; Saha, Abhijit†; Sharma, Ashutosh†; Kulkarni, Giridhar U†

Relating structure with morphology: A comparative study of perfect Langmuir-Blodgett multilayers

Atomic force microscopy and X-ray reflectivity of metal-stearate (MSt) Langmuir-Blodgett films on hydrophilic Silicon (10 0), show dramatic reduction in ‘pinhole’ defects when metal M is changed from Cd to Co, along with excellent periodicity in multilayer, with hydrocarbon tails tilted 9.6 degrees from vertical for CoSt (untilted for CdSt). Near edge X-ray absorption fine structure (NEXAFS) and Fourier transform infra-red (FTIR) spectroscopies indicate bidentate bridging metal-carboxylate coordination in CoSt (unidentate in CdSt), underscoring role of headgroup structure in determining morphology. FTIR studies also show increased packing density in CoSt, consistent with increased coverage.

Mukherjee, Smita; Datta, Alokmay; Giglia, Angelo†, Mahne, Nichole†, Nannarone, Stefano†

Intramolecular and intermolecular rearrangements in nanoconfined polystyrene

Vacuum ultraviolet spectroscopy reveals an intramolecular rearrangement involving a change in “physical dimers” of adjacent pendant benzene rings of atactic polystyrene (aPS) from “oblique” to “head-to-tail” (ht) configuration in aPS films spin coated on fused quartz, as film thickness R goes below $4R_g$ (R_g = unperturbed polystyrene gyration radius ≈ 20.4 nm). Simultaneously, transverse layering of molecular “gyration spheres”, for film thickness $R \leq 4R_g$, causes an increase in free energy (reduction in cohesion) that follows a $(R_g/R)^b$ dependence with $b \approx 3$, a clear deviation from planar confinement. The variation of in-plane and out-of-plane cohesive energy over a film of a given thickness is explained by invoking a fixed-range, repulsive, modified Pöschl-Teller intermolecular potential, with the strength of this potential decreasing with increase in R. Possible reduction of “dimer” dipole moment due to ht configuration is consistent with reduction of cohesion between aPS molecular gyration spheres.

Chattopadhyay, Sudeshna; Datta, Alokmay; Giglia, A†, Mahne, N†, Das, A; Nannarone, S

Effect of polymer confinement: Tuning self-assembled growth of monodisperse Au nanoparticles on polystyrene films

X-ray reflectivity and tapping mode atomic force microscopy reveal that, Au, sputter-deposited on polystyrene films for film thickness $\leq 4R_g$ (R_g being unperturbed polymer gyration radius), diffuse and coalesce slowly, under ambient conditions and predominantly along the polymer surface, to form nanoparticles. The nanoparticles are highly monodisperse, and their in-plane dimensions increase with decrease in polystyrene film thickness. The observed directed coalescence is caused by sharply defined, higher surface energy zones or “traps”, corresponding to lower cohesion, between gyration spheres on polystyrene film surface. Lowering of in-plane cohesion and coalescence are found only when gyration spheres are layered along film depth due to thinning of the polystyrene film. The coalescing potential of these traps is given by the spatially localized increase in surface energy and can be increased by confinement. This fact is the principle behind this tunable self-assemblya new and generalized mode of self-assembly of Au nanoparticles with monodispersity and tunability in size.

Chattopadhyay, Sudeshna; Datta, Alokmay

Electrical conduction property of molecular magnetic material—$\{N(n\text{-}C_4H_9)_4[Fe(II)Fe(III)(C_2O_4)_3]\}_n$: Before and after thermal degradation

Electrical conduction properties of a molecular magnetic system $\{(cation)[Fe(II)Fe(III)(C_2O_4)_3]\}_n$ with three different cations—$N(n\text{-}C_4H_9)_4^+$, $N(n\text{-}C_3H_7)_4^+$ and $As(C_6H_5)_4^+$ have been studied to understand the nature of electrical conduction in this molecular system as well as to explore any effect of the cation size on it. All the compounds are observed to be semiconducting in nature and their room temperature conductivity is of 10^{-15} S cm^{-1} order. Results indicate that the electrical conductivity as well as the activation energy of this system depends on the size of the cations used. Moreover, semiconducting iron oxide of hematite nature was obtained through the thermal degradation of $\{N(n\text{-}C_4H_9)_4[Fe(II)Fe(III)(C_2O_4)_3]\}_n$. The degraded material consisted of rod-like crystals of average length and diameter 350 and 140 nm, respectively.

A Bhattacharjee†, D Bhakat†, M Roy, J Kusz†

Developmental Work

Preparation, characterization and performance of conducting polypyrrole composites based on polysulfone

The poor applicability of conducting polymers due to the limitations of processibility has motivated researchersto prepare their composites. Diffusive chemical oxidative polymerization technique of pyrrole is employed toprepare polypyrrole–polysulfone (PPy–Psf) composite membranes. FTIR, TGA and AFM studies have been carriedout to provide evidence for incorporation of pyrrole moiety as well as to characterize the composites. The polysulfone–polypyrrole composite membranes show the potential of removing sodium chloride and magnesium sulfate from the solution to a certain extent. The study reveals that salt rejection performance of the composite membranesdepends on the $FeCl_3$ dopant concentration, and it follows the order $R_{MgSO4} > R_{NaCl}$

A Bhattacharya†, DC Mukherjee, JM Gohil†, Y Kumar† and S Kundu

Installation of Molecular Beam Epitaxy System for epitaxial growth of Si & Ge

Some initial studies on ultrathin layers of Si and Ge grown in our newly installed MBE unit on RCA cleaned Si(100) wafer. The wafer placed in the cleaned platen holder and preheated in the preheating chamber upto 700C. From there it is transferred to the growth chamber and there it is heated upto 950^0 C. The base pressure in MBE unit was ~$2x10^{-10}$ torr. The spot pattern from RHEED checked the crystalline structure of Si surface without the presence of SiO_2. A bilayer of Ge and Si were grown on

Si(100) using effusion cell and e-gun respectively. SIMS study showed growth Ge / Si on Si(100) with very good interface. From the x-ray reflectivity measurement, it is observed that the top surface and interface of grown Si is very rough.

Arjun Das, A Das, A Sharma, S Kundu and MK Sanyal

Fabrication of a capacitive dilatometer to measure thermal expansion and magnetostriction of solids

At low temperature the thermal expansion of solids become small and calls for dilation measurements with subangstrom resolution. We have fabricated a simple differential capacitive dilatometer to measure thermal expansion and magnetostriction. In a capacitive dilatometer the dilation ΔL of a sample of length L manifests as a change in the gap D between a pair of capacitor plates. For an ideal parallel-plate capacitive dilatometer in vacuum the relationship between the measured capacitance C and D is simply $C = \varepsilon_0 A/D$ where ε_0 is the permittivity of free space and A is the area of the capacitor plates. Measurements with respect to temperature T yield either thermal expansivity $\varepsilon = [L(T) - L(0)]/L(0)$ or the coefficient of linear thermal expansion $\alpha = d\lambda/dT = (1/L)dL/dT$ whereas isothermal measurements with respect to magnetic fields H yield the linear magnetostriction $\lambda = [L(H) - L(0)]/L(0)$. The complicated design and drawing of the capacitive dilatometer cell were completed with the help of the workshop. Using oxygen free high conductivity (OFHC) copper, Be-Cu spring, Kapton strip washers, etc. the dilatometer cell is fabricated. The dilatometer uses a high resolution capacitance bridge (M/S Andeen and Hagerling) with resolution $\sim 10^{-7}$ pF. With this setup we can measure thermal expansion and magnetostriction as a function of temperature in the temperature range of 3 – 300 K under magnetic field up to 8 Tesla with automatic data collection and control of various parameters.

S. Das , A. Pal, B. G. Ghosh, A. Midya, N Khan and P. Mandal

Versatile dielectric measurement Set Up

We have designed and fabricated two dielectric measurement set up for high temperature (300-700 K) and low temperature (4-310K) for studying the dielectric properties of multiferroic samples using Impedance Analyzer in the frequency range 20 Hz to 30 MHz. Measurements were performed on few dielectric materials for standardization of the high temperature measurement setup. The temperature and frequency dependence of dielectric constant of few rare earth cromates ($RCrO_3$) and a PZT material ($PbZr_{0.52}Ti_{0.48}O_3$) were measured. The results are close to the reported results. The standardization of the low temperature measurement setup is under progress.

S. Das , A. Pal, B. G. Ghosh, A. Midya, N Khan and P. Mandal

The development of a 30kV negative ion implanter

The earlier low energy ion accelerator is converted to a negative ion implanter by replacing the old cold cathode PIG ion source by a negative sputter ion source which produces beams of various light and heavy ion species with energies variable up to 30 keV. At present we are extracting 40 mA Si^-

beam and 10 mA Ge^- beam (8 mm spot size) at 26 keV to study metal silicide formations and the formation of thin SiGe composites near the surface by implanting the beam at various fluences.

D. Ghose

Installation of a broad beam high current ion beam milling system

This instrument consists of a 3-grid RF ion source which provides broad beam (30 mm diameter) high current (~ 1 mA/cm^2) inert gas ions in the energy range 50 – 2000 eV. Presently we are using the system to study sputtering induced nanodots and nanoripple formations on insulators, semiconductors and thin metal films. The substrate can be tilted 0 - 90^0 and rotated continuously up to 30 rpm during irradiation. The substrate is cryocooled in the temperature range – 20^0 C to 60^0 C. It can also be heated up to 500^0 C.

D. Ghose

Installation of Metalorganic Vapor Phase Epitaxy (MOVPE) system for growth of compound semiconductor devices and nanostructures

The core of my research plan and strength is on semiconductor materials and devices, especially in the area of III V and II VI compounds. Particularly, I am interested in epitaxial growth of such compounds and different low dimensional nanostructures using MOVPE technique. An MOVPE system aimed at growing Ga In Al As P based materials is at its last phase of installation.

Satyaban Bhunia

Development of chemical vapor deposition (CVD) system for growth of ZnO

We have built a CVD system for growing ZnO thin films, nanowires and other type of self organized hierarchical nanostructures. A horizontal tube furnace was modified to a two temperature zone reactor with independent oxygen and nitrogen flows. The source and substrate temperature, and the gas flow ratios could be varied independently for growth of different ZnO nanostructures on different substrates. Vertically aligned as well as randomly oriented nanowires of ZnO have been successfully grown, after systematic variation of the controlling parameters, in the CVD process.

Satyaban Bhunia

Development of low temperature Photoluminescence System

We have developed a photoluminescence system using discrete components to suit our measurements of optical emission properties of different low and high bandgap semiconductor materials grown in our laboratory. Three different excitation sources, viz., He Cd laser (325 nm), tunable Ar+ laser, and a high intensity Xe lamp could be used for excitation, depending on type of materials and study. The spectra can be recorded in the wavelength range of 200 nm to 1550 nm and the temperature range of measurement is from room temperature to 4 K.

Satyaban Bhunia

Development of Indian Beamline at Photon Factory, Japan

Synchrotron x ray based nanomaterials characterization has been another area of my research interest. In this respect, I am involved as co principal investigator of a national project entitled "Indian Beamline at Photon Factory, KEK, Japan". The experimental station has been developed at this synchrotron facility in Japan to carry out powder diffraction at low temperature and high pressure, grazing incidence x ray diffraction, single crystal x ray diffraction and x ray reflectivity.

Mrinmoy Mukhopadhyay, Satyaban Bhunia, K S R Menon, Milan K Sanyal

Development of SINP Beamline at INDUS 2 RRCAT, Indore

I have also taken a major role in the national synchrotron project of INDUS 2 at RRCAT, Indore. Here, the "SINP Beamline" has been successfully assembled to carry out grazing incidence x ray scattering studies of surfaces and interfaces in solids and liquids, reflectivity, diffuse scattering, two dimensional diffraction, small angle scattering in reflection geometry, high resolution diffraction studies as a function of temperature, structural & morphological characterization of nanomaterials etc.

Satyaban Bhunia, KSR Menon, Alokmay Datta, Manabendra Mukherjee, Satyajit Hagra, Sangam Banerjee, Milan K Sanyal

Acoustic Study of Aqueous Electrolytic Solutions

The propagation velocity and attenuation constant have been measured for ultrasonic waves of frequencies 0.8 MHz, 1 MHz and 2 MHz propagating through NaCl solution in the concentration range 0-5.31M/L (nearly saturated). For all the three frequencies the velocity values show an overall increase with the increase of c indicating an increasing interaction potential among the ions and water molecules prevailing in the solution. The velocity values for 1 MHz and 2 MHz waves are found to be same in the whole concentration range whereas for 0.8 MHz wave, the velocity values are observed to be somewhat lower particularly in the lower concentration range. The attenuation constant is found to show relatively high values at several concentrations. Small kinks are observed in the velocity versus concentration curve near the concentrations at which attenuation peaks are located. These indicate the formation of relatively large size ion-solvent clusters. Measurements at other ultrasonic frequencies are in progress. Anis Karmahapatro is providing the technical assistance.

Barnana Pal, and Srinanda Kundu

Monte Carlo Study on Particles interacting through Lennard-Jones Potential

Dynamical evolution of two-dimensional atomic clusters consisting of mono-atomic particles interacting through Lennard-Jones (L-J) potential has been investigated using Monte Carlo Method in which realistic thermal motion of the particles have been introduced through a modification of the conventional Metropolis algorithm. The proposed algorithm leads to a quick equilibration from the nonequilibrium cluster configuration in a certain temperature regime, where the relaxation time (ô), measured in terms of Monte Carlo Steps (MCS) per particle, vary inversely with the square root of system temperature

(“T) and pressure (P); ô ˜ (P”T)$^{-1}$. From this a realistic correlation between MCS and time has been predicted. In the low temperature regime the system shows the presence of two relaxation times when the particle concentration is greater than a critical concentration. With the sudden decrease in temperature it firstly attains an amorphous structure and then slowly approaches towards an ordered crystalline structure. The dynamics of the system in this region is under study.

Barnana Pal

Simulation study on 2D aqueous electrolytes

Concentration dependence of velocity and attenuation of ultrasound in aqueous electrolytes show interesting features. There are indications for the formation of large size clusters in the solution. There are also other experimental evidences indicating structural transitions in these systems. For a better understanding of the phenomenon from a theoretical point of view we study the system in two dimensions using Monte-Carlo method considering realistic interaction among the particles. We consider Lennard-Jones potential alongwith the charge-charge, charge-dipole and dipole-dipole interaction prevailing between water molecules and the ions present in the system. Preliminary results show that ion-solute clusters are formed in the solution and the cluster size grows with the increase in the concentration. The work is in progress.

Barnana Pal, Srinanda Kundu, Haimanti Chakrabarti[†]

DAE Xth Five-Year Plan Project Surface Physics and Nanomaterials (termination)

The first stage of setting up facilities for combining microscopic and spectroscopic studies of nanomaterials has been completed with the successful operation of a Near-field Scanning Optical Microscope combined with Atomic Force Microscopy and Confocal Microscopy. This facility has already been used in the various research projects outlined below. This is a part of the development of a laboratory to study structure and dynamics at interfaces in soft materials, through spectroscopy and microscopy.

Alokmay Datta, Sudeshna Chattopadhyay, Nupur Biswas, and Susanta Banerjee

DAE Xth Five-Year Plan Project Grazing Incidence X-ray Diffraction Beamline at INDUS-2 Synchrotron (termination)

A beamline for grazing incidence scattering studies has been designed and installed at the Indian Synchrotron (INDUS-2) at Raja Ramanna Centre for Advanced Technology, Indore. The beamline consists of two toroidal mirrors and a double crystal Monochromator in slightly convergent beam geometry, with the focus at the centre of the experimental hutch. An eight-circle diffractometer, with the sample position within the convergent beam, completes the set-up. The beamline works in the 5-15 keV energy range.

Milan K Sanyal, Alokmay Datta, Sangam Banerjee, Manabendra Mukherjee, Satyajit Hazra, Satyaban Bhunia, S.R. Krishnakumar Menon, Avijit Das, Subir Roy, Susanta Banerjee

DAE XIth FYPP *Ce*ntre for *N*anomaterials and *Su*rface *P*hysics (CENSUP)

Radiation-Assisted Growth (RAG) of Advanced Materials: A modular system for Radiation Assisted Growth (RAG) with the aim of a completely new mode of reproducible growth of soft materials, namely, by resonantly pumping organic and metal-organic complexes to prescribed conformational states using coherent radiation in the terahertz (THz) region, along with the study of the materials with mesoscopic spatial resolution, has been conceptualized, designed and fabricated as a customized facility with Accurion GmbH, Germany. The system consists of a fibre-laser pumped THz laser, an Imaging Ellipsometer cum Brewster Angle Microscope, and a Langmuir-Blodgett trough.

Alokmay Datta

Indo-Italy (DST-PCO) Collaborative Exchange Programme. *Vacuum Ultraviolet and X-ray Absorption Spectroscopy.* Synchrotron studies – ELETTRA

Several experimental studies on polymer films, metal-polymer nanocomposites and Langmuir-Blodgett multilayers have been carried out, the details of which has been given in the research accounts below.

Alokmay Datta, Sudeshna Chattopadhyay, Smita Mukherjee, Nupur Biswas, Angelo Giglia†, Nicola Mahne†, Bryan Doyle†, Stefano Nannarone†

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Ph D Awards

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- Pradeep Risikrishna Varadwaj [AI Jaman], Rotational Absorption spectral studies and ab initio quantum chemical calculations of molecules in gas phase, Jadavpur University, March 2008
- Bhabesh Roy [Sailendranath Das], Study of the Transport and Magnetic Properties of Some Rare-earth Transition Metal Oxides, Jadavpur University, 2010
- Sudeshna Chattopadhyay [Alokmay Datta], Optical Spectroscopy and Structure of Polystyrene Films and Au-polystyrene Nanocomposites, Calcutta University, September 2007
- Puneet Mishra [D Ghose], Morphology and nanomechanical property studies of ion sputtered solid surfaces, Jadavpur University, May 2009
- Jayeeta Chowdhury [Sachindranath Karmakar] Some Studies of the electronics and magnetic properties of mesoscopic systems, Jadavpur University, 2010
- Sanjoy Datta [Y. Sudhakar] Study of Charge Density Wave Transition in ElectronPhonon Interaction Models, Jadavpur University, 2009
- Arnab Chatterjee [Bikas K Chakrabarti] Statistical Physics of two Model Dynamical Systems : Magnets & Trading Markets, Jadavpur University, 2008

- Arnab Das [Bikas K Chakrabarti], Quantum Annealing and Some Studies on Frustrated Quantum Systems, Jadavpur University, Jadavpur University, 2008
- Debi Prasad Datta [TK Chini], Modification of silicon surface under medium energy heavy ion Bombardment, Jadavpur University, January 2009
- Debasish Datta [SR Bhattacharyya], Ion induced growth, erosion and mixing of surfaces and interfaces, Jadavpur University, Kolkata, February 2009
- Soumik Mukhopadhyay [Indranil Das], Spin dependent Transport in magnetic nanostructure, Jadavpur University, Jadavpur University, 2009
- Anish Biswas [Indranil Das], Charge ordering and related phenomena in nano-materials, Jadavpur University, 2009
- Tapas Samanta [Indranil Das], Magnetocaloric effect and related phenomenon in rare-earth based compounds, Jadavpur University, 2010
- Rajib Sarkar [Amitava Ghoshray], NMR study in some ternary intermetallic compounds, Jadavpur Unversity, 2008
- Bholanath Pahari [Kajal Ghoshray],Experimental study of the magnetic properties of quasi-one dimensional antiferromagnets, August 2009
- Somnath Bhattacharya [Asok Kumar Sen], Dynamics of Nonlinear Composite Systems and their Theoretical Modeling, University of Calcutta, Kolkata, February 2008

Awards/Distinctions

Milan K Sanyal

- J.C. Bose Fellowship (from 2007)
- Member, Scientific Advisory Committee to the Cabinet (SAC-C), Government of India (from 2009)

Soumik Mukhopadhyay

INSA Medal for young Scientist 2009

Seminars/Lectures given in Conference or elsewhere

Milan K Sanyal

- Novel structure-property relationship in nanomaterials and possible device applications, Visionary Lecture Series in Indian Statistical Institute, Kolkata, 14th November 2007
- Material characterization with synchrotron x-ray scattering techniques, School organized by MRSI (Kolkata), October 7, 2007
- Ordering of gold nanoparicles formed at liquid-liquid interface, International Conference on Advanced Materials (ICAM), Bangalor 8th to 13th October 2007

- Novel Properties of nanometer-thick films, nanowires and nanodots, Institute of Solid State Physics (ISSP), University of Tokyo, Japan 20th July 2007
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- Wigner Crystal formation in nanowires of conducting polymers, Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR), Bangalore, January 25, 2007.
- Low dimensional physics using soft nanomaterials, DAE (India) – CEA (France) Meeting, Sacley, France, October 6-10, 2008
- Synchrotron x-ray scattering studies of formation and ordering of gold nanoparticles at toluene-water interface, International Conference on Molecular Materials (MOLMAT), Bangalor 5th December 2008
- Ferromagnetism in manganese doped zinc sulfide nanocrystals, INDO-JAPAN WORKSHOP ON NOVEL MAGNETIC ORDERING IN NANOSTRUCTURED MATERIALS, University of Tokyo, Jpana June 10, 11, 2008.
- Synchrotron x-ray and neutron scattering characterization of surfaces and interfaces, India-Japan Workshop on Quantum Beam Science, SINP 9-12th March 2008
- Possibility of Wigner crystallization in polymer nanowires, International Conference ICONSAT08, Chennai, February 29, 2008
- Formation and ordering of nanoparticles at Liquid interfaces, Soft Condensed Matter Group Seminar, ESRF, Grenoble, France, December 8, 2008
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- Structure, ordering and properties of soft nanomaterials, SEMINARIO DI STRUTTURA DELLA MATERIA, University of Rome Dipartimento di Fisica, Edif. E. Fermi October 3, 2008
- Confinement-induced ordering in condensed mater physics, Bose Colloquium, S. N. Bose National Centre For Basic Sciences, September 19, 2008
- Low-dimensional physics using nanomaterials, Ramanna Memorial Lecture, JNCASR, Bangalore, September 9, 2008
- Novel switching transition in conducting polymer nanowires, Advanced Nano Characterization Centre, NIMS, Tsukuba, Japan June 12, 2008

- Formation and ordering of Gold nanoparticles on water surface and water-toluene interface, Physics Department, University Maine, Le Mans, France, May 15, 2008
- Low-dimensional physics with simple nanomaterials: Wigner crystallization in conducting polymer nanowires, Colloquium, Tata Institute of Fundamental Research, April 30, 2008
- Possibility of Wigner crystallization in polymer nanowires, Condensed-Matter Physics & Materials Science Seminar, Brookhaven National Laboratory, USA, February 29, 2008
- Ordering of Gold Nanoparticles at the Toluene-Water Interface, XSD/TRR Seminar, Advanced Photon Source, Argonne National Laboratory, USA, February 22, 2008
- Existence of disordered "Wigner crystal" in conducting polymer nanowires, Francis Bitter Magnet Lab – MIT, USA, February 20, 2008
- X-ray reflectivity and diffuse scattering from nanoparticle-decorated liquid interfaces, Physics Department, Harvard University USA, February 20, 2008
- Wigner crystallization in conducting polymer nanowires, Physics Department, University of California – San Diego, April 8, 2009
- Two-dimensional ordering in Langmuir monolayer and Langmuir-Blodgett films, National Institute of Standard and Technology (NIST), Maryland, USA, April 15, 2009
- Wigner Crystallization in Conducting Polymer Nanowires, Frontiers and Directions in Condensed Matter Physics Centenary Conference, IISc, Bangalore, May 25, 2009
- Ordering of nano-structured materials at liquid interfaces, Liquid/Soft-Surface Interest Group Meeting ChemMatCARS – Advanced Photon Source (Argonne National Laboratory), August 17, 2009
- Ordering of nanoparticles at a liquid-liquid interface, Fifth JNC Research Conference on Chemistry of Materials, ALLEPPEY, Kerala, October 3-5, 2009.
- Formation and Ordering of nanomaterials at liquid-liquid interfaces, Physics Department Seminar, University of Tubingen, Germany, November 13, 2009.
- Novel Physical Properties of Nano-structured materials, Annual Day Function Lecture of UGC-DAE CSR, Indore, December 23, 2009
- Novel Properties of Nano-structured materials, National Conference on Materials Science: Trends & Future-2010 VidyaBharati MahaVidyalaya, Amravati, January 6, 2010
- Synchrotron X-ray Scattering Techniques for Nano-structured Materials, India-Brazil-South Africa (IBSA) Nanotechnology School on Advanced Materials, Chennai, India 22-26 February 2010.
- Neutron Reflectivity Study of a Two-dimensional Heterogeneous Magnetic Phase, India-Swedish 3rd Meeting, Orange County - Coorg, India 25-26 February 2010.

A Ghoshray

- *Application of NMR in magnetic materials*, Bangla Atomic Energy Commission, Atomic Energy Centre, Dhaka, Bangladesh, August 25, 2008

Kajal Ghoshray

- Research Activities of the NMR Laboratory of SINP, Institute of Low Temperature Physics and Engineering, Kharkov, Ukraine, October 2, 2007
- *NMR study of doped Haldane spin chain compound*, The international conference on Magnetic materials, SINP, Kolkata, December, 2007
- Impurity induced magnetic order in doped Haldane system SrNi2-xMgxV2O8, Bangladesh University of Engineering and Technology, Dhaka, September 2008

Indranil Das

- *Spin polarized transport and low field magnetoresistance in magnetic nanostructures*,Indo-French workshop on Magnetism and spintronics, Varanasi, January28- 31, 2010
- *Charge Ordering in Nanocrystalline Manganites,* National conference on Recent Advances in Correlated Electron Systems (RACES 2010), I.I.T. Guwahati, January 18-21, 2010
- *Spin Polarized Transport in Manganite Nanostructures*, National Conference-on Spintronic and Magnetoelectronic Materials and Devices (NCSMMD), IACS, Toshali Sands, Puri, January 8-10, 2009
- *Use of magnetocaloric effect to understand various phenomena in magnetic materials,* One day seminar on Contemporary Issues in Condensed Matter Physics, Physics Department, Jadavpur University, Kolkata, March 16, 2009
- *Magnetocaloric effect: Powerful tool to understand various phenomena in magnetic materials,* Moscow International Symposium on Magnetism, Moscow State University, Moscow, June 20-25, 2008
- *Novel phenomena related to magnetocaloric effect and Spin polarized transport,* Bioengineering & Electronic Engineering dept, University of Tokyo, Japan, June13, 2008
- *Physics with technologically interesting magnetic materials & nanostructures,* Tohoku University Sendai, Japan, June12, 2008
- *Spin polarized transport & novel phenomena in manganite nanostructures*, Indo Japan workshop on Novel Magnetic Ordering in Nanostructured Materials, University of Tokyo, Japan, June 10-11, 2008
- *Physics with technologically interesting magnetic materials & nanostructures,* ISSP Tokyo, Japan, June 9, 2008
- *Spin Polarized Transport in Manganite Nanostructures: Our Novel Findings,* TIFR Mumbai July 8, 2008
- *Physics with technologically interesting magnetic materials & nanostructures*, National Physical Laboratory, New Delhi, July 2, 2008
- *Physics with technologically interesting magnetic materials & nanostructures*, Bhabha Atomic Research Centre, Mumbai, July 9, 2008

- *Magnetocaloric effect: Powerful tool to understand various phenomena in magnetic materials*, Discussion Meeting on India-Australia Collaboration Initiative, TIFR, Mumbai, August 23-24 2008
- *Low field magnetoresistance in magnetic nanostructures*, IIT, Bombay, August 25, 2008
- *Novel phenomena related to low field magnetoresistance in magnetic nanostructures*, 1st State Level Seminar on Recent advances in Materials Science, Department of Physics, Ramananda College, Bishnupur, WB, March 27, 2008
- *Recent Development in Magnetocaloric Effect*, International Conference on Magnetic Materials (ICMM-2007) , Saha Institute of Nuclear Physics, Kolkata, India, December 11- 16, 2007

Chandan Mazumdar

- *Determination of crystalline electric field levels of $PrNi_2B_2C$ using inelastic neutron spectroscopic studies*, Discussion meeting on "India-Australia Collaboration Initiative to utilize new ANSTO Facilities", August 23-24, 2008, Tata Institute of Fundamental Research, Mumbai, India
- *Superconductivity and magnetism in Quaternary borocarbides: an experimental overview,* Special session on "Borocarbides", Condensed Matter Days 2009 (CMDays09), Jadavpur University, Kolkata, India, August 26-28, 2009
- *Determination of Crystalline Electric Field levels of $PrNi_2B_2C$ using Inelastic Neutron Spectroscopic studies*, Conference on Neutron Scattering and Mesoscopic Systems, Goa University, Goa, India, October 12-14, 2009

P Mandal

- First-order ferromagnetic transition in $Sm_{1-x}Sr_xMnO3$ manganites, Max Planck Institute for Chemical Physics of Solids, Dresden, Germany on Nov. 12, 2009

Abhishek Pandey

- Negative temperature coefficient of resistant and negative thermal expansion in a metallic pervoskite compound, UGC-DAE Consortium for Scientific Research, Indore, MP, India, June 15, 2007

Asok K Sen

- *Dynamics of Ductile Fracture in Complex Systems using the RRTN model*, Physics Department, IIT, Mumbai (Powai), June 29, 2007
- *A Possible Scenario of Using the GARUDA-Grid for doing Physics at the SINP,* 2nd. Workshop for Developing Applications in GARUDA (a national effort on a Grid-system of supercomputer)"(DAG07), IIT, Mumbai, June 30, 2007
- *Power-law Dynamics in Nonlinear Complex Systems through the RRTN Model*, International Conference and Workshop on Perspectives in Nonlinear Dynamics, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, July 27, 2007

- *Ductile Fracture and its Power-law Dynamics in the RRTN Model for Nonlinear Complex Systems*, Eleventh International Symposium on Continuum Models and Discrete Systems, Ecole des Mines de Paris, Paris, France, August 3, 2007
- *Ductile fracture and its Power-law dynamics in the RRTN model for nonlinear complex systems*, International Conference on Condensed Matter Physics (ICCMP-2007), Jaipur, November 28, 2007
- *Dynamics and Breakdown in Complex (nonlinear) Systems*, Bose Conerence on Contemporary Physics - 08, Physics Department, Univ of Dhaka, Bangladesh, March 21, 2008
- *Strong Memory and Recognition in the RRTN Model*, Fourth International Conference on Natural Computation(ICNC2008), Jinan, China, October 20, 2008
- *Low-dimensional Disordered Mesoscopic Systems: Quantum and Semi-classical Aspects*, Institute of Physics, Chinese Academy of Sciences (CAS), Beijing, October 22, 2008

Y Sudhakar

- **C**ooperative electron-phonon interactions in molecular chains, Univ. of Bristol, UK, February 13, 2008
- **C**ooperative Jahn-Teller effect in lowdimensional manganites, Univ. of Leicester, UK, January 23, 2008
- **C**ooperative electron-phonon interactions in molecular chains, Imperial College, London, UK, January 15, 2008
- **C**ooperative Electronphonon Interactions in One Dimension, Purdue Univ., USA, December 7, 2007
- **C**ooperative Jahn-Teller effect in manganite chains, TCM group seminar, Cavendish Lab, Univ. of Cambridge, UK, October 22, 2007
- Orbital ordering in undoped manganites via a generalized Peierls instability, ICTS Condensed Matter Programme 2009, December 5–22 2009
- Critical Issues Related to Higher Temperature Superconductors, KITP, Santa Barbara, USA, June 22-26, 2009
- Supersolidity in a BoseHolstein model, Low Dimensional Electron Systems program, KITP, Santa Barbara, USA., January 2–June 12, 2009
- ECONOPHYSICSKOLKATA IV: International Workshop on Econophysics of Games and Social Choices, Indian Statistical Institute & Saha Inst. Nucl. Physics, Kolkata, India, March 9–13, 2009
- Quantum phase transition in an anisotropic nextnearestneighbor Heisenberg model, Meeting on Entanglement in quantum condensed matter systems , IMSc, Chennai, India, December 12, 2008
- Magneticoxide nanoelectronics, Workshop on Challenges in nanoelectronics, SINP, Kolkata, India, November 27, 2008

- Quantum phase transition due to cooperative electronphonon interaction in lowdimensional systems, Indian condensed matter workshop organized by ICTS of TIFR, Mumbai, India, December 922, 2008
- Miniprogram on: Sr2RuO4 and Chiral pwave Superconductivity, KITP, Santa Barbara, USA, Dec 14-21, 2007
- Cooperative Electronphonon Interactions in One Dimension,Moments and Multiplets in Mott Materials program at KITP, Santa Barbara, USA, Nov 14-Dec 14, 2007
- IOP conference (Condensed Matter and Materials Physics), Univ of Leicester, UK, April 11-13, 2007
- Quantum phase transition and phase diagram at a general filling in the spinless onedimensional Holstein model, International seminar and workshop on the Strong Correlations and AngleResolved Photoemission Spectroscopy, MPIDresden, Germany, April 10–May 11, 2007

Pradeep Kumar Mohanty

- Istanbul Technical University, Istanbul, Turkey, May 18, 2010
- Ankara University, Turkey, May 12, 2010
- Dept of Biology, TIFR, Mumbai, INDIA, Feb 17, 2010
- Tata Institute of Fundamental Research, Mumbai, INDIA, Nov 24, 2009
- Harishchandra Research Institute, Allahabad, INDIA, July 23, 2009
- *Quenching, Annealing and Quantum Computation,* International Workshop on Quantum Phase Transition and Dynamics, Saha Institute of Nuclear Physics, Kolkata, India, February 3–7, 2009
- CMDAYS10, Kalyani University, Kolkata, India, August 25-27, 2010
- Bioinformatics in Evolutionary Studies, Kalyani University, February 23–26, 2010
- Nonequilibrium Statistical Physics, *IIT Kanpur Golden Jubilee Conference,* IIT Kanpur, Kanpur, India, 30 Jan–8 Feb 2010
- *Heat conduction in low dimensional systems*, Raman Reserach Institute, Bangalore, India March 15–21,2009
- Current trends in Evolutionary Biology, 18–22, November 2008
- *Many-Body Systems far from Equilibrium: Fluctuations, Slow Dynamics and Long-Range Interactions*, MaxPlank Institute for Complex Systems, Dresden, Germany, February 16 27, 2009

Purushottam Chakraborty

- *Metal colloids in fused silica glasses as photonic elements*, Physics Department, University of Pretoria, South Africa, May 24, 2007
- *MCsn+ - SIMS'; understanding and challenging applications in materials research*, Council of Scientific and Industrial Research (CSIR), Pretoria, South Africa, July 7, 2007

- *Metal nanocluster-glass composites for switching applications*, Department of Information Technology, Monash University, South Africa, August 23, 2007
- *Fundamentals and applications of secondary ion mass mass spectrometry for compositional analysis of quantum structures*, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa, August 24, 2007
- *Fundamentals and applications of secondary ion mass mass spectrometry for compositional analysis of quantum structures*, iThemba Labs (Laboratory for Accelerator Sciences), Cape Town, South Africa, October 18, 2007
- *Ion beam induced metal quantum dots in glasses for photonic devices*, Department of Micro Engineering, Kyoto University, Japan, March 7, 2008
- *High depth resolution SIMS for surface/interface analysis*, University of Tokyo and RIKEN, Japan, March 10-11, 2008
- *High depth resolution SIMS for surface/interface analysis*, Ritsumeikan University, Japan, March 19, 2008
- *Nonlinear optics of ion beam synthesized metal quantum dot – glass composites*, School of Physical and Mathematical Sciences, Newcastle University, Newcastle, Australia, December 1, 2008
- *Perspectives of Nanomaterials Research – a popular science*, the Special Broadcasting Corporation (SBS), Sydney Radio, Australia, November 28, 2008
- *Ion Surface Collisions and Secondary Ion Mass Spectrometry* (Tutorial Talk), School of Physics, Central University of Hyderabad, India, November 25, 2009
- *Understanding and applications of MCsn+ - SIMS in direct quantification*, Materials Department, Imperial College, London, England, June 14, 2010
- *Understanding and applications of MCsn+ - SIMS in direct quantification*, Hiden Analytical Limited, Warrington, England, June 17, 2010
- *Large third-order dielectric susceptibility of silver-glass nanocomposites*, Physics Department, Vanderbilt University, Nashville, Tennessee, USA, October 4, 2010
- *Fundamentals and applications of MCsn+ molecular ion complexes in quantitative interface analysis*, Physics Department, Furman University, Greenville, South Carolina, USA, October 5, 2010
- *Metal colloids in fused silica glasses as photonic elements*, Electrical Engineering Department, Yale University, New Haven, Connecticut, USA, October 7, 2010
- Winter School on Dynamics of Solids, 52nd Annual Conference of the South African Institute of Physics (SAIP), Witwatersrand University, Johannesburg, South Africa, July 2-6, 2007
- 18th International Conference on Ion-Surface Interactions (ISI–2007), Zvenigorod, Russia, August 24-28, 2007

- 18th International Conference on Ion Beam Analysis (IBA-2007), Hyderabad, India, September 23-28, 2007
- Symposium on Ion Beam Technology and Applications, Bhabha Atomic Research Centre (BARC), Mumbai, India , September 19-21, 2007
- 10th International Conference on Advanced Materials (IUMRS-ICAM 2007), Bangalore, India, October 8-13, 2007
- Discussion Meeting on Role of Surfaces and Interfaces in Nanomaterials, Saha Institute of Nuclear Physics, Kolkata, India , October 12-13, 2007
- 53rd Annual Conference of the South African Institute of Physics, University of Limpopo, Turfloop Campus, South Africa, July 8-11, 2008
- 23rd International Conference on Atomic Collisions in Solids (ICACS-23), South Africa, August 17-22, 2008
- National Conference on Nanotechnology and its applications in Quantum Computing (NAQC 2008), Govt College of Engineering and Leather Technology, Kolkata, India, September 22-24, 2008
- 4th International Topical Meeting on High Temperature Reactor Technology, Washington DC, USA, Sep 28– Oct 1, 2008
- 8th Asian International Seminar on Atomic and Molecular Physics, Western University of Australia, Perth, Australia, November 24-28, 2008
- DST – SERC School on Science & Technology of Processing Plasmas, BIT, Mesra, India, December 15 – 27, 2008
- 2nd International Conference on Physics at Surfaces and Interfaces (PSI2009), Puri, India, February 23-27, 2009
- 18th International Conference on Ion-Surface interactions (ISI-2009), Moscow, Russia, August 21-25, 2009
- Theme Meeting on Quantum Structures, Bhabha Atomic Research Centre (BARC), Mumbai, India, November 2-3, 2009
- 11th ISMAS Triennial International Conference on Mass Spectrometry (ISMAS-TRICON-2009), Ramoji Film City, Hyderabad, India, November 24-28, 2009
- International Conferencce on Computers and Communications (CODEC-09), Kolkata, India, December 14-16, 2009
- Indian Physical Society One Day Seminar on Recent Trends on Atomic, Molecular and Optical Physics, IACS, Kolkata, India, March 17, 2010
- ICMCTF (International Conference on Metallurgical Coatings and Thin Films)-2010, San Diego, USA
- 18th International Conference on Inelastic Ion - Surface Collisions (IISC-18), Oak Ridge National Laboratory, Tennessee, USA, September 26-October 1, 2010

Debabrata Ghose

- *IBS nanostructuring of polycrystalline metal films: the role of incidence angle and surface roughness*" workshop "Nanoscale Modification of Surfaces and Thin Films", Rathen, Germany, August 30–September 3, 2009

Alokmay Datta

- *Nanoconfinement*, Bengal Engineering and Science University, Shibpur, Howrah, West Bengal, February 22, 2008
- *What are Materials?,* Chandernagore College, Chandernagore, Hooghly, West Bengal, India, March 24, 2008
- International Conference on Nanoscience & Technology - China 2007 (National Centre for Nanoscience and Technology, China), Beijing International Convention Centre, Beijing, China, June 4-6, 2007
- One Day Seminar by West Bengal Academy of Science and Technology: Presentation of the Fellows (West Bengal Academy of Science and Technology), Central Glass & Ceramic Research Institute, Kolkata, West Bengal, India, August 18, 2007
- Discussion Meeting on Role of Surface and Interfaces in Nanomaterials (Centre for Nanoscience and Surface Physics (CeNSuP)), Saha Institute of Nuclear Physics, October 12-13, 2007
- International Conference on Soft Systems (Indian Society for Surface Science & Technology), Central Glass & Ceramic Research Institute, Kolkata, West Bengal, India, February 13-15, 2008
- INDIA-JAPAN Workshop on Quantum Beam Science (Centre for Nanoscience and Surface Physics), Saha Institute of Nuclear Physics, Bidhannagar, West Bengal, India, March 7-12, 2008
- IEEE International Symposium on 'Micro-Nano Mechatronics and Human Science, 2008', Nagoya University, Japan, 6-9 November, 2008
- NAIP-ICAR Workshop on Nanomaterials, Indian Statistical Institute, 19 March, 2009.
- International Conference on Nanoscience and Nanotechnology (ChinaNANO 2009), Beijing, China, 1-3 September, 2009.
- India-Italy Workshop on Application of Synchrotron Radiation to Condensed Matter Problems: Basic and Applied Research, Indian Institute of Science, Bangalore, 23-25 November, 2009.
- 23rd National Convention of Metallurgical & Materials Engineers, RANDET-2010, Institution of Engineers (India), Kolkata, 15-16 January, 2010.
- *Reciprocal and Real Space Data: Formalism for Diffraction and Microscopy Data*, A Short Course on Advance Techniques for Materials Characterization: Microscopy and Diffraction (MRSI-Kolkata Chapter), Central Glass and Ceramic Research Institute, Kolkata, West Bengal, India, October 29-November 2, 2007
- *Materials: Soft and Nano*, Chameli Basu Memorial Lecture, Bethune College, September 8, 2009

Manabendra Mukherjee

- *An overview of synchrotron and related research*, Dinabandhu Andrews College, Kolkata, India, September 19, 2007
- *Novel structure and swelling dynamics in ultrathin films of water soluble polymer and nanocomposites*, Institute for Materials Chemistry and Engineering, Kyushu University, Japan, March 25, 2008
- *Neutralization kinetics of charged polymer surfaces: A photoemission study*, Institute of Chemical Research, Kyoto University, Japan, March 27, 2008
- *Annealing Induced Modification of Ultrathin Polyacrylamide Film*, 54th DAE Solid State Physics Symposium, M.S.University of Baroda, Vadodara, December 14-18, 2009
- *Onset Thermal Degradation of Ultrathin Polyacrylamide Films*, XPS, NEXAFS and XRR study, Elettra Synchrotron Center, Trieste, Italy October 21, 2009
- *Thermal Degradation Of Ultrathin Polyacrylamide Films*, Launch Workshop of National Agricultural Innovation Project, Indian Statistical Institute, Kolkata, March 16, 2009
- *Applications of Synchrotron Radiation and Neutron Beams to Soft Matter* Science, Study of Thermal Degradation And Structural Modification Of Ultrathin Polyacrylamide Films Using XPS, NEXAFS And XRR Techniques, IUMRS-International Conference in Asia 2008 Symposium X, Nagoya Congress Center, Nagoya, Japan, December 11-13, 2008
- *Effect of annealing induced polymer substrate attachment on swelling dynamics of ultrathin polymer films*, Global COE Seminar,Institute of Chemical Research, Kyoto University, Japan, December 09, 2008
- *Characterization of Langmuir-Blodgett film using differential Charging in X-ray photoelectron spectroscopy,* The 3rd Taiwan - Japan Workshop on Neutron Scattering of Bio-materials and Soft-matters for Nanotechnology and Biotechnology, CO-OP INN KYOTO, Kyoto, Japan, December 4-6, 2008
- *An overview of synchrotron and related research,* Workshop on Renewable Energy and Prof DP Sarkar memorial lectures and Science Exhibition at Department of Physics, Kalyani Govt. Engg. College,Kalyani University, April 30, 2008

SR Bhattacharyya

- *Energy distribution of secondary ion emission from SiO2 surface bombarded by high energy and highly charged Xeq+ ions,* 18th International Conference on Ion Beam Analysis, University of Hyderabad, Sept. 23-28, 2007
- *Production and deposition of energetic metal nanocluster ions of silver on Si substrates,* 15th International Conference on Surface Modification of Materials by Ion Beams (SMMIB-15), TIFR, Mumbai, September 30-October 5th 2007
- *Morphological aspects of Si-supported silver nanocluster films*, Discussion Meeting on Role of Surface & Interfaces in Nanomaterials, Organised by Centre for Nanoscience & Surface Physics (CENSUP), SINP, Kolkata, October 12-13, 2007

- *Ion beam mixing of metallic films due to inert gas ions in the medium keV energy regime*, DAE-BRNS Seminar-cum-Workshop om Materials Characterization and Surface Modification in Research and Industry using Ion Accelerators (MCIA), Institute of Physics, Bhubaneswar, March 31–April 4, 2008

TK Chini

- *Photoluminescence from Si: effect of ripple microstructures induced by argon ion irra- Diation*, 15th International Conference on Surface Modification of Materials by Ion Beams (SMMIB-15), University of Mumbai and Materials Research Society of India (Mumbai Chapter) in association with BARC and TIFR, Mumbai, India, September 30- October 5, 2007
- *Cross-sectional Transmission Electron Microscopy and Small Angle X-ray scattering investigation of Medium keV Ar-ion-induced Patterned Surface Nanostructures in Si*, International Conference on electron Microscopy and Allied Fields along with XXXI Annual Meeting of electron Microscopy Society of India (EMSI), BARC, Mumbai, March 8-10, 2010

Satyaban Bhunia

- *Facility for MBE and MOVPE growth of compound semiconductors*, National Review and Coordination Meeting on Nanoscience and Nanotechnology, Hyderabad, Feb 21–23, 2007
- *Our research of ZnO* (Two talks), University of Cambridge and the University of Oxford , December 10-19, 2007
- *The growth and characterization of ZnO nanostructures carried out in our laboratory,* University of Leipzig, Germany, April 2007
- *MOCVD and CVD growth of compound semiconductor nanostructures,* Indo French (DAE CEA) workshop, Saclay, France, Oct 6–10, 2008
- *Nanoelectronics: Science, Nanotechnology, Engineering & Applications*, IIT, Kharagpur, July 7-19, 2008
- *Growth and fabrication of nanostructured devices*, IIT Kharagpur, Kolkata, India, July 9, 2008
- *Science and Technology of the Nanomaterials*, Bengal Engineering and Science University, Nov 28, 2008
- *Insight of epitaxial crystal growth process by insitu grazing incidence synchrotron x ray technique*, School on Quantum Beam Science, SINP, Kolkata, March7– 12, 2008
- *Growth of semiconductor nanowires and self assembled ZnO Nanostructures*, Optoschool, TIFR, Mumbai, July28–August2, 2008
- *Observation of Fabry Perot cavity modes in the photoluminescence spectra of aligned ZnO nanowires,* The 6th International Workshop on Nano scale Spectroscopy and Nanotechnology held at Kobe, Japan, October 25-29, 2010

Satyajit Hazra

- *Surface Physics and Nanoscience at Saha Institute,* IBSA Nanotechnology Initiative, IGCAR, Kalpakkam, India, April 06, 2007

Srinanda Kundu

- Physics of Materials (2 Lectures), National Institute of Technical Teachers' Training & Research, (NITTTR), Kolkata, March 22-26, 2010

Teaching elsewhere

Bikas K Chakrabarti

- Quantum Statistical Mechanics (18), January 1, 2008 to April 30, 2008, MSc (General) Presidency College, Kolkata
- Stat. Mech II (Quantum Stat. Mech) for 2007–2010 & Cond. Matter Phys. (Spl.; Coop. phenomena) for 2007–2009 for MSc (Phys), Presidency College, Kolkata

Alokmay Datta

- Nanomaterials (30 Lectures), December 1, 2007 to March 31, 2008, M Phil 2007-08, (General) West Bengal University of Technology, Bidhannagar, West Bengal, India
- *Amorphous and Crystalline Nanomaterials* (40 Lectures Course), January to March, 2010, M Tech in Materials Science, Department of Metallurgy and Materials Science, Bengal Engineering and Science University, Shibpur

SR Bhattacharyya

- *Principle and Techniques of Mass Spectrometry,* A Course Lectures delivered along with practical demonstration under a Course, *Instrumental Techniques in Chemical Analysis* (Post-Graduate Diploma Course) in the Department of Instrumentation Science, Jadavpur University, Kolkata, during May 23 to June 5, 2007 (Organised by Department of Adult, Continuing Education & Extension, Jadavpur University, Kolkata).
- *Principle, Techniques and Applications of Mass Spectrometry,*A Course Lectures delivered along with practical demonstration under Instrumental, Techniques in Chemical Analysis (Post-Graduate Diploma Course) in the Department of Instrumentation Science, Jadavpur University, Kolkata, in July and in November, 2008, (Organised by Department of Adult, Continuing Education & Extension).

Srinanda Kundu

- Advanced experimental methods in condensed matter physics, M.Sc. (Specials), Lady Brabourne College, Calcutta, 2009

Satyajit Hazra

- Scanning tunneling microscopy for topography and beyond, A Short Course on Advance techniques for Materials Characterization:Microscopy and Diffraction, MRSI-Kolkata Chapter, CGCRI, Kolkata, India, October 29- November 02, 2007

Miscellany

Bikas K Chakrabarti

- ECONOPHYSICSKOLKATA V: International Workshop on Econophysics of Orderdriven Markets, Saha Institute of Nuclear Physics, Kolkata, India, March 9–13, 2010 ***(Organiser)***

- Interaction, Instability, Transport and Kinetics: Glassiness and Jamming, *IIT Kanpur Golden Jubilee Conference*, IIT Kanpur, Kanpur, India, February 4-8 2010 ***(Conference Summary)***
- ECONOPHYSICSKOLKATA IV: International Workshop on Econophysics of Games and Social Choices, Indian Statistical Institute & Saha Inst. Nucl. Physics, Kolkata, India, March 9–13, 2009 ***(Organiser)***
- Nonequilibrium Statistical Physics, *IIT Kanpur Golden Jubilee Conference*, IIT Kanpur, Kanpur, India, 30 Jan–8 Feb 2010 ***(Conference Summary)***
- Outstanding Refereee of the Am. Phys. Soc. (2010; selection 2009 Oct.)

Purushottam Chakraborty

- 23rd International Conference on Atomic Collisions in Solids (ICACS-23), 17-22 August, 2008, South Africa ***(Member, Organizing Committee)***
- Adjunct Professor of Physics, University of Pretoria, SOUTH AFRICA, January 2010
- Invited Member, Council of NANOAFNET (Nanosciences African Network)

Debabrata Ghose

- Invited by Prof. Dr. Rodolfo Cuerno of the University Carlos III de Madrid, Spain to contribute an article on ion beam sputtering induced metallic nanostructure formation which appeared in the special issue of *J Phys.: Condens Matter* **21** (2009) 224001

Y Sudhakar

- Awarded a fellowship to spend one year (on sabbatical/deputation leave) from 01.04.2007 to 31.03.2008 at the Theory of Condensed Matter group of Cavendish lab (Univ. of Cambridge)

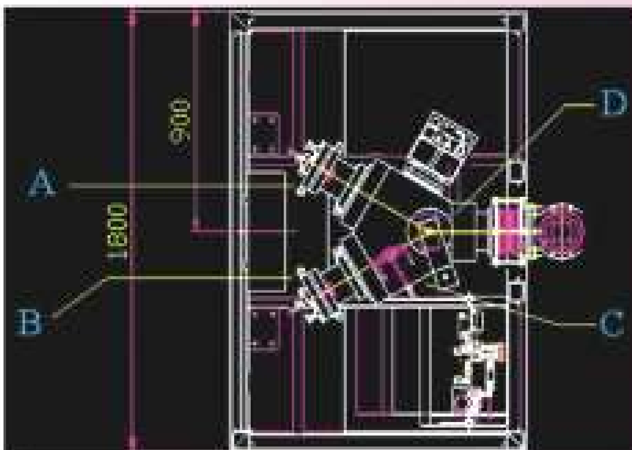
Soumik Mukhopadhyay

- Best thesis presentation award, DAE Solid State Physics Symposium, 2008

Alokmay Datta

- Young Scientists' Colloquium (Materials Research Society of India, Kolkata Chapter), Rashbehari Siksha Prangan, University of Calcutta, Kolkata, West Bengal, India, July 27, 2007 ***(Organizer)***
- A Short Course on Advance Techniques for Materials Characterization: Microscopy and Diffraction (MRSI-Kolkata Chapter), Central Glass and Ceramic Research Institute, Kolkata, West Bengal, India, October 29-November 2, 2007 ***(Organizer)***
- Young Scientists Colloquium (YSC-09), 30 October, 2009, Saha Institute of Nuclear Physics ***(Convener)***
- Research Project funded by Department of Biotechnology on Nanobiotechnology for Agricultural and Medical Sciences: An Interface with Nano Surface Physics jointly with Dr. Arunava Goswami of ISI Kolkata

Experimental Nuclear and Particle Physics



3 Experimental Nuclear and Particle Physics

Summary of Research Activities of Divisions

Nuclear Physics

The present research activities in Nuclear Physics broadly include study of nuclear structures and nuclear reactions from spectroscopic data using the different Accelerator Centre in India and a few abroad. In addition, the members of the Division are actively involved in the setting up of a **Facility for Research in Experimental Nuclear Astrophysics** (FRENA) at the Saha Institute of Nuclear Physics. The other major activities are: theoretical research, developmental activities and EDXRF spectrometry.

The highlights of Accelerator based research in nuclear structure are identification of magnetic rotation bands in ^{83}Rb, ^{111}In and ^{143}Sm, first observation of band termination in ^{111}Sn based on lifetime studies, indication of the onset of collectivity in ^{30}P, study of the yrast band in ^{155}Tm up to high spins, study of transition rates in mirror nuclei ^{35}Ar and ^{35}Cl and exploration of high spin states and isomer decays in trans-lead nuclei. Recently, experiments were performed at GSI, Darmstadt to understand the failure of magic number (N~20) through Coulomb breakup using the LAND-FRS setup and at NSCL, Michigan State University to study the lifetime of excited state of ^{16}C isotope through gamma ray spectroscopy. Both off-line and on-line studies of fission fragments are also being planned.

In Nuclear Reaction studies, measurements (fusion cross-sections and elastic and alpha angular distributions) were made with loosely bound projectiles ^{6,7}Li on different targets like ^{24}Mg, ^{28}Si, ^{159}Tb and ^{64}Ni at sub, near and above-barrier energies leading to an improved understanding of fusion mechanism vis-à-vis breakup/total/incomplete fusion components, anomaly of enhancement & suppression and effect of the breakup reaction pathways on the energy dependence of the effective interaction. Besides, measurements were carried out for the heavy systems ^{10,11}B+^{209}Bi, using pulsed beams from the Pelletron facility at the Australian National University. Alpha cluster states were studied from resonance breakup of ^{18}O from ^{12}C target (at E(^{18}O) = 94.5 MeV) into á and ^{14}C particles. Several new states between 11-18 MeV were observed and new spin parity for the 11.59 MeV cluster state was proposed.

Highlights of theoretical studies include analysis of ^{16}O breakup data at intermediate energies from a heavy target to extract the reduced alpha width and ANC of ^{16}O states, study of ^{16}O breakup from a light target to deduce its alpha spectroscopic factors, a generalized mass formula was developed for non-strange, strange and multi-strange nuclei and predicted the binding energies of pure hyperonic systems, shell model study of neutron rich nuclei near ^{132}Sn in order to generate an appropriate empirical interaction and study the evolution of collectivity in this exotic mass domain.

The developmental work includes the development of (a) Planar charged particle array, (b) gas scintillation proportional counter, (c) set up for fission gamma-ray spectroscopy and (d) high energy gamma-ray detector array. A Multi gap Multi-strip Resistive Plate Chamber (MMRPC**)** detector was developed at the SINP and the performance of the detector was studied using both cosmic background and γ**-** ray source at the laboratory. The detector has been recently tested using pulsed electron beam at Germany. This MMRPC can be used as an active part of Neutron detector of R3B, FAIR facility at Darmstadt.

Radio-isotope induced off-line studies of environmental samples are also carried out. An EDXRF spectrometer with the newly procured Super Si(Li) detector having ultra thin Be-window has been setup and optimized for detection from K to Pb and different samples e.g. Municipal Solid Wastes (MSW), Soils, Vegetables grown on MSW, Air Particulate Matter are analyzed and absolute quantification done using the AXIL/QXAS Code system.

The Nuclear Physics Division has undertaken to set up FRENA. This will constitute a major field of research in the future. FRENA is a national project and will be a unique facility in the country. The facility is centered on a 3 MV Tandetron (Tandem accelerator) that will provide low energy beams of light and heavy-ions with very large current. Highest proton beam currents will be about 500 µA. The machine will also deliver pulsed beams of light ions (H, He and D). The facility is expected to be operational within the next 3-4 years. The department has also initiated several related activities that include (i) collaboration with JINA, University of Notre Dame, (ii) preparation of thin targets by implantation, (iii) theoretical reaction network calculations and (iv) development of a windowless gas-target set up and a sophisticated detector system.

It is envisaged that a Recoil Mass Analyzer and provisions for studies of neutron-induced reactions will be augmented to the facility during the next phase of development.

High Energy Nuclear and Particle Physics

This Division is newly created in December 2010. The research activities in High Energy Physics involve the experimental and theoretical studies of matter produced in Ultra-relativistic Heavy Ion Collisions and nuclear structure studies at high spin.

In the domain of experimental high energy physics, Saha Institute has played a key role in ALICE Collaboration at Large Hadron Collider, CERN. Currently, the 1.1 Million readout channels of the Muon Spectrometer of ALICE are being successfully readout for p-p collisions using the MANAS chip which has been developed by Saha Institute. In addition, the 2nd Tracking Station of the spectrometer which has been commissioned by SINP in

February, 2008 and is fully functional since then. During 2010, which is the first year of LHC operation, SINP is responsible for the run coordination of the Muon Spectrometer of ALICE. Thus, currently SINP is playing a significant role on collection, quality monitoring and analysis of the data. SINP team has also successfully commissioned the High Level Trigger for Muon Spectrometer in May, 2010.

On the theoretical side, the photon spectra in anisotropic quark-gluon-plasma (QGP) have been calculated and compared with the experimental data measured at RHIC, BNL. We have also explored the possibility of para-ferro phase transition in dense quark system which may be realized at the core of neutron stars. We have also calculated a charge symmetry violating potential due to ñ–ω and π–ç mixing for asymmetric nuclear matter.

The nuclear structure studies are being pursued at the two Pelletron Accelerator Centres at Delhi (IUAC) and Mumbai (BARC-TIFR) using the Indian National Gamma Array (INGA). The primary objective of these studies has been to understand the various excitation modes through which the high angular momentum states are formed. In our group, we have been working in mass-100 region and have studied the properties of ^{103,104,108,109,110}Ag and ^{105,106,108,109,110}Cd. This systematic study has revealed both interplay and competition between collective rotation and Shears mechanism in this mass region.

Applied Nuclear Physics

Using nuclear tools and techniques, the structure and dynamics of crystals, composites, nano-materials and soft condensed matter systems have been probed. Positron annihilation spectroscopic techniques have been employed to carry out studies on spectroscopy and photo chemistry of uranium in solution and liquid microemulsion system, studying the aggregation behaviour of the extractant, micelles/ reversed micelles, polymers etc. These studies are corroborated with complementary techniques such as light scattering, and photochemical methods. Study of positronium (Ps) pick-off annihilation in molecular substance including liquid systems, development of theoretical models, study of electron transfer reaction of Ps and spin conversion (electron spin exchange through paramagnetic ions) using inorganic solute ions in aqueous systems, and development of corresponding theoretical models are also carried out. Investigations of polymeric systems, multi porus materials, conducting polymers, radiation damage of polymers have also been done in the laboratory and the results are compared with gas absorption BET method. Study of some biologically important molecules, and usage of positron annihilation as a tool for surface studies have also been successfully conducted by the group. Positron annihilation spectroscopy was used for the studies of properties and processes related to defects in nanomaterials including metals, alloys, ferrites and semiconductors. Irradiation induced structural changes in metals, alloys and superconducting materials have been explored using the ion beams from the tandem Pelletron facility at TIFR, Mumbai and from the cyclotron at the Variable Energy Cyclotron Centre (VECC), Kolkata.

Using time-differential perturbed angular correlation (TDPAC) technique, studies of point defects, structural and magnetic phase transitions in metallic and inter-metallic systems, thin films and nano-crystalline materials are carried out. A four-detector TDPAC spectrometer with ultra fast BaF_2 detectors has been developed for the above purpose. Highlights of the research carried out in the TDPAC lab include chemical transformation of crystalline hafnium tetrafluoride and thin films of hafnium dioxide. Dehydration pathway of $HfF_4.3H_2O$ has been clearly established by this study. Thin films of HfO_2 produced by pulsed laser deposition at various partial oxygen pressures have been studied to determine the nuclear quadrupole interaction (NQI) and presence of any ferromagnetism in HfO_2 thin film. No indication of room-temperature ferromagnetism in HfO_2 thin film was found.

In the Atomic Physics and laser spectroscopy lab, design and development of the experimental setup for the measurement of lifetimes of excited atomic and molecular states using high frequency deflection technique with a delayed coincidence single photon counting arrangement and cascade-photon-coincidence technique was done. A large number of levels of some inert gases, both neutral and singly ionized, are investigated with the help of this apparatus. Some of the atomic levels investigated are: $2p^5nd$ (n=4,5) and $2p^5ns$ (n=5,6) configuration of NeI, $3p^44p$ and $3p^44d$ configuration of ArII, etc. A time resolved laser spectroscopy (TRLS) setup for radiative lifetime measurement using selective pulsed laser excitation and time resolved observation of the reemitted fluorescence is under development.

Development of different types of gas based radiation detectors operating in ionization, proportional, avalanche and streamer modes; has been carried out. These detectors are used in various experiments involving gamma spectroscopy with charged particle tagging, exploring the nuclear dynamics of a few nucleon transfer reactions, fission and fusion reactions, and also for the detection of cosmic muons by RPC with an aim to develop indigenously built large area active detectors for a 50 kT iron calorimeter as planned for the India based Neutrino Observatory (INO). Simulation work on avalanche propagation in wire grid based avalanche counters; simple phenomenological model based nuclear structure calculations to generate input to nuclear reaction codes are also carried out for interpretation of experimental findings.

Our members have successfully implemented the Boundary Element Method (BEM) to solve for potential and flux field in a non-dissipative system governed by Laplace’s equation. The novelty of the solver lies with the formulation of the BEM following analytic integration of Green’s function of the singularities uniformly distributed over a typical rectangular and/or triangular panel and its derivative. Owing to the analytic formulation, the solver can provide nominally exact results and thus has been termed as nearly exact BEM. The solver has been applied to study the physical as well as weighting field configurations of a diverse group of detectors that includes a few wire chambers, TPC, RPC and several new generation micro-pattern gaseous detectors (MPGD) such as Micro-Wire, Micro MEGAS, THGEM etc. The neBEM has been optimized as a toolkit to be interfaced with an existing simulation software GARFIELD which performs a detailed simulation of the overall dynamics of a gaseous detector. This work has been performed as a part of RD51 collaboration launched by CERN to pursue a collective effort towards the development of MPGDs. Studies on a novel approach, named Particles on Surface (ParSur), for simulating the space charge evolution in gaseous detectors has been initiated using the fundamentals of neBEM formulation. The preliminary calculation for a simplistic model has produced promising results in comparison to the standard approach, namely particle-in-cell (PIC), used for simulating similar physical phenomena in several areas of science. Side by side, experimental efforts to study various physics issues in detector dynamics have been initiated with several developments taking place in a brief period of time. A set-up including gas handling system and test chamber has been completed. A time projection chamber (TPC) has also been procured for this purpose. The planning for the experiments is underway with the detectors.

We are also involved in the design of MANAS, a low noise ASIC readout chip for the ALICE relativistic heavy ion experiment at LHC in CERN. These chips are designed for the read out of Cathode Pad Chambers. Almost [100,000] MANAS chips are commissioned as front-end readout ASIC for the forward Muon Spectrometer of the ALICE experiment.

Work has also been initiated on the in-house developmental work on superheated drop detector (SDD) for radiation detection and dosimetry. Recent activities include development of electret microphone based acoustic pulse detector to go with SDD for fast neutron spectroscopy, wide bandwidth acoustic pulse detection technique using commercially available MEMS based piezoelectric sensors, development of acquasonic gel-based SDD, exploration of gamma response using radioactive source, neutron gamma discrimination by pulse height analysis, and GEANT based simulation of the SDD response.

Studies on neutrinoless double beta decay using CdZnTe detectors have also been pursued. Major interest in this study is the exploration of the unconventional double positron decay mode which is relatively easy to detect without significant background contamination. In collaboration with IIT Kharagpur, members are involved in planning of double beta decay experiment. Initial study on contamination level of CdZnTe, procured from CEL, New Delhi, has been carried out.

In the computational aspects of simulation of vision, investigation of the center-surround model of low level vision was carried out resulting in a proposed model. This model, which takes into account the recent physiological findings of retinal circuitry regarding “extra classical receptive field” and the presence of very narrow channels, is capable of retaining shading information, in the sense of *stochastic halftone process*, in the zero-crossing map. Contrary to the popular belief, this model, probably for the first time, suggest that several illusions like Simultaneous Brightness-Contrast, White Effect, Herman Grid, Todorovic Effect etc. could be explained by low-level computational model.

Research Activities

Electric field distribution and simulation of avalanche formation due to the passage of heavy ions in a parallel grid avalanche counter

Electric field distributions and their role in the formation of avalanche due to the passage of heavy ions in parallel grid avalanche type wire chamber detectors are evaluated using a Monte Carlo simulation. The relative merits and demerits of parallel and crossed wire grid configurations are studied. It is found that the crossed grid geometry has marginally higher gain at larger electric fields close to the avalanche region. The spatial uniformity of response in the two wire grid configurations is also compared, and found to be better for the crossed grid.

Kanjilal, D; Saha, S

An active drop counting device using condenser microphone for superheated emulsion detector

An active device for superheated emulsion detector is made. A capacitive diaphragm sensor or condenser microphone is used to convert the acoustic pulse of drop nucleation to electrical signal. An active peak detector is included in the circuit to avoid multiple triggering of the counter. The counts are finally recorded by a microprocessor based data acquisition system. Genuine triggers, missed by the sensor, were studied using a simulated clock pulse. The neutron energy spectrum of Cf-252 fission neutron source was measured using the device with R114 as the sensitive liquid and compared with the calculated fission neutron energy spectrum of Cf-252. Frequency analysis of the detected signals was also carried out.

Das, Mala; Arya, AS[†]; Marick, C; Kanjilal, D; Saha, S

Charge response of polyethylene terephthalate polymers (PET) to light and heavy nuclei

A particular brand of common polymer film has been found to have a high detection threshold value of Z/â, when used as a solid state nuclear track detector to detect energetic ion beams. From the infra-red absorption spectrum the film was identified to be polyethylene terephthalate (PET). Elemental analysis indicated the chemical formula of the polymer to be $(C_5H_4O_2)_n$, which is also the same as that for PET. The charge response of this PET detector to light nuclei has been studied using 53.6 MeV O^{16} ions from IUAC, New Delhi, India, using the air gap between the flange of the beam pipe and the detector as the energy degrader. The charge response for this PET detector has also been studied for heavy nuclei viz U^{238} using 11.1 MeV/n U-ion beam from GSI, Darmstadt, Germany, with aluminium foils of different thickness to degrade the incident energy. The charge response parameter V_t/V_g has been plotted against the Z/â of incident ions in the PET detector to calibrate so that it can be used to identify rare cosmic ray events.

Basu, B[†]; Dey, S[†]; Fischer, B[†]; Maulik, A[†]; Mazumdar, A[†]; Raha, S[†]; Saha, S; Saha, SK[†]; Syam, D[†]

Study of timing properties of single gap high-resistive bakelite RPC

The time resolution for several single gap (2 mm) prototype Resistive Plate Chambers (RPC) made of high resistive (ñ~10^{10}-10^{12} Ù-cm), 2 mm thick matt finished bakelite paper laminates with silicone coating on the inner surfaces, has been measured. The time resolution has been found to be 2.48±0.08ns at the plateau region.

Biswas, S[†]; Bhattacharya, S; Bose, S; Chattopadhyay, S[†]; Saha, S; Viyogi, YP[†]

Development of linseed oil-free bakelite resistive plate chambers

A few characteristics of the Resistive Plate Chambers (RPCs) made of a particular grade of bakelite paper laminates (P-120, NEMA LI-1989 Grade XXX), produced and commercially available in India are studied. This particular grade is used for high voltage insulation in humid conditions. The chambers are tested with cosmic rays in the streamer mode using argon, tetrafluroethane and isobutane in 34:59:7 mixing ratio. In the first set of detectors made with such grade, a thin coating of silicone fluid on the inner surfaces of the bakelite was found to be necessary for operation of the detector. Those silicone coated RPCs were found to give satisfactory performance with stable efficiency of >90% continuously for a long period as reported earlier. Results of the crosstalk measurement of these silicone coated RPC are found to be <20% for 2-strip crosstalk and <5% for the 3-strip cross-talk. Very recently RPCs made with the same grade of bakelite but having better surface finish are found to give equivalent performance even without any coating inside.

Biswas, S†; Bhattacharya, S; Bose, S; Chattopadhyay, S†; Saha, S; Viyogi, YP†

High spin states and isomeric decays in doubly-odd ^{208}Fr

Neutron deficient isotopes of francium (Z=87, N~121–123) as excited nuclei were produced in the fusion–evaporation reaction: ^{197}Au(^{16}O, xn) $^{213-x}$Fr at 100 MeV. The γ rays from the residues were observed through the high sensitivity Germanium Clover detector array INGA. The decay of the high spin states and the isomeric states of the doubly-odd ^{208}Fr nuclei, identified from the known sequence of ground state transitions, were observed. The half-lives of the E_γ=194(2) keV isomeric transition, known from earlier observations, was measured to be $T_{1/2}$=233(18) ns. A second isomeric transition at E_γ=383(2) keV and $T_{1/2}$=33(7) ns was also found. The measured half-lives were compared with the corresponding single particle estimates, based on the level scheme obtained from the experiment.

Kanjilal, D; Bhattacharya, S; Goswami, A; Kshetri, R; Raut, R; Saha, S; Bhowmik, RK†; Gehlot, J†; Muralithar, S†; Singh, RP†; Jnaneswari, G†; Mukherjee, G†; Mukherjee, B†

Electrostatics of micromesh based detectors

Three-dimensional electrostatic field configurations of several micromesh-based detectors have been estimated using the recently developed neBEM field solver. We have tried to estimate accurately, the field uniformity / distortion due to changes in the geometrical parameters of the mesh and also due to the changes in the detector configuration. In addition, the effect of the drift volume settings on the configuration of the drift field has also been estimated. The effect of these parameters on the electrostatic configuration and hence, on the performance of the detectors, are systematically studied.

Mukhopadhyay, S; Majumdar, N; Bhattacharya, S

3D field simulation in GEM-type structures

A numerical study on three dimensional field configuration of a structure based on the concept of Gaseous Electron Multiplier (GEM), namely THick GEM (THGEM) has been carried out using nearly exact Boundary Element Method (neBEM) solver. Various designs of this multiplier device have been studied to examine the effect of the geometrical and electrical properties of the structure on its field configuration.

Majumdar, N; Mukhopadhyay, S; Bhattacharya, S

Three-dimensional electrostatic field simulation of a resistive plate chamber

An electrostatic solver, namely neBEM (nearly exact Boundary Element Method), has been implemented to carry out three-dimensional electrostatic field computation of Resistive Plate Chamber (RPC). The solver has provided a detailed study on the effects of dimension and material of various chamber components on the field configuration. Its accuracy has been verified by comparing its outputs with other reported solutions.

Majumdar, N; Mukhopadhyay, S; Bhattacharya, S

Cluster dynamics in RPCs-A 3D electrostatic analysis

The important and complex physics of 3D cluster evolution in RPCs has been studied using the nearly exact boundary element method solver. A new method, namely, particles-on-surface has been proposed to simulate the effects of space charge on the development of the avalanche. This method is expected to be superior to the particle-in-cell approach that is usually adopted for simulating similar physical phenomena in several areas of science and technology. These methods have been discussed in the context of the neBEM solver in order to illustrate the merits and de-merits of employing this new tool for analyzing RPCs, in particular, and gas detectors, in general.

Mukhopadhyay, S; Majumdar, N; Bhattacharya, S

Computation of 3D electrostatic weighting field in Resistive Plate Chambers

Three-dimensional electrostatic weighting field configuration in a typical Resistive Plate Chamber (RPC) has been studied with the neBEM solver which evaluates accurate potential and field distributions in a given chamber following Boundary Element Method (BEM). The variation in three-dimensional weighting field of the RPC has been studied in detail with the change in design parameters like dimension, material, location of several components. The advantage of using the numerical solver neBEM in comparison to analytical solutions and other numerical approaches has been studied in connection to the evaluation of weighting field.

Majumdar, N; Mukhopadhyay, S; Bhattacharya, S

Some physical aspects of positron annihilation tomography: A critical review

Positron emission tomography (PET) is an imaging modality for medical diagnoses that can determine biochemical and physiological processes in vivo in a quantitative way by using radio-pharmaceuticals labeled with positron emitting radionuclides. This article brings together various aspects of the basic physics, critical design and instrumentation along with the modalities of the application of radiotracers and the radiological protections involved in the processes. A critical discussion on the various aspects of the PET system is also included. Several new advances and scope of future investigations in terms of better sensitivity, local as well as kinetic resolution, specific tracer targeting (including chemical speciation) and better spatial resolution of the PET image are also covered.

Ganguly, BN; Mondal, NN; Nandy, M; Roesch, F[†]

Lower and upper bounds on M-shell X-ray production cross sections by heavy ions

In inner-shell ionization by heavy ions, a significant shift of X-ray lines to the higher energy side and broadening of the peaks indicate that simultaneous multiple ionization of the M and higher shells can dramatically change the values of the atomic parameters. ${}_{14}Si^{3,4+}$ and ${}_{16}S^{3,4+}$ ions in the energy range of 5–10 MeV were used to bombard gold (200 ìg/cm^2) and bismuth (80 ìg/cm^2) targets. Eight main M X-ray lines have been detected with a Si(Li) detector. Without a possibility for a realistic way to modify the atomic parameters and an accurate extraction of M-subshell ionization cross sections, theoretical cross sections for M-shell ionization are converted to X-ray production cross sections with two extreme choices that presume (i) no multiple ionization and (ii) the certainty that all shells outer to the M-shell are completely ionized in the full multiple ionization. These choices impose the lower and upper limits on theoretical predictions. The X-ray production data should be bracketed by the bounds calculated with any theory. We test this proposition by comparison of the measured cross sections for production of the main X-ray lines and their sum for the total M-shell X-ray production with the predictions of the First Born and ECUSAR [G. Lapicki, Nucl. Instrum. Meth. B 189 (2002) 8] theories in those two extreme limits. With the extreme assumption of no multiple ionization, the First Born approximation shows overall satisfactory agreement with the data while the ECUSAR theory drastically underpredict our measurements. With the opposite extreme assumption of the full multiple ionization, the ECUSAR exhibits better agreement with the data than the First Born approximation. While neither agreement suggests sure preference for either of these theories, such extreme conversions – as they would have for of any ionization theories – set the lower and upper bounds on their predictions.

Mitra, D; Sarkar, M; Bhattacharya, D; Santra, S†; Mandal, AC†; Lapicki, G†

Satellites, hypersatellites and RAE from Ti, V, Cr, Mn and Fe in photoionisation

K x-ray satellites, hypersatellites and lines due to radiative Auger effect (RAE) of Ti, V, Cr, Mn and Fe were measured after exciting the samples with Ag bremsstrahlung at 35 kV. All the lines were measured with the 'Spectroscan VY' spectrometer of Spectron-OPTEL, Russia, in which a curved LiF(200) crystal was used. The spectra were deconvoluted using Voigt functions, and the peak positions of the satellites and hypersatellites were determined with errors of +/-(1-5) eV. The energy shifts of the satellite lines with respect to their parent lines were also obtained. Multi-configuration Dirac-Fock (MCDF) calculations with the inclusion of higher-order corrections were carried out to predict the peak positions of the satellite and hypersatellite lines. Our data were then compared with our own calculated values and also with the data of others. Our measured energy shifts for K alpha L1, K alpha L2, K-alpha(h) and K beta L1, when compared with our MCDF calculations, show a maximum deviation of 8, 12, 2 and 20% respectively.

Mitra, D; Sarkar, M; Bhattacharya, D; Natarajan, L†

Measurement of L subshell photoionisation cross sections of Th and U at 22.6, 25.8, 29.2 and 32.9 kev

Bremsstrahlung from an X-ray tube was used to excite secondary targets of Ag, Sn, I and Ba to get nearly monochromatic excitation energies of 22.6, 25.8, 29.2 and 32.9 keV, respectively. Th and U were used as targets. The *L* X-ray fluorescence cross sections of different lines from the targets have been measured. Of the several methods to obtain *L* subshell photoionisation cross sections from these fluorescence data, the merits and demerits of four common methods have been explained and the method with least uncertainty was suggested as the best one for such analysis. Following this method, with intensities of the resolved $L_{\tilde{a}}$ lines, three *L* subshell photoionisation cross sections have been obtained using six different sets of atomic parameters. The variation of these cross sections with different atomic parameters has been discussed. For $\acute{o}_1$, all the derived values are within 30% of one other while for $\acute{o}_2$ and $\acute{o}_3$, they are within 12%. Measured cross sections have been compared with the data of others and with the theoretical values of Scofield. Finally, the intensity ratios of different *L* lines have also been compared with available data and the theoretical values. Within experimental errors, our data are in good agreement with the data of others and with the theoretical predictions.

Santra, S; Mitra, D; Sarkar, M; Bhattacharya, D

Characterisation of Ion Implantation-induced Defects in Certain Technologically Important Materials by Positron Annihilation

The application of positron annihilation spectroscopy for the studies of defects produced by different types of charged particles and ions in a variety of materials is discussed with specific examples. The ability to detect and quantify the information through the characteristic parameters of the annihilation radiation in a totally non-destructive method has made the fundamental process of electron-positron annihilation a powerful spectroscopic probe for investigating the structure and properties of materials. Ion implantation produces defects in the structure of solids and the latter can be recovered from the defects by annealing at high temperatures. Here the annealing is done in sequential steps so that the different stages of evolution of defects and their interaction with impurity atoms can be studied systematically. Defects produced by irradiation by particles like protons, alpha, boron and neon ions in materials ranging from simple metals to binary alloys are discussed. A detailed evaluation of the positron lifetimes in terms of the popular positron trapping models is also presented. Further as a special case, the method of extraction of values of several useful physical parameters of inert gas bubbles inside a metal matrix is explained with the help of a model analysis.

Nambissan, PMG

Vacancy-Type Defects and Their Evolution under Mn Substitution in Single Crystalline ZnO Nanocones Studied by Positron Annihilation

Bipyramidal-shaped single crystalline nanocones of ZnO, doped with Mn^{2+} ions up to different concentrations, were synthesized through a solvothermal route and characterized by X-ray diffraction and transmission electron microscopy. The compositional analysis was also carried out by energy-dispersive analysis of X-rays (EDAX). Positron annihilation studies were carried out to extract information on the vacancy-type defect clusters and their evolution under doping, which may have a major influence on the physical properties of the material. In the undoped ZnO, trivacancy-type defects of the type $V_{\mathrm{Zn+O+Zn}}$ are present. Doping by Mn^{2+} ions reduced them to divacancies ($V_{\mathrm{Zn+O}}$) as a result of the ion-vacancy complex formation. These were indicated by the measured positron lifetimes and coincidence Doppler broadening measurements. An interesting observation is the reduction in base diameters of the nanocones at high (>1 atom %) dopant concentrations, an effect of increased strain due to occupancy of Zn^{2+} vacancy sites by Mn^{2+} ions of slightly larger radius. As the diameters of the grains reduce to below the thermal diffusion lengths of positrons, significant number of annihilation events seemed to result from the surfaces of the nanocones. The intercrystalline regions also gave a favorable site for the formation and "pick-off" annihilation of orthopositronium atoms.

Ghoshal Tandra†, Kar Soumitra†, Biswas Subhajit†, De SK† and Nambissan PMG

Cadmium Oxide Octahedrons and Nanowires on the Micro-Octahedrons: A Simple Solvothermal Synthesis

Cadmium oxide (CdO) micro-octahedrons and nanowires were synthesized by a simple solvothermal process using ethanol as a solvent. The amount of NaOH and the synthesis temperature were the key parameters to control the phase and morphology of the as-synthesized products. The phase purity of the samples was determined through X-ray diffraction (XRD). Lower concentration of NaOH and higher-synthesis temperature favored the formation of CdO micro/nanostructures. Morphologies of the products were identified through scanning electron microscopy (SEM) and transmission electron microscopy (TEM). At higher temperature and low NaOH concentrations, nanowires were protruded from the octahedron facets. HRTEM images and SAED patterns reveal the single-crystalline nature of the octahedrons and polycrystalline nature of the nanowires. Cd(OH)(2) samples, obtained at low synthesis temperature, were annealed at different temperatures to test the feasibility of the products to transform to CdO. Positron annihilation measurements were carried out to study the defects of the nano/ microstructures. Electrical resistivity measurement showed semiconducting behavior of CdO samples.

Ghoshal, Tandra†; Biswas, Subhajit†; Nambissan, PMG; Majumdar, Gautam†; De, SK†

Positron lifetime studies of the dose dependence of nanohole free volumes in ion-irradiated conducting poly-(ethylene-oxide)-salt polymers

Polymer based ion conducting materials have potential applications as an electrolyte and separator in the field of lithium batteries. Solid polymer electrolytes for lithium batteries are one of the best applications. The irradiation of polymeric materials with swift heavy ions results into the change of their free volume properties which have strong correlation with their macroscopic properties. Poly-ethylene-oxide (PEO)-salt polymers were prepared using solution-cast method. Irradiation of the films with 95 MeV oxygen O^{6+} ions from the pelletron accelerator at IUAC, New Delhi, India, to different fluences up to 10^{13} ions/cm^2 was carried out under high vacuum of the order of 4 x 10^{-6} Torr. Nanosized free volume parameters in PEO-salt polymer complex have been studied by positron annihilation lifetime spectroscopy (PALS) and Doppler broadening spectroscopy (DBS). From orthopositronium (o-Ps) lifetime, free volume hole radius, free volume of micro voids and fractional free volume are computed. Free volume changes with the fluence are studied. The variation of o-Ps lifetime, mean free volume and fractional free volume with the ion fluence is studied. o-Ps lifetime, free volume radius, mean free volume and fractional free volume decrease for the fluence 10^{10} and 10^{11} ions/cm^2 and then increase with fluences of 10^{12} and 10^{13} ions/cm^2 . The S parameter showed a continuous decrease with increasing fluence of irradiation. The intermediate lifetime $\hat{o}_2$ also showed a similar decrease. These results indicate the occurrence of scission in the polymer chains and the fragmentation of larger free volumes into smaller ones.

Kumar, Rajesh[†]; De, Udayan[†]; Nambissan, PMG; Maitra, M[†]; Ali, S. Asad[†]; Middya, TR[†]; Tarafdar, S[†]; Singh, F[†]; Avasthi, DK[†]; Prasad, Rajendra[†]

Mn^{2+}-induced substitutional structural changes in ZnS nanoparticles as observed from positron annihilation studies

Zinc sulfide nanoparticles doped with different concentrations of manganese ions (Mn^{2+}) were synthesized at various temperatures to investigate the effects of substitution and the associated defect evolution. Positron lifetime and Doppler broadening measurements were used as probes. The initial stage of defect recovery was dominated by the occupation of Zn^{2+} vacancies by Mn^{2+} ions, bringing in characteristic changes in the positron lifetimes, intensities and Doppler broadened lineshape parameters. Detailed analyses considering the presence of one and two types of defects were carried out to identify the type of defects which trap positrons at the different dopant concentrations. Electron paramagnetic resonance studies indicated increased Mn–Mn interaction and the formation of Mn clusters with further doping. The results are in striking contrast to those for nanorods, where vacancy recombination transformed their interior into regions free of defects.

Biswas, Subhajit[†]; Kar, Soumitra[†]; Chaudhuri, Subhadra[†]; Nambissan, PMG

Positron annihilation spectroscopy and specific heat study of neon ion irradiated MgB_2

Specific heat studies under magnetic field and positron annihilation spectroscopy were carried out on 160 MeV Ne ion irradiated polycrystalline MgB_2 samples. There is an unusual decrease in positron lifetime in the irradiated sample which may be due to neon ion implantation. This was also indicated by change in cell volume. Coincidence Doppler Broadening Spectra of Mg, B, irradiated and unirradiated MgB_2 show that positrons primarily annihilate in boron sublattice in the unirradiated sample whereas there is some similarity of the spectrum of the irradiated sample with that of Mg. There is Mg deficiency in the unirradiated sample whereas predominantly boron vacancies exist in Ne ion irradiated MgB_2 sample. Specific heat measurements show that there is a small increase in electronic part of the specific heat and electron-phonon coupling constant.

Talapatra, A; Bandyopadhyay[†], SK; Nambissan, PMG; Sen, Pintu[†]; Ganesan, V[†]

Positron annihilation spectroscopic studies of solvothermally synthesized ZnO nanobipyramids and nanoparticles

Zinc oxide (ZnO) samples in the form of hexagonal-based bipyramids and particles of nanometer dimensions were synthesized through solvothermal route and characterized by x-ray diffraction and transmission electron microscopy. Positron annihilation experiments were performed to study the structural defects such as vacancies and surfaces in these nanosystems. From coincidence Doppler broadening measurements, the positron trapping sites were identified as Zn vacancies or Zn-O-Zn trivacancy clusters. The positron lifetimes, their relative intensities, and the Doppler broadened lineshape parameter S all showed characteristic changes across the nanobipyramid size corresponding to the thermal diffusion length of positrons. In large nanobipyramids, vacancies within the crystallites also trapped positrons and the effects of agglomeration of such vacancies due to increased temperatures of synthesis were reflected in the variation of the annihilation parameters with their base diameters. The sizes of the nanoparticles used were all in the limit of thermal diffusion length of positrons and the annihilation characteristics were in accordance with the decreasing contribution from surfaces with increasing particle size.

Ghoshal, Tandra†; Biswas, Subhajit†; Kar, Soumitra†; Chaudhuri, Subhadra†; Nambissan, PMG

Thermal evolution of boron irradiation induced defects in predoped Si revealed by positron annihilation experiments

The isochronal annealing behavior of high energy (25-72 MeV) boron ion irradiation induced defects in boron-doped silicon is monitored through measurements of positron lifetimes and three distinct defect-evolution stages are identified. The initial boron doping created a defect environment where positrons could sensitively annihilate with the boron electrons, suggesting boron-decorated Si monovacancies as potential trapping sites. The irradiation results in the dissolution of boron from these sites and positrons are then trapped by the empty divacancies of Si. Charge neutralization of divacancies through interaction with boron atoms leads to enhanced positron trapping in the initial stages of isochronal annealing. The divacancies start annealing above 673 K. However, a remarkable defect evolution stage due to the diffusion of the boron atoms beyond their initial depths of penetration is seen above 873 K and it leaves the sample with defects still present even at the highest annealing temperature 1273 K used in this work.

Nambissan, PMG; Bhagwat, PV†; Kurup, MB†

Substitution-induced structural transformation in Mn-doped ZnS nanorods studied by positron annihilation spectroscopy

Zinc sulphide nanorods were doped with manganese ions and the structural changes were monitored through positron annihilation measurements. X-ray diffraction and high-resolution transmission electron microscopy revealed a transformation from hexagonal to cubic structure, and we observed characteristic changes in the measured positron lifetimes, their intensities and Doppler broadened lineshapes. These features were explained on the basis of positron trapping and subsequent annihilation at the nanorod surfaces. Further incorporation of manganese resulted in an increase of the diameter of the nanorods, and the effect was reflected in the decreasing lifetime of positrons. At sufficiently high concentration of manganese ions, Mn - Mn clusters were formed. The results are compared with those obtained for ZnS nanoparticles where vacancies within the grains trapped a significant fraction of positrons.

Kar, Soumitra†; Biswas, Subhajit†; Chaudhuri, Subhadra†; Nambissan, PMG

Positron lifetime studies and coincidence Doppler broadening spectroscopy of Al-6Mg-xSc (x=0 to 0.6 wt.%) alloy

Positron annihilation spectroscopy (PAS), comprising of both positron lifetime and coincidence Doppler broadening measurements, has been employed for studying the phase decomposition behaviour of scandium doped Al-6Mg alloys. Micro structural and age hardening studies have also been conducted to substantiate the explanation of the results of PAS. Samples with scandium concentration ranging from 0 to 0.6 wt.% have been studied. The measured positron lifetimes of undoped alloy reveal that GP zones are absent in the as-prepared Al-6Mg alloy. The observed positron lifetimes and the results of coincidence Doppler broadening measurements largely stem from the entrap of positrons at the interface between aluminium rich primary dendrites and the magnesium enriched interdendritic eutectic mixture of Mg_5Al_8 (b) and the primary solid solution of aluminium (a). The study also provides evidence of the formation of scandium vacancy complexes in Al-6Mg alloys doped with scandium upto a concentration of 0.2 wt.%. However such complex formation ceases to continue beyond 0.2 wt.% Sc; instead, the formation of fine coherent precipitates of Al_3Sc is recorded in the as prepared alloy containing 0.6 wt.% scandium. The positron annihilation studies coupled with CDBS have also corroborated with the fact that the fine coherent precipitates of Al_3Sc are formed upon annealing the Al-6Mg alloys doped with scandium of concentration 0.2 wt.% and above. Transmission electron microscopic studies have provided good evidence of precipitate formation in annealed Al-6Mg-Sc alloys. Elevated temperature annealing leads to dissociation of the scandium-vacancy complexes, thereby leading to the enhancement of the mobility of magnesium atoms. This has facilitated fresh nucleation and growth of Mg5Al8 precipitates in the above alloys at 673 K.

Kaiser, MS[†]; Nambissan, PMG; Banerjee, MK[†]; Sachdeva, A[†]; Pujari, PK[†]

A study of three-dimensional edge and corner problems using the neBEM solver

The previously reported neBEM solver has been used to solve electrostatic problems having three-dimensional edges and corners in the physical domain. Both rectangular and triangular elements have been used to discretize the geometries under study. In order to maintain very high level of precision, a library of C functions yielding exact values of potential and flux influences due to uniform surface distribution of singularities on flit triangular and rectangular elements has been developed and used. Here we present the exact expressions proposed for computing the influence Of uniform singularity distributions on triangular elements and illustrate their accuracy. We then consider several problems of electrostatics containing edges and singularities of various orders including plates and Cubes, and L-shaped conductors. We have tried to show that using the approach proposed in the earlier paper on neBEM and its present enhanced (through the inclusion of triangular elements) form, it is possible to obtain accurate estimates of integral features such as the capacitance of a given conductor and detailed Ones Such as the charge density distribution at the edges/corners without taking resort to any new or special formulation. Results obtained using neBEM have been compared extensively with both existing analytical and numerical results. The comparisons illustrate the accuracy, flexibility and robustness of the new approach quite comprehensively.

Mukhopadhyay, Supratik; Majumdar, Nayana

Simulation of 3D electrostatic configuration in gaseous detectors

A Boundary Element Method (BEM) solver based on the solution of boundary integral equations of potential and electric field has been developed to simulate 3D electrostatic configuration in gaseous detectors. Use of analytical solution of the integral equations governing electric potential and field for estimating influence coefficients of the BEM solver has empowered it to provide extremely precise estimates of the potential and field for a given geometry. The nearly exact BEM (neBEM) solver has been implemented in order to simulate physical and weighting potential and field configurations in several gaseous detectors like MultiWire Proportional Counter and Time Projection Chamber. The efficacy of the solver for simulating 3D electrostatic configuration in composite systems containing both conductors and layered dielectrics has been demonstrated for some of the MicroPattern Gas Detectors and Resistive Plate Chamber. It should be noted that the method treats the dielectric interfaces to be in a steady state with polarization charges only. The reasons why the neBEM can be a preferred tool for electrostatic simulation of gaseous detectors to other 2D or 3D numerical solvers are discussed on the basis of present results.

Majumdar, N; Mukhopadhyay, S

Lifetime measurement of some excited states belonging to the 3p(4)nd (n=4-6) configuration of ArII

The radiative lifetimes of eight levels belonging to the 3p(4)nd (n=4-6) configuration of ArII have been measured using high frequency deflection technique together with a delayed coincidence single photon counting arrangement. Lifetimes of some of the levels have been measured for the first time. The results have been compared with other experimental and theoretical values.

Karmakar, S†; Das, MB

Experimental lifetime of some level belonging to the 5p(4)6d configuration of Xell

Lifetimes of eight levels belonging to the 5p(4)6d configuration of singly ionized xenon have been measured by high frequency deflection technique with a delayed coincidence single photon counting arrangement. The results have been compared with other experimental and theoretical values. The lifetimes of the 6d F-2(3/2) and 6d F-4(3/2) levels have been measured for the first time.

Das, MB; Karmakar, S†

Coherence resonance in a unijunction transistor relaxation oscillator

The phenomenon of coherence resonance is investigated in an unijunction transistor relaxation oscillator and quantified by estimating the normal variance (NV). Depending on the measuring points, two types of NV curves have been obtained. We have observed that the degradations in coherency at higher noise amplitudes in our system is probably the result of direct interference of coherent oscillations and the stochastic perturbation.

Degradation of coherency may be minimal if this direct interference of noise and coherent oscillations is eliminated.

Nurujjaman, Md; Bhattacharya, PS; Iyengar, ANSekar; Sarkar, Sandip

A possible mechanism of stochastic resonance in the light of an extra-classical receptive field model of retinal ganglion cells

Traditionally the intensity discontinuities in an image are detected as zero-crossings of the second derivative with the help of a Laplacian of Gaussian (LOG) operator that models the receptive field of retinal Ganglion cells. Such zero-crossings supposedly form a raw primal sketch edge map of the external world in the primary visual cortex of the brain. Based on a new operator which is a linear combination of the LOG and a Dirac-delta function that models the extra-classical receptive field of the ganglion cells, we find that zero-crossing points thus generated, store in presence of noise, apart from the edge information, the shading information of the image in the form of density variation of these points. We have also shown that an optimal image contrast produces best mapping of the shading information to such zero-crossing density variation for a given amount of noise contamination. Furthermore, we have observed that an optimal amount of noise contamination reproduces the minimum optimal contrast and hence gives rise to the best representation of the original image. We show that this phenomenon is similar in nature to that of stochastic resonance phenomenon observed in psychophysical experiments.

Ghosh, Kuntal; Sarkar, Sandip; Bhaumik, Kamales

Understanding image structure from a new multi-scale representation of higher order derivative filters

We are proposing a biologically inspired multi-scale derivative filter in which the higher order derivatives are expressed as a linear combination of a smoothing function at various scales. One of the functions in the summation has been approximated to a Dirac-delta function to finally yield the new filter. This modification has some support from the point of view of authentic edge detection as well as from neurophysiological and psychophysical experiments at the retinal level. Besides, it improves the quality of the filter in a number of ways. The proposed filter can be optimized at any desired scale. Hence it is very effective in extracting the features from a noisy picture. The filter is rotationally symmetric. Zero-crossing map of any picture filtered with the proposed model gives a half-toning effect to the retrieved image and hence preserves the intensity information in the image even in the edge map.

Ghosh, Kuntal; Sarkar, Sandip; Bhaumik, Kamales

Chemical Transformation of Crystalline Hafnium Tetrafluoride Studied by Perturbed Angular Correlation Spectroscopy

The Chemical transformation of the trihydrate hafnium tetrafluoride crystal has been studied with varying temperature using the time-differential perturbed angular correlation technique. The 133-482 keV gamma-gamma cascade of Ta-181 after the $\hat{a}^-$ decay of Hf-181 has been selected and a four detector BaF_2-

BaF_2 coincidence set up has been used for measurements. The crystal was produced by evaporating a solution of HfF_6^{2-} complex in HF at room temperature. Contrary to the earlier report, it has been found that the trihydrate hafnium tetrafluoride compound dehydrates directly to HfF_4 without producing any intermediate monohydrate and present results do not support the earlier idea that two water molecules of $HfF_4.3H_2O$ are loosely bound. Present investigations exhibit a superheated state for the hafnium tetrafluoride crystal. In dehydrated HfF_4, two different Hf sites have been observed which suggests two different structures for the anhydrous HfF_4.

Dey, Chandi Charan

Behavior of hafnium fluoride octahedral complex in HF at low temperature studied by TDPAC

The behavior of HfF_6^{2-} octahedral complex in HF has been studied in the temperature range from 300 to 77 K by time differential perturbed angular correlation technique. No time dependent spin relaxation has been observed up to 223 K. At 203 and 193 K, definite nuclear spin relaxations while at 77 K a pure static interaction have been observed. These indicate that at temperatures below 223 K, a different phase of the liquid appears. The rotational correlation times characterizing the tumbling motion of the complex in HF have been determined at 203 and 193 K and found to be 1.6 ns and 2.1 ns, respectively from the measured relaxation constants at these temperatures and the value of quadrupole frequency found at 77 K. The value of rotational correlation time found at 203 K disagrees by an order of magnitude with the earlier measured value which was found to be in the picosecond range.

Dey, CC

A perturbed angular correlation spectrometer for material science studies

A four-detector perturbed angular correlation (PAC) spectrometer has been developed with ultra-fast BaF_2 detectors to acquire four coincidence spectra simultaneously, two at 180 degrees and two at 90 degrees. This spectrometer has double efficiency compared to that of a three-detector set-up. Higher efficiency is desirable for PAC studies in solid state physics where large number of coincidences are required to obtain the PAC spectra with good statistics and is particularly useful when the half-lives of the parent probe nuclei used for PAC measurements are ~ 2-3 days or less as in In-111 (2.8 d), Mo-99 (2.7 d) and La-140 (1.7 d). The performance of the spectrometer has been tested for the HfO_2 monoclinic crystal in the temperature range from 77 to 873 K and for the $HfF_4.3H_2O$ crystal at room temperature. The polycrystalline HfO_2 has been synthesized from Hf metal by heating in air. The hydrated hafnium fluoride has been crystallized by dissolving Hf metal in 40% HF and drying slowly at room temperature.

Dey, CC

Experimental study of the 2p-2h band in ^{111}Sn

The $\Delta I = 2$ intruder band in ^{111}Sn, built upon the 4074.3 keV state, was studied. The states were populated in the ^{100}Mo (^{20}Ne, á5n) reaction at a beam energy of 136 MeV. Mean lifetimes of five states up to 8737.2 keV $43/2^-$ have been measured for the first time using the Doppler shift attenuation method. In addition, an upper limit of mean lifetime has been estimated for the 9860.0 keV (spin $47/2^-$ state. The B(E2) values, derived from the present lifetime results, indicate a quadrupole deformation of $\hat{a}_2$ = 0.28 ±0.02 for the 31/2⁻ state and decrease progressively with spin, suggesting a reduction in collectivity. The dynamic moment of inertia for the band also decreases continuously up to the highest observed frequencies. These results, along with the predictions of a total Routhian surface calculation, suggest that the ΔI = 2 band in ^{111}Sn undergoes a change of shape from collective prolate to triaxial with increase in spin and possibly terminates in a noncollective oblate state at a high spin.

Ganguly, S; Banerjee, P; Ray, I; Kshetri, R; Raut, R; Bhattacharya, S; Saha-Sarkar, M; Goswami, A; Basu, SK†

Indication of the onset of collectivity in ^{30}P

^{30}P has been studied by in-beam gamma-spectroscopy following the fusion-evaporation reaction ^{16}O(^{16}O,pn) at E_{lab}=40 MeV, using the Indian National Gamma (Clover) Array (INGA) up to moderate spins (I=5). Polarization measurements of seven gamma rays have been performed for the first time. To understand the underlying structure of the levels and transition mechanisms, experimental data have been compared with the results from large basis cross-shell shell model calculations. The results for the negative parity states are especially important in this respect. Positive parity states indicate an onset of collectivity, whereas the negative parity states are members of nu-pi multiplets.

Ray, Indrani; Basu, Moumita Roy†; Kshetri, Ritesh; Saha Sarkar, Maitreyee; Sarkar, S†; Banerjee, P; Chattopadhyay, S; Dey, CC; Goswami, A; Chatterjee, JM; Mukherjee, A; Bhattacharya, S; Dasmahapatra, B; Datta, P; Jain, HC†; Bhowmik, RK†; Muralithar, S†; Singh, RP†

Study of yrast band in ^{155}Tm

The nucleus ^{155}Tm has been studied by a detailed in-beam gamma spectroscopy following the reaction ^{144}Sm(^{14}N, 3n) ^{155}Tm, at a beam energy, E_{lab} = 70 MeV, using a Compton suppressed gamma detector array. More than 25 new gamma transitions have been placed in the proposed scheme and the latter has been extended upto a spin-parity of $51^-/2$ at an excitation energy similar to 6 MeV.

Raut, R; Bhowal, S†; Ganguly, S; Kshetri, R; Banerjee, P; Bhattacharya, S; Bhowmik, RK†; Dasmahapatra, B; Gangopadhyay, G†; Mukherjee, A; Muralithar, S†; SahaSarkar, M; Singh, RP†; Goswami, A

Study of intruder band in ^{112}Sn

Excited states of the positive-parity intruder band in ^{112}Sn, populated in the ^{100}Mo (^{20}Ne, á4n) reaction at a beam energy of 136 MeV, have been studied. The band has been observed up to 11570.0 keV with spin 24⁺. Mean lifetimes have been measured for six states up to the 22⁺, 10335.1 keV level and an upper limit of the lifetime has been estimated for the 11570.0 keV (24⁺) state. The B(E2) values, derived from the present lifetime results, correspond to a moderate quadrupole deformation of $\hat{a}_2$ ~0.18 for states with spin $J^Đ$ = 12⁺, and the decrease in B(E2) for the 14⁺→12⁺ transition is consistent with a í$(h_{11/2})^2$ alignment at žω ~0.35 MeV, predicted by a cranked shell-model calculation. Total Routhian surface calculations predict a triaxial shape following the alignment.

Ganguly, S; Banerjee, P; Ray, I; Kshetri, R; Raut, R; Bhattacharya, S; Saha-Sarkar, M; Goswami, A; Mukhopadhyay, S; Mukherjee, A; Mukherjee, G; Basu, SK†

High spin structure of ^{35}Cl-and the sd-fp shell gap

The high spin states of ^{35}Cl have been studied by in-beam gamma-spectroscopy following the fusion-evaporation reaction ^{12}C (^{28}Si, áñ) ^{35}Cl at E_{lab}=70 and 88 MeV, using the Indian National Gamma (Clover) Array (INGA). Lifetimes of six new excited states have been estimated for the first time. To understand the underlying structure of the levels and transition mechanisms, experimental results have been compared with those from the large basis cross-shell shell model calculations. Involvement of orbitals from fp shell and squeezing of the sd-fp shell gap seem to be essential for reliable reproduction of high spin states.

Kshetri, Ritesh; Saha Sarkar, M; Ray, Indrani; Banerjee, P; Sarkar, S†; Raut, Rajarshi; Goswami, A; Chatterjee, JM; Chattopadhyay, S; DattaPramanik, U; Mukherjee, A; Dey, CC; Bhattacharya, S; Dasmahapatra, B;Bhowal, Samit†; Gangopadhyay, G†; Datta, P; Jain, HC†; Bhowmik, RK†; Muralithar, S†; Singh, RP†; Kumar, R†

Generalized mass formula for non-strange, strange and multiply-strange nuclear systems

A simultaneous description of non-strange nuclei, hypernuclei and multiply-strange nuclear systems is provided by a single mass formula which is shown to be useful for estimating binding energies of nuclear systems over a wide mass range, including the light mass nuclei. It not only provides a good fit to the existing experimental data on hyperon-separation energies but also reproduces results of the relativistic mean field (RMF) calculations. In addition, it can provide the lambda (Lambda), cascade-0 (Xi(0)) and cascade-minus (Xi(-)) drip lines. The existence of a range of bound pure-hyperonic systems without any neutron and proton is suggested among which 6 Lambda, 9 Xi(0)Xi(0), 10 Xi(-)Xi(-), 1 Lambda 7 Xi(0), 1 Lambda 8 Xi(-), 1 Xi(0)9 Xi(-), 1 Xi(-)8 Xi(0) and 2 Lambda + 3 Xi(0) + 3 Xi() represent the lightest species. In agreement with the RMF predictions, this generalized mass formula also predicts the nucleus 2 Xi(0)2 Lambda He-8 to be bound. An exotic 2 Xi(0)2 Xi(-)Lambda (10)n nucleus is also found to be bound. This new mass formula can be used in astrophysics for strange stellar objects, as well as in high energy physics for estimating the strangeness production yield in nucleus-nucleus or nucleon-nucleon collisions.

Samanta, C

Charged and neutral Hyperonic Effects on the Driplines

Modification of neutron and proton driplines after the capture of st range hyperon(s) by normal nuclei has been investigated. A generalised mass formula (BWMH) based on the strangeness dependent extended liquid drop model is used to calculate the binding energy of normal nuclei as well as strange hypernuclei. The neutron (Sn) and proton (Sp) separation energies of all hypernuclei with neutral hyperons Lambda(0). double Lambda(0) or charged hyperons Xi(-), Theta(+) inside are calculated using BWMH mass formula. The normal neutron and proton driplines get modified due to the addition of the hyperon(s) (Lambda, Lambda Lambda, Xi(-), Theta(+) etc.) to the core of normal nuclei. The hypernuclei containing the charged hyperon(s) like those with neutral hyperon(s) have similar nucleon separation energies like core nuclei if proton number instead of net charge is used in the symmetry term. Due to the effect of opposite charges present in Theta(+) and Xi(-) hyperons their corresponding driplines get separated from each other. All the hyperons modify mean field potential due to strong hyperon-nucleon coupling. Addition of a single charged hyperon in normal nuclei affects the entire proton drip line more prominently than that by neutral hyperon. The neutral hyperonic effect on proton dripline is significant For lighter nuclei than for heavier ones whereas both the charged as well as neutral hyperons affect almost the entire neutron dripline.

Roy Chowdhury, P; Samanta, C; Basu, DN[†]

Isobaric incompressibility of isospin asymmetric nuclear matter

The isospin dependence of the saturation properties of asymmetric nuclear matter, particularly the incompressibility K-infinity(X)=K-infinity+K tau X2+O(X-4) at saturation density, is systematically studied using density-dependent M3Y interaction. K-tau characterizes the isospin dependence of the incompressibility at saturation density rho(0). The approximate expression K-asy approximate to K-sym-6L is often used for K-tau where L and K-sym represent the slope and curvature parameters of the symmetry energy at rho(0), respectively. It can be expressed accurately as K-tau=K-sym-6L-(Q(0)/K-infinity)L, where Q(0) is the third-order-derivative parameter of symmetric nuclear matter at rho(0). The results of this addendum to [Phys. Rev. C 80, 011305(R) (2009)] indicate that the Q(0) contribution to K-tau is not insignificant.

Basu, DN[†]*; Roy Chowdhury, P; Samanta, C*

Alpha decay chains from superheavy nuclei

Magic islands for extra-stable nuclei in the midst of the sea of fission-instability were predicted to be around Z = 114,124 or, 126 with N = 184, and Z = 120, with N = 172. Whether these fission-survived superheavy nuclei with high Z and N would live long enough for detection or, undergo alpha-decay in a very short time, remains an open question. alpha-decay half lives of nuclei with 130 >= Z >= 100 have been calculated in a WKB framework using density-dependent M3Y interaction with Q-values from different mass formulae. The results are in excellent agreement with the experimental data. Fission survived Sg nuclei with Z = 106, N = 162 is predicted to have the highest alpha-decay half life (similar to 3.2 h) in the Z = 106-108, N = 160-164 region called small island/peninsula. Superheavy nuclei with Z > 118 are found to have alpha-decay half lives of the order of microseconds or less.

Samanta, C

Isospin dependent properties of asymmetric nuclear matter

The density dependence of nuclear symmetry energy is determined from a systematic study of the isospin dependent bulk properties of asymmetric nuclear matter using the isoscalar and isovector components of the density dependent M3Y interaction. The incompressibility K-infinity for the symmetric nuclear matter, the isospin dependent part K-asy of the isobaric incompressibility, and the slope L are all in excellent agreement with the constraints recently extracted from measured isotopic dependence of the giant monopole resonances in even-A Sn isotopes, from the neutron skin thickness of nuclei, and from analyses of experimental data on isospin diffusion and isotopic scaling in intermediate energy heavy-ion collisions. This work provides a fundamental basis for the understanding of nuclear matter under extreme conditions and validates the important empirical constraints obtained from recent experimental data.

Roy Chowdhury, PR; Basu, DN†; Samanta, C

Nuclear half-lives for alpha-radioactivity of elements with 100 ≤ Z ≤130

Theoretical estimates for the half-lives of about 1700 isotopes of heavy elements with 100 <= Z <= 130 are tabulated using theoretical Q-values. The quantum mechanical tunneling probabilities are calculated within a WKB framework using microscopic nuclear potentials. The microscopic nucleus-nucleus potentials are obtained by folding the densities of interacting nuclei with a density-dependent M3Y effective nucleon-nucleon interaction. The alpha-decay half-lives calculated in this formalism using the experimental Q-values were found to be in good agreement over a wide range of experimental data spanning about 20 orders of magnitude. The theoretical Q-values used for the present calculations are extracted from three different mass estimates viz. Myers-Swiatecki, Muntian-Hofmann-Patyk-Sobiczewski, and Koura-Tachibana-Uno-Yamada.

Roy Chowdhury, P; Samanta, C; Basu, DN†

Gamow-Teller strengths in ^{24}Na using the ^{24}Mg(t^{3},He) reaction at 115A MeV

Gamow-Teller transitions from Mg-24 to Na-24 were studied via the (t,He-3) reaction at 115A MeV using a secondary triton beam produced via fast fragmentation of 150A MeV O-16 ions. Compared to previous (t,He-3) experiments at this energy that employed a primary alpha beam, the secondary beam intensity is improved by about a factor of five. Despite the large emittance of the secondary beam, an excitation-energy resolution of similar to 200 keV is achieved. A good correspondence is found between the extracted Gamow-Teller strength distribution and those available from other charge-exchange probes. Theoretical calculations using the newly developed USDA and USDB sd-shell model interactions reproduce the data well.

Howard, ME†; Zegers, RGT†; Austin, Sam M†; Bazin, D†; Brown, BA†; Cole, AL†; Davids, B†; Famiano, M†; Fujita, Y†; Gade, A†; Galaviz, D†; Hitt, GW†; Matos, M†; Reitzner, SD†; Samanta, C; Schradin, LJ†; Shimbara, Y†; Smith, EE†; Simenel, C†

Nuclear equation of state at high baryonic density and compact star constraints

A mean field calculation is carried out to obtain the equation of state (EoS) of nuclear matter from a density-dependent M3Y interaction (DDM3Y). The energy per nucleon is minimized to obtain ground state of the symmetric nuclear matter (SNM). The constants of density dependence of the effective interaction are obtained by reproducing the saturation energy per nucleon and the saturation density of SNM. The energy variation of the exchange potential is treated properly in the negative energy domain of nuclear matter. The EoS of SNM, thus obtained, is not only free from the superluminosity problem but also provides excellent estimate of nuclear incompressibility. The EoS of asymmetric nuclear matter is calculated by adding to the isoscalar part, the isovector component of M3Y interaction. The SNM and pure neutron matter EoS are used to calculate the nuclear symmetry energy which is found to be consistent with that extracted from the isospin diffusion in heavy-ion collisions at intermediate energies. The beta equilibrium proton fraction calculated from the symmetry energy and related theoretical findings are consistent with the constraints derived from the observations on compact stars.

Basu, DN[†]; Roy Chowdhury, P; Samanta, C

Lambda hyperonic effect on the normal drip lines

Ageneralized mass formula is used to calculate the neutron and proton drip lines of normal and lambda hypernuclei treating non-strange and strange nuclei on the same footing. Calculations suggest the existence of several bound hypernuclei whose normal cores are unbound. Addition of Lambda or Lambda Lambda hyperon (s) to a normal nucleus is found to cause non-uniform shifts of the neutron and proton drip lines from their conventional limits making existance of a few exotic hypernuclei beyond the normal drip lines possible.

Samanta, C; Roy Chowdhury, PR; Basu, DN[†]

Search for long lived heaviest nuclei beyond the valley of stability

The existence of long lived superheavy nuclei (SHN) is controlled mainly by spontaneous fission and alpha-decay processes. According to microscopic nuclear theory, spherical shell effects at Z=114, 120, 126 and N=184 provide the extra stability to such SHN to have long enough lifetime to be observed. To investigate whether the so-called "stability island" could really exist around the above Z, N values, the alpha-decay half-lives along with the spontaneous fission and beta-decay half-lives of such nuclei are studied. The alpha-decay half-lives of SHN with Z=102-120 are calculated in a quantum tunneling model with DDM3Y effective nuclear interaction using Q(alpha) values from three different mass formulas prescribed by Koura-Uno-Tachibana-Yamada (KUTY), Myers-Swiatecki (MS), and Muntian-Hofmann-Patyk-Sobiczewski (MMM). Calculation of spontaneous fission (SF) half-lives for the same SHN are carried out using a phenomenological formula and compared with SF half-lives predicted by Smolanczuk A possible source of discrepancy between the calculated alpha-decay half-lives of some nuclei and the experimental data of GSI, JINR-FLNR, RIKEN, is discussed. In the region of Z=106-108 with N similar to 160-164, the beta-stable SHN (268)(106)Sg(162) is predicted to have highest alpha-decay half-life (T-alpha similar to 3.2 h) using Q(alpha) value from MMM. Interestingly, it is much greater than the recently measured T-alpha (similar to 22 s) of deformed doubly magic (270)(108)Hs(162) nucleus. A few fission-survived long-lived SHN which are either beta-stable or having large beta-decay half-lives are predicted to exist near (294)110(184), (293)110(183), (296)112(184), and (298)114(184). These nuclei might decay predominantly through alpha-particle emission.

Roy Chowdhury, P; Samanta, C; Basu, DN[†]

She decays near the magic island

Synthesis of new superheavy element (SHE) and measurement of it's alpha-decay lifetime are two of the major goals of the present day nuclear physics. With the advent of radioactive ion beams it is now possible to sail towards the elusive magic island where the ultimate neutron-rich SHE resides. D.N. Poenaru and his collaborators have made fundamental contributions on a-decay properties of SHE. We present theoretical estimations of a-decay half lives of several new SHE. Calculations in a WKB framework using DDM3Y interaction and experimental Q-values are in good agreement with the experimental data. Half life calculations are found to be extremely sensitive to the Q-values and reveal limitations of available mass formula in the superheavy region.

Samanta, C

Quantum tunneling in (277)112 and its alpha-decay chain

The alpha-decay half lives of nuclei in the decay from element (277)112 are calculated in a WKB framework using DDM3Y interaction and experimental Q-values. Theoretical estimation of half lives in the same quantum tunneling model, using Q-values from the mass formula of Muntian-Hofmann-Patyk-Sobiczewski, are also presented. Calculated results furnish corroborating evidence for the experimental findings at RIKEN and GSI. Certain discrepancies indicate necessity of a better mass formula. Further experimental data with higher statistics would also be useful.

Samanta, Chhanda; Basu, Devasish Narayan[†]; Roy Chowdhury, Partha

Predictions of alpha decay half lives of heavy and superheavy elements

Theoretical estimates for the lifetimes of several isotopes of heavy elements with Z = 102-120 are presented by calculating the quantum mechanical tunneling probability in a WKB framework and using microscopic nucleus-nucleus potential obtained by folding the densities of interacting nuclei with the DDM3Y effective nuclear interaction. The a-decay half lives calculated in this formalism using the experimental Q-values are in good agreement over a wide range of experimental data. Half lives are also calculated using Q-values extracted from two mass formulae. The Viola-Seaborg-Sobiczewski (VSS) estimates of a-decay half lives with the same Q-values are presented for comparison. The half life calculations are found to be quite sensitive to the choice of Q-values. Comparison with the experimental data delineates the inadequacies of older mass predictions in the domain of heavy and superheavy elements as compared to the newer one by Muntian-Hofmann-Patyk-Sobiczewski, and highlights necessity of a more accurate mass formula which can predict Q-values with even higher precision.

Samanta, C; Roy Chowdhury, P; Basu, DN[†]

Alpha decay chains from element 113

Theoretical estimates of alpha-decay half-lives of several nuclei in the decay from element 113 are presented. Calculations in a WKB framework using DDM3Y interaction and experimental Q-values are in good agreement with the experimental data. Half-life calculations are found to be quite sensitive to the Q-values and angular momentum transfers. Calculated decay lifetime decreases, owing to more penetrability as well as thinner barrier, as Q-value increases. Deviations to this predominant behavior observed in some recent experimental data may be attributed to nonzero spin-parities in some cases.

Roy Chowdhury, P; Basu, DN†; Samanta, C

Sub-barrier fusion excitation for the system ^{7}Li+^{28}Si

The sub-barrier fusion excitation functions are measured for the first time for the system ^{7}Li + ^{28}Si by the characteristic gamma-ray method in the energy range E_{lab} = 7-11.5 MeV. The results show an enhancement, below the barrier, by about a factor of two when compared with the one-dimensional barrier penetration (1D BPM) model. Introduction of coupling with the rotational 2^{+} state (1.779 MeV) of the target improves the fit somewhat, but still an enhancement of about 25-40% remains.

Sinha, Mandira; Majumdar, H; Basu, P; Roy, Subinit; Bhattacharya, R†; Biswas, M; Pradhan, MK; Kailas, S†

The study of threshold behaviour of effective potential for ^{6}Li+^{58}Ni,^{64}Ni systems

The elastic scattering for ^{6}Li + ^{64}Ni system was measured in the bombarding energy range of 13 MeV $\leq E_{lab} \leq$ 26 MeV. A phenomenological optical model analysis was performed and the behaviour of the surface strengths of the potential components with decreasing energy was extracted. A further analysis of the measured angular distributions, along with the existing data for ^{6}Li + ^{58}Ni, was performed with two different model potentials-one with the folded potential normalized with a complex factor (OMPI) and the other with a hybrid potential composed of a renormalized folded real and a phenomenological imaginary (OMP2) potential components. All the model potentials predict similar energy dependent behaviour for the interaction potential around the barrier. The observed energy dependence of the strengths of the real and imaginary potentials corroborate with the dispersion relation prediction for both the ^{6}Li + ^{64}Ni and ^{6}Li + ^{58}Ni systems. Though the evidence of breakup is distinct in the energy variation of the potential strengths, close to the barrier the variation is more in the line of conventional threshold anomaly. Also the threshold behaviour of the interaction potential does not indicate any distinct isotopic dependence.

Biswas, M; Roy, Subinit; Sinha, M; Pradhan, MK; Mukherjee, A; Basu, P; Majumdar, H; Ramachandran, K†; Shrivastava, A†

Experimental investigation of fusion of ^{7}Li+^{28}Si above the Coulomb barrier

Excitation functions for the above-barrier fusion cross sections are measured for the first time for the ^{7}Li+^{28}Si system by two methods-the characteristic gamma-ray method and the evaporation alpha measurement method-in the energy range E_{lab}=11.5-26 MeV. Experimental results are consistent and agree with each other, and the one-dimensional Barrier Penetration Model (BPM) predictions describe the data well up to twice the Coulomb barrier, but they overestimate the data by about 15-20% at higher energies.

Sinha, Mandira; Majumdar, H; Bhattacharya, R; Basu, P; Roy, Subinit; Biswas, M; Palit, R†; Mazumdar, I†; Joshi, PK†; Jain, HC†; Kailas, S†

Spectroscopic factors for alpha decay in the NpNn scheme

Lifetime values for alpha decay in even-even nuclei with Z = 84-98 and N = 128-152 have been calculated in the superasymmetric fission model. The interaction between the alpha particle and the daughter nucleus has been formed in the double folding approach using a density dependent NN interaction. The densities have been obtained using the Relativistic Mean Field formalism. The spectroscopic factors for the decays have been deduced and are shown to vary smoothly as a function of effective numbers of valence nucleons, N_p and N_n chosen with a suitable core. The implication of such a smooth behaviour has been discussed.

Bhattacharya, Madhubrata†; Roy, Subinit; Gangopadhyay, G†

Reaction mechanisms in $^{16}O+^{40}Ca$ at an incident energy of $E(^{16}O)=86$ MeV through inclusive measurements of alpha and proton spectra

The alpha and proton spectra from the $^{16}O+^{40}Ca$ reaction is measured at $E(^{16}O)=86$ MeV at several laboratory angles between 54 degrees and 138 degrees. Analysis in terms of the statistical model for compound nuclear reactions show that an event-by-event calculation of the evaporation spectra removes discrepancy observed with standard calculations.

Basu, Chinmay; Adhikari, S; Ghosh, SK; Roy, S; Ray, S†; Behera, BR†; Datta, SK†

Elemental uptake of radish grown near a Municipal Solid Waste dumping site by EDXRF

Radish plant was collected along with root and soil from the nearby area of a Municipal Solid Waste dumping site of the metropolitan city of Kolkata, West Bengal, India and analyzed for a wide range of elements using the EDXRF technique with a ^{109}Cd point source and a Si(Li) detector. The samples comprized of the root-soil, root and leaves. For quality control purposes, NIST standard reference material (SRM) 1648 Urban Particulate Matter had also been analyzed using the same procedure as for the samples. Concentrations of elements with X-ray energies in the range of 3-20 keV in the soil around the root and their uptake pattern by the root and the leaves have been estimated.

Gupta, D; Chatterjee, JM; Ghosh, R; Mitra, AK; Roy, S; Sarkar, M

EDXRF analysis of municipal solid waste using ^{109}Cd source

Elemental compositions of municipal solid waste (MSW) samples have been analyzed using the non-destructive energy dispersive X-ray fluorescence (EDXRF) technique. The samples were collected from three different dumping sites of urban and suburban areas of the city of Kolkata, West Bengal, India. The EDXRF spectrometer consisted of a ^{109}Cd radioactive source and a Si (Li) detector. To check the reliability of the system, NEST Standard Reference Material-1648 UPM had been analyzed and it was found that within the experimental errors, our results agree quite well with the certified and non-certified values. The elemental compositions of all the three MSW samples were subsequently estimated using the same procedure. The matrix effects were estimated following the emission-transmission method.

It was observed that except Fe, all the elements from Ti to Pb show concentration levels higher by a factor of 2-7 than the ecological screening values where as in the case of Fe, this factor varies from 100 to 200.

Gupta, D; Chatterjee, JM; Ghosh, R; Mitra, AK; Roy, S; Sarkar, M

New shell closure for neutron-rich Sn isotopes

The variation of $E(2_1^+)$ of $^{134-140}$Sn calculated with empirical SMPN interaction has striking similarity with that of experimental $E(2_1^+)$ of even-even $^{18-22}$O and $^{42-48}$Ca, showing clearly that N = 84-88 spectra exhibit the effect of gradually filling up the í$(2f_{7/2})$ orbital, which finally culminates in a new shell closure at N = 90. Realistic two-body interaction CWG does not show this feature. Spin-tensor decomposition of SMPN and CWG interactions and variations of their components with valence neutron number reveals that the origin of the shell closure at ^{140}Sn lies in the three-body effects. Calculations with CWG3M, which is obtained by including a simple three-body monopole term in the CWG interaction, predict decreasing $E(2_1^+)$ for ^{136}Sn, ^{138}Sn and a shell closure at ^{140}Sn.

Sarkar, S†; Saha Sarkar, M

Fusion cross sections for ^{6}Li,^{7}Li+^{24}Mg reactions at energies below and above the barrier

Measurement of fusion cross sections for the ^{6}Li,^{7}Li+^{24}Mg reactions by the characteristic gamma-ray method has been done at energies from below to well above the respective Coulomb barriers. The fusion cross sections obtained from these gamma-ray cross sections for the two systems are found to agree well with the total reaction cross sections at low energies. The relatively large difference between total cross sections and measured fusion cross sections at higher energies is consistent with the fact that other channels, in particular breakup, open up with an increase of bombarding energy. The breakup channel, however, appears not to have any influence on fusion cross sections. The critical angular momenta l_{cr} deduced from the fusion cross sections are found to have an energy dependence similar to other Li-induced reactions.

Ray, M; Mukherjee, A; Pradhan, MK; Kshetri, Ritesh; Saha Sarkar, MS; Palit, R†; Majumdar, I†; Joshi, PK†; Jain, HC‡; Dasmahapatra, B

Structure of even-even A=138 isobars and the yrast spectra of semi-magic Sn isotopes above the ^{132}Sn core

Large basis untruncated shell model (SM) calculations have been done for the A = 138 neutron-rich nuclei in the π (gdsh) ν (hfpi) valence space above the ^{132}Sn core using two (1+2) -body nuclear Hamiltonians, viz., realistic CWG and empirical SMPN. Calculated binding energies, excitation spectra, and wave function structures are compared for even-even A = 138 isobars for which experimental data are available. The nearly vibrational states in ^{138}Te, Xe, and the $B(E2;\ 2^+ \rightarrow 0^+)$ Value in ^{138}Xe are excellently reproduced by both the interactions. For ^{138}Ba, the calculated spectra and the $B(E2;\ 2^+ \rightarrow 0^+)$ value also agree very well with the experimental results. But the two theoretical results differ dramatically for ^{138}Sn, a nucleus on the r-process path. CWG predicts nearly constant energies of 2_1^+ states for the even-even Sn isotopes above the ^{132}Sn core, normally expected for semi-magic nuclei. But SMPN predicts a remarkable new feature: decreasing $E(2_1^+)$ energies with increasing neutron number. The predicted energies for the Sn isotopes fit in the systematics for the $E(2_1^+)$ energies of their isotones with Z > 50. Despite their differences, both interactions predict the 6_1^+ state to be a ≈ 0.3 μ s isomer in ^{138}Sn. Calculated magnetic dipole moments and electric quadrupole moments of the states in these isobars are compared with the experimental data wherever available. The appearance of deformation and evolution of collectivity in nuclei in this valence space are discussed.

Sarkar, S†; Saha Sarkar, M

High-spin structure and band termination in ^{103}Cd

Excited states of the neutron-deficient ^{103}Cd nucleus have been investigated via the ^{72}Ge (^{35}Cl, p3n) reaction at beam energy of 135 MeV by use of in-beam spectroscopic methods. Gamma rays depopulating the excited states were detected using the Gammasphere spectrometer with high-fold gamma-ray coincidences. A quadrupole gamma-ray coincidence analysis (γ^4) has been used to extend the known level scheme. The positive-parity levels have been established up to J=35/2ž and E_x = 7.071 MeV. In addition to the observation of a highly fragmented level scheme belonging to the positive-parity sequences at E_x ~ 5 MeV, the termination of a negative-parity sequence connected by E2 transitions has been established at J = 47/2ž and E_x = 11.877 MeV. The experimental results corresponding to both the positive- and negative-parity sequences have been theoretically interpreted in the framework of the core particle coupling model. Evidence is presented for a shape change from collective prolate to noncollective oblate above the $J_\pi=3^9/_2$(8011 keV) level and for a smooth termination of the negative-parity band.

Chakraborty, A†; Krishichayan†; Mukhopadhyay, S†; Ray, S; Chintalapudi, SN†; Ghugre, SS†; Pattabiraman, NS†; Sinha, AK†; Sarkar, S†; Garg, U†; Zhu, S†; Saha Sarkar, M

First observation of excited states in the ^{138}I nucleus

Excited states in the ^{138}I nucleus, including $T_{½}$=1.3 μs isomer decaying by a stretched E2 transition of 68 keV, were observed for the first time. The ^{138}I nucleus was populated in the spontaneous fission of ^{248}Cm and studied by means of prompt gamma-ray spectroscopy using the EUROGAM 2 array. The microsecond isomer was populated in the neutron-induced fission of U-235 and observed at the LOHENGRIN separator. Excitation scheme consists of a low-spin part and a medium-spin, ΔI=1, band based on the 7^- state with the ð $g_{7/2}$í $f_{7/2}(7^-)$ dominating configuration, as predicted by the shell model. The shell-model calculations of ^{138}I provide the optimum reproduction of the experimental scheme when the $\pi d_{5/2}$ orbital is lowered by 600 keV relative to its position in ^{133}Sb. In the calculation the isomeric level has spin and parity 3^- and deexcites by an E2 isomeric transition to the 1^- level, located only 9 keV above the predicted 0^- ground state. Considering additional information on the ground-state spin from the literature, we propose that in ^{138}I the 1^- level corresponds to the ground state and the 0^- is located above. We note, however, that additional measurements are required to resolve this problem.

Rzaca-Urban, T†; Pagowska, K†; Urban, W†; Zlomaniec, A†; Genevey, J†; Pinston, JA†; Simpson, GS†; Saha Sarkar, M; Sarkar, S†; Faust, H†; Scherillo, A†; Tsekhanovich, I†; Orlandi, R†; Durell, JL†; Smith, AG†; Ahmand, I†

First observation of medium-spin excitations in the ^{138}Cs nucleus

Medium-spin, yrast excitations in the ^{138}Cs nucleus, populated in the spontaneous fission of ^{248}Cm, were observed for the first time. ^{138}Cs was studied by means of prompt ray spectroscopy using the EUROGAM2 array. The newly observed yrast cascade, built on the known 6^{-} isomer at 80 keV, was successfully described by shell model calculations. Analogously to the ^{136}I isotone, the 6^{-} isomer in ^{138}Cs has the (ð$g^{4}_{7/2}$ $d_{5/2}^{\;\nu}$ $f_{7/2}$)6^{-} dominating configuration and the 7^{-} excitation, located 175 keV above, corresponds to the (ð$g^{3}_{7/2}$ $d^{2}_{5/2}$ $^{\nu}$ $f_{7/2}$)7^{-} as dominating configuration. Similarly as in ^{136}I, changing the position of the d(5/2) proton orbital improves the reproduction of the data. However, in ^{138}Cs the energy of this orbital should be increased compared to its energy in ^{133}Sb, to get the best description, in contrast to ^{136}I and ^{135}Sb, where it had to be decreased. The best reproduction of excitation energies in ^{138}Cs is obtained assuming that the $\pi d_{5/2}$ orbital in ^{138}Cs is located about 100 keV higher than in ^{133}Sb. These observations suggest that the lowering of the $d_{5/2}$ s. p. energy in ^{135}Sb is not a physical effect due to the appearance of a neutron skin, as proposed by other authors, but rather an artifact due to some deficiency of the input data used in the shell model calculations in the region of the doubly magic ^{132}Sn core.

Rzaca-Urban, T†; Urban, W†; SahaSarkar, M; Sarkar, S†; Durell, JL†; Smith, AG†; Varley, BJ†; Ahmad, I†

Observation of enhanced orbital electron-capture nuclear decay rate in a compact medium

The eigenstate energies of an atom increase under spatial confinement and this effect should increase the electron density of the orbital electrons at the nucleus thus increasing the decay rate of an electron capturing radioactive nucleus. We have observed that the orbital electron capture rates of ^{109}In and ^{110}Sn increased by (1.00 ± 0.17)% and (0.48 ± 0.25)% respectively when implanted in the smaller Au lattice compared to implantation in a larger Pb lattice. These observations are interpreted to be a result of the higher compression experienced by the large radioactive atoms in the smaller spatial confinement of the Au lattice.

Ray, A†; Das, P†; Saha, SK†; Goswami, A; De, A†

The unbound isotopes ^{9}He, ^{10}He

The unbound nuclei ^{9}He and ^{10}He have been produced in proton-knockout reactions from a 280 MeV/u Li-11 beam impinging on a liquid hydrogen target at the ALADIN-LAND setup at GSI. Information on their nuclear structure has been obtained from the relative-energy spectra, He-8 + n and ^{8} He+2n, employing reaction models incorporating the structure of ^{11}Li.The ^{8}He + n relative-energy spectrum is dominated by a strong peak-like structure at low energy, which may be interpreted within the effective-range approximation as the result of an s-wave interaction with a neutron scattering length of -3.17(66) fm. This spectrum also shows evidence for resonance states at 1.33(8) MeV and at 2.4 MeV above the ^{8} He+ n threshold. It is argued that the s-state might not be the He-9 ground state. For ^{8} He+ n + n, the analysis of the relative-energy spectrum gives two alternative possibilities for an interpretation: either a narrow resonance at 1.42(10) MeV (ã = 1.11(76) MeV) superimposed on a correlated background, or two overlapping resonances, a ground state at 1.54(11) MeV (ã = 1.91(41) MeV) together with an excited state at 3.99(26) MeV (ã = 1.64(89) MeV). The two possible interpretations are discussed.

Johansson, HT†; Aksyutina, Y†; Aumann, T†; Boretzky, K†; Borge, MJG†; Chatillon, A†; Chulkov, LV†; Cortina-Gil, D†; Datta Pramanik, U; Emling, H†; Forssen, C†; Fynbo, HOU†; Geissel, H†; Ickert, G†; Jonson, B†; Kulessa, R†; Langer, C†; Lantz, M†; LeBleis, T†; Mahata, K†; Meister, M†; Munzenberg, G†; Nilsson, T†; Nyman, G†; Palit, R; Paschalis, S†; Prokopowicz, W†; Reifarth, R†; Richter, A†; Riisager, K†; Schrieder, G†; Simon, H†; Summerer, K†; Tengblad, O†; Weick, H†; Zhukov, MV†

Channel coupling effects on the fusion excitation functions for Si-28+Zr-90,Zr-94 in sub- and near-barrier regions

Fusion excitation functions and angular distributions of evaporation residues (ERs) have been measured for ^{28}Si + ^{90}Zr, ^{94}Zr systems around the Coulomb barrier using the recoil mass spectrometer, Heavy Ion Reaction Analyzer (HIRA). For both systems, the experimental fusion cross sections are strongly enhanced compared to the predictions of the one-dimensional barrier penetration model (1-d BPM) below the barrier. Coupled channels formalism has been employed to theoretically explain the observed sub-barrier fusion cross section enhancement. The enhancement could be explained by considering the coupling of the low-lying inelastic states of the projectile and target in the ^{28}Si + ^{90}Zr system. In the sub-barrier region, the measured fusion cross sections for ^{28}Si + ^{94}Zr turned out to be about an order of magnitude higher than the ones for the ^{28}Si + ^{90}Zr system, which could not be explained by coupling to inelastic states alone. This observation indicates the importance of multinucleon transfer reaction channels with positive Q values in the sub-barrier fusion cross section enhancement, because ^{90}Zr, ^{94}Zr are believed to have similar collective strengths. This implies that no strong isotopic dependence of fusion cross sections is expected as far as the couplings to collective inelastic states are concerned. In addition, the role of projectile and multiphonon couplings in the enhancement has been explored.

Kalkal, Sunil†; Mandal, S†; Madhavan, N†; Prasad, E†; Verma, Shashi†; Jhingan, A†; Sandal, R†; Nath, S†; Gehlot, J†; Behera, BR†; Saxena, M†; Goyal, S†; Siwal, D†; Garg, R†; Dutta Pramanik, U; Kumar, Suresh†; Varughese, T†; Golda, KS†; Muralithar, S†; Sinha, AK†; Singh, R†

Properties of the ^{7}He ground state from ^{8}He neutron knockout

The unbound nucleus ^{7}He, produced in neutron-knockout reactions with a 240 MeV/u ^{8}He beam in a liquid-hydrogen target, has been studied in an experiment at the ALADIN-LAND setup at GSL From an R-matrix analysis the resonance parameters for ^{7}He as well as the spectroscopic factor for the ^{6}He (0(+)) + n configuration in its ground-state have been obtained. The spectroscopic factor is 0.61 confirming that ^{7}He is not a pure single-particle state. An analysis of ^{5}He data from neutron-knockout reactions of ^{6}He in a carbon target reveals the presence of ail s-wave component at low energies in the alpha + n relative energy spectrum.

A possible low-lying exited state in ^{7}He observed in neutron knockout data from He-8 in a carbon target and tentatively interpreted as a I-ð=½$^{-}$ state, could not be observed in the present experiment. Possible explanations of the shape difference between the ^{7}He resonance obtained in the two knockout reactions are discussed in terms of target-dependence or different reaction mechanisms at relativistic energies.

Aksyutina, Yu†; Johansson, HT†; Aumann, T†; Boretzky, K†; Borge, MJG†; Chatillon, A†; Chulkov, LV†; Cortina-Gil, D†; Datta Pramanik, U; Emling, H†; Forssen, C†; Fynbo, HOU†; Geissel, H†; Ickert, G†; Jonson, B†; Kulessa, R†; Langer, C†; Lantz, M†; LeBleis, T†; Lindahl, AO†; Mahata, K†; Meister, M†; Muenzenberg, G†; Nilsson, T†; Nyman, G†; Palit, R†; Paschalis, S†; Prokopowicz, W†; Reifarth, R†; Richter, A†; Riisager, K†; Schrieder, G†; Simon, H†; Summerer, K†; Tengblad, O†; Weick, H†; Zhukov, MV†

Band structures in near spherical ^{138}Ce

The high spin states of N = 80 ^{138}Ce have been populated in the fusion evaporation reaction ^{130}Te (^{12}C, 4n) ^{138}Ce at E_{beam}=65 MeV. The gamma transitions belonging to various band structures were detected and characterized using an array of five Clover Germanium detectors. The level scheme has been established up to a maximum spin and excitation energy of 23ž and 9511.3 keV, respectively, by including 53 new transitions. The negative parity $\Delta I = 1$ band, developed on the 6536.3 keV 15^{-} level, has been conjectured to be a magnetic rotation band following a semiclassical analysis and comparing the systematics of similar bands in the neighboring nuclei. The said band is proposed to have a four quasiparticle configuration of $[\pi g_{7/2} h_{11/2}] \otimes [\nu h_{11/2}]^{-2}$. Other band structures are interpreted in terms of multi-quasiparticle configurations, based on Total Routhian Surface (TRS) calculations. For the low and medium spin states, a shell model calculation using a realistic two body interaction has been performed using the code OXBASH.

Bhattacharjee, T†; Chanda, S†; Bhattacharyya, S†; Basu, SK†; Bhowmik, RK†; Das, JJ†; Datta Pramanik, U; Ghugre, SS†; Madhavan, N†; Mukherjee, A; Mukherjee, G†; Muralithar, S†; Singh, RP†

Seven-quasiparticle bands in ^{139}Ce

The high spin states in the ^{139}Ce nucleus have been studied by in-beam gamma-spectroscopic techniques using the reaction ^{130}Te(^{12}C,3n) ^{139}Ce at E_{beam}=65 MeV. A gamma detector array, consisting of five Compton-suppressed Clover detectors was used for coincidence measurements. 15 new levels have been proposed and 28 new gamma transitions have been assigned to ^{139}Ce on the basis of gamma gamma coincidence data. The level scheme of ^{139}Ce has been extended above the known 70 ns $^{19}/_{2}{}^{-}$ isomer up to ~ 6.1 MeV in excitation energy and 35/2ž in spin. The spin-parity assignments for most of the newly proposed levels have been made using the deduced Directional Correlation from Oriented states of nuclei (DCO ratio) and the Polarization Directional Correlation from Oriented states (PDCO ratio) for the de-exciting transitions. The observed level structure has been compared with a large basis shell model calculation and also with the predictions from cranked Nilsson-Strutinsky (CNS) calculations. A general consistency has been observed between these two different theoretical approaches.

Chanda, Somen†; Bhattacharjee, Tumpa†; Bhattacharyya, Sarmishtha†; Mukherjee, Anjali; Basu, Swapan Kumar†; Ragnarsson, I†; Bhowmik, RK†; Muralithar, S†; Singh, RP†; Ghugre, SS†; Datta Pramanik, U

Lithium isotopes beyond the drip line

The unbound isotopes ^{10}Li, ^{12}Li and ^{13} Li have been observed after nucleon-knockout reactions at relativistic energies with ^{11}Liand ^{14}Be beams impinging on a liquid hydrogen target. The channels ^{9}Li+n, ^{11}Li+ n and ^{11}Li+2n were analysed in the ALADIN-LAND setup at GSI. The ^{10}Li data confirm earlier findings, while the ^{12}Li and ^{13} Li nuclei were observed for the first time. The ^{11}Li + n relative-energy spectrum shows that the ground state of ^{12} Li can be described as a virtual s-state with a scattering length of -13.7(1.6) fm. A broad energy spectrum was found for the ^{11}Li+(2)n channel. Based on the assumption that the relative-energy spectrum is dominated by a correlated background presumably stemming from initial correlations in the Be-14 ground-state, evidence for a ^{13}Li resonance at 1.47(31) MeV above the ^{11}Li+2n threshold with a width around 2 MeV has been found.

Aksyutina, Y†; Johansson, HT†; Adrich, P†; Aksouh, F†; Aumann, T†; Boretzky, K†; Borge, MJG†; Chatillon, A†; Chulkov, LV†; Cortina-Gil, D†; Datta Pramanik, U; Emling, H†; Forssen, C†; Fynbo, HOU†; Geissel, H†; Hellstrom, M†; Ickert, G†; Jones, KL†; Jonson, B†; Kliemkiewicz, A†; Kratz, JV†; Kulessa, R†; Lantz, M†; LeBleis, T†; Lindahl, AO†; Mahata, K†; Matos, M†; Meister, M†; Munzenberg, G†; Nilsson, T†; Nyman, G†; Palit, R†; Pantea, M†; Paschalis, S†; Prokopowicz, W†; Reifarth, R†; Richter, A†; Riisager, K†; Schrieder, G†; Simon, H†; Summerer, K†; Tengblad, O†; Walus, W†; Weick, H†; Zhukov, MV†

Multi-quasiparticle bands in ^{137}Ce

Excited states of ^{137}Ce, populated in the ^{130}Te (^{12}C, 5n) reaction at a beam energy of 65 MeV, have been investigated by gamma gamma coincidence spectroscopy using a modest Clover Ge array. Unique spin-parity assignments have been made for most of the levels at high spin and excitation energy by using DCO ratios and polarization information. The known level scheme of ^{137}Ce has been considerably revised on the basis of the new information. A sequence of M 1 transitions, developed on the 5379.1-keV 33/2ž level has been suggested to be a positive-parity band through unambiguous assignment of multipolarity of 1124.1- and 836.1-keV gamma rays. Another positive-parity bandlike structure has been seen, starting at the 2928.4-keV 19/2^{+} level. Total Routhian surface calculations have been done to predict underlying multi-quasiparticle configurations for the observed bands.

Bhattacharjee, Tumpa†; Chanda, Somen†; Mukherjee, Anjali; Bhattacharyya, Sarmishtha†; Basu, Swapan Kumar†; Ghugre, Sandeep S†; Dutta Pramanik, U; Singh, RP†; Muralithar, S†; Madhavan, N†; Das, JJ†; Bhowmik, RK†

Systematic investigation of the drip-line nuclei ^{11}Li and ^{14}Be and their unbound subsystems ^{10}Li and ^{13}Be

Fragmentation reactions in a carbon target with beams of ^{11}Li and ^{14}Be at relativistic energies have been studied in a kinematically complete experiment at the ALADIN-LAND setup at GSI. Excited states in ^{11}Li and ^{14}Be were obtained from the data in the inelastic channel. The measured cross sections with the core nucleus in the final state show that in the ^{14}Be case core polarization plays an important role. In the one-neutron knockout channels the measured angular correlations between fragment and neutron are asymmetric, which demonstrates the presence of states with different parities in the ^{11}Li and ^{14}Be ground states. For ^{10}Li a low-lying virtual s-state, a p-state and evidence for a d-state could be extracted from the data, while the ^{12}Be+ n system shows resonances with more complicated structure.

Simon, H†; Meister, M†; Aumann, T†; Borge, MJG†; Chulkov, LV†; Datta Pramanik, U; Elze, Th W†; Emling, H†; Forssen, C†; Geissel, H†; Hellstrom, M†; Jonson, B†; Kratz, Jx†; Kulessa, R†; Leifels, Y†; Markenroth, K†; Munzenberg, G†; Nickel, F†; Nilsson, T†; Nyman, G†; Richter, A†; Riisager, K†; Scheidenberger, C†; Schrieder, G†; Tengblad, O†; Zhukov, MV†

Sub-barrier Coulomb excitation of ^{110}Sn and its implications for the ^{100}Sn shell closure

The first excited 2^+ state of the unstable isotope ^{110}Sn has been studied in safe Coulomb excitation at 2.82 MeV/u using the MINIBALL array at the REX-ISOLDE post accelerator at CERN. This is the first measurement of the reduced transition probability of this state using this method for a neutron deficient Sn isotope. The strength of the approach lies in the excellent peak-to-background ratio that is achieved. The extracted reduced transition probability, $B(E2 : 0^+ \rightarrow 2^+) = 0.220 \pm 0.022\ e^2b^2$, strengthens the observation of the evolution of the B(E2) values of neutron deficient Sn isotopes that was observed recently in intermediate-energy Coulomb excitation of ^{108}Sn. It implies that the trend of these reduced transition probabilities in the even-even Sn isotopes is not symmetric with respect to the midshell mass number A = 116 as ^{110}Sn is approached.

Cederkall, J†; Ekstrom, A†; Fahlander, C†; Hurst, AM†; Hjorth-Jensen, M†; Ames, F†; Banu, A†; Butler, PA†; Davinson, T†; Datta Pramanik, U; Eberth, J†; Franchoo, S†; Georgiev, G†; Gorska, M†; Habs, D†; Huyse, M†; Ivanov, O†; Iwanicki, J†; Kester, O†; Koster, U†; Marsh, BA†; Niedermaier, O†; Nilsson, T†; Reiter, P†; Scheit, H†; Schwalm, D†; Sieber, T†; Sletten, G†; Stefanescu, I†; de Walle, JV†; Van Duppen, P†; Warr, N†; Weisshaar, D†; Wenander, F†

The study of the reduced alpha-width and ANC of ^{16}O states through its sequential breakup

In this work we theoretically study using continuum-discretized-coupled channel (CDCC) theory, the resonant breakup of ^{16}O by comparison with a recent measurement. The ground state Asymptotic Normalization Coefficient (ANC) and the alpha spectroscopic factor of ^{16}O are evaluated in this work. The peripheral aspect of resonance breakup through a 2^+ unbound state has been also studied.

Adhikari, Sucheta; Basu, Chinmay

The Study of alpha+ ^{14}C Cluster States Luster States of ^{18}O Through the Resonant Break Reaction ^{12}C(^{18}O, ^{14}C alpha) AT E(^{18}O)=94.5 MeV

In this work, we study the alpha cluster structure of ^{18}O using resonant particle spectroscopy technique. Resonance breakup reaction of the projectile is studied experimentally to extract the excitation energy spectrum of the ^{18}O nucleus. The observed resonant states in the present work are 15.62, 15.82 (5(-)), 16.02, 16.22, 16.42, 16.92, 17.22, and 17.82 MeV.

Adhikari, S; Basu, C; Behera, BR†; Ray, S†; Mitra, AK; Kumar, Suresh†; Chatterjee, A†

Reaction mechanisms in $^{16}O+^{40}Ca$ at an incident energy of $E(^{16}O)$=86 MeV through inclusive measurements of alpha and proton spectra

The alpha and proton spectra from the $^{16}O+^{40}Ca$ reaction is measured at $E(^{16}O)$ =86 MeV at several laboratory angles between 54 degrees and 138 degrees. Analysis in terms of the statistical model for compound nuclear reactions show that an event-by-event calculation of the evaporation spectra removes discrepancy observed with standard calculations.

Basu, Chinmay; Adhikari, S; Ghosh, SK; Roy, S; Ray, S†; Behera, BR†; Datta, SK†

Influence of projectile breakup on complete fusion

Complete fusion excitation functions for B-11,B-10+ Tb-159 and Li-6,Li-7+ Tb-159 have been reported at energies around the respective Coulomb barriers. The measurements show significant suppression of complete fusion cross-sections at energies above the barrier for B-10 + Tb-159 and Li-6,Li-7 + Tb-159 reactions, when compared to those for B-11+Tb-159. The comparison shows that the extent of suppression of complete fusion cross-sections is correlated with the alpha-separation energies of the projectiles. Also, the measured incomplete fusion cross-sections show that the alpha-particle emanating channel is the favoured incomplete fusion process. Inclusive measurement of the alpha-particles produced in Li-6+ Tb-159 reaction has been carried out. Preliminary CDCC calculations carried out to estimate the alpha-yield following Li-6 breaking up into alpha+d fail to explain the measured alpha-yield. Transfer processes seem to be important contributors.

Mukherjee, A; Pradhan, MK

Suppression of complete fusion due to breakup in the reactions B-10,B-11+Bi-209

Above-barrier cross sections of fission and alpha-active heavy reaction products were measured for the reactions of B-10,B-11 with Bi-209. Systematic analysis showed that the fission originates almost exclusively from complete fusion (CF). Existing measurements of above-barrier fusion products for the Si-30 + W-186 reaction, assumed to proceed exclusively through CF, were extrapolated to the current systems using statistical model calculations. This extrapolation showed that the heavy reaction products from the B-10,B-11 + Bi-209 reactions include substantial components from incomplete fusion as well as from CF. Compared with fusion calculations without breakup, the CF cross sections are suppressed by 15% for B-10 and 7% for B-11. A consistent and systematic variation of the suppression of CF for reactions of the weakly bound nuclei Li-6,Li-7, Be-9, and B-10,B-11 on targets of Pb-208 and Bi-209 is found as a function of the breakup threshold energy.

Gasques, LR†; Hinde, DJ†; Dasgupta, M†; Mukherjee, A; Thomas, RG†

Fusion cross sections for Li-6,Li-7+Mg-24 reactions at energies below and above the barrier

Measurement of fusion cross sections for the Li-6,Li-7 + Mg-24 reactions by the characteristic gamma-ray method has been done at energies from below to well above the respective Coulomb barriers. The fusion cross sections obtained from these gamma-ray cross sections for the two systems are found to agree well with the total reaction cross sections at low energies. The relatively large difference between total cross sections and measured fusion cross sections at higher energies is consistent with the fact that other channels, in particular breakup, open up with an increase of bombarding energy. The breakup channel, however, appears not to have any influence on fusion cross sections. The critical angular momenta (l_{cr}) deduced from the fusion cross sections are found to have an energy dependence similar to other Li-induced reactions.

Ray, M; Mukherjee, A; Pradhan, MK; Kshetri, Ritesh; Saha Sarkar, M; Palit, R†; Majumdar, I†; Joshi, PK†; Jain, HC†; Dasmahapatra, B

The ALICE experiment at the CERN LHC

ALICE (A Large Ion Collider Experiment) is a general-purpose, heavy-ion detector at the CERN LHC which focuses on QCD, the strong-interaction sector of the Standard Model. It is designed to address the physics of strongly interacting matter and the quark-gluon plasma at extreme values of energy density and temperature in nucleus-nucleus collisions. Besides running with Pb ions, the physics programme includes collisions with lighter ions, lower energy running and dedicated proton-nucleus runs. ALICE will also take data with proton beams at the top LHC energy to collect reference data for the heavy-ion programme and to address several QCD topics for which ALICE is complementary to the other LHC detectors. The ALICE detector has been built by a collaboration including currently over 1000 physicists and engineers from 105 Institutes in 30 countries, Its overall dimensions are 16 x 16 x 26 m^3 with a total weight of approximately 10 000 t. The experiment consists of 18 different detector systems each with its own specific technology choice and design constraints, driven both by the physics requirements and the experimental conditions expected at LHC. The most stringent design constraint is to cope with the extreme particle multiplicity anticipated in central Pb-Pb collisions. The different subsystems were optimized to provide high-momentum resolution as well as excellent Particle Identification (PID) over a broad range in momentum, up to the highest multiplicities predicted for LHC. This will allow for comprehensive studies of hadrons, electrons, muons, and photons produced in the collision of heavy nuclei. Most detector systems are scheduled to be installed and ready for data taking by mid-2008 when the LHC is scheduled to start operation, with the exception of parts of the Photon Spectrometer (PHOS), Transition Radiation Detector (TRD) and Electro Magnetic Calorimeter (EMCal). These detectors will be completed for the high-luminosity ion run expected in 2010. This paper describes in detail the detector components as installed for the first data taking in the summer of 2008.

ALICE Collaboration

Abrupt change of rotation axis in Ag-109

The electromagnetic transition rates for all the high spin levels of the yrast sequence of Ag-109 have been measured. The observed behavior of the magnetic dipole transition rates as a function of angular momentum establishes that there is a sudden change in rotation axis associated with rotational alignment of two neutrons. The projected shell model calculations give a consistent picture of the observed phenomena in Ag-109.

Datta, P; Roy, S; Pal, S; Chattopadhyay, S; Bhattacharya, S; Goswami, A; Saha Sarkar, M; Sheikh, JA†; Sun, Y†; Rao, PVMadhusudhana†; Bhowmik, RK† ; Kumar, R†; Madhavan, N†; Muralithar, S; Singh, RP†; Jain, HC†; Joshi, PK†; Amita†

Real time global tests of the ALICE High Level Trigger data transport framework

The High Level Trigger (HLT) system of the ALICE experiment is an online event filter and trigger system designed for input bandwidths of up to 25 GB/s at event rates of up to 1 kHz. The system is designed as a scalable PC cluster, implementing several hundred nodes. The transport of data in the system is handled by an object-oriented data flow framework operating on the basis of the publisher-subscriber principle, being designed fully pipelined with lowest processing overhead and communication latency in the cluster. In this paper, we report the latest measurements where this framework has been operated on five different sites over a global north-south link extending more than 10,000 km, processing a "real-time" data flow.

Becker, B†; Chattopadhyay, S; Cicalo†, C; Cleymans, J†; de Vaux, G†; Fearick, RW†; Lindenstruth, V†; Richter, M†; Rohrich, D†; Staley, F†; Steinbeck, TM†; Szostak, A†; Tilsner, H†; Weis, R†; Vilakazi, ZZ†

Matter-induced charge-symmetry-violating N N potential

We construct a density-dependent, Class III, charge-symmetry-violating (CSV) potential due to mixing of the rho-omega meson with off-shell corrections. Here, in addition to the usual vacuum contribution, the matter-induced mixing of ñù is also included. It is observed that the contribution of the density-dependent CSV potential is comparable to that of the vacuum contribution.

Biswas, Subhrajyoti; Roy, Pradip; Dutt-Mazumder, Abhee K

First proton-proton collisions at the LHC as observed with the ALICE detector: measurement of the charged-particle pseudorapidity density at $\sqrt{s}$ = 900 GeV

On 23rd November 2009, during the early commissioning of the CERN Large Hadron Collider (LHC), two counter-rotating proton bunches were circulated for the first time concurrently in the machine, at the LHC injection energy of 450 GeV per beam. Although the proton intensity was very low, with only one pilot bunch per beam, and no systematic attempt was made to optimize the collision optics, all LHC experiments reported a number of collision candidates. In the ALICE experiment, the collision region was centred very well in both the longitudinal and transverse directions and 284 events were recorded in coincidence with the two passing proton bunches. The events were immediately reconstructed and analyzed both online and offline. We have used these events to measure the pseudorapidity density of charged primary particles in the central region. In the range |ç|< 0.5, we obtain dN_{ch}/dç = 3.10 ± 0.13 (stat.) ± 0.22(syst.) for all inelastic interactions, and dN_{ch}/dç = 3.51 +/- 0.15(stat.) +/- 0.25(syst.) for nonsingle diffractive interactions. These results are consistent with previous measurements in proton-antiproton interactions at the same centre-of-mass energy at the CERN SppS collider. They also illustrate the excellent functioning and rapid progress of the LHC accelerator, and of both the hardware and software of the ALICE experiment, in this early start-up phase.

ALICE Collaboration

Measuring the isotropization time of quark-gluon plasma from direct photons at energies available at the BNL Relativistic Heavy Ion Collider (RHIC)

We calculate transverse momentum distribution of direct photons from various sources by taking into account the initial state momentum anisotropy of quark-gluon plasma (QGP) and late stage transverse flow effects. To evaluate the photon yield from hadronic matter we include the contributions from baryon-meson reactions. The total photon yield, calculated for various combinations of initial conditions and transition temperatures, is then compared with the recent measurement of photon transverse momentum distribution by the PHENIX Collaboration. It is shown that because of the initial state anisotropy the photon yield from the QGP is larger by a factor of 8-10 than that of the isotropic case in the intermediate p(T) regime. It is also demonstrated that the presence of such an anisotropy can describe the PHENIX photon data better than the isotropic case in the present model. We show that the isotropization time thus extracted lies within the range $1.5 \geq \hat{o}_{iso} \geq 0.5$ fm/c for the initial conditions used here.

Bhattacharya, Lusaka; Roy, Pradip

Photons from anisotropic quark-gluon plasma

We calculate medium photons due to Compton and annihilation processes in an anisotropic media. The effects of time-dependent momentum-space anisotropy of quark-gluon plasma (QGP) on the medium photon production are discussed. Such an anisotropy can result from the initial rapid longitudinal expansion of the matter, created in relativistic heavy ion collisions. A phenomenological model for the time-dependence of the parton hard momentum scale, $p_{hard}(\hat{o})$, and anisotropy parameter, $\hat{\imath}(\hat{o})$, has been used to describe the plasma space-time evolution. We find significant dependency of photon yield on the isotropization time $\hat{o}_{iso}$. It is shown that the introduction of early time momentum-space anisotropy can enhance the photon production by a factor of 10(1.5) (in the central rapidity region) for the free streaming (collisionally-broadened) interpolating model if we assume fixed initial condition. On the other hand, enforcing the fixed final multiplicity significantly reduces the enhancement of medium photon production.

Bhattacharya, Lusaka; Roy, Pradip

ρ–ù mixing and spin dependent charge-symmetry violating potential

We construct the charge symmetry violating (CSV) nucleon-nucleon potential induced by the ρ^{o}–ù mixing due to the neutron-proton mass difference driven by the NN loop. Analytical expression for the two-body CSV potential is presented containing both the central and noncentral NN interaction. We show that the ρ^{NN} tensor interaction can significantly enhance the charge symmetry violating NN interaction even if the momentum dependent off-shell ρ^{o}–ù mixing amplitude is considered. It is also shown that the inclusion of form factors removes the divergence arising out of the contact interaction.

Consequently, we see that the precise size of the computed scattering length difference depends on how the short-range aspects of the CSV potential are treated.

Biswas, Subhrajyoti; Roy, Pradip; Dutt-Mazumder, Abhee K

Quenching of light hadrons at RHIC in a collisional energy loss scenario

We evaluate the nuclear suppression factor, RAA(p_T) for light hadrons by taking into account the collisional energy loss. Within the ambit of the present model we show that in the measured p_T domain of RHIC the contribution from the elastic process has a sizable magnitude.

Roy, Pradip; Alam, Jan-e†; Dutt-Mazumder, Abhee K

Matter-induced charge symmetry breaking and the pion form factor in nuclear medium

Medium modification of the pion form factor has been evaluated in asymmetric nuclear matter (ANM). It is shown that both the shape and the pole position of the pion form factor in dense asymmetric nuclear matter is different from its vacuum counterpart with rho-omega mixing. This is due to the density and asymmetry-dependent rho-omega mixing which could even dominate over its vacuum counterpart in matter. Results are presented for an arbitrarily mixing angle. The effect of the in-medium pion factor on experimental observables, e. g., invariant mass distribution of lepton pairs has been demonstrated.

Roy, Pradip; Dutt-Mazumder, Abhee K; Sarkar, Sourav†; Alam, Jan-e†

Thermal radiation from Au plus Au collisions at $\sqrt{S_{NN}}$=200 GeV energy

The transverse momentum distribution of the direct photons measured by the PHENIX Collaboration in Au+Au collisions at $\sqrt{S_{NN}}$ = 200 GeV/A has been analysed. It has been shown that the data can be reproduced reasonably well assuming a deconfined state of thermalized quarks and gluons with initial temperature more than the transition temperature for deconfinement inferred from lattice QCD. The value of the initial temperature depends on the equation of state of the evolving matter. The sensitivities of the results on various input parameters have been studied. The effects of the modifications of hadronic properties at non-zero temperature have been discussed.

Alam, Jan-e†; Nayak, Jajati K†; Roy, Pradip; Dutt-Mazumder, Abhee K; Sinha, Bikash

Matter-induced charge-symmetry-violating N N potential

We construct a density-dependent, Class III, charge-symmetry-violating (CSV) potential due to mixing of the rho-omega meson with off-shell corrections. Here, in addition to the usual vacuum contribution, the matter-induced mixing of rho-omega is also included. It is observed that the contribution of the density-dependent CSV potential is comparable to that of the vacuum contribution.

Biswas, Subhrajyoti; Roy, Pradip; Dutt-Mazumder, Abhee K

Spin susceptibility of degenerate quark matter

The expression for spin susceptibility χ of degenerate quark matter is derived with corrections up to $O(g^4 \ln g^2)$. It is shown that, at low density, χ^{-1} changes sign and turns negative, indicating a ferromagnetic phase transition. To this order, we also calculate sound velocity c_1 and incompressibility K with arbitrary spin polarization. The estimated values of c_1 and K show that the equation of state of the polarized matter is stiffer than that of unpolarized matter. Finally, we determine the finite temperature corrections to the exchange energy and derive corresponding results for the spin susceptibility.

Pal, Kausik; Dutt-Mazumder, Abhee K

Ground state energy of spin polarized quark matter with correlation

We calculate the ground-state energy of cold and dense spin-polarized quark matter with corrections due to correlation energy (E_{corr}). Expressions for E_{corr} both in the nonrelativistic and ultrarelativistic regimes have been derived and compared with the exchange and kinetic term present in the perturbation series. It is observed that the inclusion of correlation energy does not rule out the possibility of the ferromagnetic phase transition at low density within the model proposed by Tatsumi [Phys. Lett. B489, 280 (2000)]. We also derive the spin stiffness constant in the high-density limit of such a spin-polarized matter.

Pal, Kausik; Biswas, Subhrajyoti; Dutt-Mazumder, Abhee K

Spin-dependent Fermi liquid parameters and properties of polarized quark matter

We calculate the spin-dependent Fermi liquid parameters (FLPs), single-particle energies, and energy densities of various spin states of polarized quark matter. The expressions for the incompressibility K and sound velocity c_1 in terms of the spin-dependent FLPs and polarization parameter. are derived. Estimated values of K and c_1 reveal that the equation of state of the polarized matter is stiffer than the unpolarized one. Finally, we investigate the possibility of the spin polarization (ferromagnetism) phase transition.

Pal, Kausik; Biswas, Subhrajyoti; Dutt-Mazumder, Abhee K

Effects of the Dirac sea on pion propagation in asymmetric nuclear matter

We study pion propagation in asymmetric nuclear matter (ANM). One of the interesting consequences of pion propagation in ANM is the mode splitting for the different charged states of pions. First we describe the pion-nucleon dynamics using the nonchiral model in which one starts with pseudoscalar ðN coupling, and the pseudovector representation is obtained via suitable nonlinear field transformations. For both of these cases, the effect of the Dirac sea is estimated. Subsequently, we present results using the chiral effective Lagrangian where the short-distance behavior (Dirac vacuum) is included by redefining the field parameters as done in the modern effective field theory approach developed recently. The results are compared with previous calculations for symmetric nuclear matter. Closed form analytical results are presented for the effective pion masses and dispersion relations by making a hard nucleon loop approximation and suitable density expansion.

Biswas, Subhrajyoti; Dutt-Mazumder, Abhee K

Measurement of ^{241}Am–Be spectra (bare and Pb-covered) using TLD pairs in multi-spheres: Spectrum unfolding by different methods

The neutron spectra from a Pb-covered and a bare (without Pb-cover) ^{241}Am–Be (á,n) source were measured using thermoluminescent detector (TLD) pairs of ^{6}LiF and ^{7}LiF with high-density polyethylene (HDPE) multi-spheres of seven different diameters. A total of 8 distinct neutron response signals (including a bare mode exposure) were obtained from which the energy distribution for the entire energy range was generated with the help of different neutron spectrum unfolding methods, viz. BUNKI, BUNKIUT and Frascati unfolding interactive tool (FRUIT). Shape of these spectra are matching very well and is also comparable with the standard IAEA ^{241}Am–Be spectrum, thus, validating the unfolding methods used in this work. The effect of Pb-cover on the spectrum and the unfolding details are reported in the paper.

Tripathy, SP†; Bakshi, AK†; Sathian, V†; Tripathi, SM†; Vega-carrillo, HR†; Nandy, M; Sarkar PK†; and Sharma, DN†

Direction distribution of ambient neutron dose equivalent from 20 MeV protons incident on thick Be and Cu targets

Ambient neutron dose equivalent from 20 MeV protons incident on thick Be and Cu targets are measured at 0 degrees, 30 degrees, 60 degrees and 90 degrees with respect to the beam direction using a conventional dose equivalent meter. The neutron spectra calculated using nuclear reaction model codes ALICE, PRECO and earlier reported empirical expressions are converted to the ambient dose equivalent using the ICRP fluence-to-dose conversion coefficients and are compared with the measured values. The experimental energy spectra reported in the literature for 19.08 MeV protons incident on a thick Be target are also converted to ambient neutron dose equivalent and are compared with the present experimental results. It is observed that the values estimated from the neutron spectra obtained from the nuclear reaction codes are unable to predict the measured values. The results obtained from the reported experimental energy spectra compare well with the results obtained here. An empirical relation that was used to calculate the directional dependence of the measured neutron dose equivalent from heavy ion-induced reactions is used in this study to check its effectiveness for proton-induced reactions.

Sunil, C†; Shanbhag, AA†; Nandy, M; Maiti, M; Bandyopadhyay, T†; Sarkar, PK†

Measurement and theoretical estimation of induced activity in nat_I by high energy neutrons

Induced radioactivity in natural indium (nat_I) foils by high energy neutrons was measured at the KENS Facility, KEK, Japan, where a 16.7 cm thick W target was bombarded by protons of 500 MeV. High energy neutrons consequently produced irradiated the In targets placed at different depths inside a 4 m thick concrete shield placed at the beam exit. The measured activities were compared with the results calculated using the nuclear reaction model codes ALICE-91 and EMPIRE-2.18. To estimate the induced activity, excitation functions of the various radionuclides were calculated using the two codes and folded with the appropriate neutron energy distribution at different depths of the concrete shield. The calculated excitation functions of a given nuclide were found to vary widely from one another in some cases. The performances of the codes for different input parameters like level densities and inverse cross-sections are reported in this paper. Our analysis shows that neither of the two codes reproduced all the measured activities satisfactorily, requiring further improvements in the models adopted.

Nandy, Maitreyee; Sarkar, PK†; Nakao, N†; Shibata, T†

Neutron dose equivalent from 100 MeV F-19 projectiles on thick Cu target

Measured neutron doses at different angles from 100MeV F-19 projectiles bombarding a thick copper target are reported. The measurements are carried out at 0 degrees, 30 degrees, 60 degrees and 90 degrees angles with respect to the incident projectile beam using a commercially available neutron dose equivalent meter. The experimental data are compared with calculated dose from different empirical formulations proposed by earlier workers and also with earlier measured data, obtained with identical experimental conditions for 110MeV F-19 incident on a thick aluminum target.

Sunil, C†; Nandy, M; Bandyopadhyay, T†; Maiti, M; Shanbhag, AA†; Sarkar, PK†

Measurement and analysis of energy and angular distributions of thick target neutron yields from 110 MeV F-19 on Al-27

Energy distributions of emitted neutrons were measured for 110 MeV F-19 ions incident on a thick Al-27 target. Measurements were done at 0 degrees, 30 degrees, 60 degrees, 90 degrees, and 120 degrees with respect to the projectile direction employing the time-of-flight technique using a proton recoil scintillation detector. Comparison with calculated results from equilibrium nuclear reaction model codes like PACE-2 and EMPIRE 2.18 using various level-density options was carried out. It is observed that the dynamic level-density approach in EMPIRE 2.18 gives the closest approximation to the measured data. In the Fermi-gas level-density approach the best approximation of the level-density parameter is $a = A/12.0$, where A is the mass number of the composite system. The trend in the angular distribution of emitted neutrons is well reproduced by the projection of the angular momentum on the recoil axis as done in the PACE-2 code.

Sunil, C†; Nandy, Maitreyee; Sarkar, PK†

Estimation of induced activity in thick lead-bismuth and iron alloy targets by 30 MeV protons

Excitation functions of different radionuclides produced by interaction of protons and neutrons in lead-bismuth eutectic (LBE) and T91, D9 steel alloy targets are calculated using ALICE91 and EMPIRE 2.18 codes and compared with some experimental data. Radioactivity induced by 30 MeV protons is estimated in thick targets of LBE, T91 and D9 that are considered suitable target and beam window materials in accelerator driven subcritical systems (ADSS). The amount of induced radioactivity limits the allowed beam current as well as determines the criteria for hands-on-maintenance and disposal of radioactive wastes in such machines. The present estimation shows that for 500 μA proton beam ^{207}Po is produced with highest activity of around 5 x 10^6 MBq by proton induced reaction while ^{210}Bi is produced with highest activity (about 10^6 MBq) by interaction of primary neutrons in LBE.

Nandy, Maltreyee; Sarkar, PK†

Activation foils unfolding for neutron spectrometry: Comparison of different deconvolution methods

The results obtained from the activation foils measurement are unfolded using two different deconvolution methods such as BUNKI and genetic algorithm (GA). The spectra produced by these codes agree fairly with each other and are comparable with that measured previously for the same system using NE213 liquid scintillator and by unfolding the neutron-induced proton pulse height distribution using two different methods, viz. FERDOR and BUNKI. The details of various unfolding procedures used in this work are reported in this paper.

Tripathy, SP†; Sunil, C†; Nandy, M; Sarkar, PK†; Sharma, DN†; Mukherjee, B†

Estimation of angular distribution of neutron dose using time-of-flight for F-19 + Al system at 110 MeV

We have reported measured angular and energy distributions of neutron dose from 110 MeV F-19 projectiles bombarding a thick aluminum target. The measurements are carried out with BC501 liquid scintillator detector using the time-of-flight technique. We have measured neutron energy distributions at 0 degrees, 30 degrees, 60 degrees, 90 degrees, and 120 degrees and converted them to dose distributions using the ICRP recommended fluence to ambient dose equivalent and absorbed dose conversion coefficients. Similar conversions to ambient dose equivalent are done for theoretically estimated distributions from the nuclear reaction model code EMPIRE-2.18. The experimental results are compared with calculated ambient dose equivalent from different empirical formulations proposed by earlier workers. Based on the comparison, we have attempted modifications of the parameters in these empirical expressions.

Nandy, Maitreyee; Sunil, C†; Maiti, Moumita; Palit, R†; Sarkar, PK†

Light charged particle emission from neutron and alpha-induced reactions

Emissions of protons and α-particles from neutron and α-induced reactions have been estimated using two nuclear reaction model codes ALICE91 and PRECO-2000. Calculated results have been compared with available energy differential and double differential emission cross sections from experimental measurements. Analysis of the data based on different nuclear reaction mechanisms revealed the relative importance of these mechanisms as well as predictive capabilities of the codes used. These results are useful in accelerator-driven systems, radioactive ion beam facilities and space dosimetry.

Maiti, Moumita; Nandy, Maitreyee; Roy, SN†; Sarkar, PK†

Heavy Quark Physics in ALICE

With a centre-of-mass energy of 5.5 TeV per nucleon, Pb-Pb collisions at the LHC are expected to provide a copious yield of heavy quarks. In this paper, an overview of the ALICE perspectives for heavy flavour physics will be presented. The ALICE experiment will detect quarkonia both in the e^+e^- and in the $\mu^+\mu^-$ decay channels. Open heavy flavoured hadrons will be studied in the semileptonic decay channels at both central and forward rapidities. In addition, exclusive reconstruction of selected hadronic decay modes of charmed hadrons will be possible in the central rapidity region ($|\eta| < 0.9$).

ALICE Collaboration (Bose, Suvendu; Chattopadhyay, Sukalyan; Das, Indranil; Dutt-Mazumder, Abhee K ; Pal, Sanjoy; Roy, Pradip; Sinha, Tinku)

ALICE Muon Spectrometer and related physics

ALICE is the LHC experiment dedicated to the study of heavy-ion collisions at extreme energy density where formation of the quark-gluon plasma is expected. Among the different observables, open heavy flavors and heavy quarkonia states are especially relevant. Indeed they will be copiously produced and they will provide sensitive information on the collision. In this paper, the ALICE muon spectrometer will be described as well as the installation status. A few selected topics concerning the muon physics will be addressed and the related expected performances of the ALICE muon spectrometer will be given.

ALICE Collaboration (Bose, Suvendu; Chattopadhyay, Sukalyan; Das, Indranil; Dutt-Mazumder, Abhee K ; Pal, Sanjoy; Roy, Pradip; Sinha, Tinku)

Developmental work

Development of a hollow cathode discharge atom/ion source and collision chamber

A new hollow cathode discharge (HCD) atom/ion source with collision chamber has been designed and fabricated for use in the Time Resolved Laser Spectroscopy (TRLS) setup for investigation of solid substances. It is based on a low pressure, large bore hollow cathode whose one end is closed except for a small opening (~ 1mm diameter) which serves as a nozzle for forming the atomic beam. A dc discharge runs in an inert gas atmosphere between an anode and the cathode. The cathode is lined with the element to be investigated. The HCD source is attached with the collision chamber which has different ports for the passage of laser beam, transmission of emitted radiation and for vacuum pump and gauge connections. Atoms are sputtered off the cathode liner, many are collisionally excited and ionized and flow through the opening into the chamber below to collide with the pulsed laser.

Das Mihir Baran, Ghosal Amal

Indegenous bleeder circuits for the XP2020Q photomultiplier tubes for improved performance

An indigenous optimized voltage distribution circuit was made for feeding power to the various electrodes of XP2020Q photomultiplier tubes that are used in couple with BaF_2 scintillators for gamma ray energy and fast timing measurements. The potential drop across the cathode and the first focusing electrode were suitably adjusted to effect maximum focusing of electrons and the resolution showed substantial improvement accordingly. Transistor-based preamplifiers were also introduced both in the anode and dynode signal paths and the PMT operating voltages were optimized through careful monitoring of the prompt time resolution of gamma rays emitted by ^{60}Co source. The instrumental resolution spectra was fitted to a single Gaussian curve using the computer program PALSfit (developed by Risoe National Laboratory, Denmark and universally used for positron annihilation lifetime data analysis) and the resolution (full width at half maximum of the coincidence gamma ray spectrum) was found improved from 160 ps to 130 ps, which is very close to the best reported value in literature. Positron lifetime spectra could be recorded using the new circuits with a resolution 20% better than what it used to be before.

Ghosal Amal, Nambissan PMG

Development of linseed oil free bakelite single gap RPC detector

Single gap RPC detectors, made of a particular grade of phenolic resin (bakelite) bonded Paper Laminates commercially available in India for insulation under humid condition, were designed, fabricated and tested by the SINP-VECC group. A thin coating of a particular grade of polydimethylsiloxane (PDMS), popularly known as silicone, has been found to improve the efficiency and reduce noise degradation of the RPCs when operated at higher voltage necessary for sustained streamer mode operation. Several detectors of sizes 10 cm × 10 cm, 30 cm × 30 cm and 1 m × 1 m were characterized for operation under both streamer and avalanche modes of operation. Long term streamer mode operation of the RPCs yielded a stable efficiency ~ 90-95% for > 140 days in a cosmic muon test bench set up at SINP. Stable avalanche mode operation of RPC was also obtained with ~92-95% efficiency for the cosmic muons.

Saha S, Marick Chandranath, Das Ganesh[†], Bhattacharya S, Bose S, Biswas Saikat[†], Chattopadhyay S[†], Viyogi YP[†]

RPC detector related development for the INO prototype

One 10 cm × 10 cm bakelite RPC detector was sent to the Gamma Irradiation Facility (GIF) at CERN for characterizing long term operation at high radiation exposure under avalanche condition. No degradation of performance was found after 2-3 months of continuous operation at GIF. Time resolution of the bakelite RPCs of different sizes were also measured and found to be ~ 2 – 4 ns (FWHM) for both the modes of operation. The charge spectra of the RPCs in the two modes were also systematically studied. The average charge content of the signals caused by cosmic muons was found to be ~ 5 times larger for streamer mode than that for avalanche mode. Two(2) bakelite RPC detectors of 1 m × 1 m size are placed in the prototype ICAL detector set up at the VECC–INO lab for cosmic muon tracking studies, in addition to the 1 m × 1m glass RPCs. About 50 nos. of front-end preamplifier modules designed at TIFR for use with the glass RPCs, and having 8 channels per module were fabricated, assembled and tested at SINP.

Saha S, Marick Chandranath, Das Ganesh†, Bhattacharya S, Bose S, Biswas Saikat†, Chattopadhyay S†, Viyogi YP†

Development of Multi-strip Multi-gap Resistive Plate Chamber with timing resolution less than 100 ps.

We have developed a double stack glass Multi-strip Multi-gap Resistive Plate Chamber (MMRPC) using local facility. The designing, planning and fabrication have been done at SINP, Kolkata. It is a 40 cm × 20 cm prototype with segmented anode strip. The cathode plates were made by introducing a thin layer of conducting material of 1 mm thick float glass. Negative high voltage was supplied to the cathode plates while the anode plates were kept at ground potential. The detector structure was housed in an aluminum chamber. A custom-built gas system was used to deliver gas mixture to the MMRPC. A non-flammable gas mixture of 89% R134a, 4% SF_6, 7.0% iso-butane was kept in flow mode throughout the active volume of the detector. Response of MMRPC for cosmic muons and ã-rays using radioactive source (^{60}Co) have been studied in coincidence with fast scintillator detector, cerium doped Lanthanum Bromide ($LaBr_3$:Ce). The time resolution of MMRPC due to cosmic muons was found to be less than 150 ps. Latest online test using Rossendorf 's electron beam shows a timing resolution less than 100 ps after slew correction. Fig. 1 shows a coincidence set-up of MMRPC and $LaBr_3$:Ce detector at SINP Laboratory. First time in India, we build this detector with timing resolution better than 100 ps. This type detector can be used to explore various fundamental physics program in Nuclear Physics, Particle physics, Cosmology. In addition to that, it has a wide range of application in both medical science and security.

Datta Pramanik, U; Chakraborty, S; Rahaman, A; Basu, P; Bannerjee, P; Chatterjee, S; Panja, J; Roy, J

Development of experiment with Positron age-momentum correlation experiment (AMOC)

This technique combines positron life time spectroscopy with Doppler – broadening spectroscopy using the same annihilation event. Such a measurement is based on the registration of the collinear gamma quanta for the positron life time as the stop signal and simultaneously for the measurement of the Doppler broadening of the annihilation line. The start signal may be provided from a scintillators in the conventional sandwich arrangement, but that must not be arranged in a line with the stop detector. This is necessary, because the HPGe detector for the coincident detection of the Doppler signal must be arranged opposite to the scintillators for the stop signal. The positron life time measured in a fast-fast spectrometer is registered in coincidence with the Doppler signal and stored in a two-dimensional memory array (multi-parameter data acquisition system). The profile here is composed of individual Doppler curves, which are measured as a function of the positron lifetime (age). The technique has the advantage of measuring the dependence of the electron momentum distributions on the positron lifetime. In this way, Doppler curves for ortho-positronium events with a very long lifetime can be filtered out, which is important in chemical applications.

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Mandira Sinha, H.Majumdar, P.Basu, Subinit Roy, R.Bhattacharya, M.Biswas, M.K.Pradhan, R.Palit, I.Majumdar and S.Kailas, Sub- and above-barrier fusion of loosely bound ^{6}Li with ^{28}Si, Eur Phys J **A44** (2010) 403

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Ph D Awards

- Sucheta Adhikari [Chhanda Samanta], Study of some static and dynamic properties of some stable and unstable nuclei, University of Calcutta, November 2007
- Partha Roy Chowdhury [Chhanda Samanta], Radioactivity of superheavy elements and spherical proton emitters and properties of nuclear matter, Jadavpur University, September 2009
- Danish Azmi [Sukalyan Chattopadhyay], Performance study of Station 2 of Dimuon Spectrometer of the ALICE Detector, Aligarh Muslim University, 2008
- Sanjoy Pal [Sukalyan Chattopadhyay], Characterizations of cathode Pad Chamber as tracking detector for MUON spectrometer of Alice, HBNI, February, 2009
- Pradip Datta [Sukalyan Chattopadhyay], High spin spectroscopy of neutron rich nuclei in mass-100 region, Jadavpur University, January 2008
- Kuntal Ghosh [Kamales Bhaumik], A bio-mimicking approach to real time edge detection and its application in medical images, Jadavpur University, August 2007
- Ratan Kumar Saha [Swapan Sen, Subodh Sharma], Some studies on approximate methods in acoustic scattering problems, West Bengal University of Technology, December 2007
- Sourav Ganguly [Polash Banerjee], Study of the different modes of nuclear excitations in weakly deformed Nuclei, May 2009
- Ritesh Kshetri [M Saha Sarkar], Shell structure and evolution of collectivity on and away from the stability line, Calcutta University, April 2009
- Rajarshi Raut [Asimananda Goswami], Nuclear structure studies in the vicinity of N=82 shell closure, University of Calcutta, 2009

Seminars/Lectures given in Conference or elsewhere

Polash Banerjee

- *Nuclear Structure at High Angular Momentum*, Sambalpur University, Sambalpur, Orissa, India, December 12, 2007
- *FRENA – Proposed Areas of Research* at SLENA 2008 at the Saha Institute of Nuclear Physics, Kolkata during February 19-22, 2008.
- *Experimental Techniques and Particle Accelerators for Nuclear Astrophysics*, six lectures at the SERC School on Nuclear Astrophysics and Neutrino Physics at Calicut University, Kozhikode, January 19, 21 & 23, 2010.

Subinit Roy

- Does threshold anomaly exit in elastic scattering of loosely bound nuclei? DAE-BRNS National Conference in Nuclear Physics 2007, Sambalpur University, Sambalpur, Orissa, India, December 12, 2007

Manoranjan Sarkar

- *A proposed project with MIRRORCLE*, Synchrotron Light Life Science Centre, Ritsumeikan University, Shiga, Japan, February 28, 2008
- *Study of satellite lines*, Laboratory of Atomic and Molecular Physics, Kyoto, Japan, March 3, 2008

Sukalyan Chattopadhyay

- *Installation Status of 2nd Tracking Station*, CERN, October 4, 2007
- *INDIA-ALICE Collaboration proposal to the Working Group for Nuclear and High Energy Physics for IXth Plan*, BARC, Mumbai, July 18, 2007
- *Experience on Dimuon Tracking*, VECC, Kolkata, July 30, 2007
- *Social Implications of International Collaboration*, Maulana Abul Kalam Azad Institute for Asian Studies, Kolkata, August 2, 2007
- *Cosmic Muon Tracks in ALICE Muon Spectrometer*, INFN, Cagliari, May 26, 2008
- *Large Hadron Collider,* St. Xaviers College, November 7, 2008
- *Large Hadron Collider*, Presidency College, November 14, 2008

Tinku Sinha

- *Installation of Eight Cathode Pad Chambers for 2nd Muon Tracking Station of ALICE*, DAE Symposium, Sambalpur University, Orissa, 2007
- *Status of Merging Signal and Background Using Raw-Data,* Dimuon EVO offline-online meeting at LYON, France, March 18-20, 2008
- *Commissioning tests of the 2nd Muon Tracking Station of ALICE,* DAE Symposium, Roorkee IIT, Uttarakhand, 2008

Pradip Kumar Roy

- Quenching of light hadrons in a collisional energy loss scenario, Quark Matter 2008, Jaipur, India, 2008
- *Mechanisms of energy loss of jets passing through quark gluon plasma,* DAE Nuclear Physics Symposium 2008, Roorkee, India, 2008
- *Heavy quark energy loss and nuclear modification factor*, Aussiox, FRANCE, 2009

PMG Nambissan

- *Nanoscience and its relevance*, Senate House, University of Kannur, Kannur, Kerala, May 28, 2007
- *Positron annihilation techniques for studying nanomaterials*, Sir Syed College, Taliparamba, Kannur, Kerala, June 06, 2007
- *Interaction with school children*, Deshaseva Upper Primary School, Kannadiparambu, Kannur, Kerala, June 07, 2007
- *Material research using positrons*, National Institute of Foundry and Forge Technology, Ranchi, March 24, 2008
- *Doping effects in nanocrystalline ferrites and semiconductors*, Aligarh Muslim University, Aligarh,March 27, 2008
- *From nature to nanoworld*, Aligarh College of Engineering and Technology, Aligarh, March 27, 2008
- *The history of research with positrons at Saha Institute of Nuclear Physics*, National Seminar and Meeting on Positron Annihilation, SINP, Kolkata, February 9-10, 2007
- *Current areas of research using positrons in materials at Saha Institute of Nuclear Physics*, National Seminar and Meeting on Positron Annihilation, SINP, Kolkata, February 9-10, 2007
- *Ion beam induced defects studies*, DAE-BRNS Workshop on Ion Beams at VECC and Their Applications in Basic and Apllied Sciences, VECC, Kolkata, September 12-14, 2007
- *Recent studies of some of the solid state properties of novel materials*, National Seminar cum Conference on Emerging Trends in Physics, R.K. College, Madhubani, Bihar, December 17-19, 2007
- Focus nanocrystalline research on semiconductors and ferrites, UGC Sponsored National Conference on Relevance and Dimensions of Nanoscience and Nanotechnology for Development of Bihar, BS College, Danapur, Bihar, April 19-21, 2008
- *Probing the defects in nano-semiconductors using positrons*, International Workshop on Positron Studies of Defects (PSD-08), Prague, Czech Republic, September 1-5, 2008
- *o-Ps lifetime, free volume and Doppler broadening spectroscopy (DBS) studies of 50 MeV Li3+ ion irradiated polysterene*, 15th International Conference on Positron Annihilation, Saha Institute of Nuclear Physics, Kolkata, India, January 18-23, 2009
- *Li3+ ion irradiated effects on polyamide nylon6,6 studied by positron annihilation lifetime and Doppler broadening spectroscopy*, 15th International Conference on Positron Annihilation, Saha Institute of Nuclear Physics, Kolkata, India, January 18-23, 2009
- *Positron annihilation studies of NiO nanoparticles prepared through two different chemical routes*, 15th International Conference on Positron Annihilation, Saha Institute of Nuclear Physics, Kolkata, India, January 18-23, 2009

- *Mn doping in ZnO nanoparticles: effects investigated by positron lifetime and Doppler broadening studies*, 15th International Conference on Positron Annihilation, Saha Institute of Nuclear Physics, Kolkata, India, January 18-23, 2009
- *Nuclear radiation spectroscopy for the studies of materials*, Workshop on Sophisticated Instruments Studies, Department of Physics, Kannur University, Payyanur, Kannur, Kerala, April 7-8, 2009
- *Synthesis and characterization of certain semiconductor nanomaterials and the studies of defects using positrons*, National Workshop on Synthesis and Characterization of Smart Materials, Bareilly College, Bareilly, UP, September 12-14, 2009
- *Speaker in the valedictory session*, Workshop on Intellectual Property Rights and Traditional Knowledge, Payyanur, Kerala, September 18, 2009
- *Nanoscience – an interdisciplinary branch that offers the technology of the future*, National Seminar on Physics and Evolution of Technology in the 21st Century, The Zamorin's Guruvayurappan College, Kozhikode, Kerala, January 7-8, 2010

Bichitra Nandi Ganguly

- *Recent Trends in Surface and Colloid Science*, ISI , Kolkata Nov 15-16, 2007
- *Positron and Positronium Chemistry*, Wuhan University, China, May 11-15, 2008

Sudeb Bhattacharya

- *Status of the ICAL detector*, KEK, Japan, Nov29–Dec 3, 2007 as a member of the group sent by INO to discuss the various developmental issues related to INO project and future collaboration

Satyajit Saha

- *Spectroscopy of Trans Lead Nuclei*, DAE-BRNS Symposium on Nuclear Physics, IUAC Workshop on Nuclear Physics with beam hall II facilities, IUAC, New Delhi, August 30-31, 2007
- *Importance of recoil detection for the investigation of high spin states and isomer decay of trans-Lead nuclei*, International Workshop (Homi Bhabha Centenary Workshop series) on Frontiers in Gamma-ray Spectroscopy (FIGS09), TIFR, Mumbai, March 1-4, 2009

C Samanta

- *A new mass formula for Strange and multi-strange nuclei*, Physics Department, University of Richmond, Richmond, Virginia, USA, September 9, 2009
- *Cascade-binding in a generalized mass formula and the quark-meson coupling model*, 10th International Conference on Hypernuclear and Strange Particle Physics 'HypX', 'Ricotti' in Tokai, Ibaraki, Japan, September 14-18, 2009
- *Hyperons in heavy ion collisions and neutron stars*, International Symposium on Heavy Ion Physics 2008 (ISHIP2008), GSI, Darmstadt, Germany, November 17-20, 2008

- *Alpha decay chains from superheavy nuclei*, International School Of Nuclear Physics, 30th Course, Heavy-Ion Collisions from the Coulomb Barrier to the Quark-Gluon Plasma, Erice-Sicily, September 16 – 24, 2008
- How to weigh a Neutron star?, Physics Department, University of Richmond, USA, November 10, 2008
- *The mystery of Neutron stars,* Physics Department, Virginia Commonwealth University, Richmond, USA, October 24, 2008
- *Will SHE survive attack of the Fission monster and live long?*, Physics Department, University of Richmond, USA, September 05, 2007
- *Will SHE survive attack of the Fission monster and live long?,* Physics Department, Virginia Commonwealth University, Richmond, USA, July 26, 2007
- *One mass formula for normal to hypernuclei*, Osaka University, Japan, July 19, 2007
- *Hypernuclear mass formula*, Kyoto University, Japan, July 18, 2007
- *Superheavy elements in the magic islands,* Fourth International Conference on Fission and properties of Neutron-rich Nuclei, Sanibel Island, Florida, November 11-17, 2007

Maitreyee Nandy

- *Radiation environment in positive ion accelerators: Experimental and theoretical investigations*, Conference on Accelerator and Low Level Radiation Safety, Inter University Accelerator Centre, New Delhi, India April 26-27, 2007
- *Radiation Environment in a Low Energy Accelerator for Astrophysical Studies*, National Conference on Accelerator and Low Level Radiation Safety (NCALLRS), Inter University Accelerator Centre, New Delhi, India, November 18-20, 2009
- *Chemical Dosimetry for Ionizing Radiation*, National Symposium on Emerging Trends in Chemistry (NSETC-10), Dept. of Chemistry, Punjabi University, Patiala, India, February 15-16, 2010
- *Computational Neutron Dosimetry*, International Workshop on Neutron Dosimetry & Spectrum Unfolding (NDSU-2010), Bhabha Atomic Research Centre, Mumbai, India, March 15-19, 2010

N Majumdar

- *3D electrostatic field simulation of a Resistive Plate Chamber,* IX International Workshop on Resistive Plate Chambers and Related Detectors (RPC 2007), TIFR, Mumbai, India, February 13-16, 2008
- *Detailed RPC Simulation: A Brief Report*, INO Software Meeting (Video Conference), VECC, Kolkata, February 29, 2008
- *Galilei Galileo: The Starry Messenger,* Seminar on International Year of Astronomy, Diamond Jubilee Celebration, Hooghly Womens College, Hooghly, July 30, 2009

S Mukhopadhyay

- *Application of neBEM in Medical Imaging: Present Status and Possibilities,* DAE-BRNS Theme Meeting on Advanced Detectors For Imaging In Physics and Medical Diagnosis, VECC, Kolkata, India, March 4-5, 2010
- *Cross-talk in Strip RPCs,* 13th CBM Collaboration Meeting, GSI, Dermstadt, Germany, March 9-13, 2009

Ushasi Datta Pramanik

- *Journey towards neutron drip-line*, NSCL, Michigan State University, East Lansing, USA, June 11, 2007
- *Study of unstable nuclei using Coulomb and Nuclear Breakup*, Argone National Laboratory, USA, June15, 2007)
- *Study of exotic nuclei and development of high energy neutron detector*, XI than project meeting for Nuclear, Particle and Astrophysics (BARC, Mumbai, July, 2007)
- *Study of high spin states of very neutron deficient nuclei around A~120 through in-beam gamma-ray spectroscopy,* IUAC-INGA meeting, New Delhi, August 2007
- *Journey towards nuclear drip line*, 4th Oct, Physical Research Laboratory, Ahmedabad 2007
- *Exploring structure of neutron rich nuclei through Coloumb and nuclear breakup,* 4th International conference on Fission and neutron-rich nuclei, Sanibel, Nov, 2007
- *Exotic features of the Nuclei with large neutron and proton asymmetry and its impact on nucleosynthesis,* Fz-Rossendorf, Dresden, Germany, September 2008
- *Investigation of inversion of í$d_{3/2}$ – íf_p orbital in the nuclei around N=20 shell closure*, FRS-Users workshop, November13, 2008
- *Study of neutron-rich nuclei through Coulomb breakup using LAND-FRS setup,* NUSTAR seminar, GSI, Darmstadt, Germany, January 2009
- *Indian contribution in High energy neutron detector in R3B, EXL, ELISE and scientific outcome using this detector,* FAIR-NUSTAR INDIA meeting, IUAC, New Delhi, July 3-4, 2009
- *Study of high spin states through in-beam gamma-ray spectroscopy of very neutron deficient exotic nuclei around N~40,* TIFR-BARC INGA meeting, March 2010
- *Development of MMRPC prototype for NeuLAND detector of R3B setup at FAIR*, International conference on Resistive Plate Chamber and related detector (RPC2010), GSI, Darmstadt, February 10, 2010
- *Study of high spin states through in-beam gamma-ray spectroscopy of neutron deficient exotic nuclei around N~40,* National Theme Workshop on Nuclear Reaction Mechanism, Chandigarh, March 18, 2010

Maitreyee Saha Sarkar

- *Study of exotic neutron rich nuclei*, BRNS workshop on ION BEAMS AT VECC AND THEIR APPLICATIONS IN BASIC AND APPLIED SCIENCES held at VECC, Kolkata, September12-14, 2007
- *Nuclear structure around ^{132}Sn core: probable new features in semi-magic Sn isotopes*, National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan, USA, August 3-11, 2008
- *Studies on nuclear structure on and away from the stability line*, University of Notre Dame, USA, August 11-22, 2008
- *Astrophysical Implication of Low E (2^+_1) In Neutron-Rich Sn Isotopes*, 4th International Workshop on Nuclear Fission and Fission Product Spectroscopy, CEA Cadarache, France, May 13-16, 2009
- *Nuclear structure around ^{132}Sn core: probable new features in semi-magic Sn isotopes*, GSI, Germany, May 5-7, 2009
- *Studies on nuclear structure on and away from the stability line*, GANIL, Caen, France, May 8-12, 2009
- *Exciting issues in the neutron –rich ^{132}Sn region and near stability in A~40*, Institut Laue-Langevin (ILL), Grenoble, May17-19
- *Nuclear structure around ^{132}Sn core and interesting issues*, CERN, May 20-21, 2009

Asimananda Goswami

- *Magnetic rotational band observed in the vicinity of N=82 nuclei*, DAE nuclear physics symposium, IIT, Roorkee, December 22-26, 2008

Anjali Mukherjee

- *Influence of projectile breakup on complete fusion*, International DAE-BRNS Symposium on Nuclear Physics (ISNP2009), Mumbai, December 8-12, 2009
- *A facility for research in experimental nuclear astrophysics (FRENA), the Expanding Horizons in Nuclear Physics*, Mumbai, June 9-10, 2009
- *Recent results of Fusion Measurements*, the National Theme Workshop on Nuclear Reaction Mechanism, Chandigarh, March 17-19, 2010
- *Present status of FRENA*, the National Theme Workshop on Nuclear Reaction Mechanism, Chandigarh, March 17-19, 2010

Teaching elsewhere

P Basu

- Nuclear Reactions (25), February 15, 2008 to April 30, 2008, MSc 2007-08, (Special) Calcutta University
- Nuclear Reactions (25 lectures), February- April, 2008-09, M.Sc. (Special) Calcutta University

Maitreyee Saha Sarkar

- Nuclear Structure (25), November 1, 2007 - March 31, 2008, MSc 2007-2008, (Special) Presidency College, Kolkata, India

P M G Nambissan

At Kannur University, Kannur, Kerala

- Introduction to Solid State Physics (M.Sc. Physics, 1st Semester)
- Basic Concepts of Nuclear Chemistry (M.Sc. Chemistry, 1st Semester)
- Experimental Techniques (M.Sc. Physics, 3rd Semester)
- Fundamentals of Astrophysics (M.Sc. Physics, 2nd Semester)

Maitreyee Nandy

- *Radiation Protection Act and the Regulation* — Diploma Course in Industrial Safety for the session 2006-2007, Regional Labour Institute, Kolkata, 2007

Miscellany

Chhanda Samanta

- Virginia Commonwealth University, Richmond, VA, USA (Visiting Professor), 2007
- University of Richmond, Richmond, VA, USA (Visiting Professor), 2007, 2008, 2009

Manoranjan Sarkar

- Awarded JSPS (Japan Society for the Promotion of Science) scholarship for two months FY 2007 -08

Chandi Charan Dey

- Visited University of Leipzig, Germany for two months (April-May 2007) for collaborating work with (Prof) Dr T Butz

Bichitra Nandi Ganguly

- Bichitra Ganguly, Organised a conference : ICPA-15, SINP KOLKATA Jan 18-23, 2009 **(*Convenor*)**
- Guest Editor: Physica Status de Solidi (PSS C6. No11. 2253-2600, 2009)

Maitreyee Nandy

- Seventeenth National Symposium on Radiation Physics (NSRP-17), November 14-16, 2007; Saha Institute of Nuclear Physics, Kolkata, India. (***Convener)***
- Advanced School on Radiation Physics, November 17-22, 2008; Saha Institute of Nuclear Physics, Kolkata, India. (***Convener)***

Sudeb Bhattacharya, Polash Banerjee and Padmanava Basu

- Second School-cum-Workshop on Low Energy Nuclear Astrophysics (SLENA 2008), February 19-22, 2008, Saha Institute of Nuclear Physics, Kolkata.

Plasma Physics and Electronics

4 Plasma Physics and Electronics

Plasma Physics

The objective of the Plasma Physics Division has been two folds: One is to carry out basic research in theoretical and experimental Plasma Physics and the other is to use plasmas as a tool or technology for applications in other areas such as plasma based - material synthesis, development of propulsion systems, nonlinear dynamics etc. Emphasis has always been on indigenous development of the various systems and subsystems beginning from design.

A) TOKAMAK RELATED EXPERIMENTAL RESULTS

(a) Ion Acceleration by MHD Activities

Ion acceleration due to large-scale magneto hydrodynamic (MHD) activities in the Saha Institute of Nuclear Physics (SINP) Tokamak is investigated by using a retarding field ion energy analyser looking from the tangential direction. Detection of high energy ions along with the bulk low energy ions seems to have a close connection with electron acceleration due to the electric field of the m/n =2/1 tearing modes.

(b) Intermittency in heat and Particle transport in the Scrapeoff layer

In the SINP tokamak, the plasma density and the temperature have been found to exhibit burst like behaviour. The formation, propagation and decay of long-lived plasma structures are believed to be the cause of this intermittency. Wavelet analysis has shown that the cross-correlation between two probes is also intermittent in time and is connected to the passage of plasma structures. The convected and conducted heat fluxes are also intermittent in nature. The structures decay in density as they move radially outward but their temperature is found to decay more rapidly, as expected from theoretical models.

(c) Radial transport of nonthermal electrons in SINP Tokamak

X-ray bursts from nonthermal electrons (10 keV to 1 MeV) emanating from the core plasma and the limiter are measured simultaneously in runaway dominated discharges in the SINP tokamak using a tangentially viewing NaI(Tl) detector and a detector that views the limiter areas. The radial transport coefficient of the nonthermal electrons has been derived from the cross-correlation function of the two x-ray intensities. Two phases of the plasma discharges with distinct transport of the nonthermal electrons are found in these experiments.

The stochastic magnetic field fluctuations obtained from the transport coefficients are found to have a relationship with the autocorrelation functions of the x-ray emissivity signals.

d) Hard x-ray correlation analysis as a diagnostic tool for the measurement of magnetic turbulence in tokamaks

A diagnostic has been developed for the measurement and characterisation of the magnetic turbulence occurring in the core region of a tokamak. A specially shielded detector looking in the tangential direction has been employed to measure the thin target bremsstrahlung from the core plasma. The thick target bremsstrahlung from the limiter is also recorded at the same time. Auto- and cross-correlation analyses have been shown to yield respectively the stochasticity of the magnetic fluctuations in the core region and the consequent diffusion coefficient of the nonthermal electrons. The measured stochasticity bears a relationship with the diffusion coefficient. Data obtained from internal magnetic probes corroborate the above trend but the hard x-ray measurement data are shown to be more reliable than those obtained from magnetic probes

(e) Improved Confinement due to Current Profile Modification and Suppression of Drift-Alfven Mode by Biased Electrode in SINP-Tokamak

Electrode biasing experiment in the plasma edge is carried out in the normal q regime of the SINP-Tokamak to investigate L-H mode transition. A negative bias is applied to the electrode by a fast switching circuitry. Above a minimum voltage applied H_a line intensity decreases and energy confinement time increases compared to without bias case. Detailed investigations shows due to application of the bias toroidal current profile is modified and drift-Alfven mode is suppressed which is believed to cause the improvement of the plasma confinement.

(B) DNTBA (Diamond Nano Technology for Biological Applications)

(a) Laboratory synthesis of a theoretically predicted in 2007 new carbon material called GRAPHANE has been shown to be possible **(b)** Dehydrogenation of our HDLC (Hydrogenated Diamond Like Carbon) sample was possible by irradiation of 3MeV N^+ ion beams and producing crystalline graphitic crystals having applications in science & technology. **(c)** Biocompatible HDLC coating onto the steel without the need of interfacial layer of Titanium has been done successfully. **(d)** Covalent immobilization of protein onto atomically smooth surface of HDLC material has been done successfully. **(e)** Experimental results show our HDLC film is a wide band gap semiconductor which will be very useful fore storing electrical energy/decontamination of polluted water..

(C) THE MaPLE DEVICE (Magnetized plasma Linear Experimental

Setup:

(a) Construction and its Plasma aspects.

The MaPLE (Magnetized Plasma Linear Experimental) device is a low cost laboratory plasma device fabricated in-house with the primary aim of studying basic plasma physics phenomena such as plasma instabilities, wave propagation, and their nonlinear behavior in magnetized plasma regime in a controlled manner. The machine is specially designed to be a versatile laboratory device that can provide a number of magnetic and electric scenario to facilitate such studies. A total of 36 number of 20-turn magnet coils, designed such as to allow easy handling, is capable of producing a uniform, dc magnetic field of about 0.35 T inside the plasma chamber of diameter 0.30 m. Support structure of the coils is planned in an innovative way facilitating straightforward fabrication and easy positioning of the coils. Further special feature lies in the arrangement of the spacers between the coils that can be maneuvered rather easily to create different magnetic configurations. Various methods of plasma production can be suitably utilized according to the experimental needs at either end of the vacuum vessel. At present, characteristics of a steady state plasma generated by electron cyclotron resonance method using 2.45 GHz microwave power have been investigated. Scans using simple probe drives revealed that a uniform and long plasma column having electron density ~ $3–5\times10^{10}$ cm^{-3} and temperature ~7–10 eV, is formed in the center of the plasma chamber which is suitable for wave launching experiments.

(b) Parametric Decay of Pumping Waves into two Linear Modes in the MaPLE Device

Parametric decay of the pumping wave into two linear modes of plasma is observed. Experiment is performed in SINP MaPLE device with nitrogen plasma produced by ECR discharge. A low frequency mode alongwith both the lower and upper sidebands are observed. Sideband of the second harmonic is also found. Frequency of the low frequency mode is in the range of drift wave. Frequency of the other mode is in the range of ion cyclotron frequency and its harmonics. Preliminary studies show it may be ion Bernstein wave.

(D) DSPPE (Deep Space Plasma Propulsion Experiment)

(a) Experimental Setup

The objective of the DSPPE is to study the physics involved in the generation of mechanical thrust by a plasma. A main system will consist of plasma generation, heating and plasma divergence in a magnetic nozzle. Hydrogen plasma will be generated by RF source and in the presence of magnetic field will be heated to high energy by another RF source. With suitable configuration of magnetic field (magnetic nozzle, divergence of plasma in decreasing magnetic field) the gyration energy will be converted to linear energy, thereby generating the desired thrust. We have designed and fabricated 9 magnetic coils to provide a maximum magnetic field ~ 3 kGauss (axial) ; pulse duration: 10-20 Seconds, Plasma will be produced in a Quartz vacuum system of length ~1250 mm, outer diameter- 125 mm, using 13.6 MHz. RF source. Some other sub systems of this set up are ready.

(b) A Set Up for the Study of Double Layer:

A pilot experimental setup *has been* constructed for the above study. The RF power 1.25 kW maximum, 13.56 MHz is coupled to the antenna through a matching network. A helicon discharge is created in a quartz tube in an axial magnetic field provided by a Helmholtz coil pair. The plasma diffuses in a larger chamber (50 cm diam., 50cm long). The plasma in this chamber is diagnosed by Langmuir probes movable axially and radially by stepper motor controlled drives. Preliminary data on axial and radial profile have been recorded.

(E) NONLINEAR DYNAMICS EXPERIMENTS

We have shown for the first time in a glow discharge plasma the inverse bifurcation wherein the fluctuations go from chaos to order. The termination of the fluctuations is through a homoclinic bifurcation into an unstable fixed point. At this fixed point we have been able to demonstrate the very interesting results of coherence and stochastic resonance.

(F) THEORY

(a) Relaxation in magnetized plasmas

Relaxation phenomena in plasmas based on the principle of minimum dissipation rate of energy together with invariant magnetic helicity has been invoked to study relaxation in a non-driven as well as driven magnetized plasma in both MHD and two fluid and electron magneto hydrodynamic models. The merit of this model lies in its capability to predict many magnetic configurations such as reversed field pinches, tokamaks, very low-q and ultra low q-configurations, spheromaks, field reversed configurations and solar arcade structures. The model also obtains the pressure, perpendicular current profile, for all these configurations.

(b) Kinetic theory in weakly non-ideal systems.

Exact self-consistent steady state solutions of weakly correlated kinetic-Poisson's system of equations have been obtained as a counterpart of Bernstein Greene and Kruskal (BGK) modes.

(c) Directional Landau damping of wake field potentials

In contrast to the conventional problem of Landau damping that is one-dimensional, the problem of two dimensional Landau damping has been studied in the context of wake potentials produced due to moving charged particles.

(d) Study of transverse shear mode in strongly coupled dusty plasma.

Strongly coupled dusty plasmas are capable of sustaining transverse shear modes even in the fluid state. Generalized hydrodynamic model is utilized to study the linear and nonlinear characteristics of this mode.

(e) Nonlinear excitation of Geodesic acoustic mode in Tokamak plasma

Geodesic acoustic modes (GAMs) are a class of low frequency toroidal modes that are observed in a variety of tokamaks as well as plasma simulations. Simulations of study of edge plasmas provided the initial impetus to the experimental investigations. Observations with Doppler reflectometry and multipin probes have identifed details of spatial structures and spectral characteristics of the GAMs and have stimulated further theoretical and computational investigations to understand the primary excitation mechanism of these modes. In our present investigation it has been shown theoretically that GAMs can be excited by three-wave parametric processes involving drift modes .All these earlier studies (references are given in the published paper) were local theories and for electrostatic drift waves. In this article we first briefy outlined the local analysis for the coherent excitation of GAMs by resonant three-wave interactions. We present a nonlocal theory for the excitations of GAMs by electrostatic drift waves in an inhmogeneous plasma. The theory is then compared with earlier numerical studies and is found to be in good agreement. Furthermore both these studies provide an explanation of the multiple\step-like" eigenmodes observed in ASDEX-U tokamak. Nonlinear Lower-hybrid Oscillations in cold plasma In a fluid description nonlinear lower hybrid oscillation have been studied in a magnetized plasma using Lagrangian variables. An exact analytical solutions with nontrivial space and time dependence is obtained. The solution demonstrate that under well defined initial and boundary conditions the amplitude of the osillations increase due to nonlinearity and then come back to its initial condition again. These solutions indicating a class of nonlinear transient structures in magnetized plasma.

(f) Nonlinear excitation shear field and flow in electron magnetohydrodynamic waves in plasmas

The nonlinear generation of shear field and flow in whistler waves is considered. It is shown that a coherent parametric process, leads to modulational instability of four waves whistler interaction. Growth rates for the flow/field are compared with published simulations result.

Research Activities

Continuous wavelet transform based time-scale and multifractal analysis of the nonlinear oscillations in a hollow cathode glow discharge plasma

Continuous wavelet transform (CWT) based time-scale and multifractal analyses have been carried out on the anode glow related nonlinear floating potential fluctuations in a hollow cathode glow discharge plasma. CWT has been used to obtain the contour and ridge plots. Scale shift (or inversely frequency shift), which is a typical nonlinear behavior, has been detected from the undulating contours. From the ridge plots, we have identified the presence of nonlinearity and degree of chaoticity. Using the wavelet transform modulus maxima technique we have obtained the multifractal spectrum for the fluctuations at different discharge voltages and the spectrum was observed to become a monofractal for periodic signals. These multifractal spectra were also used to estimate different quantities such as the correlation and fractal dimension, degree of multifractality, and complexity parameters. These estimations have been found to be consistent with the nonlinear time series analysis.

Nurujjaman, Md; Narayanan, Ramesh; Iyengar, ANSekar

Noise-invoked resonances near a homoclinic bifurcation in the glow discharge plasma

Stochastic resonance (SR) and coherence resonance (CR) have been studied experimentally in discharge plasmas close to a homoclinic bifurcation. For the SR phenomenon, it is observed that a superimposed subthreshold periodic signal can be recovered via stochastic modulations of the discharge voltage. Furthermore, it is realized that even in the absence of a subthreshold deterministic signal, the system dynamics can be recovered and optimized using noise. This effect is defined as CR in the literature. In the present experiments, induction of SR and CR is quantified using the absolute mean difference and normalized variance techniques, respectively.

Nurujjaman, Md; Iyengar, ANSekar; Parmananda, P[†]

Parametric investigation of nonlinear fluctuations in a dc glow discharge plasma

Glow discharge plasmas exhibit various types of self-excited oscillations for different initial conditions like discharge voltages and filling pressures. The behavior of such oscillations associated with the anode glow has been investigated using nonlinear techniques like correlation dimension, largest Lyapunov exponent, etc. It is seen that these oscillations go to an ordered state from a chaotic state with an increase in input energy, i.e., with discharge voltages implying occurrence of inverse bifurcations. These results are different from the other observations wherein the fluctuations have been observed to go from ordered to chaotic state.

Nurujjaman, Md; Narayanan, Ramesh; Iyengar, ANSekar

Density distribution for a weakly non-ideal non-uniform plasma

An attempt is made to develop an equilibrium kinetic equation for a weakly non-ideal non-uniform plasma utilizing the Bogoliubov-Born-Green-Kirkwood Yvon hierarchy of equations. The time-independent pair correlation function is shown to be a product of two single-particle non-uniform distribution functions and the binary interaction potential that is taken to be Coulombian. In order to obtain a closed form of kinetic equation, it is necessary to express the first-order corrections to the Vlasov equation arising out of correlations in terms of average plasma potential. The singular nature of the Coulomb potential gives rise to certain divergences that can be removed by the choice of Landau and Debye lengths as the lower and upper limits of the impact parameter. This procedure enables a representation of pairwise interaction potential in terms of average macroscopic potential. The first-order kinetic equation is utilized to obtain a modified Boltzmann distribution that includes the effects of correlations.

Bose, Anirban; Janaki, MS

Debye-shielding potential in the presence of pair correlations

The first-order kinetic equation of the Bogoliubov-Born-Green-Kirkwood-Yvon hierarchy of equations for an equilibrium inhomogeneous plasma is shown to contain an effective force resulting from pair correlations that depends on the gradient of the average electric field modulus. Such a kinetic equation is utilized to obtain a Boltzmann distribution that includes the effects of correlations. For an electron-ion plasma with stationary ions and finite electron-electron correlations, the nature of the Debye-screening potential is investigated.

Bose, Anirban; Janaki, MS

Nonlinear electrostatic structures in the presence of correlations

The nature of nonlinear electrostatic potential distribution in a dusty plasma is investigated in the presence of dust-dust correlations by developing an equilibrium kinetic equation that contains the effects of pair correlations. For a plasma in equilibrium, the role of pair correlations is to give rise to a force in the kinetic equation that is proportional to the dust density gradient. The solutions of such a kinetic equation with pair correlations and Poisson's equation in the presence of a trapped particle population are obtained in the small-amplitude limit. The electrostatic potential represents a localized solitary wave-like structure with the amplitude and width varying with the correlation parameter.

Bose, Anirban; Janaki, MS

Preparation of diamond like carbon thin film on stainless steel and its SEM characterization

We report the formation of a very smooth, continuous and homogeneous diamond-like carbon DLC thin coating over a bare stainless steel surface without the need for a thin Si/Cr/Ni/Mo/W/TiN/TiC interfacial layer. As confirmed by the field-emission scanning electron microscopy, good adhesion is achieved as characterized by (i) the formation of a smooth, continuous film with no pores, (ii) a significant reduction of oxygen in the interfacial layer, and (iii) the development of rich carbon content at the top surface. Thickness measurements by cross-sectional secondary-emission microscopy showed that the DLC coating is essentially a 2-dimensional material.

Kumari, Kamlesh; Banerjee, S; Chini, TK; Ray, NR

Structural modifications of diamond like carbon films induced by MeV nitrogen ion irradiation

Diamond-like carbon (DLC) films were deposited on Si(100) substrates using plasma deposition technique. The deposited. films were irradiated using 2 MeV N+ ions at fluences of 1 x 10(14), 1 x 10(15) and 5 x 10(15) ions/cm(2). Samples have been characterized by using Raman spectroscopy, X-ray photoelectron spectroscopy (XPS) and high-resolution transmission electron microscopy (HRTEM). Analysis of Raman spectra shows a gradual shift of both D and G band peaks towards higher frequencies along with an increase of the intensity ratio, I(D)/I(G), with increasing ion. fluence in irradiation. These results are consistent with an increase of sp(2) bonding. XPS results also show a monotonic increase of sp(2)/sp(3) hybridization ratio with increasing ion fluence. Plan view TEM images show the formation of clusters in the irradiated DLC films. HRTEM micrographs from the samples irradiated at a fluence of 5 x 10(15) ions/cm(2) show the lattice image with an average interplanar spacing of 0.34 nm, revealing that the clusters are graphite clusters. The crystallographic planes in these clusters are somewhat distorted compared to the perfect graphite structure.

Mathew, S[†]*; Bhatta, UM*[†]*; Islam, AKMMaidul; Mukherjee, M; Ray, NR; Dev, BN*[†]

Radial transport of the nonthermal electrons in runaway discharges in the SINP tokamak from analysis of hard x-ray fluctuations

X-ray bursts from nonthermal electrons (similar to 10 keV to 1 MeV) emanating from the core plasma and the limiter are measured simultaneously in runaway dominated discharges in the SINP tokamak using a tangentially viewing NaI(Tl) detector and a detector that views the limiter areas. The radial transport coefficient of the nonthermal electrons has been derived from the cross-correlation function of the two x-ray intensities. Two phases of the plasma discharges with distinct transport of the nonthermal electrons are found in these experiments. The stochastic magnetic field fluctuations obtained from the transport coefficients are found to have a relationship with the autocorrelation functions of the x-ray emissivity signals.

Hui, AK; Saha, SK; Chowdhury, S; Raychaudhuri, Santwana; Banik, D

Intermittency in the heat and particle transports in the SINP tokamak scrape-off layer

The intermittent heat and particle transports have been studied in the scrape-off layer of the SINP tokamak. Properties of the plasma structures, responsible for the intermittency, have been measured by the conditional averaging technique. The probability distribution functions of the fluctuations, including temperature fluctuations, obey non-Gaussian statistics. Wavelet analysis has shown that the cross-correlation between two probes is also intermittent in time and is connected to the passage of plasma structures. The structures decay in density as they move radially outward but their temperature is found to decay more rapidly.

Saha, SK; Chowdhury, S

Nonlinear interaction of electron plasma waves with electron acoustic waves in plasmas

An analysis of interaction between two temperature electron species in the presence of static neutralizing ion background is presented. It is shown that electron plasma waves can nonlinearly interact with electron acoustic wave in a time scale much longer than omega(-1)(p), where omega(p) is electron plasma frequency. A set of coupled nonlinear differential equations is shown to exist in such a scenario. Propagating soliton solutions are demonstrated from these equations.

Chakrabarti, Nikhil; Sengupta, Sudip

Nonlocal analysis of the excitation of the geodesic acoustic mode by drift waves

The geodesic acoustic modes (GAMs) are typically observed in the edge region of toroidal plasmas. Drift waves have been identified as a possible cause of excitation of GAMs by a resonant three wave parametric process. A nonlocal theory of excitation of these modes in inhomogeneous plasmas typical of the edge region of tokamaks is presented in this paper. The continuum GAM modes with coupling to the drift waves can create discrete “global” unstable eigenmodes localized in the edge “pedestal” region of the plasma. Multiple resonantly driven unstable radial eigenmodes can coexist on the edge pedestal.

Guzdar, PN[†]; Kleva, RG[†]; Chakrabarti, N; Naulin, V[†]; Rasmussen, JJ[†]; Kaw, PK[†]; Singh, R[†]

Geodesic acoustic modes excited by finite beta drift waves

Presented in this paper is a mode-coupling analysis for the nonlinear excitation of the geodesic acoustic modes (GAMs) in tokamak plasmas by finite beta drift waves. The finite beta effects give rise to a strong stabilizing influence on the parametric excitation process. The dominant finite beta effect is the combination of the Maxwell stress, which has a tendency to cancel the primary drive from the Reynolds stress, and the finite beta modification of the drift waves. The zonal magnetic field is also excited at the GAM frequency. However, it does not contribute to the overall stability of the three-wave process for parameters of relevance to the edge region of tokamaks.

Chakrabarti, N; Guzdar, PN†; Kleva, RG†; Naulin, V†; Rasmussen, JJ†; Kaw, PK†

Excitation of geodesic acoustic modes by ion temperature gradient modes

Geodesic acoustic modes (GAMs) can be excited by mode coupling to primary modes such as the drift waves and ion temperature gradient modes in tokamak plasmas. Recent global numerical simulations of ion temperature gradient modes show excitation of GAMs and indicate that the radial wave-number of the excited GAMs scales inversely as the ion Larmor radius. Also the modes are excited dominantly in the edge region of the device. Furthermore there is a nonlinear downshift of the GAM frequency compared with the predicted linear mode frequency. The mode-coupling analysis presented in this paper provides an explanation of the scaling of the radial wave-number, the preferential excitation of GAMs in the outer half of the plasma and the nonlinear downshift of the frequency of GAMs.

Guzdar, PN†; Chakrabarti, N; Singh, R†; Kaw, PK†

Performances of linseed oil-free bakelite RPC prototypes with cosmic ray muons

A comparative study has been performed on Resistive Plate Chambers (RPC) made of two different grades of bakelite paper laminates, produced and commercially available in India. The chambers, operated in the streamer mode using argon. tetrafluroethane and isobutane in 34:59:7 mixing ratio, are tested for the efficiency and the stability with cosmic rays. A particular grade of bakelite (P-120, NEMA LI-1989 Grade XXX), used for high voltage insulation in humid conditions, was found to give satisfactory performance with stable efficiency of > 96% continuously for more than 130 days. A thin coating of silicone fluid on the inner surfaces of the bakelite RPC is found to be necessary for the operation of the detector.

Biswas, S; Bhattacharya, S; Bose, S; Chattopadhyay, S; Saha, S; Sharan, MK; Viyogi, YP†

Control system for a four-component gas mixing unit

Resistive Plate Chambers (RPC) planned to be used in the ICAL detector of the Indian Neutrino Observatory (INO) project, need precise mixing of four different gases, as well as precise control of the flow rate of the mixed gas. The designed system has the capability to pre-mix the gases (static mode), which can be stored in a pressurized vessel for subsequent use. The unit can also dynamically control the ratio of the four constituent gases (dynamic mode) and deliver it at a controlled flow rate through the mixing volume to the RPC.

Bose, S; Biswas, S; Saha, S; Sharan, MK; Bhattacharya, S

High Voltage Power Supply for RPC detectors

A High Voltage Power Supply Unit (HVPSU) for biasing resistive plate chamber (RPC) detector has been developed for initial testing of the RPC prototypes. The unit, based on inexpensive encapsulated DC-DC converters, is capable of delivering positive and negative polarity independently adjustable high voltages to the detector. The HVPSU is overload protected and displays the output voltage and current loading in both channels. Test performance of the unit with a 300 x 300 mm single gap RPC detector is reported.

Bose, S; Saha, S; Bhattacharya, S

Developmental work

Deep Space Plasma Propulsion Experiment

The objective of this project is to study the physics involved in the generation of mechanical thrust by a plasma. Propulsion of a spacecraft by a plasma is far more fuel efficient than chemical means. The ultimate target is the design and construction of a laboratory prototype of a plasma propulsion device for the next generation of deep space vehicles.

In this method, a light gas will be converted into a plasma by using a RF discharge. This plasma will be further heated to a high temperature by another RF antenna and made to flow along a diverging magnetic field. Gyration energy of the ions will be converted into linear energy, generating the mechanical thrust.

A system of 9 magnet coils (double-pancake type) has been constructed using OFHC copper conductors to produce a uniform field of 3 kG with 500 A current. The winding has been done in-house under collaboration with VECC and finished as per target. The coils have also been vacuum impregnated with varnish. The quartz vacuum vessel (12.5 cm diameter, 125 cm long, with flanges and diagnostic ports) has been designed and procured. A RF source (13.6 MHz, 1.25 kW) has been connected to the antenna through a matching network and tested. The matching network, consisting of two vacuum capacitors and an inductor in a p configuration has been designed and constructed here. The vacuum pumping system, gauges and data acquisition system are also ready.

Sujit Kumar Saha, Santwana Raychaudhuri, S. Chowdhury, A.K. Hui, M.S.Janaki, S.K.Das, D.Das, P. Bhattacharyya, A.Bal, S.Sil, S. Bose and M. Chattopadhyay.

The double layer experimental setup

A small scale pilot experiment has been constructed in addition to the above project. A helicon discharge has been produced in a quartz tube kept in an axial magnetic field (500 G) provided by a Helmholtz coil pair. This plasma (n~1e11 cm^{-3}, T_e~5-7 eV) diffuses into a larger chamber (50 cm diameter) along a diverging magnetic field. Formation of an electric double layer has been reported under such situations, which can accelerate ions to high energies as a beam.

Preliminary measurements of density and potential have been done by Langmuir probes movable in the radial and axial directions using stepper motor controlled drives. The system is operational and further experiments are in progress.

Sujit Kumar Saha, Santwana Raychaudhuri, S. Chowdhury, A.K. Hui, M.S.Janaki, S.K.Das, D.Das, P. Bhattacharyya, A.Bal, S.Sil, S. Bose and M. Chattopadhyay.

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NR Ray

- *Carbon Materials for Future Technologies, Institute of Physical Electronics*, Faculty of Science, Masaryk University, Brno, Czech Republic, July 27, 2007
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- *Synthesis of Diamond like Carbon Films for Various Applications*, XXVIII International Conference on Phenomena in Ionized Gases (ICPIG),Prague, Czech Republic, July 15-20, 2007

SK Saha

- *Diagnostic Instruments for Turbulence Measurements in Tokamaks*, 22nd Nat Symp on Plasma Science & Technology, Ahmedabad, India, December 6-10, 2007
- *Computing with MATLAB*, National Institute for Technical Teachers' Training and Research, Kolkata, July 31, 2008
- *The Deep Space Plasma Propulsion Experiment*, Institute for Plasma Research, Gandhinagar, March 20, 2009

M S Janaki

- *Equilibrium Potential Structures in a weakly correlated plasma*
- International workshop on Plasma Astrophysics, organized by Indian Institute of Astrophysics (Bangalore), Kodaikonal, September, 2007

Nikhil Chakrabarti

- *Nonlinear Jeans instability in presence of uniform rotation*
- *Finite beta Geodesic Acoustic mode*, Plasma department: Riso National Laboratory, Roskilde, Denmark, November 22, 2007
- *Geodesic Acoustic Mode in Toroidal plasma*, Riso National Laboratory,Denmark, November 27, 2007
- *Zonal flow geodesic acoustic mode (GAM) interaction in toroidal plasma,* Riso National Laboratory, Denmark, December 3, 2009

Rabindranath Pal

- *Parametric Decay of Pumping Waves in The MaPLE Device of SINP- Preliminary Results*, West Virginia University, U.S.A., November 16, 2009; Naval Research Laboratory, Washington DC, U.S.A., November 24, 2009; University of Iowa, U.S.A., November 19, 2009

Ph D Awarded

- Ramesh Narayanan [AN Sekar Iyengar], Investigation of High energy electrons and their implications in the SINP tokamak, Jadhavpur University, December 2007
- MD Nurujjaman [AN Sekar Iyengar], Nonlinear dynamics experiments in plasmas, HBNI, August 2009

Teaching elsewhere

Janaki Sita Mylavarapu

- Advanced Plasma Physics (30), October 1, 2007-March 31, 2008, MSc (Special) University of Calcutta
- Plasma physics course to M.Sc. students at Department of Physics, University of Calcutta (2007) 30 lectures
- Basic Quantum Mechanics and Basic Plasma physics courses to the M.Sc. students of Narendrapur Ramkrishana Mission College (University of Calcutta) (2007-2009)

Miscellany

NR Ray

- The INNOLEC LECTURESHIP in Plasma Physics, by the Faculty of Science, Masaryk University, Brno, Czech Republic, August 17, 2007

SK Saha

- Awarded DAAD fellowship for collaborative work with the Max Planck Institute for Plasma Physics at Greifswald, Germany from Dec 9, 2009 to Jan 31, 2010

Theoretical Physics Including Mathematics

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Summary of Research Activities of Divisions

Theory

Research in the Theory Division branches out in several aspects of theoretical physics. That created several subgroups within the division, which are, theoretical nuclear physics, high energy phenomenology, mathematical physics, quantum field theories and strings & gravity and AstroParticle Physics. Below we summarize the important results obatined during this period.

a.Theoretical nuclear physics:

The main focus of theoretical nuclear physics has been to study the properties of strongly interacting matter and phenomenology of heavy-ion collisions, structure of hybrid star with colour superconducting quark matter, bulk behavior of finite nuclei and infinite nuclear matter, and dynamics of nuclei as many-body chaotic quantum systems and their application, and many interesting results have been obtained, which are briefly described below:

i) Properties of strongly interacting via elctromagnetic and hadronic probes: An unitary and gauge invariant theory has been formulated using an effective Lagrangian constrained by the quantum chromodynamics (QCD) within a coupled channels K-matrix approach to investigate the hadron structure by analyzing the interaction between nucleons and mesons where the hadronic interactions are described as the exchange of known mesons and baryons. This theory has been used successfully to provide a comprehensive description of all the available data on the photoproduction of the · and the K+ meson off proton. A covariant theory has been developed to describe hypernuclear production with hadronic and electromagnetic probes. This is based on the effective Lagrangian picture and it focuses on production amplitudes that are described via excitation of the relevant baryonic resonance states. The mechanism of hypernuclear production via pion, kaon and photon induced reactions are well described by this theory. A formalism have been developed using the techniques of the effective Lagrangian method to investigate the dilepton production data in NN collisions by HADES Collaboration at GSI Dramstad. Using this method it has recently been shown that the puzzle regarding the non-description of the data by theories can be solved by including pion electromagnetic form factors.

ii) Heavy-ion phenomenology: The prime intention for ultra relativistic heavy-ion collisions is to study the behavior of nuclear or hadronic matter at extreme conditions like very high temperatures and energy densities. A particular goal lies in the identification of a new state of matter formed in such collisions, the quark-gluon plasma (QGP). Various measurements taken in CERN-SPS and BNL-RHIC do lead to wealth of information for the formation of QGP through the hadronic final states. The various aspects, viz., energy-loss of energetic partons and its consequences on secondary hadron spectra and jet quenching, recombination aspect of hadronisation of QGP, fluidity aspect of QCD matter produced in RHIC, and various static and dynamic quantities through the correlation function description within perturbative and nonperturbative approach, have been investigated.

iii) Finite nuclei and infinite nuclear matter: Unified nuclear energy density functionals, which are simultaneously compatible with the observed properties for the finite nuclei to infinite symmetric and asymmetric nuclear matters, are obtained within the non-relativistic and relativistic mean field theories. It is shown that the unified energy density functional can be obtained within the relativistic mean field theory only if the contributions from the self-interactions and cross-interactions of Ã, É and Á mesons up to the quartic order are included.

iv) Structure of hybrid stars: The static and rotating configurations of stable hybrid stars are constructed using a set of diverse equations of state for the nuclear matter and the colour superconducting quark matter. It is found that the stable hybrid stars with colour superconducting quark matter core can have masses _ 1.5Msolar and they can rotate up to the frequencies _1kHz.

v) Nuclei as many-body chaotic quantum systems and their application: Nuclei at a few MeV of excitation show properties of many-body chaotic quantum systems. Spectral distribution methods are successful in describing the averaged structure of the nuclei in this domain and even going beyond, using a few input quantities and without doing any shell model diagonalisation. Recent applications including beta decay rates for stellar evolution and r-process nucleosynthesis have been carried out.

b.Mathematical physics:

The mathematical physics subgroup has found many interesting results in a wide range of subjects like classical and quantum integrable systems, quantum groups, various properties of graphene, entangled states of quantum systems, self-similar processes etc., which are described briefly in the following. Anyon gas with compeetling delta and derivative-delta -function potentials is proposed and exactly solved by using the Bethe ansatz. Novel quantum integrable 1D anyonic lattice and field models are constructed using braided Yang-Baxter equation, including NLS and derivative NLS anyon QFT models, discovering thus the missing link for the solvable anyon gases. Integrable sine-Gordon (SG) model with variable mass is proposed with unusual soliton solution and potential application. The SG model with integrable defect is studied at classical and quantum level, with possible scattering/creation/annihilation of soliton by the defect. A novel scheme for nonlinearizing linear equations to integrable systems is proposed, generating their Lax pair, the known systems as well as their new integrable hierarchies with nonholonomic deformation, exhibiting rich features with accelerating soliton and possible applications.

Using the underlying super Yangian quantum group symmetry, it is shown that the partition function of the su(m|n) supersymmetric Haldane-Shastry (HS) spin chain satisfies a boson-fermion duality relation. It is found that the low energy excitations of the su(m|1) HS spin chain are described by a conformal field theory with central charge m/2. Novel spectra for the DN type of spin Calogero and spin Sutherland models are derived and exact partition functions of the corresponding spin chains are obtained by using the freezing trick. Inequivalent quantizations of some variants of the rational Calogero model are studied by imposing nontrivial boundary conditions through the method of self-adjoint extension.

The bound and scattering state spectra of both gapless and gapped graphene are analyzed in the presence of an external Coulomb charge impurity. When the Coulomb charge exceeds a certain critical value, bound states appear in these spectra. The corresponding RG flow has an UV stable fixed point at the value of the critical charge. For the subcritical case, for certain range of the system parameters, the combined effect of the short range interactions due to the charge impurity is modelled using a single real parameter appearing in the boundary conditions, given by the self-adjoint extension of the Dirac equation. This leads to a novel spectra of the low energy excitations near the Fermi points. The effect of turbulent flow to the electrical conductivity in graphene is analyzed and the method of self-adjoint extension is used to calculate electron scattering in polar molecules. A class of entangled states of a quantum system and a second system, where pure states of the former are correlated with mixed states of the latter, are studied and the entanglement measure with reference to the nearest separable state is derived. It is shown numerically that such an entangled state drifts towards the nearest separable state through

decoherence, with an additional tendency of equimixing among relevant groups of apparatus states. Fluctuations in capital markets, which seems to follow a self-similar process, are studied. Modelling of a hilly surface by using the surrogate data method of generating a self-similar process and a program to mark the coastline from the hilly surface are under construction.

c. High energy phenomenology:

i) Phenomenology of Physics Beyond the Standard Model:

Searches for physics beyond the Standard Model have been pursued mainly in two directions: (A) Phenomenology of Rparity violating supersymmetry - study of correlated enhancements in different meson mixing and decays, rare decays of tau lepton, muon anomalous magnetic moment, etc. (B) Phenomenology of extra dimensional theories - (i) contribution of the Kaluza-Klein (KK) excitation of Standard Model particles on the Higgs production via gluon fusion; (ii) relaxation of the lightest supersymmetric Higgs mass upper limit when supersymmetry is embedded in extra dimension; (iii) effects of KK thresholds on the running of soft supersymmetry breaking parameters.

ii) Neutrino Physics and Supernova:

The impact of the collective oscillations due to neutrino-neutrino interactions at the very high density region on the emitted flux of supernova neutrinos and their future detection was investigated in detail. The sensitive dependence of the emission rates on the relative fluxes in the different flavors for the neutrinos and antineutrinos was used to obtain constraints on the flux ratios for successful r-process nucleosynthesis in core collapse supernova. A study of Diffuse Supernova Neutrino Background including the collective effects was carried out and the possibility of distinguishing the inverted neutrino mass hierarchy from the normal investigated.

iii) Higher order QCD corrections to some BSM scenarios:

In the recent past, various non-SUSY extensions beyond the Standard Model (BSM), viz. models of extra dimensions, unparticle physics etc. have been studied extensively, but was at the qualitative level— leading order in QCD. Searches of these BSM observable at the LHC demands high precision in the theoretical predictions. We have accomplished an important task of computing all the partonic contributions at next-to-leading order (NLO) level in QCD to various observable in some direct and indirect searches of extra dimension models. NLO QCD effects are large and they substantially reduce the theoretical uncertainties, thus providing an excellent opportunity to put stringent bounds on the parameters of the BSM model when the experimental results are available.

d. Quantum field theories:

Work has mainly progressed in the non-perturbative treatment and properties of theories in the areas below.

i) QFTs on the light front:

Hamiltonian light-front quantum field theory constitutes a framework for the non-perturbative solution of invariant masses and parton amplitudes of bound systems. By choosing the light-front gauge and adopting a basis function representation, we obtain a large, sparse, Hamiltonian matrix that is solvable by adapting the ab initio methods of nuclear many-body theory. We outline our approach and present illustrative features of some non-interacting systems in a cavity. Theoretical analysis of Deeply Virtual Compton Scattering (DVCS) is particularly clear when one uses light front quantization. The Fourier transform of the amplitude is used to provide an image of the target hadron in the variable sigma which is an impact parameter in the longitudinal coordinate space. The Fourier transform exhibits diffraction patterns. The results are analogous to the diffractive scattering of a wave in optics.

ii) QFTs on lattice:

Shifting from the interesting topics of feasibility of a non-perturbative regularization of chiral gauge theories on lattice, non-perturbative gauge fixing, and lower dimensional field theories, in recent years the major activities shifted more towards numerical lattice QCD (LQCD), a main stream lattice gauge theory activity. Initial focus has been to probe the chiral regime of LQCD in terms of the behavior of the pion and rho masses and their decay constants, and the chiral condensate in dependence of the light quark masses. This is a non-trivial job keeping in mind that chiral symmetry has to be explicitly broken on the lattice by the Nielsen-Ninomiya theorem. A criterion for selection of scaling region needed for setting the lattice scale using the so-called Sommer parameter has been proposed and used to determine the lattice scale. The experimentally inaccessible tensor decay constant of the rho, important for B-meson decay studies, have been determined. Initially the simulations took place on small volumes and larger light quark masses because of limitations of hardware. Very recently larger volumes and smaller quark masses have been accessed because of installation of a more potent machine and usage of improved algorithms. On the analytic side, it has been shown explicitly that up to o(g2), parity violating terms cancel in the flavor-singlet axial Ward identity for LQCD with 'twisted mass' fermions even at finite volume and finite lattice spacing.

iii) CP-violation:

Using the zeta function regularization, the quark determinant in QCD was shown to be independent of the phase of the quark mass matrix.

This proof was then extended to include spacetime curvature.

iv) Finite temperature:

Based on the perturbative and non-perturbative approaches, various thermodynamic quantities (viz., pressure, entropy, number density, susceptibilities etc.) and dynamical quantities (correlation functions, dilepton rates etc.) for quarkgluon plasma believed to have produced in heavy-ion collisions are estimated. The results are in good agreement with lattice QCD results. In addition some aspects like huge gamma flush and 511keV line from QED plasma envisaged to be produced by ultra intense laser technology have been studied.

e. Strings and gravity:

The (intersecting) non-supersymmetric brane solutions (both single charge and two charge system) in low energy string theory have been constructed and among other things their relations to the closed string tachyon condensation have been studied. The origin of the geometric tachyon when one brane moves in the background of another has been understood and how some bound states of branes form as a result of geometric tachyon condensation was shown. The alpha-prime corrections to certain time-dependent solutions (S-branes) in heterotic string theory have been studied. Using AdS/CFT and some brane bound states the drag force on an external heavy quark moving in both relativistic and non-relativistic hot non-commutative Yang-Mills plasma has been calculated. Instability of black Dp-branes has been understood from their charge-temperature bound.

The multi-tachyon (assisted) slow-roll inflationary models, including inflation models with geometric tachyons of the NS5-D3 brane system have been studied. Certain aspects of Chern-Simons matter (ABJM) theories have been studied and new M2-brane solutions on a 'resolved' C4/Z4 has been obtained and also the Chern-Simons level flow has been studied. Interestingly a version of LBLG theory has been studied where a new way of looking at the BF models were provied. Some new Galilean solutions in massive type IIA string theory were constructed.

Holography and the AdS/CFT correspondence for the warped AdS3 black hole has been analyzed using Sullivan's theorem. The dynamics of scalar fields in the background of BTZ and warped AdS3 black holes have been studied. The universal features of the near-horizon CFT for a large class of black holes have been obtained. The quantum structure of space-time has been investigated within the framework of kappa-Minkowski noncommutative geometry. The star product, the twisted statistics and the deformed oscillator algebra for scalar fields on the kappa-Minkowski space-time have been analyzed and constraints on the noncommutativity parameter have been proposed from the GRB data. The noncommutative BTZ black hole has been studied.

Some issues in Hawking radiation in the framework of the quantum mechanics of a relativistic particle in black hole backgrounds have been clarified. Also the black hole entropy in loop quantum gravity has been studied, with the horizon area kept fixed at a definite value, unlike earlier investigations where the area was kept within a small interval. This explained a fine structure which had been observed numerically. Black hole thermodynamics has been studied through ‘isolated horizons’ in the 1st order formulation of gravity. Some issues regarding the phase space of extremal and non-extremal black holes have been clarified.

Astroparticle Physics and Cosmology

This Division is created in May 2010. In addition to ongoing research in several theoretical areas of astroparticle physics and cosmology the **Centre for Astropharticle Physics** (CaPP) has initiated new research activitties in the Institute in two major experimental/observational areas of contemporary interest in Astroparticle Physics, namely, (a) a WIMP (Weakly Interacting Massive Particle) Dark Matter search experiment using Superheated Drop Detectors (SDD), and (b) Observational High Energy Gamma Ray Astronomy using the High Altitude Gamma Ray (HAGAR) Telescope system located at Hanle, Ladakh (J&K).

For the Dark Matter search experiment, so far the main efforts have gone towards the development of the basic in-house laboratory facilities for carrying out the R&D work on SDDs. The CAPP-SINP Dark Matter search group is now a member of the ongoing international PICASSO Collaboration which is carrying out a WIMP Dark Matter search experiment using SDD in the SNOLab underground facility at Sudbury, Canada.

For the Observational High Energy Gamma Ray Astronomy programme, the CAPP-SINP group has recently joined the HAGAR Collaboration with members from the Tata Institute of Fundamental Research (TIFR), Mumbai, and Indian Institute of Astrophysics (IIA), Bangalore. CAPP has also procured a 14" optical telescope for teaching and demonstration of fundamental concepts of astronomy and for outreach activities. An observatory dome is being set up on the roof of the Institute building for housing the telescope.

The members of the AstroParticle Physics group are also working on a variety of theoretical issues of contemporary interest in Astroparticle physics, including, to mention a few, the study of implications of self-consistent models of the phase space distribution of the dark matter in the Galaxy for the phenomenology of WIMP direct- and indirect detection, ultrahigh energy cosmic ray-, gamma ray- and neutrino astrophysics, study of exotic forms of matter such as hyperons and Bose-Einstein Condensates of Kaons in the dense interior of neutron stars and their possible observational consequences, thermal holography and black hole stability, entropy of isolated horizons,

Experimental/observational research:

• R&D on Superheated Drop Detectors (SDD) related to WIMP Dark Matter search experiment:

The basic infrastructure for fabrication of SDDs for radiation and particle detection has been developed. A SDD consists of drops of superheated liquid of low boiling point suspended in a viscous gel or in a polymer medium. When radiation or a particle is incident on a drop, a bubble of the gas phase of the liquid can be nucleated inside the drop if the energy deposition by the radiation or the particle in the liquid drop exceeds a certain critical energy which depends on the composition of the liquid and on its temperature and pressure. Bubbles above a critical size expand, sending accoustic waves through the medium which can be picked by suitable sensors placed on the wall of the detector. Analysis of the characteristics of the acoustic pulses — their amplitudes, pulse shapes, etc. can be used to discriminate between various kinds of particles initiating the bubble nucleation events. The detector can be made sensitive to some desired types of particles and at the same time insensitive to other types of particles and radiation by suitably controlling the ambient temperature and pressure of the liquid, which essentially changes the threshold energy of detection. SDDs are being used by the PICASSO Collaboration searching forWIMP Dark Matter particles, and the CAPP-SINP group is involved in R&D work towards the development of large mass, low background SDDs as well as simulation and data analysis studies.

An active drop counting device using condenser microphone has been developed at the CAPP-SINP laboratory for recording of bubble nucleation events and measuring the acoustic pulse characteristics. Neutron energy spectrum of 252Cf source has been measured using this active device with a SDD consisting of superheated drops of R114 (C2Cl2F4 ; b.p. 3.7oC) in a soft gel matrix. The analysis of pulse height of the signals at neutron- and gamma-ray sensitive temperatures has been shown to provide clear identification of and discrimination between neutron and gamma-ray induced events. In another study, the threshold degree of metastability of superheated liquid drop in polymer matrix for high energy heavy ion induced nucleation was studied in collaboration with Hokkaido University and HIMAC, Japan.

Studies with different sensitive liquids and different supporting matrix to reduce the background radioactivity are also in progress.

Theoretical research (AstroParticle Physics):

• Phase space structure of Milky Way's dark matter halo from the dynamics of the dwarf spheroidals:

The dynamics of the dwarf spheroidal (dSph) galaxies in the gravitational field of the Galaxy has been investigated with particular reference to their susceptibility to tidal break-up. Based on the observed paucity of the dSphs at small Galactocentric distances, it is hypothesized that subsequent to the formation of the Milky Way and its satellites, those dSphs that had orbits with small perigalacticons were tidally disrupted, leaving behind a population that now has a relatively larger value of its average perigalacticon to apogalacticon ratio and consequently a larger value of its r.m.s. transverse to radial velocities ratio compared to their values at the time of formation of the dSphs. The implications of this hypothesis is studied for the phase space distribution of the dSphs and that of the dark matter (DM) halo of the Galaxy within the context of a self-consistent model in which the functional form of the phase space distribution of DM particles follows the King model i.e. the ‘lowered isothermal’ distribution and the potential of the Galaxy is determined self-consistently by including the gravitational cross-coupling between visible matter and DM particles. This analysis, coupled with virial arguments, yields an estimate of e” 270 kms”1 for the circular velocity of any test object at galactocentric distances of ~100 kpc, the typical distances of the dSphs. The corresponding self-consistent values of the relevant DM halo model parameters, namely, the local (i.e., the solar neighbourhood) values of the DM density and velocity dispersion in the King model and its truncation radius, are estimated to be ~0.3GeV/ cm^3, > 350 km.s^1 and > ~150 kpc, respectively. Similar self-consistent studies with other possible forms of the DM distribution function will be useful in assessing the robustness of these estimates of the Galaxy’s DM halo parameters.

- **Upper Limit on the Cosmic Gamma-Ray Burst Rate from High Energy Diffuse Neutrino Background:**

Upper limits on the ratio of the rate, of long-duration Gamma Ray Bursts (GRBs) to the rate, RCCSN, of core-collapse supernovae (CCSNe) in the Universe have been derived by using the upper limit on the diffuse TeV–PeV neutrino background given by the AMANDA-II experiment in the South Pole, under the assumption that GRBs are sources of TeV–PeV neutrinos produced from decay of charged pions produced in pr interaction of protons accelerated to ultrahigh energies at internal shocks within GRB jets. For the assumed “concordance model” of cosmic star formation rate, These limits are already comparable to (and in some cases more restrictive than) the current upper limit on this ratio inferred from other astronomical considerations, thus providing a useful independent probe of and constraint on the CCSN-GRB connection. Non-detection of a diffuse TeV–PeV neutrino background by the up-coming IceCube detector in the South pole after three years of operation, for example, will bring down the above upper limit on fGRB/CCSN(0) to below few $\times 10^{-5}$ level, while a detection will confirm the hypothesis of proton acceleration to ultra- high energies in GRBs and will potentially also yield the true rate of occurrence of these events in the Universe.

- **Direct detection of WIMPs: Implications of a self-consistent truncated isothermal model of the Milky Way’s dark matter halo:**

Direct detection of Weakly Interacting Massive Particle (WIMP) candidates of Dark Matter (DM) is studied within the context of a self-consistent truncated isothermal model of the finite-size dark halo of the Galaxy. The halo model, based on the “King model” of the phase space distribution function of collisionless DM particles, takes into account the modifications of the phase-space structure of the halo due to the gravitational influence of the observed visible matter in a self-consistent manner. The parameters of the halo model are determined by a fit to a recently determined circular rotation curve of the Galaxy that extends up to ~60 kpc. Unlike in the Standard Halo Model (SHM) customarily used in the analysis of the results of WIMP direct detection experiments, the velocity istribution of the WIMPs in this model is non-Maxwellian with a cut-off at a maximum velocity that is self-consistently determined by the model itself. For the model that provides the best fit to the rotation curve data, the 90% C.L. upper limit on the WIMP-nucleon spin-independent cross section from the recent results of the CDMS-II experiment, for example, is ~5.3 × 10^{-8} pb at aWIMP mass of ~71 GeV. It is also found, using the original 2-bin annual modulation amplitude data on the nuclear recoil event rate seen in the DAMA experiment, that there exists a range of small WIMP masses, typically ~2 – 16 GeV, within which DAMA collaboration's claimed annual modulation signal purportedly due to WIMPs is compatible with the null results of other experiments. These results, based as they are on a self-consistent model of the dark matter halo of the Galaxy, strengthen the possibility of low-mass (d”10GeV) WIMPs as a candidate for dark matter as indicated by several earlier studies performed within the context of the SHM.

- **Thermal Holography and Black Hole Stability:**

The canonical partition function of quantum gravitating systems with horizons is shown to be completely described by the boundary partition function. This leads to a general criterion for thermal stability of black holes derived without any use of classical spacetime geometry. Asymptotically flat black holes are generically seen to violate this inequality, while for AdS black holes, stability is acquired in a region of parameter space, whose boundary signifies a generalized Hawking-Page phase transition characterized by a divergent heat capacity.

- **Isolated Horizon QFT revisited**

Isolated horizons are shown to be described by an SU(2) Chern Simons theory gauge fixed to U(1) with appropriate additional constraints on the U(1) sources that reveal their SU(2) underpinning. Depending upon how bulk local Lorentz invariance is gauge fixed, they can also be described by an ISO(2) theory gauge fixed to U(1) with appropriate additional constraints. The entropy count is argued to correspond to precisely the same area law with the same logarithmic corrections as found a decade ago.

- Gravitational radiation drives the r-modes unstable due to Chandrasekhar-Friedman-Schutz mechanism. This instability may play an important role in regulating spins of young neutron stars as well as old, accreting neutron stars in low mass x-ray binaries and provides clues to the absence of very fast rotating neutron stars in nature. The r-mode instability may be damped by the large bulk viscosity coefficient due to non-leptonic processes around temperature 10^{10} K. In this connection, the bulk viscosity coefficients and damping time scales due to non-leptonic processes involving hyperons and antikaons and its influence on the r-mode instability in neutron stars is investigated. It is noted that the bulk viscosity due to the non-leptonic process involving K” mesons in the condensate alone could not damp the r-mode instability. However the bulk viscosity due to the non-leptonic processes involving hyperons in antikaons condensed matter effectively damp the r-mode instability in neutron stars.

- The problem of extracting information about composition and equation of state (EoS) of dense matter in neutron star interior using axial w-modes has been studied. The EoS with kaon condensates may lead to the appearance of a new stable branch of superdense stars, called the third family, beyond the neutron star branch. It is found that first axial w-mode frequencies of superdense stars in the third family are higher than those of the corresponding stars in the neutron star branch. Consequently neutrons stars might be distinguished from superdense stars of the third family.

● The neutral components of the extra doublet added to the Standarnd Model (Inert Doublet Model) are stable and can be considered as probable candidate of Cold Dark Matter. The detection rates calculations are made for three different types of Dark Matter experiments, namely, 76 Ge (like GENIUS), DAMA (NaI) and XENON (131 Xe).

● The rates of upward going muons induced by neutrinos from Weakly Interacting Massive Particle (WIMP) annihilation products in the sun are computed The recent CDMS bounds on WIMPnucleon scattering cross-sections for different WIMP masses are used in our rate calculation. It is observed that representation of SK upper bounds on WIMP induced up-going muon rates allows an enhancement in the calculated rates in all individual channels. An estimation of this enhancement has been made as a function of WIMP mass assuming branching fractions for each different channels to be 1 (maximum).

● A simplest extension of the Standard Model is considered through the incorporation of a real scalar singlet and an additional discrete Z2 symmetry. The model admits the neutral scalar singlet to be stable and thus, a viable component of dark matter. The parameter space of the model is explored keeping in view the constraints arise from different dark matter direct detection experiments like CDMS, XENON-10 and XENON-100, CoGeNT etc.

● Direction sensitive direct detection of Weakly Interacting Massive Particles as Dark matter would provide an unambiguous non-gravitational signature of Dark Matter (DM). The directional detection rates are calculated with their daily and yearly modulations in a earth-bound dark matter experiments considering detailed features of the geometry and dynamics of the earth-sun system along with the solar motion in galactic frame.

● Possibility of identifying the deviation from tribimaximal mixing in neutrino mass matrix texture is investigated considering ultrahigh energy (UHE) neutrinos from Gamma Ray Bursts (GRBs) considering a ratio of number of muon tracks to the shower generated due to electrons and hadrons. Analysis shows that it is very difficult to detect such deviation in case of possible detection of UHE neutrinos at ICECUBE.

● Deviation from tribimaximal mixing through generation of nonzero Ue3 within the framework of see-saw mechanism and Zee mechanism and corresponding allowed CP violation , m_ee in the context of a modified Altarelli-Feruglio A4 symmetric model. • 'Four zero' Yukawa coupling matrix coupled with 'Mu-tau' symmetry has been investigated within the framework of type-I seesaw mechanism. The number of allowed textures drastically reduces to only 'four' out of 'seventy two' possible forms. We have studied the prameter space allowed by present oscillation data and further generation of nonzero Ue3 through RG group running.

● A further detailed study on generation of baryon asymmetry due to leptogenesis is also investigated.

Research Activities

Upper limit on the cosmic gamma-ray burst rate from high energy diffuse neutrino background

We derive upper limits on the ratio $f_{\mathrm{GRB/CCSN}}(z) \equiv R_{\mathrm{GRB}}(z)/R_{\mathrm{CCSN}}(z) \equiv f_{\mathrm{GRB/CCSN}}(0)(1+z)^{\alpha}$, the ratio of the rate, R_{GRB}, of long-duration gamma-ray bursts (GRBs) to the rate, R_{CCSN}, of core-collapse supernovae (CCSNe) in the Universe (z being the cosmological redshift and $\alpha \geq 0$), by using the upper limit on the diffuse TeV-PeV neutrino background given by the AMANDA-II experiment in the South Pole, under the assumption that GRBs are sources of TeV-PeV neutrinos produced from decay of charged pions produced in *pã* interaction of protons accelerated to ultrahigh energies at internal shocks within GRB jets. For the assumed “concordance model” of cosmic star formation rate, R_{SF}, with $R_{\mathrm{CCSN}}(z)$””$R_{\mathrm{SF}}(z)$, our conservative upper limits are $f_{\mathrm{GRB/CCSN}}(0) \leq 5.0\times10^{-3}$ for *á*=0, and $f_{\mathrm{GRB/CCSN}}(0) \leq 1.1\times10^{-3}$ for $\alpha = 2$, for example. These limits are already comparable to (and, for áe”1, already more restrictive than) the current upper limit on this ratio inferred from other astronomical considerations, thus providing a useful independent probe of and constraint on the CCSN-GRB connection. Nondetection of a diffuse TeV–PeV neutrino background by the upcoming IceCube detector in the South Pole after three years of operation, for example, will bring down the upper limit on $f_{\mathrm{GRB/CCSN}}(0)$ to below a few $\times10^{-5}$ level, while a detection will confirm the hypothesis of proton acceleration to ultrahigh energies in GRBs and will potentially also yield the true rate of occurrence of these events in the Universe.

Bhattacharjee, Pijushpani; Chakraborty, Sovan; Das Gupta, Srirupa; Kar, Kamales

Dynamics of dwarf-spheroidals and the dark matter halo of the galaxy

The dynamics of the dwarf-spheroidal (dSph) galaxies in the gravitational field of the Galaxy is investigated with particular reference to their susceptibility to tidal break-up. Based on the observed paucity of the dSphs at small Galactocentric distances, we put forward the hypothesis that subsequent to the formation of the Milky Way and its satellites, those dSphs that had orbits with small perigalacticons were tidally disrupted, leaving behind a population that now has a relatively larger value of its average perigalacticon to apogalacticon ratio and consequently a larger value of its r.m.s. transverse to radial velocities ratio compared to their values at the time of formation of the dSphs. We analyze the implications of this hypothesis for the phase space distribution of the dSphs and that of the dark matter (DM) halo of the Galaxy within the context of a self-consistent model in which the functional form of the phase space distribution of DM particles follows the King model, i.e. the ‘lowered isothermal’ distribution and the potential of the Galaxy is determined self-consistently by including the gravitational cross-coupling between visible matter and DM particles. This analysis, coupled with virial arguments, yields an estimate of greater than or similar to 270 km/s for the circular velocity of any test object at galactocentric distances of ~100 kpc, the typical distances of the dSphs. The corresponding self-consistent values of the relevant DM halo model parameters, namely, the local (i.e., the solar neighbourhood) values of the DM density and velocity dispersion in the King model and its truncation radius, are estimated to be ~0.3 GeV cm-3, > 350 kms^{-1} and greater than or similar to 150 kpc, respectively. Similar self-consistent studies with other possible forms of the DM distribution function will be useful in assessing the robustness of our estimates of the Galaxy’s DM halo parameters.

Cowsik, R; Ratnam, Charu; Bhattacharjee, Pijushpani; Majumdar, Subhabrata

Holography, Gauge-Gravity Connection and Black Hole Entropy

The issues of holography and possible links with gauge theories in spacetime physics is discussed, in an approach quite distinct from the more restricted AdS-CFT correspondence. A particular notion of holography in the context of black hole thermodynamics is derived (rather than conjectured) from rather elementary considerations, which also leads to a criterion of thermal stability of radiant black holes, without resorting to specific classical metrics. For black holes that obey this criterion, the canonical entropy is expressed in terms of the microcanonical entropy of an Isolated Horizon which is essentially a local generalization of the very global event horizon and is a null inner boundary of spacetime, with marginal outer trapping. It is argued why degrees of freedom on this horizon must be described by a topological gauge theory. Quantizing this boundary theory leads to the microcanonical entropy of the horizon expressed in terms of an infinite series asymptotic in the cross-sectional area, with the leading 'area-law' term followed by finite, unambiguously calculable corrections arising from quantum spacetime fluctuations.

Majumdar, Parthasarathi

Generalized Hawking-Page phase transition

The issue of radiant spherical black holes being in stable thermal equilibrium with their radiation bath is reconsidered. Using a simple equilibrium statistical mechanical analysis incorporating Gaussian thermal fluctuations in a canonical ensemble of isolated horizons, the heat capacity is shown to diverge at a critical value of the classical mass of the isolated horizon, given (in Planckian units) by the *microcanonical* entropy calculated using loop quantum gravity. The analysis reproduces the Hawking–Page phase transition discerned for anti-de Sitter black holes and generalizes it in the sense that nowhere is any classical metric made use of.

Majumdar, Parthasarathi

Shear viscosity in antikaon condensed matter

We investigate the shear viscosity of neutron star matter in the presence of an antikaon condensate. The electron and muon number densities are reduced due to the appearance of a K^- condensate in neutron star matter, whereas the proton number density increases. Consequently, the shear viscosity due to scatterings of electrons and muons with themselves and protons is lowered compared to the case without the condensate. On the other hand, the contribution of proton-proton collisions to the proton shear viscosity through electromagnetic and strong interactions becomes important and comparable to the neutron shear viscosity.

Nandi, Rana; Banik, Sarmistha; Bandyopadhyay, Debades

Probing dense matter in neutron stars with axial w modes

We study the problem of extracting information about composition and equation of state of dense matter in neutron star interior using axial *w* modes. We determine complex frequencies of axial *w* modes for a set of equations of state involving hyperons as well as Bose-Einstein condensates of antikaons adopting the continued fraction method. Hyperons and antikaon condensates result in softer equations of state leading to higher frequencies and lower damping times of first axial *w* modes than those of the nuclear matter case. The presence of condensates may lead to the appearance of a new stable branch of superdense stars beyond the neutron star branch called the third family. The existence of the same mass compact stars in both branches is known as neutron star twins. Further investigation of twins reveals that first axial *w*-mode frequencies of superdense stars in the third family are higher than those of the corresponding twins in the neutron star branch.

Chatterjee, Debarati; Bandyopadhyay, Debades

Hyperon bulk viscosity in strong magnetic fields

We study the bulk viscosity of neutron star matter including *Ë* hyperons in the presence of quantizing magnetic fields. Relaxation time and bulk viscosity due to both the nonleptonic weak process involving hyperons and direct Urca processes are calculated here. In the presence of a strong magnetic field of 10^{17} G, the hyperon bulk viscosity coefficient is reduced, whereas bulk viscosity coefficients due to direct Urca processes are enhanced compared with their field free cases when many Landau levels are populated by protons, electrons, and muons.

Sinha, Monika; Bandyopadhyay, Debades

Critical temperature of antikaon condensation in nuclear matter

We investigate the critical temperature of Bose-Einstein condensation of K^- mesons in neutron star matter. This is studied within the framework of relativistic field theoretical models at finite temperature where nucleon-nucleon and (anti)kaon-nucleon interactions are mediated by the exchange of mesons. The melting of the antikaon condensate is studied for different values of antikaon optical potential depths. We find that the critical temperature of antikaon condensation increases with baryon number density. Further it is noted that the critical temperature is lowered as antikaon optical potential becomes less attractive. We also construct the phase diagram of neutron star matter with K^- condensate.

Banik, Sarmistha†; Greiner, Walter†; Bandyopadhyay, Debades

Bulk viscosity and r-modes of neutron stars

The bulk viscosity due to the non-leptonic process involving hyperons in K″ condensed matter is discussed here. We find that the bulk viscosity is modified in a superconducting phase. Further, we demonstrate how the exotic bulk viscosity coefficient influences r-modes of neutron stars which might be sources of detectable gravitational waves.

Chatterjee, Debarati; Bandyopadhyay, Debades

Hyperon bulk viscosity in the presence of antikaon condensate

We investigate the hyperon bulk viscosity due to the nonleptonic process n + p == p + Λ in K^{-} condensed matter and its effect on the *r*-mode instability in neutron stars. We find that the hyperon bulk viscosity coefficient in the presence of antikaon condensate is suppressed compared with the case without the condensate. The suppressed hyperon bulk viscosity in the superconducting phase is still an efficient mechanism to damp the *r*-mode instability in neutron stars.

Chatterjee, Debarati; Bandyopadhyay, Debades

Bulk viscosity in kaon condensed matter

We investigate the effect of K^{-} condensed matter on bulk viscosity and *r*-mode instability in neutron stars. The bulk viscosity coefficient due to the nonleptonic process n Ì! $p+K^{-}$ is studied here. In this connection, equations of state are constructed within the framework of relativistic field theoretical models where nucleon-nucleon and kaon-nucleon interactions are mediated by the exchange of scalar and vector mesons. We find that the bulk viscosity coefficient due to the nonleptonic weak process in the condensate is suppressed by several orders of magnitude. Consequently, kaon bulk viscosity may not damp the *r*-mode instability in neutron stars.

Chatterjee, Debarati; Bandyopadhyay, Debades

Exotic bulk viscosity and its influence on neutron star r-modes

We investigate the effect of exotic matter in particular, hyperon matter on neutron star properties such as equation of state (EoS), mass-radius relationship and bulk viscosity. Here we construct equations of state within the framework of a relativistic field theoretical model. As hyperons are produced abundantly in dense matter, hyperon-hyperon interaction becomes important and is included in this model. Hyperon-hyperon interaction gives rise to a softer EoS which results in a smaller maximum mass neutron star compared with the case without the interaction. Next we compute the coefficient of bulk viscosity and the corresponding damping time scale due to the non-leptonic weak process including Lambda hyperons. Further, we investigate the role of the bulk viscosity on gravitational radiation driven r-mode instability in a neutron star of given mass and temperature and find that the instability is effectively suppressed.

Chatterjee, Debarati; Bandyopadhyay, Debades

μτ symmetry, tribimaximal mixing and four zero neutrino Yukawa textures

Within the type-I seesaw framework with three heavy right chiral neutrinos and in the basis where the latter and the charged leptons are mass diagonal, a near ìô symmetry in the neutrino sector is strongly suggested by the neutrino oscillation data. There is further evidence for a close to the tribimaximal mixing pattern which subsumes ìô symmetry. On the other hand, the assumption of a (maximally allowed) four zero texture in the Yukawa coupling matrix $Y_{í}$ in the same basis leads to a highly constrained and predictive theoretical scheme. We show that the requirement of an exact ìô symmetry, coupled with observational constraints, reduces the *seventy two* allowed textures in such a Y_i to *only four* corresponding to just two different forms of the light neutrino mass matrix m_i. The effect of each of these on measurable quantities can be described, apart from an overall factor of the neutrino mass scale, in terms of two real parameters and a phase angle all of which are within very constrained ranges. The additional input of a tribimaximal mixing reduces these three parameters to **only one** with a very nearly fixed value. Implications for both flavored and unflavored leptogenesis as well as radiative lepton flavor violating decays are discussed. We also investigate the stability of these conclusions under small deviations due to renormalization group running from a high scale where the four zero texture as well as ìô symmetry or the tribimaximal mixing pattern are imposed.

Adhikary, Biswajit; Ghosal, Ambar; Roy, Probir

Nonzero U_{e3}, *CP* violation, and leptogenesis in a seesaw type softly broken A_4 symmetric model

We have shown that nonzero U_{e3} is generated in a seesaw type softly broken A_4 symmetric model through a single parameter perturbation in m_D in a single element. We have explored all possible 9 cases to study the neutrino mixing angles considering the best fitted values of $\Delta m_{™”}{}^2$ and $\Delta m_{\mathrm{atm}}{}^2$ with all parameters real. We have extended our analysis for the complex case and demonstrated large low energy *CP* violation (J_{CP}C”10^{-2}) and m_{ee} in addition to mixing and mass pattern. We have also investigated leptogenesis and for a reasonable choice of model parameters compatible with low energy data, the Wilkinson Microwave Anisotropy Probe (WMAP) value of baryon asymmetry 6×10^{-10} is obtained for right-handed neutrino mass scale M_0C”10^{13} GeV. We have obtained a relation among the phases responsible for leptogenesis and have shown that those phases also have correlations with low energy *CP* violating phases.

Adhikary, Biswajit; Ghosal, Ambar

Probing deviations from tribimaximal mixing through ultrahigh energy neutrino signals

We investigate deviation from the tribimaximal mixing in the case of ultrahigh energy neutrino using the ICECUBE detector. We consider the ratio of the number of muon tracks to the shower generated due to eletrons and hadrons. Our analysis shows that for tribimaximal mixing the ratio comes out around 4.05. Keeping Θ_{12} and Θ_{23} fixed at tribimaximal value, we have varied the angle Θ_{13}=3°, 6°, 9° and the value of the ratio gradually decreases. The variation of ratio lies within 8% to 18% from the tribimaximal mixing value and it is very difficult to detect such a small variation by the ICECUBE detector.

Majumdar, Debasish; Ghosal, Ambar

Constraining CP violation in a softly broken A(4) symmetric model

To understand the mass spectra of charged lepton and neutrino A_4 symmetry has been proposed in addition with the standard $SU(2)_L\times U(1)_Y$ model. We break A_4 symmetry softly and the deviation from the tribimaximal mixing arises due to Zee mechanism. In the present work, we express two mixing angles θ_{13} and θ_{23}, in terms of a single model parameter and experimental observables, such as, mixing angle θ_{12}, mass-squared differences $\Delta m_{21}{}^2$ and $\Delta m_{32}{}^2$. Using the experimental values of θ_{23}, θ_{12}, $\Delta m_{21}{}^2$, and $\ddot{A}m_{32}^2$ we restrict the model parameter and we predict θ_{13}. This model gives rise to θ_{13}C"11° if we allow 1σ deviation of θ_{23} and 2° deviation of θ_{12} from their best fit values. Utilizing all those constraints, we explore the extent of *CP* violation parameter J_{CP} in the present model and found a value of $J_{CP} \approx 2.65\times10^{-3}$ (for 1σ deviation of θ_{23} and 2° deviation of θ_{12}) consistent with the other neutrino experimental results. We have studied the mass pattern of neutrino and neutrinoless double beta decay ($\beta\beta_{0i}$) parameter $|(M_{\nu})_{ee}|$ in this model.

Adhikary, Biswajit; Ghosal, Ambar

Dark matter candidate in a heavy Higgs model: Direct detection rates

We investigate direct detection rates for Dark Matter candidates arise in a $SU(2)_L\times U(1)_Y$ with an additional doublet Higgs proposed by Barbieri, Hall and Rychkov. We refer to this model as "Heavy Higgs Model". The Standard Model Higgs mass comes out from this model is very heavy, so there is very slim chance that there is no Higgs boson mass below 200 GeV. The additional Higgs boson develops neither any VEV due to the choice of coefficient of the scalar potential of the model nor it has any coupling with fermions due to the incorporation of a discrete parity symmetry. Thus, the neutral components of the extra doublet are stable and can be considered as probable candidate of Cold Dark Matter. We have made calculations for three different types of Dark Matter experiments, namely, ^{76}Ge (like GENIUS), DAMA (NaI) and XENON (^{131}Xe). Also demonstrated the annual variation of Dark Matter detection in case of all three

Majumdar, Debasish; Ghosal, Ambar

Probing pseudo-Dirac neutrino through detection of neutrino-induced muons from gamma ray burst neutrinos

The possibility to verify the pseudo-Dirac nature of neutrinos is investigated here via the detection of ultra-high energy neutrinos from distant cosmological objects like γ-ray bursts (GRBs). The very long baseline and the energy range from <"TeV to <"EeV for such neutrinos invoke the likelihood to probe very small pseudo-Dirac splittings. The expected secondary muons from such neutrinos that can be detected by a kilometer scale detector such as ICECUBE are calculated and compared with the same in the case of mass-flavour oscillations and for no oscillation cases. The calculated muon yields indicate that to probe such small pseudo-Dirac splittings one needs to look for a nearby GRB (red shift *z* <" 0.03 or less) whereas for a distant GRB (*z* <" 1) the flux will be much depleted and such phenomenon cannot be distinguished. Also calculated are the muon-to-shower ratios.

Majumdar, Debasish

Probing deviations from tribimaximal mixing through ultrahigh energy neutrino signals

We investigate deviation from the tribimaximal mixing in the case of ultrahigh energy neutrino using the ICECUBE detector. We consider the ratio of the number of muon tracks to the shower generated due to eletrons and hadrons. Our analysis shows that for tribimaximal mixing the ratio comes out around 4.05. Keeping θ_{12} and θ_{23} fixed at tribimaximal value, we have varied the angle θ_{13}=3°, 6°, 9° and the value of the ratio gradually decreases. The variation of ratio lies within 8% to 18% from the tribimaximal mixing value and it is very difficult to detect such a small variation by the ICECUBE detector.

Majumdar, Debasish; Ghosal, Ambar

The effect of collective flavor oscillations on the diffuse supernova neutrino background

Collective flavor oscillations driven by neutrino–neutrino interactions inside core-collapse supernovae have now been shown to drastically alter the resultant neutrino fluxes. This would in turn significantly affect the diffuse supernova neutrino background (DSNB), created by all core-collapse supernovae that have exploded in the past. In view of these collective effects, we re-analyze the potential for detecting the DSNB in currently running and planned large scale detectors meant for detecting both ν_e and ν_e. We find that the event rate can be different from previous estimates by up to 50%, depending on the value of θ_{13}. The next generation detectors should be able to observe DSNB fluxes. Under certain conducive conditions, one could learn about neutrino parameters. For instance, it might be possible to determine the neutrino mass hierarchy, even if $\theta_{13} \rightarrow 0$.

Chakraborty, Sovan; Choubey, Sandhya[†]; Dasgupta, Basudeb[†]; Kar, Kamales

A geant-based study of atmospheric neutrino oscillation parameters at INO

We have studied the dependence of the allowed space of the atmospheric neutrino oscillation parameters on the time of exposure for a magnetized Iron CALorimeter (ICAL) detector at the India-based Neutrino Observatory (INO). We have performed a Monte Carlo simulation for a 50 kTon ICAL detector, generating events by the neutrino generator NUANCE and simulating the detector response by GEANT. A $\div^2$ analysis for the ratio of the up-going and down-going neutrinos as a function of L/E is performed and the allowed regions at 90% and 99% CL are displayed. These results are found to be better than the current experimental results of MINOS and Super-K. The possibilities of further improvement have also been discussed.

Samanta, Abhijit; Bhattacharya, Sudeb; Ghosal, Ambar; Kar, Kamales; Majumdar, Debasish; Raychaudhuri, Amitava[†]

Associated photoproduction of K^+ mesons off protons within a coupled-channels K-matrix approach

We investigate the $p(\gamma,K^+)\Lambda$ and $p(\gamma,K^+)\Sigma^0$ reactions within a coupled-channels effective-Lagrangian method that is based on the K-matrix approach. The two-body final channels included are πN, ηN, *ÕN*, ρN, γN, $K\Lambda$, and $K\Sigma$. Nonresonant meson-baryon interactions are included in the model via nucleon intermediate states in the *s* and *u* channels and meson exchanges in the *t*-channel amplitude and the *u*-channel resonances. The nucleon resonances $S_{11}(1535)$, $S_{11}(1650)$, $S_{31}(1620)$, $P_{11}(1440)$, $P_{11}(1710)$, $P_{13}(1720)$, $P_{33}(1232)$, $P_{33}(1600)$, $D_{13}(1520)$, $D_{13}(1700)$, and $D_{33}(1700)$ are included explicitly in the calculations. With a single parameter set that was derived earlier from our analysis of *ç*-meson photoproduction, the model describes all the available cross-section and polarization data of the SAPHIR Collaboration well for the two investigated channels. The description of the data from the CLAS Collaboration, however, is not of the same quality. In contrast to some previous studies, we do not find any compelling need to include a D_{13} state with a mass of about 2.0 GeV to reproduce the data for the $p(\gamma,K^{+})\Lambda$ reaction at photon energies corresponding to the invariant mass around 1.9 GeV.

Shyam, R; Scholten, O†; Lenske, H†

Open and Hidden Strangeness Production in Nucleon-Nucleon Collisions

Strange meson production reactions are expected to provide information on the manifestation of quantum chromodynamics in the non-perturbative regime of energies larger than that of the low energy pion physics. The K meson contains a strange quark (s) or antiquark ((s) over bar) while the eta meson has hidden strangeness as it contains some component of the s (s) over bar pair. In this lecture we present an overview of describing the production of K and eta mesons in nucleon-nucleon collisions with in an effective Lagrangian model (ELM) where meson production proceeds via excitation, propagation and subsequent decay of intermediate baryonic resonant states. Specific examples are discussed where proper understanding of the data is still lacking.

Shyam, Radhey

Photoproduction of hypernuclei within the quark-meson coupling model

We study the photoproduction of the ${}^{12}_{\ddot{E}}$B hypernucleus within a fully covariant effective Lagrangian based model, employing $\ddot{E}$ bound state spinors derived from the latest quark–meson coupling model. The kaon production vertex is described via creation, propagation and decay of N^{*}(1650), N^{*}(1710), and N^{*}(1720) intermediate baryonic resonant states in the initial collision of the photon with a target proton in the incident channel. The parameters of the resonance vertices are fixed by describing the total and differential cross section data on the elementary $\gamma p' \rightarrow \ddot{E}K^{+}$ reaction in the energy regime relevant to the hypernuclear production. It is found that the hypernuclear production cross sections calculated with the quark model based hyperon bound state spinors differ significantly from those obtained with the phenomenological Dirac single particle wave functions.

Shyam, R; Tsushima, K†; Thomas, AW†

Dilepton production in nucleon-nucleon collisions reexamined

We present a fully relativistic and gauge-invariant framework for calculating the cross sections of dilepton production in nucleon-nucleon (*NN*) collisions that is based on the meson-exchange approximation for the *NN*-scattering amplitudes. Predictions of our model are compared with those of other covariant models that have been used earlier to describe this reaction. Our results are also compared with those of the semiclassical models that are employed to get the input elementary cross sections in the transport model calculations of the dilepton production in nucleus-nucleus collisions. It is found that cross sections obtained within the semiclassical and quantum mechanical models differ noticeably from each other.

Shyam, R; Mosel, U†

Photoproduction of η mesons within a coupled-channels K-matrix approach

We investigate photoproduction of η mesons off protons and neutrons within a coupled-channels effective-Lagrangian method that is based on the K-matrix approach. The two-body final channels included are πN, ηN, $\tilde{O}N$, ρN, γN, $K\Lambda$, and $K\Sigma$. Nonresonant meson-baryon interactions are included in the model via nucleon intermediate states in the s and u channels and meson exchanges in the t-channel amplitude and the u-channel resonances. The nucleon resonances $S_{11}(1535)$, $S_{11}(1650)$, $S_{31}(1620)$, $P_{11}(1440)$, $P_{11}(1710)$, $P_{13}(1720)$, $P_{33}(1232)$, $P_{33}(1600)$, $D_{13}(1520)$, $D_{13}(1700)$, and $D_{33}(1700)$ are included explicitly in calculations. Our model describes simultaneously the available data as well on total and differential cross sections as on beam and target asymmetries. This holds for the $\gamma p \rightarrow \eta p$ reaction for photon energies ranging from very close to threshold to up to 3 GeV. The polarization observables show strong sensitivity to resonances that otherwise contribute only weakly to the total cross section. It is found that the pronounced bumplike structure seen in the excitation function of the $\gamma n \rightarrow \eta n$ cross section at $\tilde{a}$ energies around 1 GeV can be explained by the interference effects of S_{11}, P_{11}, and P_{13} resonance contributions.

Shyam, R; Scholten, O†

Coulomb dissociation of ^{9}Li and the rate of the ^{8}Li(n,γ)^{9}Li reaction

We calculate the Coulomb dissociation of ^{9}Li on Pb and U targets at 28.5 MeV/A beam energy within a finite range distorted wave Born approximation formalism of the breakup reactions. Invoking the principle of detailed balance, these cross sections are used to determine the excitation function and subsequently the rate of the radiative capture reaction ^{8}Li(n,γ)^{9}Li at astrophysical energies. Our method is free from the uncertainties associated with the multipole strength distributions of the ^{9}Li nucleus. The rate of this reaction at a temperature of 10 K is found to be about 2900 cm^{3} mole^{-1} s^{-1}.

Banerjee, P; Chatterjee, R; Shyam, R

Production of hypernuclei with hadronic and electromagnetic probes

We present an overview of a fully covariant formulation for describing hypernuclear production with hadronic and electromagnetic probes. This theory is based on an effective Lagrangian picture and it focuses on production amplitudes that are described via creation, propagation and decay into relevant channels of N*(1650), N*(1710) and N*(1720) intermediate baryonic resonance states in the initial collision of the projectile with one of the target nucleons. The bound state nucleon and hyperon wave functions are obtained by solving the Dirac equation with appropriate scalar and vector potentials. Specific examples are discussed for reactions which are of interest in current and future experiments on hypernuclear production.

Shyam, R

Hypernuclear production by the (g,K+) reaction within a relativistic model

Within a fully covariant model based on an effective Lagrangian picture, we investigate the hypernuclear production in a photon-nucleus interaction on an ^{16}O target. The explicit kaon production vertex is described via creation, propagation, and decay into relevant channels of N^*(1650), N^*(1710), and N^*(1720) intermediate baryonic resonance states in the initial interaction of the incident photon with one of the target protons. Bound state nucleon and hyperon wave functions are obtained by solving the Dirac equation. Using vertex parameters determined in the previous studies, contributions of the N^*(1710) baryonic resonance dominate the total production cross sections which are found to peak at photon energies below 1 GeV. The results show that photoproduction is the most appropriate means for studying the unnatural parity hypernuclear states, thus accessing the spin dependence of the hyperon-nucleon interaction.

Shyam, R; Lenske, H[†]; Mosel, U[†]

η-meson production in nucleon-nucleon collisions within an effective Lagrangian model

We investigate the *pp*’!*pp*η and *pn*’!*pn*η reactions within an effective Lagrangian model for laboratory kinetic energies ranging from very close to the ç-meson production threshold to about 10 GeV. Production amplitudes include contributions from the mechanisms of excitation, propagation, and decay of N^*(1535),N^*(1650), and N^*(1710) baryonic resonances. The initial interaction between two incoming nucleons is modeled by the exchange of π,ρ,ω, and σ mesons where the vertex parameters are taken to be the same as those used in the previous applications of this model. Parameters of the resonance vertices also are taken from our earlier studies wherever applicable. Calculations are done for total as well as differential ç-production cross sections. To describe the data for energies closer to the production threshold, final state interactions among the outgoing particles are included by means of a generalized Watson-Migdal method. Terms corresponding to the excitation of N^*(1535) resonance and the pion exchange process dominate the cross sections. With a single set of vertex parameters, our model describes well the available data on total cross sections for beam energies ranging from close to threshold to up to 10 GeV.

Shyam, R

Shape Changing and Accelerating Solitons in the Integrable Variable Mass Sine-Gordon Model

The sine-Gordon model with a variable mass (VMSG) appears in many physical systems, ranging from the current through a nonuniform Josephson junction to DNA-promoter dynamics. Such models are usually nonintegrable with solutions found numerically or perturbatively. We construct a class of VMSG models, integrable at both the classical and the quantum levels with exact soliton solutions, which can accelerate and change their shape, width, and amplitude simulating realistic inhomogeneous systems at certain limits.

Anjan Kundu

Two-fold integrable hierarchy of nonholonomic deformation of the derivative nonlinear Schrödinger and the Lenells-Fokas equation

The concept of the nonholonomic deformation formulated recently for the Ablowitz-Kaup-Newell-Segur family is extended to the Kaup-Newell class. Applying this construction we discover a novel integrable mixed twofold hierarchy related to the deformed derivative nonlinear Schrödinger (DNLS) equation and found the exact soliton solutions exhibiting unusual accelerating motion for both its field and the perturbing functions. Extending the idea of deformation the integrable perturbation of the gauge related Chen-Lee-Liu DNLS equation is constructed together with its soliton solution. We show that the recently proposed Lenells-Fokas (LF) equation falls in the deformed DNLS hierarchy, sharing the accelerating soliton and other unusual features. Higher order integrable deformations of the LF and the DNLS equations are proposed.

Kundu, Anjan

Nonlinearizing linear equations to integrable systems including new hierarchies with nonholonomic deformations

We propose a scheme for nonlinearizing linear equations to generate integrable nonlinear systems of both the Ablowitz-Kaup-Newell-Segur (AKNS) and the Kaup-Newell classes based on the simple idea of dimensional analysis and detecting the building blocks of the Lax pair. Along with the well-known equations, we discover a novel integrable hierarchy of higher order nonholonomic deformations for the AKNS family, e.g., the Korteweg-de Vries (KdV), the modified KdV, the nonlinear Schrödinger, and the sine-Gordon equation, showing thus a twofold universality of the recently found deformation for the KdV equation [A. Karsu , J. Math. Phys. 49, 073516 (2008)].

Kundu, Anjan

Nonholonomic deformation of KdV and mKdV equations and their symmetries, hierarchies and integrability

The recent concept of integrable nonholonomic deformation found for the Korteweg-de Vries (KdV) equation is extended to the modified KdV (mKdV) equation and generalized to the AKNS system. For the deformed mKdV equation we find a matrix Lax pair, a novel two-fold integrable hierarchy and exact N-soliton solutions exhibiting unusual accelerating motion. We show that both the deformed KdV and mKdV systems possess infinitely many generalized symmetries, conserved quantities and a recursion operator.

Kundu, Anjan; Sahadevan, R[†]*; Nalinidevi, L*[†]

Changing Solitons in Classical & Quantum Integrable Defect and Variable Mass Sine-Gordon Model

Sine-Gordon (SG) models with position dependent mass or with isolated defects appear in many physical situations, ranging from fluxon or semi-fluxon in nonuniform Josephson junction to spin-waves in quantum spin chain with variable coupling or DNA solitons in the active promoter region. However such phenomena usually break the integrability of the model, allowing only numerical or perturbative result. We investigate two types of inhomogeneous sine-Gordon (SG) models: one with a variable mass and the other with a defect at the center and show integrability of both these models, in classical as well as in exact quantum level. The variable mass SG exhibits accelerating and shape changing exact solitons and can describe realistic problems at certain limits, while the defect SG possesses a rich class of exact solutions with creation or annihilation of solitons by the defect point. Based on our result theories for exact semi-fluxion solution in 0-ï-Josephson junction is proposed.

Kundu, Anjan

Integrable nonautonomous nonlinear Schrödinger equations are equivalent to the standard autonomous equation

A class of nonautonomous nonlinear Schrödinger equations, claiming to be novel integrable systems with rich properties, continues to appear in the literature. All such equations are shown to be not new, but equivalent to the standard autonomous equation, which trivially explains their integrability features.

Kundu, Anjan

Exact accelerating solitons in nonholonomic deformation of the KdV equation with a two-fold integrable hierarchy

The recently proposed nonholonomic deformation of the KdV equation is solved through the inverse scattering method by constructing an AKNS-type Lax pair. Exact N-soliton solutions are found for the basic field and the deforming function showing an unusual accelerated (decelerated) motion. A two-fold integrable hierarchy is revealed, one with the usual higher order dispersion and the other with novel higher nonholonomic deformations.

Kundu, Anjan

One-dimensional anyons with competing delta-function and derivative delta-function potentials

We propose an exactly solvable model of one-dimensional anyons with competing delta-function and derivative delta-function interaction potentials. The Bethe ansatz equations are derived in terms of the N-particle sector for the quantum anyonic field model of the generalized derivative nonlinear Schrodinger equation. This more general anyon model exhibits richer physics than that of the recently studied one-dimensional model of delta-function interacting anyons. We show that the anyonic signature is inextricably related to the velocities of the colliding particles and the pairwise dynamical interaction between particles.

Batchelor, MT[†]; Guan, XW[†]; Kundu, A

Quantum and classical integrable sine-Gordon model with defect

Defects which are predominant in a realistic model, usually spoil its integrability or solvability. We on the other hand show the exact integrability of a known sine-Gordon field model with a defect (DSG), at the classical as Well as at the quantum level based on the Yang-Baxter equation. We find the associated classical and quantum R-matrices and the underlying q-algebraic structures, analyzing the exact lattice regularized model. We derive algorithmically all higher conserved quantities C_{-n}, n = 1, 2,..., of this integrable DSG model, focusing explicitly on the contribution of the defect point to each C_n. The bridging condition across the defect, defined through the Backlund transformation is found to induce creation or annihilation of a soliton by the defect point or its preservation with a phase shift.

Habibullin, Ismagil†; Kundu, Anjan

q-Boson in Quantum Integrable Systems

q-bosonic realization of the underlying Yang-Baxter algebra is identified for a series of quantum integrable systems, including some new models like two-mode q-bosonic model leading to a coupled two-component derivative NLS model, wide range of q-deformed matter-radiation models, q-anyon model etc. Result on a new exactly solvable interacting anyon gas, linked to q-anyons on the lattice is reported.

Kundu, Anjan

Hawking temperature and higher order calculations

Hawking radiation has recently been explained by using solutions of wave equations across black hole horizons in a WKB approximation. Higher order calculations using both Usual and non-singular coordinates are found to change the solution for zero spin, but this change is not an alteration of the Hawking temperature. For spin 1/2, there is no correction to the simplest form of the solution.

Chatterjee, Bhramar; Mitra, P

Fine-Grained State Counting for Black Holes in Loop Quantum Gravity

A state of a black hole in loop quantum gravity is given by a distribution of spins on punctures on the horizon. The distribution is of the Boltzmann type, with the area playing the role of the energy. In investigations where the total area was kept approximately constant, there was a kind of thermal equilibrium between the spins which have the same analogue temperature and the entropy was proportional to the area. If the area is precisely fixed, however, multiple constraints appear, different spins have different analogue temperatures and the entropy is not strictly linear in the area, but is bounded by a linear rise.

Ghosh, A; Mitra, P

Time-reversal and parity conservation for gravitating quarks

The complex mass term of a quark does not violate time reversal or parity in gravitational interactions, in spite of an axial anomaly.

Mitra, P

Tunnelling from black holes and tunnelling into white holes

Hawking radiation is nowadays being understood as tunnelling through black hole horizons. Here, the extension of the Hamilton-Jacobi approach to tunnelling for non-rotating and rotating black holes in different non-singular coordinate systems not only confirms this quantum emission from black holes but also reveals the new phenomenon of absorption into white holes by quantum mechanical tunnelling. The role of a boundary condition of total absorption or emission is also clarified.

Chatterjee, Bhramar; Ghosh, A; Mitra, P

Complex fermion mass term, regularization and CP violation

It is well known that the CP violating theta term of QCD can be converted to a phase in the quark mass term. However, a theory with a complex mass term for quarks can be regularized so as not to violate CP, for example through a zeta function. The contradiction is resolved through the recognition of a dependence on the regularization or measure. The appropriate choice of regularization is discussed and implications for the strong CP problem are pointed out.

Mitra, P

Hawking temperature from tunnelling formalism

It has recently been suggested that the attempt to understand Hawking radiation as tunnelling across black hole horizons produces a Hawking temperature double the standard value. It is explained here how one can obtain the standard value in the same tunnelling approach.

Mitra, P

Mixing and Decoherence to Nearest Separable States

We consider a class of entangled states of a quantum system (S) and a second system (A) where pure states of the former are correlated with mixed states of the latter, and work out the entanglement measure with reference to the nearest separable state. Such “pure-mixed” entanglement is expected when the system S interacts with a macroscopic measuring apparatus in a quantum measurement, where the quantum correlation is destroyed in the process of environment-induced decoherence whereafter only the classical correlation between S and A remains, the latter being large compared to the former. We present numerical evidence that the entangled S-A state drifts towards the nearest separable state through decoherence, with an additional tendency of equimixing among relevant groups of apparatus states.

Lahiri, Avijit[†]*; Ghosh, Gautam; Nag, Sankhasubhra*[†]

Angular momentum non-conserving decays in isotropic media

Various processes that are forbidden in vacuum due to angular momentum conservation can occur in a medium that is isotropic and does not carry any angular momentum. We illustrate this by considering explicitly two examples. The first one is the decay of a spin-0 particle into a photon and another spin-

0 particle, using a model involving the Yukawa interactions of the scalar particles with a charged fermion field. The second one involves the decay of a neutrino into another neutrino and a graviton, in the standard model of particle interactions augmented with the linearized gravitational couplings.

Nieves, Jose F†, Pal, Palash B

Lorentz-symmetry violating decays in a medium

Various decay processes, such as the decay of a spin-1 particle into two photons or the gravitational decay of a spin-1/2 fermion, are forbidden in the vacuum by a combination of requirements, including angular momentum conservation, Lorentz invariance, and gauge invariance. We show that such processes can occur in a medium, such as a thermal background of particles, even if it is homogeneous and isotropic. We carry out a model-independent analysis of the vertex function for such processes in terms of a set of form factors, and show that the amplitude can be nonzero while remaining consistent with the symmetry principles mentioned above. The results simulate Lorentz symmetry violating effects, although in this case they arise from completely Lorentz-invariant physics.

Nieves, Jose F†, Pal, Palash B

Hamiltonian light-front field theory in a basis function approach

Hamiltonian light-front quantum field theory constitutes a framework for the nonperturbative solution of invariant masses and correlated parton amplitudes of self-bound systems. By choosing the light-front gauge and adopting a basis function representation, a large, sparse, Hamiltonian matrix for mass eigenstates of gauge theories is obtained that is solvable by adapting the ab initio no-core methods of nuclear many-body theory. Full covariance is recovered in the continuum limit, the infinite matrix limit. There is considerable freedom in the choice of the orthonormal and complete set of basis functions with convenience and convergence rates providing key considerations. Here we use a two-dimensional harmonic oscillator basis for transverse modes that corresponds with eigensolutions of the soft-wall anti-de Sitter/quantum chromodynamics (AdS/QCD) model obtained from light-front holography. We outline our approach and present illustrative features of some noninteracting systems in a cavity. We illustrate the first steps toward solving quantum electrodynamics (QED) by obtaining the mass eigenstates of an electron in a cavity in small basis spaces and discuss the computational challenges.

Vary, JP†; Honkanen, H†; Li, Jun†; Maris, P†; Brodsky, SJ†; Harindranath, A; de Teramond, GF†; Sternberg, P†; Ng, EG†; Yang, C†

Chiral anomaly in lattice QCD with twisted mass Wilson fermion

The flavour singlet axial Ward identity with Osterwalder–Seiler twisted mass Wilson fermion action is studied on a finite lattice, with finite fermion mass and the Wilson parameter *r* up to 1. Approach to the infinite volume chiral limit and emergence of the anomaly is significantly better than that obtained with $\mathcal{O}(o)$ and $\mathcal{O}(o^2)$ improved fermion actions. We have shown explicitly that up to $\mathcal{O}(g^2)$, parity violating terms cancel in the Ward identity even at finite volume and finite lattice spacing.

De, Asit K; Harindranath, A; Mondal, Santanu

Hadron optics in three-dimensional invariant coordinate space from deeply virtual Compton scattering

The Fourier transform of the deeply virtual Compton scattering amplitude (DVCS) with respect to the skewness parameter $\zeta = Q^2/2p \cdot q$ can be used to provide an image of the target hadron in the boost-invariant variable σ, the coordinate conjugate to light-front time $\tau = t + z/c$. As an illustration, we construct a consistent covariant model of the DVCS amplitude and its associated generalized parton distributions using the quantum fluctuations of a fermion state at one loop in QED, thus providing a representation of the light-front wave functions (LFWFs) of a lepton in ó space. A consistent model for hadronic amplitudes can then be obtained by differentiating the light-front wave functions with respect to the bound-state mass. The resulting DVCS helicity amplitudes are evaluated as a function of σ and the impact parameter $b\times_{\text{¥”}}$, thus providing a light-front image of the target hadron in a frame-independent three-dimensional light-front coordinate space. Models for the LFWFs of hadrons in (3+1) dimensions displaying confinement at large distances and conformal symmetry at short distances have been obtained using the AdS/CFT method. We also compute the LFWFs in this model in invariant three-dimensional coordinate space. We find that, in the models studied, the Fourier transform of the DVCS amplitudes exhibit diffraction patterns. The results are analogous to the diffractive scattering of a wave in optics where the distribution in σ measures the physical size of the scattering center in a one-dimensional system.

Brodsky, SJ†; Chakrabarti, D; Harindranath, A; Mukherjee, A; Vary, JP†

Scattering in graphene with impurities: A low energy effective theory

We analyze the scattering sector of the Hamiltonians for both gapless and gapped graphene in the presence of a charge impurity using the 2D Dirac equation, which is applicable in the long wavelength limit. We show that for certain range of the system parameters, the combined effect of the short range interactions due to the charge impurity can be modelled using a single real parameter appearing in the boundary conditions. The phase shifts and the scattering matrix depend explicitly on this parameter. We argue that this parameter for graphene can be fixed empirically, through measurements of observables that depend on the scattering data.

Gupta, KS; Samsarov, A†; Sen, S†

Scalar field dynamics in warped AdS_3 black hole background

We study the normal modes of a scalar field in the background of a warped AdS_3 black hole which arises in topologically massive gravity. We discuss the normal mode spectrum using the brick wall boundary condition. In addition, we investigate the possibility of a more general boundary condition for the scalar field.

Chakrabarti, Sayan K; Giri, Pulak Ranjan; Gupta, KS

Deformed oscillator algebras and QFT in kappa-Minkowski spacetime

In this paper, we study the deformed statistics and oscillator algebras of quantum fields defined in kappa-Minkowski spacetime. The twisted flip operator obtained from the twist associated with the star product requires an enlargement of the Poincare algebra to include the dilatation generators. Here we propose a novel notion of a fully covariant flip operator and show that to the first order in the deformation parameter it can be expressed completely in terms of the Poincare generators alone. The R matrices corresponding to the twisted and the covariant flip operators are compared up to first order in the deformation parameter and they are shown to be different. We also construct the deformed algebra of the creation and annihilation operators that arise in the mode expansion of a scalar field in kappa-Minkowski spacetime. We obtain a large class of such new deformed algebras which, for certain choice of realizations, reduce to results known in the literature.

Govindarajan, TR†; Gupta, Kumar S; Harikumar, E†; Meljanac, S†; Meljanac, D†

Normal-mode analysis for scalar fields in BTZ black-hole background

We analyze the possibility of inequivalent boundary conditions for a scalar field propagating in the BTZ black-hole space-time. We find that for certain ranges of the black-hole parameters, the Klein-Gordon operator admits a one-parameter family of self-adjoint extensions. For this range, the BTZ space-time is not quantum mechanically complete. We suggest a physically motivated method for determining the spectra of the Klein-Gordon operator.

Chakrabarti, Sayan K; Giri, Pulak Ranjan; Gupta, Kumar S

Bound States in Graphene

We present a quantum analysis of the massless excitations in graphene with a charge impurity. When the effective charge exceeds a certain critical value, the spectrum is quantised and unbounded from below. The corresponding eigenstates are square-integrable at infinity and have a rapidly oscillatory behaviour in the short distance, which can be interpreted as a fall to the centre. Using a cutoff regularisation, we show that the effective Coulomb interaction strength is driven to its critical value under the renormalisation group flow. In the subcritical region, we find bound states with imaginary values of the energy for certain range of the system parameters. The physical significance of these bound states with imaginary eigenvalues is discussed.

Gupta, Kumar S; Sen, Siddhartha†

Bound states in gapped graphene with impurities: Effective low-energy description of short-range interactions

We obtain a bound-state spectrum of low-energy excitations near the Fermi points of gapped graphene in the presence of a charge impurity. The effects of possible short-range interactions induced by the impurity are modeled by suitable boundary conditions. The spectrum in the subcritical region of the effective Coulomb coupling is labeled by a parameter which characterizes the boundary conditions and determines the inequivalent quantizations of the system. In the supercritical region we obtain a renormalization-group flow for the effective Coulomb coupling.

Gupta, Kumar S; Sen, Siddhartha†

Inequivalent quantizations of the rational Calogero model with a Coulomb type interaction

We consider the inequivalent quantizations of a N-body rational Calogero model with a Coulomb type interaction. It is shown that for a certain range of the coupling constants, this system admits a one-parameter family of self-adjoint extensions. We analyze both the bound and scattering state sectors and find novel solutions of this model. We also find the ladder operators for this system, with which the previously found solutions can be constructed.

Basu-Mallick, B; Gupta, Kumar S; Meljanac, S†; Samsarov, A†

Universal near-horizon conformal structure and black hole entropy

It is shown that a massless scalar probe reveals a universal near-horizon conformal structure for a wide class of black holes, including the BTZ. The central charge of the corresponding Virasoro algebra contains information about the black hole. With a suitable quantization condition on the central charge, the CFT associated with the black hole in our approach is consistent with the recent observation of Witten, where the dual theory for the BTZ in the AdS/CFT framework has been identified with the construction of Frenkel, Lepowsky and Meurman. This CFT admits the Fischer-Griess monster group as its symmetry. The logarithm of the dimension of a specific representation of the monster group has been identified by Witten as the entropy of the BTZ black hole. Our algebraic approach shows that a wide class of black holes share the same near-horizon conformal structure as that for the BTZ. With a suitable quantization condition, the CFT's for all these black holes in our formalism can be identified with the FLM model, although not through the AdS/CFT correspondence. The corresponding entropy for the BTZ provides a lower bound for the entropy of this entire class of black holes.

Chakrabarti, Sayan K; Gupta, Kumar S; Sen, Siddhartha†

Twisted statistics in κ-Minkowski spacetime

We consider the issue of statistics for identical particles or fields in κ-deformed spaces, where the system admits a symmetry group *G*. We obtain the twisted flip operator compatible with the action of the symmetry group, which is relevant for describing particle statistics in the presence of the noncommutativity. It is shown that for a special class of realizations, the twisted flip operator is independent of the ordering prescription.

Govindarajan, TR†; Gupta, Kumar S; Harikumar, E†; Mejanac, S†; Mejanac, D†

Interacting quantum topologies and the quantum Hall effect

The algebra of observables of planar electrons subject to a constant background magnetic field B is given by $\mathcal{A}_\theta(\mathbb{R}^2) \otimes \mathcal{A}_\theta(\mathbb{R}^2)$ $\left(\theta = -\frac{4}{eB}\right)$, the product of two mutually commuting Moyal algebras. It describes the free Hamiltonian and the guiding center coordinates. We argue that $\mathcal{A}_\theta(\mathbb{R}^2)$ itself furnishes a representation space for the actions of these two Moyal algebras, and suggest physical arguments for this choice of the representation space. We give the proper setup to couple the matter fields based on $\mathcal{A}_\theta(\mathbb{R}^2)$ to electromagnetic fields which are described by the Abelian commutative gauge group

$\mathcal{G}_c(U(1))$, i.e. gauge fields based on $\mathcal{A}_0(\mathbb{R}^2)$. This enables us to give a manifestly gauge covariant formulation of integer quantum Hall effect (IQHE). Thus, we can view IQHE as an elementary example of interacting quantum topologies, where matter and gauge fields based on algebras $\mathcal{A}_\theta$ with different θ' appear. Two-particle wave functions in this approach are based on $\mathcal{A}_\theta(\mathbb{R}^2) \otimes \mathcal{A}_\theta(\mathbb{R}^2)$. We find that the full symmetry group in IQHE, which is the semidirect product SO(2) × $\mathcal{G}_c$(U(1)) acts on this tensor product using the twisted coproduct Δ_θ. Consequently, as we show, many particle sectors of each Landau level have twisted statistics. As an example, we find the twisted two particle Laughlin wave functions.

Balachandran, AP†; Gupta, Kumar S; Kuerkcueoglu, Seckin†

Electron capture and scaling anomaly in polar molecules

We present a new analysis of the electron capture mechanism in polar molecules, based on von Neumann's theory of self-adjoint extensions. Our analysis suggests that it is theoretically possible for polar molecules to form bound states with electrons, even with dipole moments smaller than the critical value $D_0=1.63\times10^{-18}$ esu cm. We argue that the quantum mechanical scaling anomaly is responsible for the formation of these bound states.

Giri, Pulak Ranjan; Gupta, Kumar S; Meljanac, S†; Samsarov, A†

k-Minkowski spacetime and the star product realizations

We investigate a Lie algebra-type k-deformed Minkowski spacetime with undeformed Lorentz algebra and mutually commutative vector-like Dirac derivatives. There are infinitely many realizations of k-Minkowski space. The coproduct and the star product corresponding to each of them are found. An explicit connection between realizations and orderings is established and the relation between the coproduct and the star product, provided through an exponential map, is proved. Utilizing the properties of the natural realization, we construct a scalar field theory on k-deformed Minkowski space and show that it is equivalent to the scalar, nonlocal, relativistically invariant field theory on the ordinary Minkowski space. This result is universal and does not depend on the realizations, i.e. the orderings, used.

Meljanac, S†; Samsarov, A†; Stojic, M†; Gupta, Kumar S

Exploring the universal extra dimension at the LHC

Besides supersymmetry, the other prime candidate of physics beyond the Standard Model (SM), crying out for verification at the CERN Large Hadron Collider (LHC), is extra-dimension. To hunt for effects of Kaluza–Klein (KK) excitations of known fermions and bosons is very much in the agenda of the LHC. These KK states arise when the SM particles penetrate in the extra space-like dimension(s). In this paper, we consider a 5d scenario, called 'Universal Extra Dimension', where the extra space coordinate, compactified on an orbifold S^1/Z_2, is accessed by *all* the particles. The KK number (n) is conserved at all tree level vertices. This entails the production of KK states in pairs and renders the lightest KK particle stable, which leaves the detector carrying away missing energy. The splitting between different KK flavors is controlled by the zero mode masses and the bulk- and brane-induced one-loop radiative corrections. We concentrate on the production of an n=1 KK electroweak gauge boson in association with an n=1 KK quark. This leads to a signal consisting of *only one* jet, one or more leptons and missing p_T. For definiteness we usually choose the inverse radius of compactification to be R^{-1}=500 GeV, which sets the scale of the lowest lying KK states. We show on a case-by-case basis (depending on the number of leptons in the final state) that with 10 fb^{-1} integrated luminosity at the LHC with $\sqrt{s}$ = 14 TeV this signal can be detected over the SM background by imposing appropriate kinematic cuts. We record some of the expectations for a possible intermediate LHC run at and also exhibit the integrated luminosity required to obtain a 5σ signal as a function of R^{-1}.

Bhattacharyya, Gautam; Datta, Anindya[†]; Majee, Swarup Kumar; Raychaudhuri, Amitava[†]

Probing warped extra dimension via $gg \to h$ and $h \to \gamma\gamma$ at LHC

The processes $gg \to h$ and $h \to \gamma\gamma$ are of paramount importance in the context of Higgs search at the LHC. These processes are loop driven and hence could be sensitive to the presence of any new colored fermion states having a large coupling with the Higgs. Such a scenario arises in a warped extra-dimensional theory, where the Higgs is confined to the TeV brane and the hierarchy of fermion masses is addressed by localizing them at different positions in the bulk. We show that the Yukawa coupling of the Higgs with the fermion Kaluza–Klein (KK) states can be order one irrespective of their zero mode masses. We observe that the $gg \to h$ and $h \to \gamma\gamma$ rates are substantially altered if the KK states lie within the reach of LHC. We provide both intuitive and numerical comparison between the RS and UED scenarios as regards their quantitative impact in such processes.

Bhattacharyya, Gautam; Ray, Tirtha Sankar

Electroweak symmetry breaking and beyond the Standard Model physics - A review

In this talk, I shall first discuss the Standard Model Higgs mechanism and then highlight some of its deficiencies making a case for the need to go beyond the Standard Model (BSM). The BSM tour will be guided by symmetry arguments. I shall pick up four specific BSM scenarios, namely, supersymmetry, little Higgs, gauge-Higgs unification, and the Higgsless approach. The discussion will be confined mainly on their electroweak symmetry breaking aspects.

Bhattacharyya, Gautam

A simultaneous explanation of the large phase in B_s-$\bar{B}_s$ mixing and $B \to \pi\pi/\pi K$ puzzles in R-parity violating supersymmetry

Recent data on B meson mixings and decays are, in general, in accord with the standard model expectations, except showing a few hiccups: (i) a large phase in B_s mixing, (ii) a significant difference ($>3.5\sigma$) between CP-asymmetries in $B^{\pm} \to \pi^0 K^{\pm}$ and $B_d \to \pi^{\mp} K^{\pm}$ channels, and (iii) a larger than expected branching ratio in $B_d \to \pi^0\pi^0$ channel. We show that selective baryon-number violating Yukawa couplings in R-parity violating supersymmetry can reconcile all the measurements.

Bhattacharyya, Gautam; Chatterjee, Kalyan Brata; Nandi, Soumitra

Radiative corrections to the lightest neutral Higgs mass in warped supersymmetry

We compute radiative correction to the lightest neutral Higgs mass (m_h) induced by the Kaluza-Klein (KK) towers of fermions and sfermions in a minimal supersymmetric scenario embeded in a 5-dimensional warped space. The Higgs is confined to the TeV brane. The KK spectra of matter supermultiplets is tied to the explanation of the fermion mass hierarchy problem. We demonstrate that for a reasonable choice of extra-dimensional parameters, the KK-induced radiative correction can enhance the upper limit on m_h by as much as 100 GeV beyond the 4d limit of 135 GeV.

Bhattacharyya, Gautam; Majee, Swarup Kumar; Ray, Tirtha Sankar

Universal doublet-singlet Higgs couplings and phenomenology at the CERN Large Hadron Collider

We consider a minimal extension of the standard model where a real, gauge singlet scalar field is added to the standard spectrum. Introducing the Ansatz of universality of scalar couplings, we are led to a scenario which has a set of very distinctive and testable predictions: (i) the mixing between the standard model Higgs and the new state is near maximal, (ii) the ratio of the two Higgs mass eigenstates is fixed (<“”3), (iii) the decay modes of each of the two eigenstates are standard model like. We also study how electroweak precision tests constrain this scenario. We predict the lighter Higgs to lie in the range of 114 and 145 GeV, and hence the heavier one between 198 and 250 GeV. The predictions of the model can be tested at the upcoming LHC.

Bhattacharyya, Gautam; Branco, Gustavo C[†]*; Nandi, S*[†]

CP violation and flavor mixings in orbifold grand unified theories

We address the flavor problem by incorporating the hypothesis of universal strength of Yukawa couplings in the framework of a 5D GUT model compactified on an $S^1/(Z_2 \times Z_2^{2})$ orbifold. We show that a quantitatively successful picture of fermion masses and mixings emerges from the interplay between the bulk suppression factors of geometric origin and the phases of the Yukawa matrices. We give an explicit example, where we obtain a good fit for both the Cabibbo-Kobayashi-Maskawa and Pontecorvo-Maki-Nakagawa-Sakata matrices.

Bhattacharyya, Gautam; Branco, Gustavo C[†]*; Silva-Marcos, Joaquim I*[†]

Extra-dimensional relaxation of the upper limit of the lightest supersymmetric neutral Higgs mass

The upper limit on the mass of the lightest CP-even neutral Higgs in the minimal supersymmetric standard model is around 135 GeV for soft supersymmetry breaking masses in the 1 TeV range. We demonstrate that this upper limit may be sizably relaxed if supersymmetry is embedded in extra dimensions. We calculate, using the effective potential technique, the radiative corrections to the lightest Higgs mass induced by the Kaluza-Klein towers of quarks and squarks with one and two compactified directions. We observe that the lightest Higgs may comfortably weigh around 200 GeV (300 GeV) with one (two) extra dimension(s).

Bhattacharyya, Gautam); Majee, Swarup Kumar; Raychaudhuri, Amitava[†]

Probing universal extra dimension at the international linear collider

We consider the UED scenario and study the detectability of the first KK electron-positron pair at the ILC. A few hundred GeV KK electron decays into a nearly degenerate KK photon, which carries away missing energy, and the standard electron. The mass splitting between the KK electron and KK photon is controlled by the bulk-and brane-induced radiative corrections. We look for the signal event $e^+ e^-$ + large missing energy for $\sqrt{s}$ = 1 TeV and observe that with a few hundred fb^{-1} luminosity the signal can be deciphered from the standard model background. We briefly outline how the UED signals may be distinguished from the supersymmetric signals.

Bhattacharyya, Gautam

Unraveling unparticles through violation of atomic parity and rare beauty

We put constraints on unparticle physics, specifically on the scale and the scale dimension of unparticle operators, using (i) measurements of atomic parity violation as well as (ii) branching ratio and CP-asymmetry measurements in some rare non-leptonic B decay channels.

Bhattacharyya, Gautam; Choudhury, Debajyoti; Ghosh, Dilip Kumar[†]

Remarks on the instability of black D*p*-branes

We show that for black D*p*-branes having charge Q and Hawking temperature T, the product QT^{7-p} is bounded from above for $p\leq 5$ and is unbounded for p=6. While the maximum occurs at some finite value of a parameter for $p\leq 4$, it occurs at infinity of the parameter for p=5. As a consequence, for fixed charge, there are two black D*p*-branes (for $p\leq 4$) at any given temperature less than its maximum value, and when the temperature is maximum there is one black D*p*-brane. For p=5, there is only one black D5-brane at a given temperature less than its maximum value, whereas, for p=6, since there is no bound for the temperature, there is always a black D6-brane solution at a given temperature. Of the two black D*p*-branes (for $p \leq 4$), one is large which is shown to be thermodynamically unstable and the other is small which is stable. But for p=5,6, the black D*p*-branes are always thermodynamically unstable. The stable, small black D*p*-brane, however, under certain conditions, can become unstable quantum mechanically and decay either to a BPS D*p*-brane or to a Kaluza–Klein “bubble of nothing” through closed string tachyon condensation. The small D5, D6 branes, although classically unstable, have the same fate under similar conditions.

Lu, JX[†]*; Roy, Shibaji*

Holography and drag force in thermal plasma of non-commutative Yang-Mills theories in diverse dimensions

We use holography and a string probe approach to compute the drag force on a quark moving in a thermal plasma of non-commutative Yang–Mills (NCYM) theories in various dimensions. The gravity background in these cases are described by a particular decoupling limit of non-extremal (D(p–2),Dp)-brane bound state system. We show how the drag force on an external quark moving in the dual NCYM theories gets corrected due to non-commutativity and as a result the effective viscosity of the plasma gets reduced. We have obtained the drag force for both small and large non-commutativity. This was known earlier for (3+1)-dimensional NCYM theory, however, we find that the corrections for the general case typically depend on the dimensionality of the NCYM theories, indicating that the structure of the drag force is non-universal.

Roy, Shibaji

Non-supersymmetric D1/D5, F/NS5 and closed string tachyon condensation

We construct the intersecting non-supersymmetric (non-susy) D1/D5 solution of type IIB string theory. While, as usual, the solution is charged under an electric two-form and an electric six-form gauge field, it also contains a non-susy chargeless (non-BPS) D0-brane. The S-dual of this solution is the non-susy F/NS5 solution. We show how these solutions nicely interpolate between the corresponding black (or non-extremal) solutions and the Kaluza–Klein (KK) "bubble of nothing" (BON) by continuously changing some parameters characterizing the solutions from one set of values to another. We show, by a time symmetric general bubble initial data analysis, that the final bubbles in these cases are static and stable and the interpolations can be physically interpreted as closed string tachyon condensation. As special cases, we recover the transition of two charge black F-string to BON, considered by Horowitz, and also the transition from AdS_3 black hole to global AdS_3.

Lu, JX†; Roy, Shibaji; Wang, Zhao-Long†; Wu, Rong-Jun†

Intersecting non-SUSY branes and closed string tachyon condensation

Following [H. Bai, J.X. Lu, S. Roy, Intersecting non-SUSY *p*-brane with chargeless 0-brane as black *p*-brane, JHEP 0701 (2007) 094, hep-th/0610264] we here consider the supergravity solutions representing the charged non-supersymmetric *p*-brane (for $1 \le p \le 6$) intersecting with chargeless non-supersymmetric 1-brane and 0-brane of type II string theories. We show how these solutions nicely interpolate between black *p*-branes and the Kaluza–Klein "bubble of nothing" (BON) by continuously varying some parameters characterizing the solutions from one set of values to another. By performing a time symmetric general bubble initial data analysis, we show that the interpolation implies a possible transition from black *p*-branes to KK BON only for $p \le 4$, as in these cases there exist locally stable static bubbles under certain conditions. However, for $p>4$, black branes always decay into dynamical bubbles. Contrary to what is known in the literature, we argue that under certain conditions, the mechanism causing this transition to stable static bubbles can be the closed string tachyon condensation for all $p \le 4$. We also show that the configurations indeed contain (chargeless) F-strings required for the closed string tachyons to appear causing the transitions to occur.

Lu, JX†; Roy, Shibaji; Wang, Zhao-Long†; Wu, Rong-Jun†

Proper acceleration, the geometric tachyon and the dynamics of a fundamental string near D*p* branes

We present a detailed analysis of our recent observation that the origin of the geometric tachyon, which arises when a D*p* brane propagates in the vicinity of a stack of coincident NS5 branes, is due to the proper acceleration generated by the background dilaton field. We show that when a fundamental string (F-string), described by the Nambu–Goto action, is moving in the background of a stack of coincident D*p* branes, the geometric tachyon mode can also appear since the overall conformal mode of the induced metric for the string can act as a source for proper acceleration. We also studied the detailed dynamics of the F-string as well as the instability by mapping the Nambu–Goto action of the F-string to the tachyon effective action of the non-BPS D-string. We qualitatively argue that the condensation of the geometric tachyon is responsible for the (F,D*p*) bound state formation.

Das, Ashok; Panda, Sudhakar†; Roy, Shibaji

Origin of the geometric tachyon

The motion of a D*p*-brane in the background of a stack of coincident NS5-branes is analyzed as the motion of a relativistic point particle in the transverse space of the five-branes. In this system, the particle experiences a proper acceleration orthogonal to its proper velocity due to the background dilaton field which changes the dynamics from that of a simple geodesic motion. In particular, we show that in the vicinity of the five-branes, it is this acceleration which is responsible for modifying the motion of the radial mode to that of an inverted simple harmonic oscillator leading to the tachyonic instability.

Das, Ashok; Panda, Sudhakar†; Roy, Shibaji

Alpha-prime corrections to space-like branes

Space-like branes or S-branes are certain class of time dependent solutions of M/string theories having isometries ISO(p+1) × SO(d” p”2,1), where d = 11,10 respectively and have singularities at $t = 0$. In [1], we found that the asymptotically flat S-branes have the structure of generalized Kasner geometry near $t = 0$. In this work we evaluate higher order α’ corrections perturbatively to the heterotic string Kasner backgrounds to probe the singularity at $t = 0$. We generally find that the perturbative corrections do not permit us to reach the singular point, as the supergravity framework fails near $t \sim \sqrt{\alpha'}$ blurring the origin of space-like singularities. This is analogous to the concept of stretched horizons in the case of black holes.

Roy, Shibaji; Singh, Harvendra

On brane-antibrane forces

In this note, we will discuss two aspects of brane–antibrane forces. In one aspect, we generalize the force calculation of D0- 0 of Banks and Susskind to D p- p for $1 \leq p \leq 8$. In particular, we find that the force is also divergent for $p = 1$ while for the other cases ($p \geq 2$) the forces are in general finite when $Z \to 0^+$, where $Z = (Y^2)/(2\pi^2\alpha)-1$ with Y, the brane–antibrane separation. However, the forces are divergent for all cases when $Z < 0$, signalling the occurrence of open string tachyon condensation in this regime. The other deals with the puzzling static nature of the supergravity brane–antibrane configurations. We will show that the force on a brane probe due to a brane–antibrane back...

Lu, Jian-Xin†; Ning, Bo†; Xu, Shan-Shan†; Roy, Shibaji

Color-singlet clustering of partons and recombination model for hadronization of quark-gluon plasma

SU(N_c) color-singlet restriction, along with flavor and spin symmetry, on a thermal partonic ensemble is shown to recombine the partons with internal color structure into color-singlet multiquark clusters, which can be identified with various hadronic modes at a given temperature. This can provide a possible basis for a recombination model for hadronization of quark-gluon plasma. This also leads to a natural explanation for the ratio of (anti)protons to pions and the quark number scaling of the elliptic flow coefficient in relativistic heavy-ion collisions.

Abir, Raktim; Mustafa, Munshi G

Gamma flashes from relativistic electron-positron plasma droplets

Ultraintense lasers are expected to produce, in the near future, relativistic electron-positron plasma droplets. Considering the local photon production rate in complete leading order in quantum electrodynamics, we point out that these droplets are interesting sources of gamma ray flashes.

Mustafa, Munshi G; Kämpfer, B[†]

Polyakov-Nambu-Jona-Lasinio model with a Vandermonde term

We extend the Polyakov-Nambu-Jona-Lasinio model for two degenerate flavors by including the effect of the SU(3) measure with a Vandermonde term. This ensures that the Polyakov loop always remains in the domain [0, 1]. The pressure, energy density, specific heat, speed of sound, and conformal measure show small or negligible effects from this term. However various quark number and isospin susceptibilities are all found to approach their respective ideal gas limits around $2T_c$. We compare our methods with other similar approaches in Polyakov-Nambu-Jona-Lasinio model and also present a quantitative comparison with lattice QCD data.

Ghosh, Sanjay K; Mukherjee, Tamal K; Mustafa, Munshi G; Ray, Rajarshi

Radiative and collisional jet energy loss in the quark-gluon plasma at the BNL relativistic heavy ion collider

We calculate and compare bremsstrahlung and collisional energy loss of hard partons traversing a quark-gluon plasma. Our treatment of both processes is complete at leading order in the coupling and accounts for the probabilistic nature of the jet energy loss. We find that the nuclear modification factor R_{AA} for neutral π^0 production in heavy ion collisions is sensitive to the inclusion of collisional and radiative energy loss contributions while the averaged energy loss only slightly increases if collisional energy loss is included for parent parton energies Ek”T. These results are important for the understanding of jet quenching in Au+Au collisions at 200A GeV at the Relativistic Heavy Ion Collider (RHIC). Comparison with data is performed applying the energy loss calculation to a relativistic ideal (3+1)-dimensional hydrodynamic description of the thermalized medium formed at RHIC.

Qin, Guang-You[†]*; Ruppert, Joerg*[†]*; Gale, Charles*[†]*; Jeon, Sangyong*[†]*; Moore, Guy D*[†]*; Mustafa, Munshi G*

Wakes in a collisional quark-gluon plasma

Wakes created by a parton moving through a static and infinitely extended quark-gluon plasma are considered. In contrast to former investigations, collisions within the quark-gluon plasma are taken into account using a transport theoretical approach (Boltzmann equation) with a Bhatnagar-Gross-Krook collision term. Within this model, it is shown that the wake structure changes significantly compared to the collisionless case.

Chakraborty, Purnendu; Mustafa, Munshi Golam; Ray, Rajarshi; Thoma, Markus H[†]

Energy gain of heavy quarks by fluctuations in a quark-gluon plasma

The collisional energy gain of a heavy quark due to chromoelectromagnetic field fluctuations in a quark-gluon plasma is investigated. The field fluctuations lead to an energy gain of the quark for all velocities. The net effect is a reduction of the collisional energy loss by 15-40% for parameters relevant at RHIC energies.

Chakraborty, Purnendu; Mustafa, Munshi Golam; Thoma, Markus H[†]

Thermodynamics of the Polyakov-Nambu-Jona-Lasinio model with nonzero baryon and isospin chemical potentials

We have extended the Polyakov-Nambu-Jona-Lasinio (PNJL) model for two degenerate flavors to include the isospin chemical potential (μ_I). All the diagonal and mixed derivatives of pressure with respect to the quark number (proportional to baryon number) chemical potential (μ_0) and isospin chemical potential up to sixth order have been extracted at μ_0=μ_I=0. These derivatives give the generalized susceptibilities with respect to quark and isospin numbers. Similar estimates for the flavor diagonal and off-diagonal susceptibilities are also presented. Comparison to lattice QCD (LQCD) data of some of these susceptibilities for which LQCD data are available show similar temperature dependence, though there are some quantitative deviations above the crossover temperature. We have also looked at the effects of instanton induced flavor mixing coming from the $U_A(1)$ chiral symmetry breaking 't Hooft determinantlike term in the NJL part of the model. The diagonal quark number and isospin susceptibilities are completely unaffected. The off-diagonal susceptibilities show significant dependence near the crossover. Finally we present the chemical potential dependence of specific heat and speed of sound within the limits of chemical potentials where neither diquarks nor pions can condense.

Mukherjee, Swagato; Mustafa, Munshi G; Ray, Rajarshi

Spectral properties of supersymmetric Polychronakos spin chain associated with A_{N-1} root system

By using the exact partition function of $su(m|n)$ Polychronakos spin chain associated with A_{N-1} root system, we numerically study some statistical properties of the related spectrum. It appears that the corresponding energy level density satisfies the Gaussian distribution and the cumulative distribution of spacing between consecutive energy levels obeys a certain 'square root of a logarithm' law.

Basu-Mallick, B; Bondyopadhaya, Nilanjan

Fermionic dual of one-dimensional bosonic particles with derivative delta function potential

We investigate the boson-fermion duality relation for the case of quantum integrable derivative ä-function bose gas. In particular, we find out a dual fermionic system with nonvanishing zero-range interaction for the simplest case of two bosonic particles with derivative ä-function interaction. The coupling constant of this dual fermionic system becomes inversely proportional to the product of the coupling constant of its bosonic counterpart and the centre-of-mass momentum of the corresponding eigenfunction.

Bireswar Basu-Mallick and Tanaya Bhattacharyya

Exactly solvable D_N-type quantum spin models with long-range

We derive the spectra of the D_N-type Calogero (rational) su(m) spin model, including the degeneracy factors of all energy levels. By taking the strong coupling limit of this model, in which its spin and dynamical degrees of freedom decouple, we compute the exact partition function of the su(m) Polychronakos–Frahm spin chain of D_N type. In particular, we show that this partition function cannot be obtained as a limiting case of its BC_N counterpart. With the help of the partition function we study several statistical properties of the chain's spectrum, such as the density of energy levels and the distribution of spacings between consecutive levels.

Basu-Mallick, B; Finkel[†], F; Gonzalez-Lopez, A[†]

Low energy properties of the $SU(m|n)$ supersymmetric Haldane-Shastry spin chain

The ground state and low energy excitations of the $SU(m|n)$ supersymmetric Haldane–Shastry spin chain are analyzed. In the thermodynamic limit, it is found that the ground state degeneracy is finite only for the $SU(m|0)$ and $SU(m|1)$ spin chains, while the dispersion relation for the low energy and low momentum excitations is linear for all values of m and n. We show that the low energy excitations of the $SU(m|1)$ spin chain are described by a conformal field theory of m non-interacting Dirac fermions which have only positive energies; the central charge of this theory is $m/2$. Finally, for $n1$, the partition functions of the $SU(m|n)$ Haldane–Shastry spin chain and the $SU(m|n)$ Polychronakos spin chain are shown to be related in a simple way in the thermodynamic limit at low temperatures.

Basu-Mallick, B; Bondyopadhaya, Nilanjan; Sen, Diptiman[†]

Boson-fermion duality in SU(m|n) supersymmetric Haldane-Shastry spin chain

By using the Y(gl(m|n)) super Yangian symmetry of the SU(m|n) supersymmetric Haldane-Shastry spin chain, we show that the partition function of this model satisfies a duality relation under the exchange of bosonic and fermionic spin degrees of freedom. As a by product of this study of the duality relation, we find a novel combinatorial formula for the super Schur polynomials associated with some irreducible representations of the Y(gl(m|n)) Yangian algebra. Finally, we reveal an intimate connection between the Global SU(m|n) symmetry of a spin chain and the boson-fermion duality relation.

Basu-Mallick, B; Bondyopadhaya, Nilanjan; Hikami, Kazuhiro[†]; Sen, Diptiman[†]

Dijet production at the LHC through unparticles

We report the phenomenological impact of unparticles in the production of dijet at the LHC. We compute the scalar, spin-1 and spin-2 unparticle contributions to the dijet cross sections and present our results in different kinematical distributions. We find that the scalar unparticle contribution is dominant over that of the spin-1 and spin-2 unparticles for the same coupling values.

Agarwal, Neelima†; Kumar, MC†; Mathews, Prakash; Ravindran, V†; Tripathi, Anurag†

Unparticles in diphoton production to next-to-leading order in QCD at the LHC

We compute to next-to-leading order in QCD the tensor unparticle contribution to the diphoton production at the LHC, wherein the unparticle sector is a consequence of (a) scale invariance but not full conformal invariance and (b) conformal invariance. We use the semianalytical two cutoff phase-space slicing method to handle the $O(\alpha_s)$ corrections to the $pp \rightarrow \gamma\gamma X$ and show that our results are insensitive to the soft and collinear cutoffs. In order to avoid the contribution of the photons due to fragmentation, we employ the smooth cone isolation criterion. Significance of the QCD corrections to the diphoton events including unparticles is highlighted.

Kumar, MC; Mathews, Prakash; Ravindran, V†; Tripathi, Anurag†

Direct photon pair production at the LHC to $\mathcal{O}(\alpha_s)$ in TeV scale gravity models

The first results on next-to-leading order QCD corrections to production of direct photon pairs in hadronic collisions in the extra dimension models — ADD and RS are presented. Various kinematical distributions are obtained to order α_s in QCD by taking into account all the parton level subprocesses. Our Monte Carlo based code incorporates all the experimental cuts suitable for physics studies at the LHC. We estimate the impact of the QCD corrections on various observables and find that they are significant. We also show the reduction in factorization scale uncertainty when $\mathcal{O}(\alpha_s)$ effects are included.

Kumar, MC; Mathews, Prakash; Ravindran, V†; Tripathi, Anurag†

Working group report: Quantum chromodynamics sub-group

This is the report of the QCD working sub-group at the Tenth Workshop on High Energy Physics Phenomenology (WHEPP-X).

Mukherjee, Asmita†; Basu, R; Dahiya, H†; Gamberg, L†; Godbole, R†; Gupta, S†; Kumar, MC; Magnea, L†; Mathews, P; Mathur, N†; Mukherjee, A; Mulders, PJ†; Ravindran, V†; Tripathi, A†

Diphoton signals in theories with large extra dimensions to NLO QCD at hadron colliders

We present a full next-to-leading order (NLO) QCD corrections to diphoton production at the hadron colliders in both standard model and ADD model. The invariant mass and rapidity distributions of the diphotons are obtained using a semi-analytical two cut-off phase space slicing method which allows for a successful numerical implementation of various kinematical cuts used in the experiments. The fragmentation photons are systematically removed using smooth-cone-isolation Cuts on the photons.

The NLO QCD corrections not only stabilise the perturbative predictions but also enhance the production cross section significantly.

Kumar, MC; Mathews, Prakash; Ravindran, V†; Tripathi, Anurag†

Unparticle physics in diphoton production at the CERN LHC

We have considered the diphoton production in the unparticle physics at the LHC. The contributions of spin-0 and spin-2 unparticles to the diphoton production are studied in the invariant mass and other kinematical distributions, along with their dependencies on the model dependent parameters. It is found that the signal corresponding to the unparticles is significant for moderate values of the couplings.

Kumar, MC; Mathews, Prakash; Ravindran, V†; Tripathi, Anurag†

Unparticle physics at hadron collider via dilepton production

The scale invariant unparticle physics recently proposed by Georgi could manifest at low energies as non-integral number d_u of invisible particles. Unparticles if existing, could couple to the Standard Model fields and consequently affect the collider phenomenology. We consider the DY process to explore effects of the peculiar propagator of the scalar and tensor unparticle operators. To probe these effects at hadron collider one needs to go beyond LO in QCD and hence the quantitative impact of QCD corrections for unparticle physics at LHC is investigated. We present the K-factors at LHC. Inclusion of QCD corrections to NLO stabilises the cross section with respect to scale variations.

Mathews, Prakash; Ravindran, V†

Extra dimension searches at hadron colliders to next-to-leading order-QCD

The quantitative impact of NLO-QCD corrections for searches of large and warped extra dimensions at hadron colliders are investigated for the Drell-Yan process. The K-factor for various observables at hadron colliders are presented. Factorisation, renormalisation scale dependence and uncertainties due to various parton distribution functions are studied. Uncertainties arising from the error on experimental data axe estimated using the MRST parton distribution functions.

Kumar, MC; Mathews, Prakash; Ravindran, V†

PDF and scale uncertainties of various DY distributions in ADD and RS models at hadron colliders

In the extra dimension models of ADD and RS we study the dependence of the various parton distribution functions on observables of Drell–Yan processes to NLO in QCD at LHC and Tevatron energies.Uncertainties at LHC due to factorisation scales in going from leading to next-to-leading order in QCD for the various distributions get reduced by about 2.75 times for a μF range $0.5Q<\mu F < 1.5Q$. Further uncertainties arising from the error on the experimental data are estimated using the MRST parton distribution functions.

MC Kumar, Prakash Mathews, V Ravindran†

Galilean anti-de-Sitter spacetime in Romans theory

The Romans type IIA theory is the only known example of 10-dimensional maximal supergravity where (tensor) fields are explicitly massive. We provide an example of a non-relativistic anti-de-Sitter $NRadS_4 \times S^6$ background as a solution in massive type IIA. A compactification of which on S^6 gives immediately the prototype NRadS background in D=4 which is proposed to be dual to 'cold atoms' or unitary fermions on a wire.

Singh, Harvendra

More on the scalar-tensor BF theory

This work is based on an earlier proposal [H. Singh, Phys. Lett. B 673, 68 (2009)] that the membrane BF theory consists of matter fields along with Chern-Simons fields as well as the auxiliary pairs of scalar and tensor fields. In particular, we discuss the supersymmetry aspects of such a membrane theory. It is concluded that the theory possesses maximal supersymmetry, and it is related to the L-BLG theory via a field map. We obtain fuzzy-sphere solution, and corresponding tensor field configuration is given.

Singh, Harvendra

M2-brane flows and the Chern-Simons level

The Chern-Simons level k of ABJM gauge theory captures the orbifolding in the dual geometry. This suggests that if we move the membranes away from the tip of the orbifold to a smooth point, it should trigger an RG flow that changes the level to $k = 1$ in the IR. We construct an explicit supergravity solution that is dual to this shift from generic k to $k = 1$. In the gauge theory side, we present arguments for why this shift is plausible at the end of the RG flow. We also consider a resolution of the orbifold for the case $k = 4$ (where explicit metrics can be found), and construct the smooth supergravity solution that interpolates between $AdS_4 \times S^7/Z_4$ and $AdS_4 \times S^7$, corresponding to localized branes on the blown up six cycle. In the gauge theory, we make some comments about the dimension four operator dual to the resolution as well as the associated RG flow.

Krishnan, Chethan†; Maccaferri, Carlo†; Singh, Harvendra

SU(*N*) membrane *BF* theory with dual-pairs

We construct an $SU(N)$ membrane BF theory with dual pairs of scalar and tensor fields. The moduli space of the theory is precisely that of N M2-branes on the noncompact flat space. The theory possesses explicit $SO(8)$ invariance and is an extension of the maximal $SU(N)$ super-Yang–Mills theory.

Singh, Harvendra

M2-branes on a resolved C_4/Z_4

We write down M2-branes on the resolved C_4/Z_4 orbifold space. The resolved spatial geometry is such that it interpolates between $R^2 \times CP_3$ near the branes and C_4/Z_4 asymptotically. The near horizon geometry of these branes is a deformation of $AdS_4 \times S^7/Z_4$. An interesting aspect is that for $k = 4$ Chern-Simons theory coupling becomes vanishing near the IR cutoff leading to spontaneous compactification to type IIA.

Singh, Harvendra

Spinflation from geometric tachyon

We study the assisted inflation scenario from the rolling of N BPS D3-brane into the NS5-branes, on a transverse geometry of $R^3 \times S^1$, coupled to four dimensional gravity. We assume that the branes are distributed along S^1 and the probe D3-branes spin along R^3 plane. Qualitatively this process is similar to that of N-tachyon assisted inflation on unstable D-branes. We further study the spinflation scenario numerically and analyze its effect.

Panigrahi, Kamal L[†]*; Singh, Harvendra*

Assisted inflation from geometric tachyon

We study the effect of rolling of N D3-branes in the vicinity of NS5-branes. We find out that this system coupled with the four dimensional gravity gives the slow roll assisted inflation of the scalar field theory. Once again this expectation is exactly similar to that of N-tachyon assisted inflation on unstable D-branes.

Panigrahi, Kamal L[†]*; Singh, Harvendra*

The N-tachyon assisted inflation

In continuation of the papers hep-th/0505012 and hep-th/0508101 we investigate the consequences when N open-string tachyons roll down simultaneously. We demonstrate that the N-tachyon system coupled to gravity does indeed give rise to the assisted slow-roll inflation.

Singh, Harvendra

3-Branes on Eguchi-Hanson 6D instantons

We use the approach used by Eguchi-Hanson in constructing four-dimensional instanton metrics and construct a class of regular six-dimensional instantons which are nothing but S^2 x S^2 resolved conifolds. We then also obtain D3-brane solutions on these EH-resolved conifolds.

Singh, Harvendra

Asymmetric nuclear matter and neutron skin in an extended relativistic mean-field model

The density dependence of the symmetry energy, instrumental in understanding the behavior of the asymmetric nuclear matter, is investigated within the extended relativistic mean-field (ERMF) model, which includes the contributions from the self- and mixed-interaction terms for the scalar-isoscalar (σ), vector-isoscalar (ω), and vector-isovector (ρ) mesons up to the quartic order. Each of the 26 different parametrizations of the ERMF model employed is compatible with the bulk properties of the finite nuclei. The behavior of the symmetry energy for several parameter sets is found to be consistent with the empirical constraints on them as extracted from the analyses of the isospin diffusion data. The neutron-skin thickness in the ^{208}Pb nucleus for these parameter sets of the ERMF model lies in the range of ~0.20-0.24 fm, which is in harmony with the thickness predicted by the Skyrme Hartree-Fock model. We also investigate the role of various mixed-interaction terms that are crucial for the density dependence of the symmetry energy.

Agrawal, BK

Equations of state and stability of color-superconducting quark matter cores in hybrid stars

The stable configurations of nonrotating and rotating hybrid stars composed of color-superconducting quark matter cores are constructed using several equations of state (EOSs). We use a set of diverse EOSs for the nuclear matter which represents the low density phase. The EOSs at higher densities correspond to the quark matter in the color-superconducting phase and are computed within the Nambu-Jona-Lasinio-like model for different values of the scalar diquark and vector current couplings strengths. The phase transition to the quark matter is computed by a Maxwell construction. We find that the stability of the hybrid stars are mainly governed by the behavior of the EOSs for the color-superconducting quark matter. However the compositions of hybrid stars are sensitive to the EOS of the nuclear matter. The value of the critical rotation frequency for the hybrid star depends strongly on the EOS of the nuclear matter as well as that for the color-superconducting quark matter. Our results indicate that the EOS for the color-superconducting quark matter can be obtained, by adjusting the parameters of the Nambu-Jona-Lasinio model, to yield the stable configurations of the hybrid star having the maximum mass <“1.5*M*™” in the nonrotating limit and the critical rotation frequency <“1 kHz.

Agrawal, BK

Stable configurations of hybrid stars with color-flavor-locked core

We construct static and mass-shedding limit sequences of hybrid stars, composed of a color flavour locked (CFL) quark matter core, for a set of equations of state (EOSs). The EOS for the hadronic matter is obtained using an appropriately calibrated, extended field theoretical based, relativistic mean-field model. The MIT bag model is employed to compute the EOSs of the CFL quark matter for different values of the CFL gap parameter in the range of 50–150 MeV with the deconfinement phase transition density ranging from $4\rho_0$ to $6\rho_0$ (ρ_0=0.16 fm^{-3}). We find that, depending on the values of the CFL gap parameter and the deconfinement phase transition density, the sequences of stable configurations of hybrid stars either form third families of the compact stars or bifurcate from the hadronic sequence. The hybrid stars have masses 1.0–2.1*M*™” with radii 9–13.5 km. The maximum values of the mass-shedding limit frequency for such hybrid stars are 1–2 kHz. For the smaller values of the CFL gap parameter and the deconfinement phase transition density, mass-radius relationships are in harmony with those deduced by applying an improved hydrogen atmosphere model to fit the high quality spectra from compact star X7 in the globular cluster 47 Tucanae. We observed, for some cases, that the third family of compact stars exist in the static sequence but disappear from the mass-shedding limit sequence. Our investigation suggests that the third family of compact stars in the mass-shedding limit sequence is more likely to appear, provided these stars have maximum mass in the static limit higher than their second-family counterpart composed of pure hadronic matter.

Agrawal, BK; Dhiman, Shashi K

Correlations in the properties of static and rapidly rotating compact stars

Correlations in the properties of the static compact stars (CSs) and the ones rotating with the highest observed frequency of 1122 Hz are studied using a large set of equations of state (EOSs). These EOSs span various approaches and their chemical composition varies from the nucleons to hyperons and quarks in *â*-equilibrium. It is found that the properties of static CS, like the maximum gravitational mass $M_{\rm maxa}{}^{\rm stat}$ and radius $R_{1.4}{}^{\rm stat}$ corresponding to the canonical mass and supramassive or nonsupramassive nature of the CS rotating at 1122 Hz are strongly correlated. In particular, only those EOSs yield the CS rotating at 1122 Hz to be nonsupramassive for which $(M_{\rm maxa}{}^{\rm stat}/M_{\text{™»}})^{1/2}(10\ {\rm km}/R_{1.4}{}^{\rm stat})^{3/2}$ is greater than unity. A suitable parametric form which can be used to split the $M_{\rm maxa}{}^{\rm stat}$–$R_{1.4}{}^{\rm stat}$ plane into the regions of different supramassive nature of the CS rotating at 1122 Hz is presented. Currently measured maximum gravitational mass $1.76M_{\text{™»}}$ of PSR J0437-4715 suggests that the CS rotating at 1122 Hz can be nonsupramassive provided $R_{1.4}{}^{\rm stat}$d≤12.4 km.

Agrawal, BK; Kumar, Raj; Dhiman, Shashi K

Nonrotating and rotating neutron stars in the extended field theoretical model

We study the properties of nonrotating and rotating neutron stars for a new set of equations of state (EOSs) with different high-density behavior obtained using the extended field theoretical model. The high-density behavior for these EOSs are varied by varying the ù-meson self-coupling and hyperon-meson couplings in such a way that the quality of fit to the bulk nuclear observables, nuclear matter incompressibility coefficient, and hyperon-nucleon potential depths remain practically unaffected. We find that the largest value for maximum mass for the nonrotating neutron star is $2.1M_{\text{™»}}$. The radius for a neutron star with canonical mass is 12.8–14.1 km, provided only those EOSs are considered for which the maximum mass is larger than $1.6M_{\text{™»}}$, the lower bound on the maximum mass measured so far. Our results for the very recently discovered fastest rotating neutron star indicate that this star is supramassive with mass $1.7M_{\text{™»}}$–$2.7M_{\text{™»}}$ and circumferential equatorial radius 12–19 km.

Dhiman, Shashi K; Kumar, Raj; Agrawal, BK

Developmental Work

As part of the 11th five-year plan project "Frontiers of Theoretical Physics" of the Theory Division, the Cray XT5 supercomputer which had been procured and installed in late 2009 was inaugurated by the Chairman, DAE in presence of Director, SINP on 11th January, 2010, the foundation day of SINP. The Cray XT5 configuration comprises of 2 cabinets having 1376 compute cores all connected in a 3 dimensional mesh of highly potent Cray Sea Star 2.0 interconnects in a parallel architecture. The peak performance of the configuration is close to 14 Tera Flops, and the DDHMC lattice QCD codes run with approximately 30% efficiency producing a sustained performance of about 5 Tera Flops.The facility is meant for dedicated use of theoretical physics problems like lattice QCD needing massive parallelization.

Asit K De, A. Harindranath

Major efforts in the **Centre for AstroParticle Physics** (CAPP) were directed towards developmental activities pertaining to the formulation and initiation of the main new science objectives of the Centre. After careful consideration of the facilities and expertise available in SINP and within the country, the CAPP has initiated new re-search activities in the Institute in two major experimental/observational areas of contemporary interest in Astroparticle Physics, namely, (a) a WIMP (Weakly Interacting Massive Particle) Dark Matter search experiment using Superheated Drop Detectors (SDD), and (b) Observational High Energy Gamma Ray Astronomy using the High Altitude Gamma Ray (HAGAR) Telescope system located at Hanle, Ladakh (J&K). For the WIMP Dark Matter search experiment, sustained efforts have been devoted towards the development of the basic in-house laboratory facilities for carrying out the R&D work on SDDs. The CAPP-SINP Dark Matter search group is now an official member of the ongoing international PICASSO Collaboration which is carrying out a WIMP Dark Matter search experiment using SDD in the SNOLab underground facility at Sudbury, Canada.

Mala Das, Satyajit Saha, Sudeb Bhattacharya, Susnata Seth, Pijushpani Bhattacharjee

For the Observational High Energy Gamma Ray Astronomy programme, the CAPP-SINP group is a part of the HAGAR Collaboration with members from the Tata Institute of Fundamental Research (TIFR), Mumbai, and Indian Institute of Astrophysics (IIA), Bangalore.

Lab Saha, Pijushpani Bhattacharjee

CAPP has also procured a 142 2 optical telescope for teaching and demonstration of fundamental concepts of astronomy and for outreach activities. An observatory dome is being set up on the roof of the Institute building for housing the telescope.

Pijushpani Bhattacharjee

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- *Dilepton production in nucleon-nucleon collisions*, Kernfysisch, Versneller Instituut (KVI), Groningen, The Netherlands, July 31, 2009
- *Dilepton production in nucleon-nucleon collisions: a Theoretical update*, Institute fuer Theoretische Physik, Universitaet Giessen, Germany, January 15, 2010

Parthasarathi Mitra

- *Black hole state counting in loop quantum gravity,* the Himalayan Relativity Dialogue, Mirik, Apr 18-20, 2007
- *Excursions in Field Theory: A Deconstruction of Strong CP,* the Probir Roy Fest, TIFR, Mumbai, Oct 5, 2007
- *Counting of black hole states in loop quantum gravity,* the Workshop on Field Theoretic Aspects of Gravity VI, HRI, Allahabad, Nov 13-18, 2007
- *Deconstruction of Strong CP and its Gravitational analogue,* the Non-perturbative aspects of Gauge Theories and Gravity, SNBNCBS, Calcutta, Jan 7-12, 2008
- *Black hole state counting in loop quantum gravity,* the Workshop on Field Theoretic Aspects of Gravity VII, Simla, Nov 15-19, 2008
- *Non-perturbative regularization of QCD,* the Strong Frontiers 2009, PPISR, Bangalore, Jan 12-18, 2009
- *Black Hole Entropy,* the XXV-th Meeting of Indian Association for General Relativity and Gravitation, SINP, Calcutta, Jan 28-31, 2009
- *Strong CP and its gravitational analogue,* Colloquium, IOP, Bhubaneswar, Feb 14, 2008
- *Black holes, white holes and tunnelling*, TIFR, Mumbai, March 6, 2008
- *Parity and time-reversal in the fundamental interactions,* Bose Colloquium, SNBNCBS, Calcutta, Nov 28, 2008

Palash B Pal

- *Demystifying Majorana neutrinos,* the conference Aspects of neutrinos (International Centre for Theoretical Sciences), Goa University Conference Centre, April 08–15, 2009
- *Level crossing phenomena in astrophysics*, the conference “Particle Physics: achievements and challenges”, Calcutta University, Feb 04, 2008
- *Lorentz symmetry violating signatures in a medium*, the conference “Contemporary issues in nuclear and particle physics”, Jadavpur University, Calcutta, Feb 01, 2008
- *Dirac, Majorana and Weyl fermions* (Two lectures), the Instituto Superior Tecnico, Lisbon, November 16 and 23, 2009
- *Measurement of length*, the Physics Department Colloquium, IIT Kanpur, Aug 21, 2009
- *Measurement of length*, Colloquium, IISER Bhopal, Aug 20, 2009
- *Quantum Field Theory* (6 lectures), Refresher Course, Physics Department, Calcutta University, Sep 05-09, 2008
- *Thermodynamics* (5 lectures), the Refresher Course, Physics Department, Calcutta University, Sep 05-11, 2007
- *Kyalendarer rohosyo (The mystery of calendars)*, Dinabandhu Andrews College, Garia, Feb 12, 2010
- *History and mystery of calendars*, the Chemistry Department Reunion, Jadavpur University, Feb 3, 2010
- *Why a scientist’s career is fun at a science camp*, Jagadis Bose National Science Talent Search for high school students, August 1, 2009
- *Mohabishwer shoishob (The childhood of the universe)*, the PashchimBanga Bigyan Mancha as part of their celebration of the international year of astronomy, June 14, 2009
- *Bigyan o dorshon (Science and Philosophy)*, AmarNath Bhaduri memorial lecture, Ekushe Songsod, June 13, 2009
- *Jyotirbider jontropati (The instruments of astronomy)*, the celebration of the International Year of Astronomy organized by the Manindra-Narayan Trust, Calcutta, Jan 10, 2009
- *Doirghyer porimap (Measurements of length)*, Narasingha Dutt College, Howrah, Sep 18, 2008
- *Doirghyer porimap (Measurements of length)*, Bethune College, Calcutta, Sep 15, 2008
- *Measurements of length*, Bibharani Debi Memorial lecture, Calcutta University, May 21, 2008
- *On scientific and technical terminology in Bangla*, the “Celebration of 100 years of Vidyasagar College”, Calcutta, Mar 18, 2008
- *Bigyaner poridhi (The realm of science)*, DhirendraNath Gangopadhyay Memorial lecture of the Pavlov Institute, Calcutta, Dec 20, 2007

- *Doirghyer porimap (Measurements of length)*, Ramakrishna Mission Residential College, Narendrapur, Oct 4, 2007

Debades Bandyopadhyay

- *Dense matter in neutron stars and FAIR*, FAIR meet 2010, VECC, Kolkata, March 8-10, 2010
- *Exotic bulk viscosity in quantizing magnetic fields*, Thirty Years of Magnetars: New Frontiers, Aspen, USA, February 2-6, 2009
- *Novel Phases of Dense Matter in the Cosmos and Laboratory*, QGP Meet'08, VECC, Kolkata, November 25-27, 2008
- *Hadrons in Neutron Stars*, Hadrons@FAIR workshop, Frankfurt, Germany, June 25-27, 2008
- *R-modes of neutron stars with exotic matter*, Workshop on Matter at extreme densities and gravitational waves from compact stars, ECT*, Trento, Italy, September 10-15, 2007
- *Supernova Explosions*, Institute for Theoretical Physics, JWGoethe University, Frankfurt am Main, Germany, September 18, 2007

Bireswar Basu-Mallick

- *Spectral properties of the SU(mjn) supersymmetric Haldane-Shastry spin chain*, University of Zagreb, Croatia, June 5, 2007
- *Yangian quantum group symmetry in integrable models with long-range interaction* (4 lectures), the Workshop 'Integrable Systems', IISc, Bangalore, February 18-29, 2008

Harvendra Singh

- Strings-2007', Univ of Autonoma di Madrid, Madrid, June 25-29, 2007
- Advanced String School, IOP, Bhubaneswar, October 8-14, 2007
- New Trends in Field Theories, Department of Physics, BHU, Varanasi, Nov 1-2, 2008
- International Workshop 'Indian Strings Meeting' ISM08, Pondicherry, Dec 6-13, 2008
- National StringsWorkshop (NSM10, IIT Mumbai), Feb10-15, 2010
- *Non-relativistic AdS solutions of massive type IIA theory*, the Workshop NSM10, Dept of Physics, IIT Mumbai, Feb 10-15, 2010
- *Recent developments in string theory*, QIP program, organised by Department of Physics, IIT-Guwahati, Guwahati, September 6, 2007
- *Assisted Inflation with Multiple Tachyons*, TPSC, Department of Physics, Gauhati University, Guwahati, September 07, 2007
- *Space -like branes and accelerating cosmologies*, IOP, Bhubaneswar, October 15,2007
- *Inflating with geometric tachyons*, String Discussion Group Meeting, IACS-SINP, IACS, Kolkata, March5, 2008

- *Slow-roll inflation from NS5-D3 brane system*, INFN/University of Padova, Padova, Italy, July 22, 2008
- *M2-branes and Chern-Simons matter theories*, New Trends in Field Theories, Department of Physics, BHU, Varanasi, November 01, 2008
- *A membrane B-F action with dual-pairs*, Indian Strings Meeting (ISM08), IMSC, Chennai & Pondicherry, December 11, 2008
- *The scalar-tensor B-F theory: (STBF vs LBLG)*, IMSc, Chennai, November 04, 2009
- *M2-branes on resoved C4/Z4 and Chern-Simons level*, CMI, Chennai, November 05, 2009

Prakash Mathews

- *Diphoton signals in TeV scale gravity models to NLO QCD*, DESY, Zeuthen, Germany, September 2009
- *Unparticle Stuff*, Discussion meeting on LHC related physics, Invited talk, ICTP, Trieste, Italy, December 2008
- *Unparticle Physics at hadron collider*, PLANCK 2008, Barcelona, Spain, May 2008
- *Unparticle physics at hadron collider*, ICTP, Trieste, Italy, 27 September 2007
- *QCD at hadron colliders*, invited talk at the LHC and New Frontiers of Particle Physics, University of Calcutta, December 7 – 9, 2009
- Diphoton signals in TeV scale gravity models to NLO QCD, invited talk at the LHC Physics Workshop, TIFR, Mumbai, October 21-27, 2009
- QCD corrections to some Non-SUSY BSMs at the LHC, Workshop on Getting Ready for Physics at the LHC, invited talk, RECAPP, Harish-Chandra Research Institute, Allahabad, February 16 – 20, 2009
- *Unparticle Stuff*, Topical Meeting on Beyond the Standard Model Physics at the LHC, Indian Association for the Cultivation of Science, Kolkata, January 15 – 17, 2009
- *Unparticle Stuff*, RECAPP Workshop, Harish-Chandra Research Institute, Allahabad, September 21–26, 2008
- *Unparticle Physics*, Initial conditions in heavy-ion collisions: QCD at high parton densities, Dona Paula, Goa, 31 Aug-6 Sept 2008
- *Unparticle Physics*, Institute of Physics, Bhubaneswar, TPSC visit, March 2008
- *Unparticle Physics versus extra dimension*, Workshop on “The physics of warped extra dimensions, IIT Kharagpur, February 21 – 23, 2008
- *Extra dimension searches at hadron colliders to NLO-QCD*, Centre for High Energy Physics, IISc, Bangalore, May 2007

Bijay K Agrawal

- *Correlations in the properties of static and rapidly rotating compact stars*, Quarks in Astrophysics and Cosmology, Toshali Sands, Puri, Orissa, India, February 15, 2008

- *Neutron Stars: An Astrophysical Laboratory*, Vellore Institute of Technology, Vellore, Tamilnadu, India, August 25, 2007

Gautam Bhattacharyya

- *Theoretical Overview of Electroweak Symmetry Breaking Scenarios*, IMSc (WHEPP-10), Chennai, India, January 2, 2008

  LPT, Univ. de Paris XI, Orsay, France, Jul 2008, Annual Monsoon Meeting on recent developments in Theoretical Sciences (in memory of C.K. Majumdar), IACS, Kolkata, India, Aug 2008, RECAPP Workshop, HRI, Allahabad, Sep-Oct 2008, Institute de Physique Theorique, UCL, Louvain-la-Neuve, Belgium, Nov 2008, LHC Workshop, ICTP, Trieste, Italy, Nov-Dec 2008, Physical Research Laboratory, Ahmedabad, India, Mar 2009, Physics Department, T.U. Dortmund, Germnay, Apr 2009, Physics Department, Chulalongkorn University, Bangkok, Jul 2009, Physics Department, Calcutta University, Dec 2009, Department of Theoretical Physics, TIFR, Mumbai, Mar 2010.

- *SUSY Higgs in Extra Dimensions*, ICTP, Trieste, Italy, May 14, 2007
- CERN, Geneva, Switzerland, October 25, 2007, TIFR, Mumbai, India, November 29, 2007, Warsaw University, Warsaw, Poland, February 15, 2008
- *SUSY Higgs in Extra Dimensions, From Strings to LHC II* (Bangalore), Bangalore, India, December 17-22, 2007
- Particle/Cosmology joint seminar, Saclay, France, Nov 2008, BSMLHC-2009 Conference, IACS, Kolkata, India, Jan 2009, Physical Research Laboratory, Ahmedabad, India, Mar 2009.
- *New Challenges in Particle Physics*, Nuclear and Particle Physics Research Centre, Jadavpur Univ, Kolkata, Feb 2008.
- Department of Physics, Calcutta Univ, Kolkata, Feb 2008, Seacom Engineering College, Dhulagarh, Howrah, Sep 2008, Midnapore College (Applied Mathematics Dept.), Midnapore, Feb 2009
- *Neutrino properties in SUSY*, Workshop on ‘Neutrinos and beams’, Darjeeling, India, May 2008.
- *Phenomenology of 5d supersymmetry*, 7th Workshop on ‘Particles and Cosmology’, Warsaw University, Poland, Feb 2010
- Physics Department, University of Rome, La Sapienza, Rome, Italy, Oct 2010,International Centre for Theoretical Physics, Trieste, Italy, Oct 2010, Physics Department, University of Padova, Italy, Oct 2010
- *Probing KK leptons at the International Linear Collider*, International ‘LC09’ Conference, Perugia, Sep 2009

Debarati Chatterjee

- *Probing Exotic Matter in Neutron Stars from the Study of R-Modes, European Centre for Theoretical Studies in Nuclear Physics and Related Areas* (ECT*), Trento, Italy, September 19, 2007

Asit K De

- *Field Theories on the Lattice at the Saha Institute*, Tata Institute of Fundamental Research, Mumbai, India, May 28, 2007
- *Hadrons from Lattice QCD* at the Orientation day of the DAE Symposium on Nuclear Physics at the Sambalpur University, Sambalpur, December 10, 2007
- *On Scale Determination in Lattice QCD with Dynamical Quarks" at the XXVI International Symposium on Lattice Field Theory (LATTICE 2008),* July 14-19, 2008 at the College of William and Mary, Williamsburg, Virginia, USA

Bikash Sinha

- *The fundamental spirit of science*, Haldia Government College, Midnapore (East), West Bengal, India, June 2, 2007
- *The Nuclear Programme of India - present & future*, (organised by the Rotary Club of Kolkata, Midtown) Saturday Club, Kolkata, West Bengal, India, August 6, 2007
- *The Mini Bang and the Big Bang - from Collider to Cosmolgy - Relics of QCD Phase Transition*, North Eastern Hill University, Shillong, Meghalaya, India, September 19, 2007
- *A Cosmic journey through the Universe - from the Big Bang to man and bones* at the Continuing Orthopedic Education Course 2007, Taj Bengal, Kolkata, West Bengal, India, September 22, 2007
- *Nuclear Programme of India - Present and Future*, Jibananda Sabhaghar, Kolkata, West Bengal, India, October 27, 2007
- *The Cosmic Journey through through the Universe - from the Big Bang to now*, Lady Brabourne College, Kolkata, West Bengal, India, November 26, 2007
- *Advances in Modern Science and International Understanding*, Ramkrishna Mission Institute of Calture, Kolkata, West Bengal, India, December 1, 2007
- *Mega Science*, Indian Institute of Social Welfare and Business Management (IISWBM), Kolkata, West Bengal, India, December 13, 2007
- *The Cosmic Journey through the Universe - from Big Bang to now*, Central Glass & Ceramic Research Institute, Kolkata, West Bengal, India, December 14, 2007
- *The Cosmic Journey through the Universe - from Big Bang to now*, Bose Institute Campus, Darjeeling, West Bengal, India, December 17, 2007

Munshi G Mustafa

- *Collisional Energy Loss: A welcoming component for jet quenching phenomena in HIC*, Physics Department, McGill University, Montreal, Quebec, Canada, September 10, 2007
- *Electromagnetic Radiations from Relativistic electron-positron plasma*, FZD-Rossendorf, Germany, Septemebr 5, 2008.
- *Jet Quenching Phenomena in Heavy Ion-Collisions*, Department of Physics, University of Giessen, Germany, September 10, 2008.

- *Jet Quenching Phenomena in Heavy Ion-Collisions*, Max-Planck-Institut fuer extraterrestrische Physik, Garching, Germany, September 11, 2008
- *Color-singletness and recombination model of hadronisation*, Institute of Physics, Bhubaneswar, India, November 19, 2009.

Kumar S Gupta

- *Noncommutative BTZ Black Hole and Quantum Structure of Space-time*, Dublin Institute for Advanced Studies, Dublin, Ireland, December 2009
- *Quantization of Graphene with Charge Impurities*, Rudjer Boskovic Institute, Zagreb, Croatia, September 2009
- *Noncommutative Black Holes and Quantum Structure of Space-time*, Feza Gursey Institute, Istanbul, Turkey, June 19, 2009
- *Noncommutative Black Holes and Quantum Structure of Space-time*, Workshop on Noncommutative Geometry and Quantum Field Theory, The Institute of Mathematical Sciences, December 18-23, 2008, Chennai, India
- *Noncommutative Black Holes and QFT*, FTAG-VII, November 15-19, 2008, Shimla, India
- *Holography and Quasinormal Modes of Black Holes*, High Energy Group, Abdus Salam ICTP, Trieste, Italy, October 09, 2008
- *Noncommutativity and Quantum Structure of Space-Time*, Fourth International Workshop DICE2008, Castiglioncello, Italy, September 22-26, 2008
- *Holography and Quasinormal Modes of Black Holes*, Department of Physics, University of Zagreb, Zagreb, Croatia, September 11, 2008
- *Noncommutative Gravity and Black Holes*, Rudjer Boskovic Institute, Zagreb,Croatia, September 17, 2008
- *Black Holes in Noncommutative Gravity*, Fifteenth Irish Quantum Field Theory Meeting, NUI Maynooth, Ireland, May 2008 .
- *BTZ Black Hole and Holography*, Dublin Institute for Advanced Studies, Dublin, Ireland, May 2008
- *Noncommutative Gravity and Black Holes*, Tata Intitute of Fundamental Research, Mumbai, India, February 2008
- *Noncommutative Gravity and Black Holes*, School of Physics, University of Hyderabad, Hyderabad, India, February 2008
- *Noncommutative Gravity and Black Holes*, Workshop on Nonperturbative Gauge Theories and Gravity, SNBNCBS, Kolkata, India, January 7-12, 2008
- *Noncommutative Gravity and Black Holes*, International Conference on Gravitation and Cosmology (ICGC) 2007, IUCAA, Pune, India, December 16 - 21, 2007
- *Noncommutative Gravity and Black Holes*, Field Theoretic Aspects of Gravity - VI (FTAG - VI), Harish Chandra Research Institute, Allahabad, India, November 13 - 18, 2007

- *Noncommutative Gravity and Black Holes*, Raman Research Institute, Bangalore, October 16, 2007
- *Noncommutative Gravity and Black Holes*, Institute of Mathematical Sciences, Chennai, 11 October, 2007
- *Holography and Quasinormal Modes of Black Holes*, Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan, September 05, 2007
- *BTZ Black Holes and Holography*, VIII Asia-Pacific International Conference on Gravitation and Astrophysics (ICGA8), Nara University, Nara, Japan, August 29-September 01, 2007
- *Aspects of Noncommutative Gravity - I and Aspects of Noncommutative Gravity*, Workshop on Noncommutative Geometry, Department of Physics, Comenius University, Bratislava, Slovakia, June 25-July 13, 2007
- *Aspects of Noncommutative Gravity*, Rudjer Boskovic Institute, Zagreb, Croatia, June 2007
- *Noncommutative Gravity*, Himalayan Relativity Dialogue, Mirik, India, April 18-20, 2007

Pijushpani Bhattacharjee

- *Supernovae, Gamma Ray Bursts, Cosmic Rays and Neutrinos*, Colloquium, IIAp, Bangalore, April 10, 2007
- *Origin of Cosmic Rays: The Neutrino Connection*, the India-Japan Symposium, SINP, Kolkata, June 6–7, 2007
- *Introduction to Astroparticle Physics*, (Three lectures), UGC Refresher Course, University of Calcutta, Kolkata, September 19 – 25, 2007
- Origin *of Cosmic Rays: Supernovae, Gamma Ray Bursts and Exotica*, Colloquium, HRI, Allahabad, November 5, 2007
- *Radiation in the Cosmos*, 17-th National Symposium on Radiation Physics (NSRP-17), SINP, Kolkata, November 14-16, 2007
- *Gamma-ray Astronomy: Window to the High Energy Universe*, National Symposium on Gamma Ray Astronomy, IIAp, Bangalore, November 22 – 23, 2007
- *Fermi acceleration of cosmic rays*, (Two lectures), the Astroparticle Physics Workshop, Darjeeling, December 22-23, 2007
- *The Micro - Macro connection in physics and the technology of the extreme*, NIT, Durgapur, January 19, 2008
- *Dark Matter in the Galaxy*, the Topical meeting on Quarks in Astrophysics and Cosmology, Toshali Sands, Puri, February 13 – 16, 2008
- *Perspectives in Astroparticle Physics*, Workshop on High Energy Physics, IIT-Guwahati, February 21 – 23, 2008

- *Dark Matter in the Milky Way*, HEPCOS'08, Jamia Milia Islamia, New Delhi, March 11 – 13, 2008
- *Neutrino factories in the sky: Unveiling the cosmic ZeV particle accelerators*, International Workshop on Neutrinos and Beams (NuBeam'08), Darjeeling, May 5–7, 2008
- *Sizing up the WIMPs of Milky Way*, Colloquium(TPSC Programme), IMSc, Chennai, December 3, 2008
- *Phase space distribution of Milky Way's Dark Matter Halo: Implications for neutrino*
- *Signals from WIMP annihilation in the Sun*, Neutrinos in Particle Astrophysics and Cosmology (NuPAC), Mahabalipuram, April 5–7, 2009
- *Astro-Particle Physics Frontier: Connecting the Big and the Small*, S S College, Hailakandi, Assam, August 21, 2009
- *From Quarks to Cosmos: The Micro - Macro Connection*, Science City, Kolkata, October 30, 2009
- *WIMPs in the Milky Way: The Standard Halo Model Revisited*, the Indian Conference on Cosmology and Galaxy Formation (ICCGF-09), IIT-Kanpur, 1 November 2009
- *Detecting the WIMPs of Milky Way*, LHC and the New Frontiers in Particle Physics, University of Calcutta, Kolkata, December 7, 2009
- *Ultrahigh Energy Cosmic Rays and Neutrinos*, the Kodai Winter School, Kodaikanal, December 10–12, 2009
- *Dark Matter in the Universe: Sizing up the WIMPs of Milky Way*, SERC School on Nuclear Physics, Calicut University, Kozhikode, January 28, 2010
- *Big-Bang Nucleosynthesis: Probing the Early Universe* (Two lectures), SERC School on Nuclear Physics, Calicut University, Kozhikode, January 30, 2010
- *Neutrinos from WIMP Annihilations in the Sun*, NuHoRIzons-III, HRI, Allahabad, February 10, 2010
- *Cosmic Rays*, the COSPAR FERMI Workshop, Bangalore, February 18, 2010
- *Gamma Rays from WIMP Dark Matter Annihilations*, the COSPAR FERMI Workshop, Bangalore, February 19, 2010
- *Dark Matter in the Universe: Sizing up the WIMPs of Milky Way*, Physics Colloquium at Indian Institute of Science, Bangalore, February 19, 2010

Bijay Kumar Agrawal

- *Neutron Stars : An Astrophysical Laboratory,* Vellore, Institute of Technology, Vellore, July 27, 2007
- Quarks in Astrophysics and Cosmology in Toshali Sands, Puri, India, February 15-17, 2008

Teaching elsewhere

Anjan Kundu

- *Integrable systems* (Two Lectures), Phys Dept Viswabharati University, December 1-2, 2008
- Quantum group and quantum integrability, MSc/PhD SERC School on Dynamical Systems, (Special) CTS, IISC, Bangalore, India, February 10-29, 2008

Parthasarathi Mitra

- *Tensors and General Relativity*, UGC Refresher course, University of Calcutta, July 2009

Prakash Mathews

- Guest Faculty for the School on QCD at LHC at the Regional Centre for Accelerator based Particle Physics, Harish-Chandra Research Institute, Allahabad, November 26 – 29, 2007

Palash B Pal

- *Thermodynamics* (5 lectures), Refresher Course, Physics Department, University of Calcutta, September 05-11, 2007

Harvendra Singh

- *Recent developments in string theory* (QIP-STC program), IIT, Guwahati, India, September 6-7, 2007

Munshi G Mustafa

- *Electromagnetic Theory* (24), 2007, MSc (General) Bose Institute, Kolkata, India, September 16-December 21
- *Electromagnetism* (24), jointly organised by J C Bose Institute, Kolkata and St Xavier College, Kolkata, September 2008-09 and 2009-10

Gautam Bhattacharyya

- *Standard Model and beyond* (8 lectures, 4 tutorials), 15th Vietnam School of Physics, Dong Hoi, Vietnam, July 2009

Miscellany

Anjan Kundu

- Senior Associate, ICTP, Trieste, Italy 2006-11

Pijushpani Bhattacharjee

- Serving as a member of the Programme Advisory Committee (PAC) on “Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics” constituted by the Science & Engineering Research Council (SERC) of the Department of Science & Technology (DST), Government of India.
- Served as the Chairman of the “Planning Committee” set up by DST in 2009 for organizing a new series of SERC Schools in the area of Astronomy & Astrophysics.
- Distinguished Adjunct Professorship at HRI, Allahabad

Debades Bandyopadhyay

- Awarded the Research Group Linkage Programme of the Alexander von Humboldt Foundation for the period December 2008 – November, 2011
- Alexander von Humboldt Fellowship October-December, 2007

Bireswar Basu-Mallick

- Recipient of Senior Associateship award (for the period 2008-2013) from Abdus Salam ICTP, Trieste, Italy in the year 2008.

Prakash Mathews

- Associate at the Abdus Salam International Centre for Theoretical Physics, Italy, 1 Jan 2002 to 31 Dec 2009
- Associate, ICTP, Italy, 22 Aug 07 - 6 Oct 07
- Affiliate, Regional Centre for Accelerator-based Particle Physics

Munshi G Mustafa

- Visiting Fellow, McGill India Strategic Research Initiative (MISRI) June 19 - September 17, 2007
- Forschunzentrum-Dresden (FZD) Fellow, Dresden, Germany, July-September, 2008

Harvendra Singh

- ICTP Associateship 2004-2009

Gautam Bhattacharyya

- Adjunct Faculty of Tata Institute of Fundamental Research, Mumbai, for 2009-12
- Scientific Associate, CERN, Geneva, Switzerland, 1 Jun - 31 Oct 2007

6 Teaching

The Post-M Sc Associateship Course

Physics

54th Session (2006-07)
Second Term

Advance Course (Teachers)

Quantum Field Theory (Shibaji Roy)

Condensed Matter Physics (Krishnendu Sengupta)

Molecular Spectroscopy (Alokmay Datta, AI Jaman)

Diffrential Geometry and General Relativity (Amit Ghosh)

Particle Physics (Palash Baran Pal)

High energy Astrophysics and Astroparticle Physics (Debades Bandyopadhyay and Pijushpani Bhattacherjee)

Plasma Physics (Nikhil Chakrabarti)

Computational Physics (Asok Sen)

Advance Experiments Teacher

Saturation absorption spectroscopy of rubidium Satyajit Saha

Study of interfacial evolution using X-ray Reflectivity Satyajit Hazra

Magnetic and Magnetotransport properties of Sml–xSrx MnO3 Manganites Prabhat Mandal

Growth Study of MB Egrown films by SPM, XPS and X–rays cattering Srinanda Kundu

Techniques of Gamma – ray Spectroscopy using clover and NaI (TI) Detectors Palash Banerjee

ElementalAnalysisbyenergy – dispersive X – rays pectroscopy Tapas Kumar Chini

Experimental aspects of Quantum Criticalpointindense Kondo Latticesystems Chandan Mazumdar

Third Term (Review): [Student, Review Title Supervisor(Div)]

Sudip Kumar Nath; Modeling and characterization of ultra-thin high-k gae dielectric-based metal oxide-semiconductor (MOS) devices [(Supratic Chakraborty (Microelectronics)])

Abhisakh Sarma; The effect of electron-electron interaction in determining conductivity of nanowires (Milan K Sanyal (SP))

Nupur Biswas; Thermodynamics of a nano-confined polymers (Alokmay Datta (SP)) Sanjoy Kr Mahatha; Quantum-Well States and Surface States in ultra-thin films investigated by ARPES (Krishnakumar Menon (SP))

Safiul Alam Mollick; Measurement of mechanical properties of thin films by nanoindentation (D Ghosh (SP))

Bishnudas Ghosh; Magnetism in non-magnetic material arising from atomic vacancies (Sangam Banerjee (SP))

Dilip Kumar Bhoi; Nanoscale phase Separation in Strongly Correlated Systems (Prabhat Mandal (ECMP))

Soumini Chaudhury; Dark Matter in the Galaxy (P Bhattacharjee , (Theory))

Rana Nandi; Neutron Star Crust (D Bandyopadhyay (Theory))

Pritibhajan Byakti; Path-integral quantization of field theories (Palash B Pal (Theory))

Srijit Bhattacharjee; Functional approach towards the Coleman-Weinberg mechanism (Parthasarathi Majumdar (Theory))

Shreyoshi Mondal; Some aspects of low dimensional condensed matter physics. (Krishnendu Sengupta (TCMP))

Debhashis Samanta;Macroscopic properties of percolating matter (BK Chakrabarti, (TCMP), Krishnendu Sengupta (TCMP))

The following students successfully completed the course: Abhisakh Sarma, Debashis Samanta, Dilip Kumar Bhoi, Nupur Biswas, Paramita Chatterjee, Priti Bhajan Byakti, Rana Nandi, Saiful Alam Mollick, Sanjoy Kr Mahatha, Shreyoshi Mondal, Soumini Chaudhury, Srijit Bhattacharjee, Sudip Kumar Nath

55th Session: 2007-2008

Arindam Midya, Bipasha Chakraborty, Debabrata Banerjee, Debarshee Bagchi, Kush Saha, Lab Saha, Mahashweta Basu, Manjula Sharma, Mayukh Mukumdar, Nazir Khan, Pabitra Das, Rakesh Chatterjee, Raktim Abir, Sanhita Modak, Santanu Mondal, Susmita Kundu, Susnata Seth, Tanusree Samanta, Urna Basu, Ashim Ghosh

First Term Courses (Teachers)

Mathematical Methods ((Parthasarathi Mitra, Asok Sen (TA Debasish Samanta))

Saturation absorption Spectroscopy of Rubidium (Satjait Saha (NAP))

Study of interfacial evolution using X-ray reflectivity (Satyajit Hazra (SP))

Magnetic and Magnetotransport properties of Sm(1"x) Srx Mn)3 (Prabhat Mondal (ECMP))

Growth study of MBE grown films by SPM, XPS and X-ray scattering (Srinanda Kundu (SP))

Techniques of Gamma-ray spectroscopy using clover and Nacl(TI) detectors (Polash Banerjee (NAP))

Elemental analysis by energy-dispersive X-ray spectroscopy (EDS) (Tapas Kumar Chini SP)

Experimental aspects of Quantum Critical point in dense Kondo Lattice systems (Chandan Mazumdar (ECMP))

55th Session 2007-2008

Second Term

Advanced Courses (Teachers)

Advanced Thoretical courses 2007-2008

COURSE TITLE TEACHER

(1) CONDENSED MATTER PHYSICS (Full), Abhik Basu, TCMP Division

(2) QUANTUM MANY-BODY SYSTEMS (Full), Krishnendu Sengupta,TCMP Division

(3) QUANTUM FIELD THEORY (Full), Parthasarathi Majumdar,Theory Division

(4) HIGH ENERGY ASTROPHYSICS (Full), Pijushpani Bhattacharjee,
& ASTROPARTICLE PHYSICS Debades Bandyopadhyay,Theory Division

(5) GENERAL RELATIVITY & COSMOLOGY (Full), Amit Ghosh, Theory Division

(6) PARTICLE PHYSICS (full), Prakash Mathews, Theory division

(7) COMPUTER APPLICATIONS IN THE Supratik Mukhopadhyay,INO section STUDY OF PHYSICAL SYSTEMS (full),

(8) FIRST INTRODUCTION TO STRING Harvendra Singh, Theory Division THEORY (Half),

(9) NEUTRINO PHYSICS (Half), Debasish Majumdar, INO Section

(10) QUANTUM HALL EFFECT and (Half), Sachindranath Karmakar, TCMP Division RELATED TOPICS

Advanced Experimental Courses (2007-08)

1. Study of sol-gel coated thin film using x-ray reflectivity
   Satyajit Hazra, Surface Physics Division
2. Study of self-assembled monolayer using scanning probe microscopy
   Satyajit Hazra, Surface Physics Division
3. Study of thermal dynamics of nanocomposites using Dynamic Light Scattering
   Manabendra Mukherjee, Surface Physics Division
4. Photoelectron spectroscopic studies of metal nano particles templated from amphiphilic block copolymer

   Manabendra Mukherjee, Surface Physics Division
5. Positron Annihilation Eeperiment to know the molecular structural characteristics of a given substance.

   Bichitra Nandi Ganguly, Nuclear and Atomic Physics Division.
6. Spin, charge and orbital ordering: Evidence from transport studies

   Prabhat Mandal, ECMP Division.

7. Measurements of time correlated events in subatomic field, happen within nanosec (10^{-9} sec) or microsec (10^{-6} sec) or even picosec (10^{-12} sec).

   U. Datta Pramanik, NAP division

8. Preparation of Multiferroic Materials and Study the Giant Electrocaloric Behaviour.

   Indranil Das, ECMP Division

Third Term (Review)

[*Student*, Review Title (Supervisor)]

1. *Sanhita Modak,* Review of non-perturbative RG method for bosons.

   Krishnendu Sengupta, TCMP Division

2. *Susmita Kundu,* The Universe on a brane.

   Amit Ghosh, Theory Division

3. *Santanu Mondal,* Gauge Fields on a Euclidean Lattice

   A. Harindranath, Theory Group

4. *Tanusree Samanta,* Properties of Polyelectrolytes in solution and thin films

   Manabendra Mukherjee, Surface Physics Division

5. *Raktim Abir,* Performance studies of ALICE Dimuon Spectrometer

   Sukalyan Chattopadhyay, High Energy Physics Division

6. *Rakesh Chatterjee,* Fluctuation-induced forces in nematic liquid crystals

   Abhik Basu, TCMP Division

7. *Mahasweta Basu,* Kinetics of Enzyme Reaction; Michaelis-Menten Law

   P. K. Mohanty, TCMP Division

8. *Urna Basu,* Matrix Product Ansatz for Non-equilibrium steady states

   P. K. Mohanty, TCMP Division

9. *Arindam Midya,* Coexistence and correlation between different order parameters in hexagonal manganites

   Prabhat Mandal, ECMP Division

10. *Asim Ghosh,* Econophysics of Wealth Distributions in Societies.

    Bikas K. Chakrabarti, TCMP Division

11. *Bipasha Chakraborty,* Chiral Symmetry and its Lagrangians

    Palash Baran Pal, Theory Group

12. *Debarshee Bagchi,* Novel class of driven lattice gas models

    Abhik Basu, TCMP division

13. *Kush Saha,* Review of Kondo physics in low-dimensional electron systems.

    Krishnendu Sengupta, TCMP Division

14. *Lab Saha,* HIGH ENERGY GAMMA RAY ASTRONOMY

    Pijushpani Bhattacharjee, Theory Division

15. *Manjula Sharma,* Properties of germanium nanostructures on silicon surface formed by molecular beam epitaxy technique.

    Milan Sanyal, Surface Physics Division

16. *Mayukh Majumdar,* Manganese doped diluted magnetic semiconductors formed by ion-beam and other techniques.

    Milan Sanyal, Surface Physics Division

17. *Nazir Khan,* Role of quenched disorder on magnetic and electronic phase transitions in manganites

    Prabhat Mandal, ECMP Division

18. *Pabitra Das,* Luminescence studies of low dimensional semiconductor structures using local probe method with high spatial resolution spectroscopic and imaging capability

    Tapas Kumar Chini, Surface Physics Division

19. *Susnata Seth,* Dark Matter and its Detectability using superheated droplet detector

    Pijushpani Bhattacharjee, Theory Division,
    and
    Satyajit Saha, Atomic & Nuclear Physics Division

20. *Debabrata Banerjee,* Design Optimization of the Muon Tracker for CBM Collaboration

    Sukalyan Chattopadhyay, High Energy Physics Division

The following 20 Physics students successfully completed the course:

Arindam Midya, Ashim Ghosh, Bipasha Chakraborty, Debabrata Banerjee, Debarshee Bagchi, Kush Saha, Lab Saha, Mahashweta Basu, Manjula Sharma, Mayukh Majumdar, Nazir Khan, Pabitra Das, Rakesh Chatterjee, Raktim Abir, Sanhita Modak, Santanu Mondal, Susmita Kundu, Susnata Seth, Tanusree Samanta, Urna Basu

Smt. Urna Basu received the Professor A.P. Patra Memorial Award. (For 2007-2008 first term)

56th Session (2008-09)

The following 23 Physics students were admitted:

Amaresh Metya, Anwesa Sarkar, Arindam Mazumdar, Baishali Chakraborty, Chandan Maity, Jayanta Das, Moumita Dey, Najmul Haque, Niladri Sarkar, Paramita Dutta, Pratyay Banerjee, Purba Bhattacharya, Sangita De Sarkar, Santanu Maiti, Santosh Chakraborty, Shyamal Mondal, Somdeb Chakraborty, Soumyajyoti Biswas, Sreemoyee Sarkar, Srilekha Saha, Ajanta Kundu, Anuradha Bhattacharya, Satyajit Seth.

First Term

Course (Teachers)

Statistical Mechanics (Abhik Basu)
Computer Applications (Supratik Mukhopadhyay)
Quantum Mechanics (Gautam Ghosh)
Field Theory (Palash Baran Pal)
Basic Experiments & Techniques (Bijay Bal and Sandip Sarkar)

Ms. Sangita De Sarkar received the Professor A.P. Patro Memorial Award.

Second Term 2008-09

(Advanced Courses) : Teachers

(Quantum Field Theory): Parthasarathi Majumdar, Theory Group
(Condensed Matter Physics): Sachindranath Karmakar, TCMP Division
(Soft Matter Physics): Abhik Basu, TCMP Division
(High Energy Astrophysics): Pijushpani Bhattacharya, Kamales Kar, Theory Group
(Finite temperature Field Theory): M.G. Mustafa, Theory Group
(Electroweak part of the Standard Model): Gautam Bhattacharyya, Theory Group
(Particle Physics): Prakash Mathews, Theory Group
(Nuclear Structure): Maitreyee Saha Sarkar, NAP Division
(Microelectronics): Madhusudan Roy and Supratic Chakraborty, Microelectronics Division
(Nuclear Reactions): Chinmay Basu, NAP Division
(Black Hole Physics): Parthasarathi Mitra, Theory Group

Experimental Courses:

1. Photoelectron spectroscopic studies of polymer-metal interaction in block-copolymer metal nanocomposites, Manabendra Mukherjee, Surface Physics Division.
2. Study of hydrodynamic radius and surface plasmon resonance of polyelectrolyte silver nanocomposites,Manabendra Mukherjee, Surface Physics Division.
3. Preparation, characterization and transport properties study on recently discovered Fe-based superconductors. Prabhat Mandal, ECMP Division
4. Determination of the Internal Conversion Coefficients. Maitreyee Saha Sarkar, Nuclear and Atomic Physics Division.
5. Fabrication of Porous Anodized Alumina Template (PAAT) and studying it using Atomic Force Microscopy. Sangam Banerjee, Surface Physics Division.
6. Fabrication and characterization of humidity sensor. Madhusudan Roy and Supratic Chakraborty, Microelectronics Division.
7. Photoluminescence characterization of semiconductor materials Satyaban Bhunia, Surface Physics Division.

8. Magnetic Heusler alloys preparation using arc furnace for the study of magnetocaloric effect. Indranil Das, ECMP Division.
9. Preparation of Multilayer thin film of complex materials using Pulsed Laser Deposition (PLD) and study. Indranil Das, ECMP Division.
10. Preparation of Nano materials with charge-ordered or ferromagnetic ground state and study. Indranil Das, ECMP Division.
11. Preparation and study of Nano wire in nano pore template. Indranil Das, ECMP Division.
12. Characterization of MANAS chip. Sukalyan Chattopadhyay & Sandip Sarkar, Muon Arm Laboratory.

Third Term (Review): [Student, Review Title (Supervisor)

An*wesa Sarkar,* Fermions on the Lattice, Supervisor: Asit K De,

Sangita De Sarkar, Chiral Gauge Theories on the Lattice, Supervisor: Asit K De, Theory Group

Arindam Mazumdar, Beyond the standard model of particle interactions, Supervisor: Palash Baran Pal, Theory Group

Baishali Chakraborty, Inequivalent quantization of a graphene system with charge impurities. Supervisor: Kumar S. Gupta, Theory Group

Pratyay Banerjee, Exact solutions of some quantum integrable systems with long-range interactions, Supervisor: Bireswar Basu-Mallick, Theory Group.

Najmul Haque, Hard thermal loop approximation and its application to quark-gluon plasma, Supervisor: Munshi Golam Mustafa, Theory Group.

Satyajit Seth, Two cutoff phase space slicing method— next-to-leading order in QCD. Supervisor: Prakash Mathews/ A. Harindranath, Theory Group

Anuradha Bhattacharya, Application of Nanotechnology in Biosensors, Supervisor: Sangam Banerjee, Surface Physics Division

Amaresh Metya, Magnetic nanoparticles and their application to bioscience, Supervisor: Sangam Banerjee, Surface Physics Division

Purba Bhattacharya, Detailed Numerical Simulation of Gas Detectors, Supervisor: Supratik Mukhopadhyay, INO Section

Chandan Maity, Review of nonlinear cold plasma oscillations (nonrelativistic & relativistic), Supervisor: Nikhil Chakrabarti, Plasma Physics Division

Shymal Mondal, Energetic metal nanocluster production, deposition and Characterization, Supervisor: Satyaranjan Bhattacharyya, Surface Physics Division.

Santanu Maiti, Two dimensional ordering of nano-structured materials on liquid surfaces/interfaces, Supervisor: Milan Sanyal, Surface Physics Division

Ajanta Kundu, Stochastic Resonance in physical and biophysical systems, Supervisor: Sandip Sarkar, Microelectronics division.

Sreemoyee Sarkar, Thermal field theory, Supervisor: Abhee K. Dutt-Mazumder, HEP division.

Srilekha Saha, Magnetic response in mesoscopic rings and cylinders, Supervisor: Sachindranath Karmakar, TCMP division

Paramita Datta, Quantum transport in molecular bridge systems, Supervisor: Sachindranath Karmakar, TCMP division

Niladri Sarkar, Universality scaling and critical exponents of Ising model in three dimensions, Supervisor: Abhik Basu, TCMP division

Moumita Dey, Spin polarized Transport in low dimensional systems, Supervisor: Sachindranath Karmakar, TCMP division

Jayanta Das, Low field Magnetoresistance in dc, low and high frequency, Supervisor: Indranil Das.

Soumyajyoti Biswas, Microscopic theory of solid-solid friction, Supervisor: Bikas Chakrabarti, TCMP division

Somdeb Chakraborty, The study of Ads/CFT correspondence, Supervisor: Shibaji Roy, Theory Group.

Santosh Chakraborty, Exploring horizon of exotic nuclei through electromagnetic probe. Supervisor: Ushasi Datta Pramanik, NAP division

The following students have successfully completed the Post M.Sc. (Physics) course for the year 2008-09.

Sangita De Sarkar, Purba Bhattacharya, Shyamal Mondal, Santosh Chakraborty, Arindam Mazumdar, Anwesa Sarkar, Anuradha Bhattacharya, Sreemoyee Sarkar, Najmul Haque, Satyajit Seth, Baishali Chakraborty, Somdeb Chakraborty, Niladri Sarkar, Srilekha Saha, Moumita Dey, Pratyay Banerjee, Chandan Maity, Santanu Maiti, Amaresh Metya, Paramita Dutta, Soumyajyoti Biswas, Ajanta Kundu, Jayanta Das

57th Session (2009-10)

The following 26 Physics students were admitted:

Abdul Wahid, Abhishek Chowdhury, Abhishek Majhi, Anirban Biswas, Avirup Ghosh, Ishani Roy, Mahatsab Mandal, Mainak Chakraborty, Md Anisur Rahaman, Muzafar Qadir Lone, Parijat Dey, Protick Mohanta, Sourish Bondyopadhyay, Sudipta Mondal, Suvankar Chakraborty, Debabrata Adak, Abhijit Bisoi, Arpan Bhattacharyya , Atanu Kumar , Kalipada Das , Palash Khan , Ravindra Pankaj , Samik Dutta Gupta , Sohan Kr. Jha , Sumona Sinha, Ujjal Kumar Gayen

First Terms:

Courses (Teachers)

Statistical Mechanics (P. K. Mohanty)
Computer Applications (Supratik Mukhopadhyay)
Quantum Mechanics (Debades Bandyopadhyay)
Field Theory (Palash Baran Pal, Amit Ghosh)
Basic Experiments & Techniques (Bijay Bal and Sandip Sarkar)

Mr. Abhishek Chowdhury received the Professor A.P. Patro Memorial Award.

Biophysical Sciences

2007

Review topics of existing Post M.Sc students

Brotati Chakraborty : Biological applications of acridine derivatives (Samita Basu)

Moumita Datta: Transcriptional dysregulation in huntington's disease (Nitai P Bhattacharyya)

Jayeeta Ghose: Unscrambling the complex regulation of hematopoietic stem cells: implications for hematological malignancies (Subrata Banerjee)

Sukanya Halder: Role of N- and C-terminal propeptides in folding, regulation and activation of proteolytic enzymes (Sampa Biswas)

Sudip Majumder: Structural epitopes that determine the inhibitory power of serine protease inhibitors (Jiban K Dattagupta)

Sutapa Mondal: Membrane fusion: mechanism and perspectives (Munna Sarkar)

Sanchita Mukherjee: A study of biochemical networks: structure, prediction and evolution from the bioinformatics point of view (Rahul Banerjee)

Biswa Pathik Pahari: Protein-ligand interaction study by Raman spectroscopic method (Pradeep K Sengupta)

Swati Panigrahi: Algorithm of computational based ligand receptor interactions (Dhanajay Bhattacharyya)

Kamalika Roy Choudhury: Regulated intramembrane PROTEOLYSIS-RIPping the signal apart (Debashis Mukhopadhyay)

Students joined the Post M.Sc

Sankar Chandra Basu, Nandini Pal, Anita Roy, Soma Chakraborty, Eashita Das, Kasturi Guha (Sengupta), Binita Dutta, Manas Kumar Sarangi, Samir Das, Arunabha Chakrabarti, Sreeja Chakraborty, Mousumi Banerjee and Swadesh Mandal.

2008

Review topics of existing Post M.Sc students

Sankar Chandra Basu: Effects of DNA-fllexibility on nucleosome positioning and gene expression (Dhananjay Bhattacharyya)

Nandini Pal: Mitochondria: a matter of life and death (Subrata Banerjee)

Anita Roy: Of flies, mice and men - emerging role of polycomb group of proteins in Leukemia (Subrata Banerjee)

Soma Chakraborty: "Intramolecular Dynamic Networks" and their role in modeling packing within proteins (Rahul Banerjee)

Eashita Das: Involvement of MicroRNA in Neurodegenerative diseases (Nitai P. Bhattacharyya)

Kasturi Guha (Sengupta): Life and death of messenger RNA in Eukaryotic cell (Partha Saha)

Binita Dutta: One atom at-a-time chemistry - a perfect blend of Physics, Chemistry, Technology and Imagination (Susanta Lahiri)

Manas Kumar Sarangi: Charge transfer in DNA (Samita Basu)

Samir Das: Involvement of SRC homology domains in Alzheimer's disease (Udyaditya Sen)

Arunabha Chakrabarti: Brain "senescenceomics" - understanding senescence through "omics"! (Debashis Mukhopadhyay)

Sreeja Chakraborty: Metal complexes of Non-steroidal Anti-inflammatory Drugs (NSAIDs) (Munna Sarkar)

Mousumi Banerjee: Heme release from haemoglobin (Abhijit Chakrabarti)

Swadesh Mandal: Trace scale speciation of Mercury and Iodine (Dalia Nayak)

Students joined the Post M.Sc

Seema Nath, Barnali Waugh, Sudip Kundu, Kasturi Roy, Shounak Baksi, Amrita Chakraborty, Saurav Roy, Saptaparni Ghosh, Suchismita Halder, Manas Mondal, Avik Basu, Srijit Das, Ajoy Mandal and Ramanuj Banerjee.

2009

Review topics of existing Post M.Sc students

Seema Nath: Protein Tyrosine Phosphatase: Structure, Mechanism, Redox regulation and Inhibitor Design (Udyaditya Sen)

Barnali Waugh: Genome comparison : Algorithm parameters and genetic mutation (Rahul Banerjee)

Sudip Kundu: Role of Cip/Kip proteins in cellular plasticity, migration and differentiation (Subrata Banerjee)

Kasturi Roy: Rafting, Conveyance and Walking: The Traffic Within (Debashis Mukhopadhyay)

Shounak Baksi: Non-coding RNAs in Neurodegeneration (Debashis Mukhopadhyay)

Saurav Roy: Origin of Mutants (Rahul Banerjee)

Saptaparni Ghosh: Unusual DNA structures as targets for small compounds with therapeutic potential (Dipak Dasgupta)

Suchismita Halder: A Glass of Milk for Memory-Calcium in Alzheimer's disease (Debashis Mukhopadhyay)

Manas Mondal: Grand Canonical Ensemble Simulation by GC Monte Carlo method and its application in Structural Biology (Dhanajay Bhattacharyya)

Avik Basu: Defects in Membrane Skeletal Architecture (Avijit Chakrabarti)

Srijit Das: Huntington's disease and cancer: are they opposite sides of the same coin? (Nitai P. Bhattacharyya)

Ajoy Mandal: Current trends in research with Naturally Occurring Radioactive Materials (NORM) (Susanta Lahiri)

Ramanuj Banerjee: Rho-dependent termination and transcription elongation by Nus-G (Udyaditya Sen)

Students joined the Post M.Sc

Agnik Dasgupta, Amrita Banerjee, Anindita Deb, Ankan Dutta Chowdhury, Ayesha Kabir, Gourab Bhattacharje, Kallol Bera, Kaustab Ghosh, Madhurima Mitra, Mahan Ray, Moupriya Nag, Poorna Roy, Rakhi Paul, Shilpita Karmakar, Shreyasi Dutta, Sourav Kumar Dey and Sujay Ghosh.

Course out line for Post M.Sc. Biophysical Sciences

1. Macromolecular Structure (Dhananjay Bhattacharyya, Rahul Banerjee, Abhijit Chakrabarti)
2. Protein Crystallography and Structural Biology (Jiban K. Dattagupta, Chandana. Chakrabarti, Udayaditya Sen, Sampa Biswas)
3. Basics in Cell and Molecular Biology (Partha Saha, Debashis Mukhopadhyay, Sanghamitra Raha, Arun Pal, Subrata Banerjee, Nitai P. Bhattacharyya)

3.1 Historical Overview

3.2 Introduction to Microbiology

3.3 Molecular Biology

3.4 Basics in Cell Biology

3.5 Experimental Techniques in Cellular & Molecular Biology

3.6 Immunology

3.7. Genomics & Proteomics

3.8 Genetic Diseases & Therapy

4. Chemical Biology (Dipak Dasgupta)
5. Disease & Drug Action (Dipak Dasgupta, Munna Sarkar)
6. Bioinformatics (Dhananjay Bhattacharyya, Rahul Banerjee, Debashis Mukhopadhyay)
7. Protein Folding (Soumen Basak)
8. Spectroscopy (Samita Basu, Munna Sarkar, Pradeep K Sengupta)
9. Biophysical / Biochemical Methods (Soumen Basak, Munna Sarkar)
10. Basic Radiochemistry & Analytical Chemistry (Susanta Lahiri, Dalia Nayak)
11. Basic Radiation Physics & Safety (Maitrayee Nandy)
12. Conducting Polymer (Amitava De)
13. Computer Programming (Pulak Ray, Dhanajay Bhattacharyya)
14. Electron Microscopy (Pulak Ray)

Undergraduate Associateship Course

Session : 2007 – 2008

Special Theory of Relativity (Amit Ghosh)

A Short Course on Particle Physics (Pijushpani Bhattacharjee)

An Introduction to Complex Analysis (Debabrata Basu)

Ranjan R Shenoy: Production of nanoclusters in gas phase and their deposition on a substrate (SR Bhattacharyya)

Pratik Tarafdar: Gamma radiation and its application (U Datta Pramanik)

Moupiya Maji: Energy calibration of an unknown ^{3}-ray spectrum and efficiency determination of a HPGe detector (Anjali Mukherjee)

Sambit Bikas Pal: Study of state of polarisation of light emitted from tunable laser (Satyajit Saha)

Challenger Mishra: Estimation of isotope ratio of natural Rubidium using laser spectroscopy (Satyajit Saha)

Anwesha Ghosh: Spectroscopic study of protein folding (Abhijit Chakrabarti)

Protein and Proteomics (Abhijit Chakrabarti)

Stem Cell and Gene Therapy (Subrata Banerjee)

Malini Pramanik and Mohiny Lahiri: Membrane partitioning of heme released from hemoglobin (Abhijit Chakrabarti)

Candidates selected for UGA Programme in 2007

Subhabrata Majumdar	(Mentors	:	NP Bhattacharya and PK Mohanty)
Anish Mallick	(Mentor	:	S Saha)
Atreyee Sinha	(Mentor	:	P Majumdar)
Debayan Mitra	(Mentor	:	MK Sanyal)
Alisha Chakrabarti	(Mentors	:	A Chakrabarti and S Banerjee)
Aniket Patra	(Mentor	:	P Majumdar)
Arnab Dhabal	(Mentor	:	KRK Menon)
Sayan Choudhury	(Mentor	:	P Majumdar)
Abhisek Choudhury	(Mentor	:	P Majumdar)
Ujani Chakrabarti	(Mentor	:	A Chakrabarti)
Aveek Chandra	(Mentor	:	S Saha)

Candidates selected for UGA Programme in 2008

Vijay Ahlawat	(Mentors	:	D Bhattacharya and S Banerjee)
Arkaprava Bokshi	(Mentor	:	ANS Iyengar)
Chumki Chakraborty	(Mentor	:	A Chakrabarti)
Atasi Dan	(Mentor	:	SR Bhattacharya)

Saurav Islam	(Mentor	:	S Saha)
Rahul Jha	(Mentor	:	PB Pal)
Vishes Kothari	(Mentor	:	P Majumdar)
Ravi Kunjwal	(Mentor	:	P Mitra)
Subhajit Mazumdar	(Mentors	:	A Ghosh / AK Dutt-Mazumder)
Debasish Sanyal	(Mentor	:	PP Bhattacharjee)
Subhendu Som	(Mentor	:	P Roy)

Candidates selected for UGA Programme in 2009

Paromita Mukherjee	(Mentor	:	U Datta-Pramanik)
Sidhartha Pandey	(Mentor	:	PP Bhattacharjee)
Sridip Pal			
Soubhik Kumar	(Mentor	:	MG Mustafa)
Sumanta Bandyopadhyay	(Mentor	:	PK Mohanty)
Tathagata Paul	(Mentor	:	T Chini)
Saswata Roy	(Mentor		S Sarkar)
Juhi Dutta	(Mentor	:	M Saha-Sarkar)
Anjishnu Bandyopadhyay	(Mentor	:	D Bandyopadhyay)
Sumitabha Bramhachari	(Mentor	:	SR Bhattacharya)
Vidhi Shingla	(Mentor	:	M Saha-Sarkar)
Souradeep Sasmal	(Mentor	:	S Ray)
Archak Purkayastha	(Mentor	:	S Saha)
Saikat Banerjee	(Mentor	:	P Mitra)
Sagnik Chakraborty	(Mentor	:	P Mandal)
Chandrima Ganguly	(Mentor	:	D Bandyopadhyay)
Ankita Mitra	(Mentor	:	S Basu)
Preeti Bhattacharjee	(Mentor	:	D Mukhopadhyay)
Kaustav Patra	(Mentor	:	A Chakrabarti)

Summer Students' Programme

One of the major human resource development activities where SINP has been playing a significant role to the academic community is the Summer Students' Programme. Every year, we invite applications from the pre-final year graduate students (M Sc / B Tech / B E) for Summer Students' Programme in which students participate in research and developmental work that are of interest in SINP. This programme is normally offered between the months of May and July and the expected duration of a project is approximately 8 weeks. Hundreds of applications are received each year from all over India, out of which we select a few students. These students are mentored by SINP scientists whose areas of research interest broadly match with those of the selected students. In course of this programme, the students work on research projects assigned to them by their mentors. They also get to handle state-of-the-art research instruments, learn new techniques of analysis and presentation of scientific research output, and the flavour of research activities, which continue to benefit them in shaping their career as research scientists. Selected candidates are provided a daily allowance for the duration of their stay and travel reimbursement as per rules. Limited hostel facilities are provided for the outstation candidates.

List of summer students for 2007:

Name	*Affiliation*	*Mentor*
Abhisek Sen	IIT Bombay	Debasish Majumdar
Amit Kumar Mukhopadhyay	IIT Kanpur	Milan K Sanyal
Anirban Saha	IITKGP	Abhijit Sanyal
Avik Halder	IIT Kanpur	Chandan Mazumdar
Baishali Chakraborty	IITKGP	Partha Majumdar
Ch Hareesh	J.N.T.U.	Susanta Lahiri
Dipanjan Mukherjee	IIT Kanpur	Avik Basu
Kuntal Nag	IIT Madras	Pijushpani Bhattacharjee
Manoshi Gayen	WBUT	Sampa Biswas
Neelanjan Bose	IIT Kanpur	Soumen Basak
Nilok Bose	SNBNCBS	Amit Ghosh
Paramananda Biswas	IIT Kanpur	R Ranganathan
Ria Sircar	IIT Kanpur	Soumen Basak
Ritobroto Sengupta	IIT Kanpur	Dipak Dasgupta
Sandipan Saha	IITKGP	Abhijit Sanyal
Saurabh Paul	IIT Kanpur	Asit De
Sayan Chakraborty	Calcutta U	Subrata Banerjee
Shravanti Mukherjee	Calcutta U	Nitai Bhattacharya
Shreyasi Goswami	IIT Mumbai	Amitava De

Sougata Rakshit	IIT Delhi	Prabhat Mandal
Soumee Chakraborty	NIT-Rourkela	Sita Janaki
Sreemoyee Sarkar	IITKGP	Debasish Majumdar
Subrata Dutta	IIT Kanpur	Abhijit Chakrabarti
Sugata Barui	IITKGP	Samita Basu
Suvadip Das	IIT Bombay	Parthasarathi Majumdar

List of summer students for 2008:

Name	*Affiliation*	*Mentor*
Aanindeeta Banerjee	IIT Kanpur	Udayaditya Sen
Abhinandan Madhu	IIT Kanpur	Pijushpani Bhattacharjee
Abhishek Chowdhury	IIT Kharagpur	Munshi Golam Mustafa
Agnik Dasgupta	Calcutta University	Soumen Basak
Amandeep Kaur	NIT Jalandhar	Suvendu Bose
Anjan Roy	IIT Bombay	Satyaban Bhuniya
Arghya Majee	IIT Kanpur	Asok K Sen
Arnab Ghosh	Calcutta University	Debashis Mukhopadhyay
Basudev Chowdhury	VIT Vellore	Sanghamitra Raha
Dasees Gupta	IIT Delhi	Supratic Chakrabarti
Debarati Roy	IIT Guwahati	Maitreyee Saha Sarkar
Devdeep Mukherjee	WBUT	Dalia Nayak
Lipsa Das	WBUT	Susanta Lahiri
Madhav Haridas M K	VIT Vellore	Bijay Agrawal
Md Anisur Rahaman	IIT Kharagpur	Ushasi Dutta Pramanik
Naazneen Sofeo	NIT Durgapur	Abhijit Chakrabarti
Nagarjuna Ramamurthy K	IIIT Hyderabad	Dhananjay Bhattacharyya
Pranab Kumar Das	IIT Kharagpur	Krishnakumar S R Menon
Proma Basu	NIT Durgapur	Sampa Biswas
Rajeswari Ramanathan	VIT Vellore	Abhijit Chakrabarti
Ranadeep Talukdar	IIT Kanpur	Soumen Basak
Saachi Das	WBUT	Partha Saha
Saikat Debnath	IIT Bombay	Sailendra Nath Das
Sree Deepthi Muthukrishnan	University of Madras	Subrata Banerjee

Subir Parui	IIT Kanpur	K K Bardhan
Sudeshna Ganguly	IIT Delhi	Debasish Majumdar
Sujay Ray	IIT Kharagpur	Ambar Ghosal
Tanmay Pal	IIT Bombay	Nikhil Chakrabarti

List of summer students for 2009:

Name	*Affiliation*	*Mentor*
Ananya Dutta	IIT Kanpur	Subrata Banerjee
Anirban Kundu	IIT Bombay	Y Sudhakar
Aparajita Singha	IIT Bombay	Sangam Banerjee
Arkaprabha Sarangi	IIT Bombay	Kamal Kumar Bardhan
Ashish Mittal	IIT Roorkee	Debashis Mukhopadhyay
Basudev Chakraborty	ISM Univ, Dhanbad	Sanghamitra Raha
Chinmoy Kumar Hazra	IIT Kanpur	Soumen Basak
Chirantana Sengupta	Calcutta University	Partha Saha
Debjit Kar	IIT Kanpur	Sailendranath Das
Fatema Calcuttawala	Calcutta University	Sanghamitra Raha
Kuntal Kumar Ghosh	IIT Bombay	Debasish Majumdar
Niladri Gomes	IIT Bombay	Sangam Banerjee
Pradip Dey	IIT Kanpur	Sampa Biswas
Pradipta Samanta	IIT Kanpur	Samita Basu
Sanmay Ganguly	TIFR	Palashbaran Pal
Sayoni Das	WBUT	Sanghamitra Raha
Sneha Kumar	VIT University	Nitai Pada Bhattacharya
Soham Roy	IIT Kanpur	Susanta Lahiri
Sourav Maiti	IIT Madras	Samita Basu
Sourav Sarkar	IIT Delhi	Chandidas Mukherjee
Subhodeep Barman	IIT Bombay	Bichitra Nandi Ganguly
Sumit Sahu	IIT Kanpur	Amitabha De
Susmita Adhikari	IIT Bombay	Chhanda Samanta
Tathamay Basu	IIT Bombay	Satyajit Hazra
Trina Chakraborty	IIT Kharagpur	Maitreyee Saha Sarkar
Uttam Pal	Calcutta University	Abhijit Chakrabarti

7 Research Fellows and Associates

VISITING FELLOWS/RESEARCH ASSOCIATES/RESEARCH FELLOWS

Division	*Name*	*Designation*
Theory	Dr. Swapan Majhi	Research Associate-II
Theory	Dr. Tapan Naskar	Post Doctoral Fellow
Theory	Ms. Sonika	Post Doctoral Fellow
Theory	Shri Tamal Kr. Mukherjee	Visiting Fellow
Theory	Shri Kalyan Brata Chatterjee	Senior Research Fellow
Theory	Smt. Bhramar Chatterjee	Senior Research Fellow
Theory	Shri Sovan Chakraborty	Senior Research Fellow
Theory	Shri Srijit Bhattacharjee	Senior Research Fellow
Theory	Smt. Soumini Chaudhury	Senior Research Fellow
Theory	Shri Rana Nandi	Senior Research Fellow
Theory	Shri Priti Bhajan Byakti	Senior Research Fellow
Theory	Smt. Susnata Seth	Senior Research Fellow
Theory	Smt. Susmita Kundu	Senior Research Fellow
Theory	Shri Santanu Mondal	Senior Research Fellow
Theory	Shri Raktim Abir	Senior Research Fellow
Theory	Shri Lab Saha	Senior Research Fellow
Theory	Smt. Anwesha Sarkar	Junior Research Fellow
Theory	Smt. Sangita De Sarkar	Junior Research Fellow
Theory	Md. Najmul Haque	Junior Research Fellow
Theory	Smt. Baishali Chakraborty	Junior Research Fellow
Theory	Shri Arindam Majumdar	Junior Research Fellow
Theory	Shri Somdeb Chakraborty	Junior Research Fellow
Theory	Shri Pratyay Banerjee	Junior Research Fellow

Plasma Physics	Shri Debjyoti Basu	Senior Research Fellow
Plasma Physics	Shri Subir Biswas	Senior Research Fellow
Plasma Physics	Shri Debabrata Banerjee	Senior Research Fellow
Plasma Physics	Shri Chandan Maity	Junior Research Fellow
Surface Physics	Dr. Subhendu Mondal	Post Doctoral Fellow
Surface Physics	Dr.(Smt.) Sayanee Majumdar	Post Doctoral Fellow
Surface Physics	Shri Mrinal Kanti Bera	Visiting Research Fellow
Surface Physics	Dr. Amulya Krishna Mahapatra	Post Doctoral Fellow
Surface Physics	Shri Subhrangsu Mukherjee	Senior Research Fellow
Surface Physics	Shri Biswajit Saha	Senior Research Fellow
Surface Physics	Smt. Smita Mukherjee	Senior Research Fellow
Surface Physics	Shri Rupak Banerjee	Senior Research Fellow
Surface Physics	Shri Sirshendu Gayen	Senior Research Fellow
Surface Physics	Smt. Binita Ghosh	Senior Research Fellow
Surface Physics	Shri Suman Mandal	Senior Research Fellow
Surface Physics	Shri Mojammel Haque Mandal	Senior Research Fellow
Surface Physics	Shri A.K.M. Maidul Islam	Senior Research Fellow
Surface Physics	Shri Jayanta Kumar Bal	Senior Research Fellow
Surface Physics	Smt. Paramita Chatterjee	Senior Research Fellow
Surface Physics	Md. Safiul Alam Mollick	Senior Research Fellow
Surface Physics	Shri Abhisakh Sarma	Senior Research Fellow
Surface Physics	Shri Sanjoy Kumar Mahatha	Senior Research Fellow
Surface Physics	Shri Bishnudas Ghosh	Senior Research Fellow
Surface Physics	Smt. Manjula Sharma	Senior Research Fellow
Surface Physics	Smt. Tanusree Samanta	Senior Research Fellow
Surface Physics	Shri Pabitra Das	Senior Research Fellow
Surface Physics	Shri Amaresh Metya	Junior Research Fellow
Surface Physics	Shri Santanu Maiti	Junior Research Fellow
Surface Physics	Shri Jayanta Das	Junior Research Fellow
Surface Physics	Shri Shyamal Mondal	Junior Research Fellow
Nuclear & Atomic Physics	Dr. (Smt.) Sucheta Adhikari	Research Associate-II
Do	Dr. (Smt.) Sudatta Ray	Research Associate-I
Do	Shri Dhrubajyoti Gupta	Visiting Fellow
Do	Smt. Mandira Sinha	Post Doctoral Fellow

Do	Shri Mukesh Kr. Prodhan	Senior Research Fellow
Do	Smt. Debasmita Kanjilal	Senior Research Fellow
Do	Shri Santosh Chakraborty	Junior Research Fellow
India-based Neutrino Observatory Section (INO)	Smt. Purba Bhattacharya	Junior Research Fellow
High Energy Physics	Dr. Debasish Das	Research Associate-I
High Energy Physics	Dr. Kushal Das	Post Doctoral Fellow
High Energy Physics	Shri Santosh Roy	Post Doctoral Fellow
High Energy Physics	Shri Indranil Das	Senior Research Fellow
High Energy Physics	Smt. Lusaka Bhattacharya	Senior Research Fellow
High Energy Physics	Smt. Sreemoyee Sarkar	Junior Research Fellow
Microelectronics	Shri Subhajit Karmakar	Senior Research Fellow
Theoretical Condensed Matter Physics	Dr. Anjan Chandra	Research Associate-I
Do	Dr.(Smt.) Anasuya Kundu	Post Doctoral Fellow
Do	Shri Suman Sinha	Post Doctoral Fellow
Do	Shri Debashis Samanta	Senior Research Fellow
Do	Shri Rakesh Chatterjee	Senior Research Fellow
Do	Smt. Mahashweta Basu	Senior Research Fellow
Do	Shri Debarshee Bagchi	Senior Research Fellow
Do	Shri Asim Ghosh	Senior Research Fellow
Do	Dr. Monodeep Chakraborty	Post Doctoral Fellow
Do	Smt. Paramita Dutta	Junior Research Fellow
Do	Shri Niladri Sarkar	Junior Research Fellow
Do	Smt. Moumita Dey	Junior Research Fellow
Do	Smt. Srilekha Saha	Junior Research Fellow
Do	Shri Soumyajyoti Biswas	Junior Research Fellow
Experimental Condensed Matter Physics:	Dr. Kausik Sengupta	Post Doctoral Fellow
Do	Shri Deep Talukdar	Senior Research Fellow
Do	Shri Dilip Kumar Bhoi	Senior Research Fellow
Do	Md. Nazir Khan	Senior Research Fellow
Do	Shri Mayukh Majumder	Senior Research Fellow
Do	Shri Arindam Midya	Senior Research Fellow
Do	Shri Joydip Sengupta	Post Doctoral Fellow

Crystallography & Molecular Biology	Dr.(Smt.) Sumana Roy	Research Associate-II
Do	Dr.(Smt.) Antara De	Post Doctoral Fellow
Do	Shri Dipankar Bhandari	Senior Research Fellow
Do	Smt. Anupama Ghosh (Sardar)	Senior Research Fellow
Do	Shri Anup Kumar Maity	Senior Research Fellow
Do	Smt. Moumita Datta	Senior Research Fellow
Do	Smt. Jayeeta Ghose	Senior Research Fellow
Do	Shri Sudip Majumder	Senior Research Fellow
Do	Smt. Kamalika Roy Choudhury	Senior Research Fellow
Do	Shri Sankar Chandra Basu	Senior Research Fellow
Do	Smt. Kasturi Sengupta nee Guha	Senior Research Fellow
Do	Smt. Eashita Das	Senior Research Fellow
Do	Shri Sourav Roy	Junior Research Fellow
Do	Smt. Barnali Waugh	Junior Research Fellow
Do	Smt. Seema Nath	Junior Research Fellow
Structural Genomics Section:	Dr. Sibnath Ray	Post Doctoral Fellow
Do	Smt. Sutapa Saha	Senior Research Fellow
Do	Smt. Aditi Banerjee (Sengupta)	Senior Research Fellow
Do	Smt. Mithu Raychaudhuri	Senior Research Fellow
Do	Shri Mithun Sinha	Senior Research Fellow
Do	Smt. Nandini Pal Basak	Senior Research Fellow
Do	Shri Samir Das	Senior Research Fellow
Do	Shri Sudip Kundu	Junior Research Fellow
Do	Smt. Kasturi Roy	Junior Research Fellow
Do	Smt. Suchismita Halder	Junior Research Fellow
Do	Shri Shounak Baksi	Junior Research Fellow
Biophysics	Smt. Sudipta Pal	Senior Research Fellow
Do	Smt. Madhumita Chakraborty	Senior Research Fellow
Do	Shri Suman Kalyan Pradhan	Senior Research Fellow
Do	Smt. Parijat Majumder	Senior Research Fellow
Do	Shri Shibojyoti Lahiri	Senior Research Fellow
Do	Smt. Sukanya Halder	Senior Research Fellow
Do	Smt. Swati Panigrahi	Senior Research Fellow

Do	Shri Biswapathik Pahari	Senior Research Fellow
Do	Smt. Sanchita Mukherjee	Senior Research Fellow
Do	Smt. Saptaparni Ghosh	Junior Research Fellow
Do	Shri Manas Mondal	Junior Research Fellow
Chemical Sciences	Smt. Aurkie Ray	Post Doctoral Fellow
Do	Smt. Sutapa Mondal	Senior Research Fellow
Do	Smt. Brotati Chakraborty	Senior Research Fellow
Do	Shri Manas Kumar Sarangi	Senior Research Fellow
Do	Smt. Mousumi Banerjee	Senior Research Fellow
Do	Smt. Binita Dutta	Senior Research Fellow

CSIR/UGC/DBT/DST/DAE-BRNS/CAMCS.0

Division	Name	Designation	Division
CSIR	**Dr. J.K. Dattagupta**	**Emeritus Scientist**	**C&MB**
CSIR	Dr. Moumita Maiti	Research Associate	CSD
CSIR	Smt. Nupur Biswas	Senior Research Fellow(NET)	AMS
CSIR	Shri Satya Ranjan Halder	Senior Research Fellow(NET)	SPD
CSIR	Dr. Sruti Datta	Research Associate	C&MB
CSIR	Smt. Urna Basu	SPM Fellow	TCMP
CSIR	Smt. Anita Roy	Senior Research Fellow(NET)	SGS
CSIR	Shri Arunabha Chakraborti	Senior Research Fellow(NET)	SGS
CSIR	Smt. Sreeja Chakraborty	Junior Research Fellow(NET)	CSD
CSIR	Smt. Shreyasi Dutta	Junior Research Fellow(NET)	Biophysics
CSIR	Shri Srijit Das	Junior Research Fellow(NET)	C&MB
CSIR	Shri Avik Basu	Junior Research Fellow(NET)	SGS
CSIR	Shri Ramanuj Banerjee	Junior Research Fellow(NET)	C&MB
CSIR	Smt. Ajanta Kundu	Junior Research Fellow(NET)	ANP
CSIR	Smt. Anuradha Bhattacharya	Junior Research Fellow(NET)	SPD
DST	Dr.(Smt.) Debi Chowdhury	Principal Investigator (WomenScientist Scheme-A)	
DST	Shri Hirok Chaudhuri	Junior Research Fellow	Helium
DST	Dr.(Smt.) Papri Dasgupta	Women Scientist-A	ECMP
DST	Dr. Subarna Mitra	Post Doctoral Fellow	SPD
DST	Dr. Santosh Kumar Samaddar	Principal Investigator	

DAE-BRNS	Shri Anupam Banerjee	Junior Research Fellow	CSD
DBT	Dr.(Smt.) Aruna Biswas	Research Associate	SGS
DBT	Dr.(Smt.) Lakshmishri Lahiry	Research Associate-I	SGS
UGC	Shri Swadesh Mandal	Junior Research Fellow(NET)	CSD
UGC	Shri Ajoy Mondal	Junior Research Fellow(NET)	CSD
UGC	Shri Satyajit Seth	Junior Research Fellow(NET)	Theory
CAMCS	Md. Sahinur Reja	Cavendish-Saha Research Fellow	TCMP
CAMCS	Dr.(Smt.) Kamalika Hajra (Basu)	Post Doctoral Fellow	TCMP
CAMCS	Dr.(Smt.) Alakananda Goswami (Nag)	Visiting Scientist	TCMP

Post M.Sc. 2009-2010

Stream	**Name**	**SINP Fellow**	Division
Physics	Shri Avirup Ghosh	SINP Fellow	Theory
Physics	Shri Sourish Bondyopadhyay	SINP Fellow	TCMP
Physics	Mr. Muzafar Qadir Lone	SINP Fellow	TCMP
Physics	Shri Protick Mohanta	SINP Fellow	
Physics	Shri Abhishek Chowdhury	SINP Fellow	Theory
Physics	Mr. Abdul Wahid	SINP Fellow	
Physics	Shri Mainak Chakraborty	SINP Fellow	APC
Physics	Shri Abhishek Majhi	SINP Fellow	
Physics	Smt. Ishani Roy	SINP Fellow	
Physics	Shri Suvankar Chakraborty	SINP Fellow	SPD
Physics	Shri Sudipta Mandal	SINP Fellow	ECMP
Physics	Shri Mahatsab Mandal	SINP Fellow	
Physics	Smt. Parijat Dey	SINP Fellow	Theory
Physics	Shri Anirban Biswas	SINP Fellow	APC
Physics	Md. Anisur Rahaman	SINP Fellow	
Physics	Shri Ujjal Kumar Gayen	CSIR/UGC	TCMP
Physics	Shri Abhijit Bisoi	CSIR/UGC	
Physics	Shri Sohan Kr. Jha	CSIR/UGC	TCMP
Physics	Shri Rabindra Pankaj	CSIR/UGC	
Physics	Shri Arpan Bhattacharyya	CSIR/UGC	SPD
Physics	Shri Atanu Kumar	CSIR/UGC	Theory
Physics	Shri Samik Dutta Gupta	CSIR/UGC	ECMP

Physics	Shri Kalipada Das	CSIR/UGC	ECMP
Physics	Shri Palash Khan	CSIR/UGC	HEP
Physics	Smt. Sumona Sinha	CSIR/UGC	
Biophysical Sciences	Smt. Moupiya Nag	SINP Fellow	
Biophysical Sciences	Shri Gourab Bhattacharjee	SINP Fellow	
Biophysical Sciences	Smt. Ayesha Kabir	SINP Fellow	
Biophysical Sciences	Shri Sourav Kumar Dey	SPM Fellow	
Biophysical Sciences	Smt. Shilpita Karmakar	SINP Fellow	SGD
Biophysical Sciences	Shri Mahan Ray	SINP Fellow	
Biophysical Sciences	Shri Agnik Dasgupta	SINP Fellow	
Biophysical Sciences	Smt. Poorna Roy	SINP Fellow	
Biophysical Sciences	Smt. Amrita Banerjee	SINP Fellow	Biophysics
Biophysical Sciences	Smt. Madhurima Mitra	SINP Fellow	
Biophysical Sciences	Smt. Rakhi Paul	SINP Fellow	
Biophysical Sciences	Shri Kaustab Ghosh	CSIR/UGC	CSD
Biophysical Sciences	Shri Kallol Bera	CSIR/UGC	CSD
Biophysical Sciences	Smt. Anindita Deb	CSIR/UGC	SGD
Biophysical Sciences	Shri Ankan Datta Chowdhury	CSIR/UGC	CSD
Biophysical Sciences	Shri Sujay Ghosh	CSIR/UGC	CSD
Biophysical Sciences	Shri Debabrata Adak		APC

8 Science Review

Academic Review of the Institute

Subject area : Condensed Matter Physics (CMP) including

Surface Physics and Nanoscience

Members of the Review Committee:

1. Prof. Peter Pershan, Harvard University, USA
2. Prof. Sir Michael Pepper, University College, London, UK
3. Prof. T V Ramakrishnan, Benaras Hindu University, Varanasi
4. Prof. Peter Littlewood, Cambridge University, London, UK
5. Prof. Samuel Bader, Argonne National Laboratory, USA
6. Prof. Ajay Sood, Indian Instituite of Science, Bangalore
7. Prof. Mustansir Barma, Tata Institute of Fundamental Research, Mumbai
8. Prof. E V Sampathkumaran, Tata Institute of Fundamental Research, Mumbai
9. Prof. S K Joshi, National Physical Laboratory, Delhi

Period of review : August 31 - September 2, 2010

Subject area : Biophysical Sciences including Chemistry

Members of the Review Committee:

1. Prof. Akira Ishihama, Hosei University, Japan
2. Prof. Alan Cooper, University of Glasgow, Scotland, UK
3. Prof. Maxim Frank-Kamenetski, Boston University, Boston, USA
4. Prof. M R S Rao, JNCASR, Bangalore
5. Prof. M Vijayan, Indian Instituite of Science, Bangalore
6. Prof. Ch Mohan Rao, CCMB, Hyderabad
7. Prof. T K Chandrashekar, NISER, Bhubaneswar
8. Prof. G Padmanabhan, Indian Instituite of Science, Bangalore

Period of review : November 25 - 27, 2010

Subject area : Plasma Physics

Members of the Review Committee:

1. Prof. Abhijit Sen, Institute of Plasma Research, Gandhinagar
2. Prof. Paul M Bellan, California Institute of Technology, Pasadena, USA
3. Prof. A Surjalal Sharma, University of Maryland, College Park, USA

   Period of review : December 3, 2010

Subject area : Applied Nuclear Physics, High Energy Nuclear and Particle

Physics and Nuclear Physics

Members of the Review Committee:

1. Prof. V S Ramamurthy, NIAS, Indian Instituite of Science, Bangalore
2. Prof. Gilles de France, GANIL, CAEN, France
3. Prof. B R Fulton, University of York, Heslington, York, UK
4. Prof. Nasser Kalantar, KVI, Groningen, The Netherlands
5. Prof. Witold Nazarewicz, University of Tennessee, Knoxville, Tennessee, USA
6. Prof. Tony Noble, Queen's University, Kingston, Ontario, Canada
7. Prof. Ludivico Riccati, INFN, Torino, Italy
8. Prof. Deepak Mathur, Tata Institute of Fundamental Research, Mumbai
9. Prof. S B Patel, University of Mumbai, Mumbai
10. Dr. Amit Roy, Inter Universities Accelerator Centre, New Delhi

    Period of review : December 6-8, 2010

Subject area : Theoretical Physics including Mathematics

Members of the Review Committee:

1. Prof. Luis Alvarez-Gaume, CERN, Geneva, Switzerland
2. Prof. Emmanuel Paschos, Technical University, Dortmund, Germany
3. Prof. Sudhendu Rai Choudhury, IISER, Bhopal
4. Prof. Sanjay Reddy, Los Alamos National Laboratory, Los Alamos, USA
5. Prof. Subir Sarkar, University of Oxford, Oxford, UK
6. Prof. Riu Sasaki, Kyoto University, Japan
7. Prof. Virendra Singh, Tata Institute of Fundamental Research, Mumbai
8. Prof. Peter Weisz, Max Planck Institute of Physics, Munich, Germany

   Period of review : December 13-15, 2010

9 Facility

Computer

Developmental Work

Post April 2007, the Computer Section has undertaken the following development and enhancement works

1. Installation of wireless services in the entire SINP campus.
2. Installation of more modules for Matlab and Mathematica Softwares.
3. Procurement of software licenses of sytem and aplication softwares for servers and desktops.
4. Augmentation of local network to the 3rd phase and 4th phase in the Salt Lake Campus.
5. Installation of 60 KVA UPS systems for it's data center and numerous 1.5/2 KVA for network components.
6. Upgradation of internet bandwidth from 2mbps/256kbps to 18mbps/12mbps.
7. Procurement of Power 6 SMP architecture machines for scientifc computing.
8. Procurement of new router and switches to accomodate the earlier mentioned network expansion.
9. Procurement of new Desktops/Laptops for it's users and for section use.
10. Procurement of a new Digital Copier.
11. Procurement and enhancement of existing HA Cluster setup to a new infrastruture with DC-DR functionality and exnterprise class backup is underway.

Publications

1. G.Garai and B.B.Chaudhurii, "A Novel Pattern Matching Technique with Hybrid Genetic ALgorithm ", Proc. of the IEEE TENCON 2009, Singapore,, November 23-26, Online version: http://dx.doi.org/2010.1109/ TENCON.2009.5395860 <http://dx.doi.org%2010.1109/ TENCON.2009.5395860>, 2009.
2. B. B. Chaudhuri, G. Garai, "Grid clustering with Genetic Algorithm and Tabu Search Process", Journal of Pattern Recognition Research, 1(2009), pp. 152-168.

3. G. Garai and B. B. Chaudhurii, “Hybrid Genetic Algorithm for 2-D Dot Pattern Matching problem”, Proc. of the National Conf. on Research and Development in Hardware & Systems (CSI_RDHS 2008), Kolkata, India, June 20-21, 2008, pp.55-58.

4. G. Garai and B. B. Chaudhuri, “A distributed hierarchical genetic algorithm for efficient optimization and pattern matching”, Pattern Recognition, Vol. 40, 2007, pp. 212-228.

Centre for Advanced Research & Education (CARE)

The CARE has been running the undergraduate associate (UGA) program in Physics and Biophysics with about 60 students from all over the country, organizing the summer project program (30 students), institutes colloquium, monthly seminars on the history and popular science, foundation day lecture, open house for high school and college students, visits of the science gallery and SINP labs to KVPY & JBNSTS fellows, science day celebration and arranging visits of students from high school and undergraduate colleges to SINP. The CARE has been acting as the nodal center of SINP for the Homi Bhabha National Institute.

CARE has set-up laboratory cum classroom for the undergraduate associates and summer students. CARE Lab presently has good computational facilities and three spectroscopy set-ups on Electronic absorption, emission and laser based experiments. For biophysical studies, chromatography set-up, refrigerated centrifuge, pH metre, balance and PCR machines have been used in the Lab.

The Centre for Advanced Research and Education (CARE) stands for a novel effort in establishing a symbiotic relation between the educational institutions and the centre of scientific research in the country. Undergraduate Associate (UGA) program involves bright undergraduates in physics, chemistry and biophysical sciences all over India coming to the Institute during vacation periods, taking advanced level courses and doing actual research projects. Summer Students’ program has been running successfully. In June 2010 CARE has been made a Central Facility.

Electron Micorscope Facility

Transmission Electron Microscope Facility is working as an independent facility and equipped with a 200kV Transmission Electron Microscope. It caters to the need of researchers of almost all divisions of the Institite to study biological samples like bacteria & their thin section, lipid vesicles, detergent micelles,lipid-protein complexes, peptide aggregation, material sciences samples like nanomaterials, metal oxides, nanocrystalline solids, diamond like carbon etc. Other research institutes and universities e.g. VECC, IACS, CGCRI, Jadavpur University, Calcutta University, Kalany University, WBUT, DAE-IUC, SNBCBS, IIT (Kgp), Presidency College etc. use the E.M. Facility extensively. Some of the institutes outside West Bengal, also use the facility, e.g. Benaras Hindu University, NIT-Rourkela, Rajiv Gandhi Centre-Trivandram, Tezpur University to name a few. The instrument has been utilized more than 90% of the available days. More than 33 publications have come out in reputed scientific journals, contributed by different scientists using the Transmission Electron during this period. In December 2010 this has been made a Central Facility.

Electronics Workshop Facility

The Electronics Workshop Facility (EWF) is a central facility of the Institute. It caters to the different electronics-related requirements of different experimental projects of the Institute. It can provided services in the following possible areas:

a) Design, development and modification of electronic circuits/modules/ equipment/ systems.

b) Fabrication, testing and installation of electronic gadgets as per the design given by the user.

c) Maintenance and servicing of the general purpose electronic equipment including nuclear instrumentation modules.

d) Fabrication of Printed Circuit Boards.

e) Calibration of Multimeters and some electronic instruments.

f) Providing technical information on various electronic components and on any electronics related problems.

g) Training to Engineering students for completing their vocational projects.

Radiological Safety

As per the rules of Atomic Energy Regulatory Board, Government of India, centralised documentation of personal dose records of radiation workers of the Institute are maintained. Renewal and issuance of TLD and CR39 personnel monitoring badges, radiation protection survey of radioactive hot laboratory, maintenance of inventory and supervision of safe storage and handling of radioactive isotopes, disposal of solid and liquid radioactive wastes,maintenance of the Environmental TLD monitor as supplied by the Environmental Assessment Division, BARC, Mumbai, through HPU, VECC, Calcutta are carried out.

Library

The Library of SINP is one of the major information resource centres in the Eastern India in the field of Physics, Biophysics and Biochemistry.

The Library is privileged to support the institute's march towards its vision to be the pioneer research Institute of India. It strives to connect outstanding faculty, staff and brilliant research scholars, engineers at the SINP and other institutions of DAE. The Library not only acquires, organizes and disseminates knowledge; it has put its foot ahead towards policies and procedures, systems and services and created a suitable atmosphere which facilitates assimilation and generation of new knowledge through single window. The details of our library are given below.

MEMBERSHIP:

- **Number of members & types of facilities are available for each category of members.**
- **(A) SINP members (No. 600)**
    (1) Borrowing facility

(2) Xerox facility

(3) Inter-library-loan

(4) Online searching & downloading.

- **(B) VECC members (No. 119)**

  (1) Borrowing facility

  (2) Online searching & downloading

- **(C) External members (No. 562)**

  (1) Reading room facility for reference use

  (2) Xerox facility against payment

  (3) Online searching & downloading

- **(D) Institutional Members**

  (1) Reading room facility for reference use

  (2) Borrowing facility

  (3) Online searching & downloading

Collection: Library has a huge collection of books & non-book materials.

- Books: 30406 (technical) + 3776 (non-technical)
- Bound volumes of journals: 49274
- Subscribed journals: 200 (Foreign 143 + Indian 57)
- Reports: 25000
- Number of CD/DVD Rom: 876

Online Archive/E-books:

Library has more than 3000 online journals as well as online archives of the following publishers from volume one to current:

1. Institute of Physics, London
2. AIP/APS
3. American Chemical Society
4. Wiley-Interscience
5. World Scientific
6. Springer
7. Taylor & Francis
8. Science Classic
9. Nature Publishing Group

Library has the online e-books (2800+) of ebrary (Physical & life science) & serial publications of Annual Reviews. Library also has “Web of Science” from 1945.

•**Major achievements for digitization:**

Year 2007-2008:

- Set-up a Cyber zone
- E-Brary ebooks (Life & Physical Sciences - 2800 titles)
- Nature Journals Achieve (NPG)
- Subscription of Science Classic (Volume 1 onwards)
- Wiley Journals Achieve (Materials Science & Biotech)
- Ten Pc (IBM/Lenovo desktop)
- ISI Web of Science
- **Year 2008-2009:**
- Journal of Fluid Mechanics Archive (Cambridge) 1956-1996
- World Scientific Journals archive (MPLB & Surface Review & Letters)
- Turpion Archive Perpetual
- **Year 2009-2010:**
- World Scientific Journal Archive (Six titles)
- Wiley Journal Archive (Physics & Astronomy)
- Hp Scanjet 4050
- ACS Legacy Archives (Volume 1 onwards)
- IoP journals Archive 1974-1998
- Electronic Back volume of Annual Reviews
- Springer Lecture Notes in Physics (V.1 - 476)

Publication & Documentation

- SINP Annual Reports
- SINP Progress Reports.
- Preservation and Digitization of documents and artifacts of M.N.Saha Archive.
- Visual Archive: Making CDs, Preserving the photos in albums.
- Started making History of Various Departments, Sections. History of CARE, SINP is prepared and ready to publish
- Helping in Research and Education on History of Science

- Organizing "History of Science and Technology Conference"/Popular Lectures related to History of Science and Archive.

  Conference

  National Symposium on History of Indian Science and Technology: Pre and Post Independence Era(HISTPPIE-07),was jointly organised by P&D Unit & CARE ,SINP on October 4-5, 2007

  Popular Lectures

  Science, Nationalism and Colonial Contestations: P.N.Bose talk given by Dr. Subhayu Chattopadhyay, Dept of History, Visvabharati University on June 8, 2007 at SINP Lecture Hall

- Making Scientific Posters for different special occasion in SINP. A Tale of Two Giants: Prof Meghnad Saha and Prof. H.N. Russell a.nd Saha and Freedom Movement of India were displayed on the occasion of Inauguration of National Symposium on History of Indian Science and Technology: Pre and Post Independence Era (HISTPPIE-07) on October 4-5, 2007.

  Sir J.C.Bose and Marconi controversy was displayed on the occasion of 149th Birthday of Sir Jagadish Chandra Bose on November 30, 2007 at SINP.

  Bird Flu: a growing threat" was displayed on the occasion of Science Day Celebration on 28th Feb,2008 at SINP.

- Compiling scientific booklets after Poster Presentation

- Participations in Science Day Celebrations.

  Posters were displayed in Meghnad Saha Mancha by the members of P&D Unit on the occasion of 15th State Science and Technology Congress on 28th Feb.2008 at Bengal Engineering and Science University, Shibpur, jointly organised by DST, Govt. of West Bengal & BESU in collaboration with Pashimbanga Vigyan Mancha

- Members of P&D Unit have participated and presented papers in National Conferences like

  a) Conference on Recent Advances in Information Science and Technology"(READIT-2007) from July12-13,2007 at Indira Gandhi Centre for Atomic Research, Kalpakkam.

  b) National Conference on Digitisation and Digital Preservation from Dec.11-12, 2008 at Indian National Science Academy, New Delhi , organised by Defence Scientific Information and Documentation Centre,Defence Research and Development Organisation, New Delhi.

  Since June 2010 it has been merged with the CARE

Central Workshop

The Computerized Numerical Control (CNC) machine tools, installed in the workshop, are continuously being used in fabrication of precission experimental devices for different departments of the Institute. The welding section in the workshop is equipped with a pulse TIG welding machine, a plasma cutting machine, an arc welding machine and gas welding facility. This section has successfully developed its skill in welding of thin walled stainless steel and aluminium components. The Glass blowing section is one of the best performing sections of the workshop. This section completed 87 jobs during the year including some complicated quartz items. Most of the components, fabricated in the workshop were designed and drafted by the design & drafting section. Workshop also prepared posters, diagrams and charts for scientific presentations in the various conferences.

Medical Benefit Scheme

The Institute runs a Contributory Medical Benefit Scheme (CMBS) for all its employees and their dependents with credit facilities in 13 leading hospitals of Kolkata.

Building Maintenance (Civil)

Building Maintenance (Civil) section was involved in activities of different nature related to the day-to-day maintenance work, up-keeping of the whole institute campus and its surroundings and implementation of various Infrastructural development projects of this institute. The specific fields are as follows:

- The section was involved in maintenance of all the civil related existing facilities in the institute e.g., (i) maintenance of all R.C.C. & steel building structures, (ii) water supply, plumbing and sanitary systems, (iii) carpentry trade, (iv) gardening and landscaping , (v) house-keeping etc. in the office premises as well as in two housing complexes.
- The Section renders their services in renovation, modification and extension works of various laboratories according to their requirements.
- The Section is associated with the development and beautification of the open areas with greeneries.
- The section takes up project related to infrastructure development works like site development, temporary roads, fencing work, water supply and drainage facilities.

Building Maintenance (Electrical)

- The divisional activity is multifaceted and spread over, developmental electrical projects, extension of existing electrical system to suit requirements, induce flexibility in existing electrical system by introducing improvised mechanism, imposing higher protection to system depending on their vulnerability and maintenance of the total electrical system on annual and daily basis.
- As major developments the following changes in the electrical system have been made to assert the demand and consumption of SINP, MDI (Maximum Demand Indicator) has been successfully introduced with summation metering and thus can be compared with demand and consumption raised by VECC. To minimize the power consumption; twilight switching to outdoor lighting has been introduced; so also we have introduced CFL lamps instead of conventional fluorescent lamps of higher wattage. Age old less reliable MOCB (Minimum Oil Circuit Breaker) has been replaced with SIEMENS' make VCB (Vacuum Circuit Breaker) to increase reliability of the electrical system and reduce maintenance.

Telephone Section

The Telephone Section was set up in 1984 with 3+9 EPBX. Since then the Section has been grown up steadily. Presently a large EPABX system (ARIA-1000, AGC Networks Ltd.) with 500 Extension lines is being operated. The Section maintained telephone lines, extensions and cables with the help of Building Maintenance Electrical Divisions and processes the monthly Telephone Bills of Institute through proper channel. The Section always keeps contact with BSNL, local exchange for rectification of any type of external fault. Updating of Telephone Directory at Website is carried out routinely.

Auditorium Complex

The SINP Auditorium Complex is mainly used for holding various programmes, seminars, symposium, Conferences of national and international stature, etc.

Programmes Held

2007-08	32
2008-09	41
2009-10	74

Guest House

Guest House provides accommodation in 4 rooms with double occupancy throughout the year. Student hostel provides accommodation of Girl student of 13 nos. and Boy students of 36 numbers. Students include Ph D student as well as Post M Sc Students. There is separate canteen facility for the students only. These facilities for the students are provided throughout the year.

Departmental Canteen

The SINP Departmental Canteen remains active from 8 AM to 8 PM for preparation and serving food to members and guests of the Institute. The performance begins by receiving raw materials early morning, followed by preparation of cooking lunch and breakfast items. The Canteen serves breakfast, lunch, afternoon tea and snacks and evening meal. Occasionally canteen also serves special food for guest of the Institute coming for meeting and small conferences.

10 Administration

GOVERNING COUNCIL

Dr. Srikumar Banerjee
Chairman, Atomic Energy Commission &
Secretary to the Government of India
Department of Atomic Energy, *Mumbai*

Professor Dhrubajyoti Chattopadhyay
Pro Vice-Chancellor (Academic)
University of Calcutta
Calcutta

Professor P. K. Kaw
Director
Institute for Plasma Research
Near Indira Bridge Ghat
Gandhinagar

Chief Secretary
Chief Secretary,
Government of West Bengal

Professor Mustansir Barma
Director
Tata Institute of Fundamental Research
Mumbai

Smt. Revathy Iyer
Joint Secretary (R&D) to the Government of India
Department of Atomic Energy, Mumbai

Shri. V. R. Sadasivam
Joint Secretary (Finance)
Govt. of India
Department of Atomic Energy

Prof. Susanta Sen
Dean, Faculty Council for Post-Graduate Studies
in Technology,
Institute of Radiophysics & Electronics,
University of Calcutta

Professor Amitava Raychaudhuri
Director
Harish Chandra Research Institute
Allahabad

Professor Milan K. Sanyal
Director
Saha Institute of Nuclear Physics
Kolkata

Mr. V V Mallikarjuna Rao (Ex-Officio Secretary)
Registrar
Saha Institute of Nuclear Physics
Kolkata

Purchase Section

No of Purchase order Placed:

	Foreign	Domestic
2007-08	184	1159
2008-09	263	1338
2009-10	132	1001

Accounts Section

The main functions of the Accounts as supporting unit to assist the research and development activities of the Institute are:

i. Management of funds both of DAE (More than Rs.100.00 Crores per annum including recurring and non-recurring) and other sponsors' projects.

ii. Payment of Salary to the academic as well as non-academic staff and fellowship to Research Fellows.

iii. Timely payment of bills for procurement of consumables and equipments

iv. Remittance to foreign supplies through Bank

v. Reimbursement of other facilities to the employees of the Institute like (a) LTC (b) Medical (c) Tution fees (d) Liveries to the Auxiliary Staff.

Establishment Section

This section is involved in the recruitments and promotion of staff (Academic/Technical/ Adm/Auxiliary), consolidation of weekly/monthly absentee statements received from about 30 Divisions/Sections, retirement and internal posting, all leave related matters, pay fixation, preparation of holiday list, LTC, leave encashment, issuance of identity cards and certificates of different kinds, RTI matters, publication of advertisement/s regarding recruitment/tender to name a few and many other administrative jobs for the smooth running of the Institute.

SAHA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2008

	Schedule	2007-08	2006-07
CAPITAL FUND & LIABILITIES			
Capital Fund	1	456427760.77	608,481,014.71
Capital Reserve	2	7116996.30	7,116,996.30
Earmarked Funds	3	17292672.00	15,750,048.00
Current Liabilities and Provisions	4	1085646293.95	1,045,137,040.54
TOTAL		**1566483723.02**	**1576485097.55**
ASSETS			
Fixed Assets			
Gross Block	5	1670170516.17	1,615,433,400.93
Less : Accumulated Depreciation	5	522154673.00	440271032.00
		1148015843.17	1175162368.93
Investment	6	42309095.00	143606232.11
Current Assets, Loans & Advances	7	376158784.85	257716495.51
TOTAL		**1566483723.02**	**1576485097.55**
Significant Accounting Policies	15		
Contingent Liabilities and Notes on Accounts	16		

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(Bikash Sinha)
Director

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road
2nd Floor, Kolkata-700 001
Dated : 25th August, 2008

SAHA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2008

	Schedule	2007-08	2006-07
INCOME :			
Income from Sales/Services	8	152330.00	637970.00
Grants	9	333106727.28	333085286.38
Interest Earned	10	14085395.89	7416246.00
Other Income	11	11612384.27	3162512.50
Prior Period Income			
Excess of Expenditure over Income transferred to Capital Fund		101641338.18	138360917.00
TOTAL		**460597175.62**	**482662831.88**
EXPENDITURE :			
Establishment Expenses	12	249436276.00	220907873.00
Administrative Expenses	13	129249996.54	173497479.00
Interest/Bank charges	14	27262.08	116339.88
Depreciation	5	81883641.00	88141240.00
TOTAL		**460597175.62**	**482662931.88**

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(Bikash Sinha)
Director

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road
2nd Floor, Kolkata-700 001
Dated : 25th August, 2008

SAHA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Accounts for the year ended 31st March, 2008

Receipts	2006-07	2007-08	Payments	2006-07	2007-08
Opening Balance b/f :-			Establishment Expenses	183811873.00	204838546.00
Cash in hand	29044.00	424089.00	Administrative Expenses	172014652.00	127780187.54
Current Account Balances	95214712.52	9839110.53	Bank charges	116339.88	27262.08
Grant-in-aid received from DAE :-			Assets	118572582.00	54737115.24
Recurring	257000000.00	286000000.00	Expenses paid for ongoing projects		
Non-Recurring	215000000.00	206800000.00	of other agencies	74639010.00	14536459.87
Housing	2500000.00		HBA & Other Advances paid	2680541.00	2365793.00
Grant received from other agencies			Margin Money deposit	200776347.00	132113708.75
for on going projects	145116421.50	32633067.92	Other Deposit	127100.00	40600.00
HBA & Other Advance recovery	2503360.00	2851532.00	Advances paid	11838694.00	8911709.82
Realisation of Margin Money Deposit	149006950.00	206654226.00	Prepaid Expenses	117852.00	
Realisation of other deposits	145000.00	519881478.11	Last Year's provision paid	1595077.00	1462627.00
Interest Received	7416246.00	14085395.89	Last Year's current liabilities paid ;-		
Miscellaneous Receipt	3800482.50	5810984.27	Professional Tax		200.00
Refund of CPF Contribution			Income Tax	109018.00	
Earnest Money Receipt	592250.00		Sales Tax	19518.00	
GSLIS Claim Receipts	132		Other Current liabilities		73748.00
Pension Fund Receipts	1275405.00	1307456.00	Investment	99336618.11	418550341.00
Current Liabilities :			Security Money Refunded	4093363.00	231570.00
Professional Tax	200		Earnest Money Refunded		76750.00
Sales Tax		4.00	Closing Balance c/f :-		
Other liabilities	511581.00		Cash in hand	424089.00	387697.00
			Current Account Balance	9839110.53	189302928.42
	880111784.52	**1286287343.72**		**880111784.52**	**1286287343.72**

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

(Bikash Sinha)
Director

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road, Kolkata-700 001
Dated : 25th August, 2008

SAHA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2009

	Schedule	2008-09	2007-08
CAPITAL FUND & LIABILITIES			
Capital Fund	1	464275215.39	456,427,760.77
Capital Reserve	2	7116996.30	7,116,996.30
Earmarked Funds	3	19367804.00	17,292,672.00
Current Liabilities and Provisions	4	1454418543.64	1,085,646,293.95
TOTAL		**1945178559.33**	**1,566,483,723.02**
ASSETS			
Fixed Assets			
Gross Block	5	1907367564.54	1670170516.17
Less : Accumulated Depreciation	5	634875166.00	522164673.00
		1272492398.54	1148015843.17
Investment	6	9861283.00	42309095.00
Current Assets, Loans & Advances	7	662824877.79	376158784.85
TOTAL		**1945178559.33**	**1566483723.02**
Significant Accounting Policies	15		
Contingent Liabilities and Notes on Accounts	16		

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(Milan K. Sanyal)
Director

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road
2nd Floor, Kolkata-700 001
Dated : 23rd October, 2009

SAHA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2009

	Schedule	2008-09	2007-08
INCOME :			
Income from Sales/Services	8	921250.00	152330.00
Grants	9	584433688.19	333105727.28
Interest Earned	10	9742699.00	14085395.89
Other Income	11	5416376.25	11612384.27
Prior Period Income			
Excess of Expenditure over Income transferred to Capital Fund		565624112.75	101641338.18
TOTAL		**1166138126.19**	**460597175.62**
EXPENDITURE :			
Establishment Expenses	12	847311325.09	249436276.00
Administrative Expenses	13	206041900.42	129249996.54
Interest/Bank charges	14	64407.68	27262.08
Depreciation	5	112720493.00	81883641.00
TOTAL		**1166138126.19**	**460597175.62**

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(Milan K. Sanyal)
Director

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road
2nd Floor, Kolkata-700 001
Dated : 23rd October, 2009

SAHA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Accounts for the year ended 31st March, 2009

Receipts	2007-08	2008-09	Payments	2007-08	2008-09
Opening Balance b/f :-			Establishment Expenses	204838546.00	389822325.09
Cash in hand	424089.00	387697.00	Administrative Expenses	127780187.54	195228358.42
Current Account Balances	9839110.53	189302928.42	Bank charges	27262.08	64407.68
Grant-in-aid received from DAE :-			Assets	54737115.24	237197048.37
Recurring	285000000.00	416300000.00	Expenses paid for ongoing projects		
Non-Recurring	206800000.00	603900000.00	of other agencies	14536459.87	53857467.00
Housing			HBA & Other Advances paid	2365793.00	2117339.00
Grant received from other agencies			Margin Money deposit	132113708.75	500261382.00
for on going projects	32633067.92	26385568.00	Other Deposit	40500.00	80845.00
HBA & Other Advance recovery	2851532.00	3615772.00	Advances paid	8911709.82	68007263.25
Realisation of Margin Money Deposit	206654226.00	177751982.54	Prepaid Expenses		
Realisation of other deposits	519881478.11	435173000.00	Last Year's provision paid	1482627.00	1505336.00
Interest Received	14085395.89	9742699.00	Last Year's current liabilities paid ;-		
Miscellaneous Receipt	5810984.27	5330884.35	Professional Tax	200.00	
Earnest Money Receipt		7990642.00	Other Current liabilities	73748.00	
Pension Fund Receipts	1307456.00	2725188.00	Investment	418560341.00	402725183.00
Current Liabilities :			Security Money Refunded	231570.00	525871.00
Income Tax		104779.00	Earnest Money Refunded	76750.00	
Professional Tax		390.00	Closing Balance c/f :-		
Sales Tax	4.00	24141.00	Cash in hand	387697.00	199888.00
Other liabilities		54434000.00	Current Account Balance	189302928.42	81577162.12
	1286287343.72	**1933169681.21**		**1286287343.72**	**1933169681.21**

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
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(V. V. Mallikarjuna Rao)
Registrar

(Milan K. Sanyal)
Director

In terms of our attached Report of even date
For Dutta Sarkar & Company
CHARTERED ACCOUNTANTS

(K. M. Roy)
Partner
7A, Kiron Sankar Roy Road, Kolkata-700 001
Dated : 23rd October, 2009

SAHA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2010

	Schedule	2009-10	2008-09
CAPITAL FUND & LIABILITIES			
Capital Fund	1	535279262.02	464275215.39
Capital Reserve	2	7116996.30	7116996.30
Earmarked Funds	3	22482568.00	19367804.00
Current Liabilities and Provisions	4	2006291015.25	1454406048.64
TOTAL		**2571169841.57**	**1945166064.33**
ASSETS			
Fixed Assets			
Gross Block	5	2346438382.25	1907367564.54
Less : Accumulated Depreciation	5	846836405.08	6348.75166.00
		1499601977.17	1272492398.54
Investment	6	212458448.00	9861283.00
Current Assets, Loans & Advances	7	859109416.40	662812382.79
TOTAL		**2571169841.57**	**1945166064.33**
Significant Accounting Policies	15		
Contingent Liabilities and Notes on Accounts	16		

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Nemani Garg Agarwal & Co
CHARTERED ACCOUNTANTS

(Milan K. Sanyal)
Director

(Nirmal Kr. Pal)
Partner
135, B R Basu Road,
2nd Floor, Kolkata-700 001
Dated : 29th October, 2010

SAHA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2010

	Schedule	2009-10	2008-09
INCOME :			
Income from Sales/Services	8	78960.00	921250.00
Grants	9	730731939.26	584433688.19
Interest Earned	10	8038216.00	9742699.00
Other Income	11	2700168.00	5416376.25
Prior Period Income			
Excess of Expenditure over Income transferred to Capital Fund		162609419.08	565624112.75
TOTAL		**904158702.34**	**1166138126.19**
EXPENDITURE :			
Establishment Expenses	12	528371206.00	847311325.09
Administrative Expenses	13	163802411.26	206041900.42
Interest/Bank charges	14	23846.00	64407.68
Depreciation	5	211961239.08	112720493.00
TOTAL		**904158702.34**	**1166138126.19**

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

In terms of our attached Report of even date
For Nemani Garg Agarwal & Co
CHARTERED ACCOUNTANTS

(Milan K. Sanyal)
Director

(Nirmal Kr. Pal)
Partner
135, B R Basu Road,
2nd Floor, Kolkata-700 001
Dated : 29th October, 2010

SAHA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Accounts for the year ended 31st March, 2010

Receipts	2008-09	2009-10	Payments	2008-09	2009-10
Opening Balance b/f :-			Establishment Expenses	389822325.09	360475206.00
Cash in hand	387697.00	199868.00	Administrative Expenses	195228358.42	157160299.26
Current Account Balances	189302928.42	81577182.12	Bank charges	64407.68	23846.00
Grant-in-aid received from DAE :-			Assets	237197048.37	439070817.71
Recurring	416300000.00	526700000.00	Expenses paid for ongoing projects		
Non-Recurring	603900000.00	815000000.00	of other agencies	53857467.28	44338665.92
Grant received from other agencies			HBA & Other Advances paid	2117339.00	3100149.00
for on going projects	26385568.00	107418650.50	Investment	402725188.00	202597165.00
HBA & Other Advance recovery	3615772.00	3020470.00	Margin Money deposit	500261382.00	183794821.00
Realisation of Margin Money Deposit	177751982.54	396343162.00	Other Deposit	80845.00	60079760.00
Realisation of other deposits	435173000.00		Advances paid	68007263.25	159229256.00
Interest Received	9742699.00	8038216.00	Prepaid Expenses		
Income Receipt	5330864.25	2779128.00	Last Year's provision paid	1505336.00	9806780.00
Pension Fund Receipts	2725188.00	2594441.00	Last Year's current liabilities paid		55280854.00
Increase in Current Liabilities	62028311.00				
			Closing Balance c/f :-		
			Cash in hand	199868.00	409422.00
			Current Account Balance	81577182.12	268304075.73
	1932644010.21	**1943671117.62**		**1932644010.21**	**1943671117.62**

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(V. V. Mallikarjuna Rao)
Registrar

(Milan K. Sanyal)
Director

In terms of our attached Report of even date
For Nemani Garg Agarwal & Co
CHARTERED ACCOUNTANTS

(Nirmal Kr. Pal)
Partner
135, B R Basu Road, 2nd floor, Kolkata-700 001
Dated : 29th October, 2010

11 Staff List

AS ON 31.03.2010

Prof. Milan K. Sanyal : Director

ADMINISTRATION

1. DIRECTOR'S SECRETARIATE

1. Shri Amalesh Chandra Saha : A.A.O. (D.O.)
2. Sri Subhasish Ghosal : U.D.C.
3. Sri Gautam Mandal : U.D.C.
4. Sri Ratan Lal Ram : Technician 'C'
5. Sri Babu Rajak : Helper 'B'

2. REGISTRAR'S OFFICE

1. Sri V. V. Mallikarjuna Rao : Registrar
2. Sri Alok Mitra : A.A.O.(R.O.)
3. Sri Bimlesh Kr. Tripathi : Sr. Hindi Translator
4. Sri Bibekbijay Bandyopadhyay : U.D.C.
5. Sri Rudal Prasad Ram : Technician 'C'
6. Sri Mahadev Das : Helper 'E'

3. ESTABLISHMENT

1. Sri S. K. Gupta : Establishment Officer
2. Sri Biplab Kumar Ray : A.A.O.(E-I)
3. Sri Prasanta Kumar Das : Sr. Superintendent
4. Smt. Chandana Basu : Sr. Superintendent
5. Smt. Suparna Das : Senior Assistant
6. Sri Asim Haldar : U.D.C.
7. Sri Rajeswar Roy : Driver V
8. Sri Subhash Ch. Gayen : Technician 'B'

4. DESPATCH

1. Smt. Chandana Mitra : Sr. Superintendent
2. Sri Tapan Chakraborty : Superintendent
3. Sri Swadesh Ch. Deb : U.D.C.
4. Sri T. N .Bhattacharya : Technician 'B'
5. Sri Pintu Ram : Helper 'B'

5. ACCOUNTS

1. Sri Niladri Sanyal : Dy. Controller of Accounts
2. Sri V. P. Mishra : Accounts Officer
3. Sri S. K. Bose : A.A.O.(Cash)
4. Sri M. Dey : A.A.O.(Budget)
5. Sri Asit Ranjan Deb : A.A.O.(Bills)
6. Sri Ram Mohan Moitra : A.A.O.(Salary)
7. Sri Niranjan Sarkar : A.A.O.(PF & Pension)
8. Sri T. K. Bhattacharyya : Sr. Superintendent
9. Sri Ashoke Maity : Sr. Superintendent
10. Sri Somnath Sarkar : Accountant
11. Smt. Tul Tul Dutta : Superintendent
12. Sri Ranjit Dutta : Superintendent
13. Sri Gautam Ghosh : Sr. Assistant
14. Sri Rathu Nath Naskar : Sr. Assistant
15. Sri Avijit Saha : U.D.C.
16. Sri Mantu Bhattacharjee : U.D.C.
17. Smt. Seethalakshmi Rath : U.D.C.
18. Sri Sanat Kumar Kotal : Technician 'B'
19. Sri Madhu Bose : Helper 'E'
20. Sri Biswanath Paul : Helper 'E'
21. Sri Kartick Hari : Helper 'E'
22. Sri Pradip Dutta Sharma : Helper 'C'
23. Sri Pradip Das : Driver V
24. Sri Pradip Ram : Bearer-II

6. PURCHASE SECTION

Smt. Seema Bhattacharya : A.O.-III & Overall-in-charge of Purchase Section.

6A. DOMESTIC CELL

1. Sri Sanjoy Chakraborty : A.P.O.(Purchase-Domestic)
2. Sri Ashim Kumar Sarkar : Sr. Superintendent
3. Sri Shyamal Chandra Biswas : Superintendent
4. Sri Ajoy Kumar Biswas : Sr. Assistant
5. Ms. Rekha Ram : L.D.C.
6. Sri Ashok Kr. Roy : Helper 'C'

6B. FOREIGN CELL

1. Sri J. S. Raychaudhuri : A.P.O.(Purchase-Foreign)
2. Sri Sankar Nath Dewan : Sr. Superintendent
3. Sri Debasish Das : Sr. Superintendent
4. Sri Gobinda Chakraborty : Superintendent
5. Sri Ranjit Roy : Sr. Assistant
6. Sri G. H. Das : Helper 'E'

7. STORE

1. Sri Gautam Das : Superintendent
2. Sri Ramesh Hari : Helper 'C'

8. MEDICAL UNIT

Prof. (Sm.) Munna Sarkar : Chairperson, Medical Advisory Com.

1. Dr. Sumalay Kar : Part -time Attending Physician
2. Dr. Arup Kumar Sahu : Part -time Attending Physician
3. Sri Gautam Dutta : Technician 'E'
4. Smt. Dipali Saha : Sr. Superintendent
5. Sri Dipak Kr. Das : Superintendent
6. Sri Biswajit Dutta : Accountnt
7 Sm. Nirupama Halder : U.D.C.
8. Sri Nabin Chandra Halder : Helper 'D'

9. TELEPHONE:

Prof. (Smt.) Samita Basu : In-Charge

1. Smt. Sunanda Chakraborty : Technician 'F'
2. Smt. Bithi Biswas : Technician 'E'
3. Smt. Pampa Bhattacharjee : Technician 'C'

10. LIBRARY

Prof. R. Ranganathan : Chairman

1. Sri Swapan Kr. Banerjee : Librarian (F)
2. Smt. Ratna Raychaudhuri : Scientific Officer 'C'
3. Sri Abhijit Kumar Malakar : Scientific Assistant 'E'
4. Sri Samit De : Scientific Assistant 'D'
5. Sri Subrata Chowdhury : Technician 'E'
6. Smt. Anupama Saha : Technician 'B'
7. Sri Manoj Karmakar : Technician 'B'
8. Sri Kishori Lal Ram : Technician 'B'
9. Sri Kartick Ch. Panigrahi : Helper 'B'

11. PUBLICATION & DOCUMENTATION UNIT

Prof. A.N.S. Iyengar : Chairman & Head and Chairman, Housing Allotment Committee.

1. Sri Amit Kumar Saha : Scientific Officer 'C'
2. Smt. Dipa Dasgupta : Scientific Officer 'C'
3. Sri Bidyut Kumar Mallick : Scientific Assistant 'E'
4. Sri Pradip Das : Scientific Assistant 'A'
5. Sri Sanjib Kr. Roy : Helper 'B'

12. AUDITORIUM MANAGEMENT SECTION

Smt. Seema Bhattacharya : Officer-In-Charge

1. Sri Sushanta Chakraborty : Scientific Assistant 'E'

13. BUILDING MAINTENANCE (ELECTRICAL)

Prof. Debabrata Ghose : Chairman, BM (E) Committee

1. Sri D. P. Ghosh : Engineer 'G'
2. Sri K. P. Panja : Scientific Officer 'D'
3. Sri P. C. Majumdar : Scientific Assistant 'E'
4. Sri Nepal Ch. Mitra : Technician 'J'
5. Sri Swapan Kr. Mandal : Scientific Assistant 'D'
6. Sri Somenath Ghosh : Scientific Assistant 'C'
7. Sri Saral Guha : Technician 'G'
8. Sri Sujit Kr. De : Technician 'G'
9. Sri Kali Kanto Dey : Technician 'F'
10. Sri M. Kaity : Technician 'F'
11. Sri Asok Kr. Majumdar : Technician 'E'
12. Sri K. P. Roy : Technician 'D'
13. Sri G. K. Sabui : Technician 'C'
14. Sri Pratap Dhanuk : Technician 'C'
15. Sri Dilip Kr. Chakraborty : Technician 'C'
16. Sri Mahendra Manohar Khapekar : Technician 'C'
17. Sri Jai Prakash Tiwari : Technician 'B'
18. Sri Jagannath Mandal : Technician 'B'
19. Sri Dilip Ram : Helper 'E'
20. Sri Bijay Ram : Helper 'C'

21. Sri Sankar Adhikari : Helper 'B'

14. BUILDING MAINTENANCE (CIVIL)

Prof. A. I. Jaman : Chairman, BM (C) Committee

1. Sri Rajkumar Sengupta : Engineer 'E'
2. Sri S. S. Kundu : Technician 'G'
3. Sri Arup Polley : Technician 'G'
4. Sri Nil Kanta Sinha : Scientific Assistant 'C'
5. Sri Gobinda Pal : Scientific Assistant 'C'
6. Sri Ashok Kumar Das : Technician 'F'
7. Sri Sisir Kumar Mondal : Technician 'E'(Structural Draftsman)
8. Sri Gangadhar Maity : Technician 'E' (Supervisor Mali)
9. Sri Sunil Murmu : Technician 'C'
10. Sri Subir Modak : U.D.C.
11. Sri Samir Kr. Chakraborty : Helper 'E' (Mali)
12. Sri Sakhi Chand Hari : Helper 'E' (Sweeper)
13. Sri Banarshi Mallick : Helper 'E' (Sweeper)
14. Sri Dulal Dey : Helper 'E' (Mali)
15. Sri Sushil Kumar De : Helper 'E' (Mali)
16. Sri Santosh Kr. Sarkar : Helper 'E' (Mali)
17. Sri K. K. Sarkar : Helper 'E' (Mali)
18. Sri Santosh Kr. Bachar : Helper 'E' (Mali)
19. Sri Shyamal Kr. Bose : Helper 'D'
20. Sri Badal Hari : Helper 'D' (Sweeper)
21. Sri Swapan Kr. Mondal : Helper 'D' (Mali)
22. Sri Siblal Hari : Helper 'D' (Sweeper)
23. Smt. Anjali Hari : Helper 'C' (Sweeper)
24. Sri G. C. Das : Helper 'C' (Sweeper)
25. Sri Santosh Hari : Helper (Sweeper)
26. Sri Ashok Mallick : Helper 'A'
27. Sri Kala Chand Hela : Helper 'A' (Sweeper)
28. Sk. Mostakin : Helper 'A'
29. Sri Amit Hari : Helper 'A'

15. SECURITY

1. Sri Supriya Gangopadhyay : Security Officer
2. Sri Ratan Kr. Bose : Security Supervisor-B
3. Sri Tapas Kr. Dalal : Security Supervisor-B
4. Sri Swaraj Nath Sarkar : Security Supervisor 'B
5. Sri Ashok Kr. Singh : Security Supervisor 'B'
6. Sri Ganesh Prasad Sharma : Security Supervisor 'B'
7. Sri Tarak Ch. Nath' : Security Supervisor 'A'
8. Sri Gobinda Ch. Roy : L. D. C.
9. Sri Balli Rana : Technician 'A'(Watchman)
10. Sri Dukha Krishna Reddy : Technician 'A' (Watchman)
11. Sri Subrata Kr. Chowdhury : Technician 'A' (Watchman)
12. Sri P. B. Thapa : Helper 'E' (Watchman)
13. Sri Madhusudan Bhakta : Helper 'E' (Watchman)
14. Sri Joyram Murmu : Helper 'D' (Watchman)
15. Sri Sudhangsu Sekhar Mondal : Helper 'D' (Watchman)
16. Sri Swapan Mukherjee : Helper 'D'
17. Sri Mongal Oraon : Helper 'D' (Watchman)
18. Sri Sibu Oraon : Helper 'C' (Watchman)
19. Sri Tapan Kr. Sinha : Helper 'C' (Watchman)
20. Sri Ranjit Kr. Roy : Helper 'C'(Watchman)
21. Sri Sudhir Kr. Debnath : Helper 'C'(Watchman)
22. Md. Manayar Hasan Mondal : Helper 'C'(Watchman)
23. Sri Arun Kr. Dutta : Helper 'B' (Watchman)
24. Sri Pran Gopal Das : Helper 'B' (Watchman)
25. Sri Gopal Ch. Saren : Helper 'B' (Watchman)

16. TRANSPORT

Prof. R.N. Pal : Chairman, Transport Committee

Sri K. P. Panja : Officer-In-Charge

1. Sri Dharmendra Prasad : Scientific Assistant 'C'
2. Sri Ajoy Kumar Sarkar : Transport Supervisor-II
3. Sri S. K. Mondal : Technician 'G'
4. Sri Trinath Maharana : Technician 'E' (Vehi. Mech.)
5. Sri Surai Mandi : Technician 'C' (Vehi. Mech.)
6. Sri K. L. Malakar : Technician 'C'
7. Sri Aloke Kumar Sarkar : Driver – V
8. Sri Gouri Sankar Singh : Driver – V
9. Sri Tarak Nath Ghosh : Driver – IV
10. Sri Kashi Nath Prosad : Driver – IV
11. Sri Dilip Baidya : Driver – IV
12. Sri Madhusudan Mondal : Driver – IV
13. Sri Gopal Ch. Ghosh : Driver – III
14. Sri Uttam Kumar Roy : Driver – II

15. Sri Kartick Ch. Pal : Driver – II
16. Sri Prabir Kumar Mistri : Driver – II
17. Sri Prabir Biswas : Driver – II
18. Sri Mongal Ch. Mondal : Helper ‘E’
19. Sri Asit Kr. Mahapatra : Technician ‘B’
20. Sri Shankar Ram : Helper ‘B’

17. WORKSHOP

Dr. Suvendu Nath Bose : Chairman, Workshop Committee

1. Dr. Jisnu Basu : Engineer ‘F’ & Officer-In-Charge
2. Sri A.K.Mondal : Technician ‘H’
3. Sri Sukumar Kundu : Technician ‘G’
4. Sri Sadananda Datta : Technician ‘G’
5. Sri D. N. Debnath : Technician ‘G’
6. Sri Ramen Jana : Technician ‘F’
7. Sri Sudipta Barman : Sscientific Assistant ‘C’ (Fitter)
8. Sri Debashis Sen : Technician ‘F’
9. Sri Supriya Mondal : Technician ‘F’
10. Sri Biplab Kumar Dey : Technician ‘E’
11. Sri Partha Sarathi Karmakar : Technician ‘F’ (Turner)
12. Sri Narayan Chandra Dey : Scientific Assistant ‘A’ (CNC Operator)
13. Sri Tarun Tapan Biswas : Technician ‘E’ (Fitter)
14. Sri Gopal Kumar Chatterjee : Technician ‘E’ (Engn. Stores)
15. Sri Ramkrishna Ray : Technician ‘E’ (Machinist)
16. Sri H.B.Dhar : Technician ‘E’
17. Sri Bhairab Ch. Nath : Technician ‘D’ (Milright Fitter)
18. Sri Sunil Das : Technician ‘D’ (Milright Fitter)
19. Sri Durlav Tudu : Technician ‘D’ (Turner)
20. Sri Sadip Patra : Technician ‘C’ (Welder)
21. Sri Himadri Chakraborty : Technician ‘C’ (Machinist)
22. Sri Subrata Baidya : Technician ‘C’ (Machinist)
23. Sri Subal Ch. Bindi : Technician ‘C’
24. Sri Adhir Sarkar : Technician ‘B’
25. Sri Santosh Kumar Barman : Helper ‘E’
26. Sri D. P. Sardar : Helper ‘E’
27. Sri Gopal Das : Helper ‘B’

18. THEORY GROUP

1. Prof. Kamales Kar : Sr. Professor ‘H+’ & Head
2. Prof. Radhey Shyam : Sr. Professor ‘H+’
3. Prof. P. S. Majumdar : Sr. Professor ‘H+’
4. Prof. Anjan Kundu : Sr. Professor ‘H+’
5. Prof. Parthasarathi Mitra : Sr. Professor ‘H+’
6. Prof. A.Harindranath : Sr. Professor ‘H’
7. Prof. Polash B. Pal : Sr. Professor ‘H’
8. Prof. Pijush Pani Bhattacharjee : Sr. Professor ‘H’
9. Prof. Gautam Ghosh : Professor ‘G’
10. Prof. T. K. Roy : Professor ‘G’
11. Prof. Asit Kr. De : Professor ‘G’
12. Prof. Kumar Sankar Gupta : Professor ‘G’
13. Prof. Shibaji Roy : Professor ‘G’
14. Prof. Gautam Bhattacharyya : Professor ‘G’
15. Prof. Debades Bandyopadhyay : Professor ‘G’
16. Prof. Munshi Golam Mustafa : Professor ‘G’
17. Prof. Debabrata Mukhopadhyay : Professor ‘F’
18. Prof. Bireswar Basu-Mallick : Professor ‘F’
19. Prof. Prakash Mathews : Professor ‘F’
20. Prof. Harvendra Singh : Professor ‘F’
21. Prof. B. K. Agrawal : Professor ‘F’
22. Prof. Amit Ghosh : Professor ‘F’
23. Sm. Dola Mallick : Superintendent
24. Sri Pradyut Kumar Mitra : Technician ‘E’
25. Sri Sudarshan Hazra : Technician ‘A’
26. Sri Arun Kumar Bose : Helper ‘E’

19. MATERIAL PHYSICS GROUP

19A. PLASMA PHYSICS DIVISION

1. Prof. A.N.S. Iyengar : Sr. Professor ‘H’ & In-Charge and Chairman, Housing Allotment Committee
2. Prof. Rabindra Nath Pal : Sr. Professor ‘H’
3. Prof. (Smt.) S. Roychoudhury : Professor ‘G’
4. Prof. N. R. Roy : Professor ‘G’
5. Prof. S. K. Saha : Professor ‘G’
6. Prof. (Smt.) M.S.Janaki : Professor ‘G’
7. Prof. Nikhil Chakrabarti : Professor ‘F’
8. Sri Shantanu Chowdhury : Engineer ‘F’
9. Sri. P. S. Bhattacharya : Scientific Officer ‘C’
10. Sri S. Basu : Scientific Officer ‘C’

11. Sri Monobir Chattopadhyay : Scientific Officer 'C'
12. Sri Amalendu Bal : Scientific Assistant 'E'
13. Sri Abhijit Betal : Scientific Assistant 'C'
14. Sri Dulal Chatterjee : Superintendent
15. Sri S. S. Sil : Technician 'E'
16. Sri Dipankar Das : Technician 'C'
17. Sri Ashok Kumar Ram : Helper 'B'

19B. SURFACE PHYSICS DIVISION

1. Prof. M. K. Sanyal : Director & HOD
2. Prof. P. Chakraborty : Sr. Professor 'H'
3. Prof. D. Ghose : Sr. Professor 'H'
4. Prof. Alokmay Dutta : Professor 'G'
5. Prof. S. R. Bhattacharyya : Professor 'G'
6. Prof. Tapas Kr. Chini : Professor 'F'
7. Prof. Sangam Banerjee : Professor 'F'
8. Prof. Manabendra Mukherjee : Professor 'F'
9. Prof. (Sm.) S. Kundu : Professor 'F'
10. Prof. Satyajit Hazra : Professor 'F'
11. Dr. Satyaban Bhunia : Associate Professor 'E'
12. Dr. Krishnakumar S. R. Menon : Associate Professor 'E'
13. Sri Subir Roy : Scientific Officer 'C'
14. Sri Avijit Das : Scientific Officer 'C'
15. Sri Susanta Bandyopadhyay : Scientific Officer 'C'
16. Sri Souvik Banerjee : Scientific Assistant 'C'
17. Sri Goutam Sarkar : Scientific Assistant 'A'
18. Sri Mukul Ch. Das : Superintendent
19. Sri Harendra Nath Jana : Helper 'E'
20. Sri Gobardhan Jana : Helper 'B'

20. NUCLEAR SCIENCE GROUP

20A. NUCLEAR & ATOMIC PHYSICS DIVISION

1. Prof. Sudeb Bhattacharya : Sr. Professor 'H+' - H.O.D.
2. Prof. (Smt.) C. Samanta : Sr. Professor 'H'
3. Prof. P. Banerjee : Professor 'G'
4. Prof. (Smt.) Bichitra Ganguly : Professor 'G'
5. Prof. Satyajit Saha : Professor 'G'
6. Prof. Manoranjan Sarkar : Professor 'G'
7. Prof. P.M.G. Nambissan : Professor 'G'
8. Prof. P. Basu : Professor 'G'
9. Prof.(Smt.) Maitreyee Saha Sarkar: Professor 'G'
10. Prof. Subinit Roy : Professor 'G'
11. Dr. M. B. Das : Scientist 'G'
12. Prof. Ashimananda Goswami : Professor 'G'
13. Prof. Chandi Charan Dey : Professor 'F'
14. Prof.(Smt.) Ushasi Datta Pramanik: Professor 'F'
15. Prof. Chinmay Basu : Professor 'F'
16. Prof. (Smt.) Anjali Mukherjee : Professor 'F'
17. Sri Amal Ghosal : Scientific Officer 'C'
18. Sri Pradipta Kumar Das : Scientific Officer 'C'
19. Sri Kaushik Chatterjee : Scientific Officer 'C'
20. Smt. Jonaki Panja : Scientific Officer 'C'
21. Sri Sujib Ch. Chattopadhyay : Scientific Officer 'C'
22. Sri Ajoy Kumar Mitra : Scientific Officer 'C'
23. Smt. Rita Ghosh : Scientific Assistant 'E'
24. Sri Haradhan Dhar : Scientific Assistant 'D'
25. Sri Dilip Sil : Scientific Assistant 'D'
26. Sri N. C. Sarkar : Officer-in-Charge
27. Smt. Soma Roy : Scientific Assistant 'C'
28. Sri Chandra Nath Marik : Scientific Assistant 'C'
29. Sri Jeevan Shaw : Sr. Assistant
30. Sri Pradip Barua : Technician 'C'
31. Sri S. P. Singh : Technician 'C'
32. Sri Dilip Kr. Sardar : Technician 'C'
33. Sri Dulal Chandra Ghoshal : Helper 'E'
34. Sri Kuntal Sarkhel : Helper 'B'
35. Sri Prabir Das : Helper 'B'
36. Sri Siladitya Chakraborty : Helper 'A'

20B. INDIA-BASED NEUTRINO OBSERVATORY SECTION

Prof. Sudeb Bhattacharyya : Sr. Professor 'H' - H.O.S.

1. Prof. Supratik Mukhopadhyay : Professor 'G'
2. Prof. Manoj Sharan : Professor 'F'
3. Prof. Debasish Majumdar : Professor 'F'
4. Prof. Ambar Ghosal : Professor 'F'
5. Prof. (Smt.) Nayana Majumdar : Professor 'F'

21. HIGH ENERGY PHYSICS & MICROELECTRONICS GROUP

21A. HIGH ENERGY PHYSICS DIVISION

1. Prof. Sukalyan Chattopadhyay : Professor 'G', HOD & Project Leader

2. Prof. Pradip Kr. Roy : Professor ‘F’
3. Prof. Abhee Kanti Dutt-Mazumdar: Professor ‘F’
4. Dr. (Smt.) Tinku Sinha : Scientist ‘E’
5. Sri Dipankar Das : Scientific Assistant ‘C’
6. Smt. Lipy Das : Scientific Assistant ‘C’
7. Sri Sanjib Kr. Mondal : U.D.C.
8. Sri Rakesh Kr. Ram : Helper ‘B’

21B. NEW GENERATION DETECTOR R & D Section

1. Prof. Pratap Bhattacharya : Professor ‘G’
2. Sri Sudam Bagdi : Helper ‘A’

21D. MICROELECTRONICS DIVISION

1. Prof. Sandip Sarkar : Professor ‘F’ & In-Charge
2. Sri A. Sanyal : Engineer ‘G’
3. Dr. Madhusudan Roy : Associate Professor ‘E’
4. Dr. Supratic Chakraborty : Associate Professor ‘E’
5. Sri Shaibal Saha : Scientific Officer ‘C’
6. Sri Avedananda Bhattacharya : Scientific Assistant ‘C’
7. Sri S. P. Mallick : Technician ‘E’
8. Sri Subhasish Sanyal : Superintendent
9. Sri Provash Halder : Helper ‘D’

21E. ELECTRONICS WORKSHOP FACILITY

1. Dr. Suvendu Nath Bose : Sr. Scientist ‘H’ - In-Charge
2. Sri Debasish Bandyopadhyay : Scientific Assistant ‘E’
3. Sri Dwijendra Das : Scientific Assistant ‘C’
4. Sri Dulal Das : Technician ‘G’
5. Sri Singh Bahadur Thapa : Helper ‘B’

22. CONDENSED MATTER PHYSICS GROUP

22A. THEORETICAL CONDENSED MATTER PHYSICS DIVISION

1. Prof. B. K. Chakraborti : Sr. Professor ‘I’ & H.O.D.
2. Prof. Atindra Nath Das : Sr. Professor ‘H’
3. Prof. Asok K. Sen : Professor ‘G’
4. Prof. S. N. Karmakar : Professor ‘G’
5. Prof. Sudhakar Yarlagadda : Professor ‘G’
6. Prof. Pradeep Kr. Mohanty : Professor ‘F’
7. Prof. Abhik Basu : Professor ‘F’
8. Sri Ashoke Kumar Nayak : Officer-in-Charge
9. Sri P. S. Bhattacharjee : Sr. Superintendent
10. Sri Kausik Das : Scientific Assistant ‘C’
11. Sri Jhantu Mallick : Helper ‘B’
12. Sri Asish Ram : Helper ‘A’

22B. EXPERIMENTAL CONDENSED MATTER PHYSICS DIVISION

1. Prof. Amitabha Ghosh Ray : Sr. Professor ‘H’ & H.O.D.
2. Prof. R. Ranganathan : Sr. Professor ‘H’
3. Prof. K. K. Bardhan : Sr. Professor ‘H’
4. Prof. A. I. Jaman : Sr. Professor ‘H’
5. Prof. (Mrs) K. Ghosh Ray : Professor ‘G’
6. Prof. Chandidas Mukherjee : Professor ‘G’
7. Prof. S. N. Das : Professor ‘G’
8. Prof. Indranil Das : Professor ‘G’
9. Prof. P. Mandal : Professor ‘F’
10. Prof. (Mrs.) Barnana Pal : Professor ‘F’
11. Prof. Asok Podder : Professor ‘F’
12. Prof. Bilwadal Bandyopadhyay : Professor ‘F’
13. Prof. Chandan Mazumdar : Professor ‘F’
14. Sri Ajoy Kumar Bhattacharya : Scientific Officer ‘C’
15. Sri Tapan Kr. Pyne : Scientific Officer ‘C’
16. Sri Arun Kumar Pal : Technician ‘G’
17. Sm. Sankari Chakrabarti : Scientific Assistant ‘D’
18. Sri Arindam Chakraborti : Scientific Assistant ‘C’
19. Sri Dhrubajyoti Seth : Scientific Assistant ‘C’
20. Smt. Papia Mondal : Scientific Assistant ‘B’
21. Sri Anish Karmahapatra : Technician ‘E’
22. Sri Tapan Kr. Sarkar : Superintendent
23. Sri Sambu Hembrom : Technician ‘C’
24. Sri Prabir Kumar Das : Technician ‘B’
25. Sri P. P. Ranjit : Helper ‘E’

23. BIOPHYSICAL SCIENCES GROUP

23A. CRYSTALLOGRAPHY & MOLECULAR BIOLOGY DIVISION :

1. Prof. Nitai Pada Bhattacharyya : Professor ‘G’ & Head
2. Prof.(Smt.)Chandana Chakrabarti: Professor ‘G’
3. Prof. (Smt.) Sanghamitra Raha : Professor ‘G’
4. Prof. Rahul Banerjee : Professor ‘F’
5. Prof. Partha Saha : Professor ‘F’

6. Prof. (Sm) Sampa Biswas : Professor ‘F’
7. Prof. Udayaditya Sen : Professor ‘F’
8. Sri Utpal Basu : Scientific Officer ‘C’
9. Sri Abhijit Bhattacharya : Scientific Assistant ‘D’
10. Sri Bikram Nath : Scientific Assistant ‘C’
11. Sri Sushanta Debnath : Scientific Assistant ‘C’
12. Sri Saikat Mukhopadhyay : Scientific Assistant ‘C’
13. Sri Ashis Kumar Dutta : Scientific Assistant ‘B’
14. Smt. Durga Hazra : Superintendent
15. Sri. Samir Kr. Majumdar : Technician ‘C’
16. Sri Chinmoy Chatterjee : Helper ‘D’
17. Sri Sakal Dev Ram : Helper ‘B’
18. Sri Bipin Bose : Helper ‘B’

23B. STRUCTURAL GENOMICS SECTION

Prof. Subrata Banerjee : Professor ‘G’ & Head

1. Dr. Debashis Mukhopadhyay : Associate Professor ‘E’
2. Sri Madhu Sudan Samal : Assistant Halwai-cum-Cook

23C. BIOPHYSICS DIVISION

1. Prof. Dipak Dasgupta : Sr. Professor ‘H’ & H.O.D.
2. Prof. P. K. Sengupta : Sr. Professor ‘H’
3. Sri Pulak Kumar Roy : Engineer ‘G’
4. Prof. Abhijit Chakrabarti : Professor ‘G’
5. Prof. Subrata Banerjee : Professor ‘G’
6. Prof. Dhananjay Bhattacharyya : Professor ‘G’
7. Dr. (Sm.) Radha Bhattacharyya : Scientist ‘F’
8. Prof. Arun Kr. Pal : Professor ‘F’
9. Dr. T. K. Mondal : Asso. Prof. ‘E’
10. Sri T. K. Roy : Scientific Officer ‘D’
11. Sri Sekhar Bhattacharya : Scientific Officer ‘C’
12. Sri Ajoy Chakraborty : Scientific Assistant ‘D’
13. Sri Arijit Pal : Scientific Assistant ‘C’
14. Sri B. K. Das : Superintendent
15. Sri Raju Dutta : Technician ‘B’
16. Sri Nirmal Ch. Das : Technician ‘B’
17. Sri Sanjay Show : Helper ‘B’
18. Sri Shyamal Ch. Digar : Helper ‘B’

23D. CHEMICAL SCIENCES DIVISION

1. Prof. S. Basak : Sr. Professor ‘H’ & H.O.D.
2. Prof. (Sm.) Samita Basu : Professor ‘G’
3. Prof. Amitabha De : Professor ‘G’
4. Prof. Susanta Lahiri : Professor ‘G’
5. Prof. (Sm.) Munna Sarkar : Professor ‘F’
6. Prof. (Sm.) Maitreyee Nandy : Professor ‘F’
7. Sri Ajay Das : Scientific Assistant ‘E’
8. Sm. Chitra Raha : Scientific Assistant ‘D’
9. Sri Avijit Shome : Scientific Assistant ‘C’
10. Sri Subir Bandyopadhyay : Sr. Assistant
11. Sri Bablu Ram : Technician ‘C’
12. Sri Deepak Kr. Ram : Helper ‘C’
13. Sri J. N. Ray : Helper ‘C’

24. TEACHING

Prof. Palash Baran Pal : HOS (w.e.f.01.08.2006)

1. Dr. B. B. Bal : Scientist ‘G’
2. Sri Jayant Kr. Mukherjee : Scientific Assistant ‘C’
3. Sri Sudarshan Mondal : Sr. Assistant
4. Sri Nirmal Ch. Biswas : Helper ‘D’

25. COMPUTER

Prof. Asit Kr. De : Professor ‘G’ & Prof.-in-Charge

1. Sri Gautam Garai : Scientist ‘G’
2. Sri Deeptish Dey : Engineer ‘F’
3. Sri Gautam Datta : Scientific Assistant ‘E’
4. Sri Sumit Basu : Scientific Assistant ‘B’
5. Sri Nanda Lal Sanpui : Technician ‘C’
6. Sri Soumya Majumdar : Technician ‘B’

26. GUEST HOUSE & HOSTEL

Prof. Nihar Ranjan Ray : Chairman, Guest House & Hostel, MSA-I, SLC, Bidhannagar.

Prof. Satya Ranjan Bhattacharya : Prof-In-Charge, Guest House & Hostel, SINP Housing Committee (MSA-II), E M Bye-pass.

1. Sri Ramesh Singh : Helper ‘B’
2. Sri Somenath Das : Helper ‘A’
3. Smt. Suro Mahato : Helper ‘A’
4. Sri Suresh Ch. Das : Assistant Halwai-cum-Cook
5. Sri Sakti Pada Bisui : Assistant Halwai-cum-Cook

27. CANTEEN STAFF (SALT LAKE CAMPUS)

Prof. Dhananjay Bhattacharyya : Chairman, Canteen Committee

1. Sri Ashok Roy : Canteen Clerk-II
2. Sri Shankar Panda : Halwai-cum-Cook
3. Sri Prabhat Maity : Halwai-cum-Cook
4. Sri Kartick Ch. Maity : Asstt. Halwai-cum-Cook
5. Sri Sujan Ch. Mistry : Asstt. Halwai-cum-Cook
6. Sri Sailen Halder : Bearer - II (New Scale)
7. Sri Nemai Ch. Das : Bearer - II (New Scale)
8. Sri Amar Das : Bearer - II (New Scale)
9. Sri Barun Kr. Barua : Bearer - II (New Scale)
10. Sri Subodh Kr. Pradhan : Bearer-I
11. Sri Sunil Ram : Bearer
12. Sri Shankar Andia : Bearer

Staff list as on 16.12.2010

Category	Division	I.D. No.	Name of Employee	Designation
	Director	196	Prof. Milan Kr. Sanyal	Director, SINP
Administrative	Director's Office	396	Sri Amalesh Ch. Saha	A.A.O.(D.O.)
Administrative	Director's Office	777	Sri Subhasish Ghoshal	Upper Division Clerk
Administrative	Director's Office	786	Sri Goutam Mandal	Upper Division Clerk
Technical	Director's Office	395	Sri Ratanlal Ram	Technician 'C'
Auxiliary	Director's Office	879	Sri Babu Rajak	Helper 'B'
Administrative	Registrar's Office	664	Sri V.V. Mallikarjuna Rao	Registrar
Administrative	Registrar's Office	443	Sri Alok Mitra	A.A.O.(R.O.)
Administrative	Registrar's Office	820	Sri Bimlesh Kr. Tripathi	Senior Hindi Translator
Administrative	Registrar's Office	779	Shri Bibekbijay Bandyopadhyay	Upper Division Clerk
Technical	Registrar's Office	399	Sri Rudal Prasad Ram	Technician 'C'
Auxiliary	Registrar's Office	398	Sri Mahadev Das	Helper 'E'
Administrative	E.O.	1054	Sri Suchintya Kumar Gupta	Establishment Officer
Administrative	Establishment	444	Shri Biplab Kumar Ray	A.A.O.(E-I)
Administrative	Establishment	416	Sri Prasanta Kr. Das	Sr. Superintendent
Administrative	Establishment	446	Smt. Chandana Basu	Sr. Superintendent
Administrative	Establishment	447	Sm. Suparna Das	Senior Assistant
Administrative	Establishment	771	Sri Asim Haldar	Upper Division Clerk
Technical	Establishment	448	Sri Subhash Ch. Gayen	Technician 'B'
Auxiliary	Establishment	347	Sri Rajeswar Roy	Driver - V
Administrative	Despatch	407	Smt. Chandana Mitra	Sr. Superintendent
Administrative	Despatch	415	Sri Tapan Chakraborty	Superintendent
Administrative	Despatch	424	Sri Swadesh Ch. Deb	Upper Division Clerk
Technical	Despatch	442	Sri Tarak Nath Bhattacharya	Technician 'B'
Auxiliary	Despatch	593	Shri Pintu Ram	Helper 'B'

Administrative	Accounts	400	Sri Niladri Sanyal	Dy. Controller of Accounts
Administrative	Accounts	1022	Shri Ved Prakash Mishra	Accounts Officer
Administrative	Accounts	401	Sri Swarup Kr. Bose	A.A.O.(Cash)
Administrative	Accounts	406	Sri Mrityunjoy Dey	A.A.O.(Budget)
Administrative	Accounts	410	Sri Asit Ranjan Deb	A.A.O.(Accounts)
Administrative	Accounts	411	Sri Rammohan Moitra	A.A.O.(Salary)
Administrative	Accounts	413	Sri Niranjan Sarkar	A.A.O.(PF &Pension)
Administrative	Accounts	408	Sri Tapan Kr. Bhattacharyya	Sr.Superintendent
Administrative	Accounts	430	Sri Ashoke Maity	Sr. Superintendent
Administrative	Accounts	394	Smt. Tultul Dutta	Superintendent
Administrative	Accounts	417	Sri Somnath Sarkar	Accountant
Administrative	Accounts	397	Sri Ranjit Dutta	Superintendent
Auxiliary	Accounts	350	Sri Pradip Kr. Das	Driver - V
Administrative	Accounts	328	Shri Raghunath Naskar	Senior Assistant
Administrative	Accounts	441	Sri Goutam Ghosh	Senior Assistant
Administrative	Accounts	594	Sri Avijit Saha	Upper Division Clerk
Administrative	Accounts	778	Smt. Seethalakshmi Rath	Upper Division Clerk
Administrative	Accounts	774	Sri Mantu Bhattacharya	Upper Division Clerk
Administrative	Accounts	775	Sm. Nirupama Halder	Upper Division Clerk
Auxiliary	Accounts	439	Sri Madhu Bose	Helper ‘E’
Auxiliary	Accounts	423	Sri Biswanath Paul	Helper ‘E’
Auxiliary	Accounts	118	Sri Kartick Hari	Helper ‘E’
Technical	Accounts	425	Sri Sanat Kumar Kotal	Technician ‘B’
Auxiliary	Accounts	912	Sri Pradip Dutta Sharma	Helper ‘C’
Auxiliary	Accounts	643	Shri Pradip Ram	Sr. Bearer
Administrative	A.O.-III	393	Smt. Seema Bhattacharyya	A.O.-III & Off.-In-Charge of Purchase Cell
Administrative	Purchase (Domestic Cell)	409	Sri Sanjoy Chakraborty	A.A.O.(Purchase-Domestic)
Administrative	Purchase (Domestic Cell)	429	Sri Asim Krmar Sarkar	Sr. Superintendent
Administrative	Purchase (Domestic Cell)	432	Sri Shyamal Ch. Biswas	Superintendent
Administrative	Purchase (Domestic Cell)	434	Sri Ajoy Kumar Biswas	Senior Assistant
Administrative	Purchase (Domestic Cell)	952	Ms. Rekha Ram	Upper Division Clerk
Auxiliary	Purchase (Domestic Cell)	913	Sri Ashok Kr. Roy	Helper ‘C’
Administrative	Purchase (Foreign Cell)	428	Sri J.S. Raychaudhuri	A.A.O.(Purchase-Foreign)
Administrative	Purchase (Foreign Cell)	414	Sri Sankar Nath Dewan	Sr. Superintendent
Administrative	Purchase (Foreign Cell)	431	Sri Debasish Das	Sr. Superintendent
Administrative	Purchase (Foreign Cell)	433	Sri Ranjit Roy	Sr. Assistant
Auxiliary	Purchase (Foreign Cell)	436	Sri Gour Hari Das	Helper ‘E’
Administrative	Stores	419	Sri Gautam Das	Superintendent
Auxiliary	Stores	278	Sri Ramesh Hari	Helper ‘C’
	Medical Unit	96	Prof. Abhijit Chakrabarti	Chairman, MAC

	Medical Unit		Dr. Sumalay Kar	Part-time Attending Physician
	Medical Unit		Dr. Arup Kumar Sahu	Part-time Attending Physician
Administrative	Medical Unit	445	Smt. Dipali Saha	Sr. Superintendent
Technical	Medical Unit	106	Sri Gautam Dutta	Technician ‘E’
Administrative	Medical Unit	418	Sri Gobinda Chakraborty	Superintendent
Administrative	Medical Unit	45	Sri Dipak Kr. Das	Superintendent
Administrative	Medical Unit	421	Sri Biswajit Dutta	Accountant
Auxiliary	Medical Unit	449	Sri Nabin Chandra Halder	Helper ‘D’
	Telephone	92	Prof. (Smt.) Samita Basu	Prof. & In-Charge
Technical	Telephone	103	Smt. Sunanda Chakraborty	Technician ‘F’
Technical	Telephone	104	Smt. Bithi Biswas	Technician ‘E’
Technical	Telephone	763	Smt. Pampa Bhattacharjee	Technician ‘C’
	Library	182	Prof. R. Ranganathan	Chairman
Administrative	Library	302	Sri Swapan Kr. Banerjee	Librarian (F)
Technical	Library	310	Smt. Ratna Raychaudhuri	Scientific Officer ‘C’
Technical	Library	314	Sri Abhijit Kumar Malakar	Scientific Assistant-E
Technical	Library	313	Sri Samit De	Scientific Assistant-D
Technical	Library	317	Sri Subrata Chowdhury	Technician ‘E’
Technical	Library	605	Smt. Anupama Saha	Technician ‘B’
Technical	Library	792	Sri Manoj Karmakar	Technician ‘C’
Technical	Library	788	Sri Kishori Lal Ram	Technician ‘B’
Auxiliary	Library	883	Sri Kartick Ch. Panigrahi	Helper ‘B’
	Centre for Advanced Research & Education (CARE)	30	Prof. Abhijit Chakrabarti	Head
Technical	Centre for Advanced Research & Education (CARE)	309	Smt. Dipa Dasgupta	Scientific Officer ‘C’
Technical	Centre for Advanced Research & Education (CARE)	308	Sri Amit Kumar Saha	Scientific Officer ‘C’
Technical	Centre for Advanced Research & Education (CARE)	307	Sri Bidyut Kumar Mallick	Scientific Assistant-E
Technical	Centre for Advanced Research & Education (CARE)	318	Sri Pradip Das	Scientific Assistant ‘A’
Auxiliary	Centre for Advanced Research & Education (CARE)	884	Sri Sanjib Kr. Roy	Helper ‘B’
	Auditorium Management Section	393	Smt. Seema Bhattacharyya	Officer-In-Charge
Technical	Auditorium Management Section	377	Sri Sushanta Chakraborty	Scientific Assistant-E
	Building Maintenance (Electrical)	199	Prof. Debabrata Ghose	Chairman, BM(Electrical) Com.
Technical	Building Maintenance (Electrical)	283	Sri Debi Prasad Ghosh	Engineer ‘G’

Technical	Building Maintenance (Electrical)	284	Sri Kamal Prakash Panja	Scientific Officer-D
Technical	Building Maintenance (Electrical)	285	Sri Paresh Ch. Majumdar	Scientific Assistant-E
Technical	Building Maintenance (Electrical)	286	Sri Nepal Ch. Mitra	Technician ‘J’
Technical	Building Maintenance (Electrical)	705	Sri Swapan Kr. Mandal	Scientific Assistant-D
Technical	Building Maintenance (Electrical)	703	Sri Somenath Ghosh	Scientific Assistant-C
Technical	Building Maintenance (Electrical)	289	Sri Saral Guha	Technician ‘G’
Technical	Building Maintenance (Electrical)	291	Sri Sujit Kr. De	Technician ‘G’
Technical	Building Maintenance (Electrical)	293	Sri Kali Kanto Dey	Technician ‘F’
Technical	Building Maintenance (Electrical)	295	Sri Madhusudan Kaity	Technician ‘F’
Technical	Building Maintenance (Electrical)	296	Sri Asok Kr. Majumdar	Technician ‘E’
Technical	Building Maintenance (Electrical)	297	Sri Kalyan Paul Roy	Technician ‘D’
Technical	Building Maintenance (Electrical)	299	Sri Gautam Kr. Sabui	Technician ‘C’
Technical	Building Maintenance (Electrical)	301	Sri Pratap Dhanuk	Technician ‘C’
Technical	Building Maintenance (Electrical)	644	Sri Dilip Kr. Chakraborty	Technician ‘C’
Technical	Building Maintenance (Electrical)	995	Shri Jai Prakash Tiwari	Technician ‘B’
Technical	Building Maintenance (Electrical)	997	Sri Jagannath Mondal	Technician ‘B’
Technical	Building Maintenance (Electrical)	998	Sri Mahendra M. Khapekar	Technician ‘C’
Auxiliary	Building Maintenance (Electrical)	298	Sri Dilip Ram	Helper ‘E’
Auxiliary	Building Maintenance (Electrical)	300	Sri Bijay Ram	Helper ‘C’
Auxiliary	Building Maintenance (Electrical)	911	Sri Sankar Adhikari	Helper ‘B’
	Building Maintenance (Civil)	156	Prof. A.I. Jaman	Chairman, BM (Civil) Committee
Technical	Building Maintenance (Civil)	698	Sri Rajkumar Sengupta	Engineer ‘E’
Technical	Building Maintenance (Civil)	108	Sri Subha Sankar Kundu	Technician ‘G’

Technical	Building Maintenance (Civil)	109	Sri Arup Polley	Technician 'G'
Technical	Building Maintenance (Civil)	704	Sri Nil Kanta Sinha	Scientific Assistant-C
Technical	Building Maintenance (Civil)	804	Sri Gobinda Pal	Scientific Assistant-C
Technical	Building Maintenance (Civil)	111	Sri Asok Kumar Das	Technician 'F'
Technical	Building Maintenance (Civil)	806	Sri Sisir Kumar Mondal	Technician 'E' (Structural Draftsman)
Technical	Building Maintenance (Civil)	112	Sri Gangadhar Maity	Tech 'E' (Supervisor Mali)
Technical	Building Maintenance (Civil)	340	Sri Sunil Murmu	Technician 'C'
Administrative	Building Maintenance (Civil)	773	Sri Subir Modak	Upper Division Clerk
Auxiliary	Building Maintenance (Civil)	269	Sri Samir Kr. Chakraborty	Caretaker (Mali)
Auxiliary	Building Maintenance (Civil)	119	Sri Sakhi Chand Hari	Helper 'E' (Sweeper)
Auxiliary	Building Maintenance (Civil)	120	Sri Banarshi Mallick	Helper 'E' (Sweeper)
Auxiliary	Building Maintenance (Civil)	122	Sri Dulal Dey	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	123	Sri Sushil Kr. De	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	125	Sri Santosh Kr. Sarkar	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	270	Sri Kamala Kanta Sarkar	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	272	Sri Shyamal Kr. Bose	Helper 'E'
Auxiliary	Building Maintenance (Civil)	271	Sri Badal Hari	Helper 'E' (Sweeper)
Auxiliary	Building Maintenance (Civil)	546	Sri Santosh Kr. Bachar	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	273	Sri Swapan Kr. Mondal	Helper 'E' (Mali)
Auxiliary	Building Maintenance (Civil)	276	Sri Siblal Hari	Helper 'D' (Sweeper)
Auxiliary	Building Maintenance (Civil)	280	Smt. Anjali Hari	Helper 'C' (Sweeper)
Auxiliary	Building Maintenance (Civil)	279	Sri Gobinda Ch. Das	Helper 'C' (Sweeper)
Auxiliary	Building Maintenance (Civil)	750	Sri Santosh Hari	Helper 'B' (Sweeper)
Auxiliary	Building Maintenance (Civil)	880	Sri Ashok Mallick	Helper 'B'
Auxiliary	Building Maintenance (Civil)	881	Sri Kala Chand Hela	Helper 'B' (Sweeper)
Auxiliary	Building Maintenance (Civil)	941	Sk. Mostakin	Helper 'B'
Auxiliary	Building Maintenance (Civil)	1060	Sri Amit Hari	Helper 'A'
Administrative	Security	992	Sri Supriya Gangopadhyay	Security Officer
Administrative	Security	710	Sri Ratan Kr. Bose	Security Supervisor-B
Administrative	Security	711	Sri Tapas Kr. Dalal	Security Supervisor-B
Administrative	Security	799	Sri Swaraj Nath Sarkar	Security Supervisor 'B'
Administrative	Security	840	Sri Ashok Kr. Singh	Security Supervisor 'B'
Administrative	Security	838	Sri Ganesh Prasad Sharma	Security Supervisor 'B'
Administrative	Security	965	Sri Tarak Chandra Nath	Security Supervisor-A
Administrative	Security	839	Sri Gobinda Ch. Roy	Lower Division Clerk
Technical	Security	796	Sri Balli Rana	Technician 'A'
Technical	Security	802	Sri Dukha Krishna Reddy	Technician 'A'
Technical	Security	841	Sri Subrata Kr. Chowdhury	Technician 'A'
Auxiliary	Security	333	Sri P.B. Thapa	Helper 'E' (Watchman)
Auxiliary	Security	336	Sri Joyram Murmu	Helper 'E' (Watchman)

Auxiliary	Security	337	Sri Madhusudan Bhakta	Helper ‘E’ (Watchman)
Auxiliary	Security	338	Sri Sudhangsu Sekhar Mondal	Helper ‘D’ (Watchman)
Auxiliary	Security	335	Sri Swapan Mukherjee	Helper ‘D’
Auxiliary	Security	339	Sri Mongol Oraon	Helper ‘D’ (Watchman)
Auxiliary	Security	341	Sri Sibu Oraon	Helper ‘C’ (Watchman)
Auxiliary	Security	713	Sri Tapan Kr. Sinha	Helper ‘C’ (Watchman)
Auxiliary	Security	789	Sri Sudhir Kr. Debnath	Helper ‘C’ (Watchman)
Auxiliary	Security	797	Md. Manayar Hasan Mondal	Helper ‘C’ (Watchman)
Auxiliary	Security	798	Sri Ranjit Kr. Roy	Helper ‘B’ (Watchman)
Auxiliary	Security	966	Sri Arun Kumar Dutta	Helper ‘B’ (Watchman)
Auxiliary	Security	964	Sri Pran Gopal Das	Helper ‘C’ (Watchman)
Auxiliary	Security	967	Sri Gopal Chandra Saren	Helper ‘C’ (Watchman)
	Transport	32	Prof. R.N. Pal	Chairman, Transport Committee
	Transport	284	Shri K.P. Panja	Officer-In-Charge, Transport
Technical	Transport	830	Sri Dharmendra Prasad	Scientific Assistant-C
Administrative	Transport	348	Sri Ajoy Kumar Sarkar	Transport Supervisor-II
Technical	Transport	344	Sri Swapan Kumar Mondal	Technician ‘G’
Technical	Transport	712	Sri Trinath Maharana	Technician ‘E’(Vehi.Mech.)
Technical	Transport	346	Sri Surai Mandi	Technician ‘C’(Vehi.Mech.)
Technical	Transport	364	Sri Kanai Lal Malakar	Technician ‘C’
Auxiliary	Transport	353	Sri Aloke Kr. Sarkar	Driver - V
Auxiliary	Transport	352	Sri Gouri Sankar Singh	Driver - V
Auxiliary	Transport	355	Sri Tarak Nath Ghosh	Driver - IV
Auxiliary	Transport	356	Sri Kashi Nath Prasad	Driver - IV
Auxiliary	Transport	357	Sri Dilip Baidya	Driver - IV
Auxiliary	Transport	358	Sri Madhusudan Mondal	Driver - IV
Auxiliary	Transport	360	Sri Gopal Ch. Ghosh	Driver - III
Auxiliary	Transport	701	Sri Uttam Kr. Roy	Driver - II
Auxiliary	Transport	708	Sri Kartick Ch. Pal	Driver - II
Auxiliary	Transport	702	Sri Prabir Kr. Mistri	Driver - III
Auxiliary	Transport	359	Sri Prabir Biswas	Driver - II
Technical	Transport	121	Sri Asit Kr. Mahapatra	Technician ‘B’
Auxiliary	Transport	124	Sri Mongol Ch. Mondal	Helper ‘E’
Auxiliary	Transport	282	Sri Sankar Ram	Helper ‘B’
	Workshop	137	Dr. Suvendu Nath Bose	Chairman, Workshop Committee
Technical	Workshop	791	Sri Jisnu Basu	Engineer ‘F’ & Officer-In-Charge
Technical	Workshop	371	Sri Asit Kr. Mondal	Technician ‘H’
Technical	Workshop	375	Sri Sukumar Kundu	Technician ‘G’

Technical	Workshop	380	Sri Dhirendra Nath Debnath	Technician ‘G’
Technical	Workshop	379	Sri Sadananda Dutta	Technician ‘G’
Technical	Workshop	378	Sri Ramen Jana	Technician ‘F’
Technical	Workshop	709	Sri Sudipta Barman	Scientific Assistant ‘C’ (Fitter)
Technical	Workshop	381	Sri Debasish Sen	Technician ‘F’
Technical	Workshop	383	Sri Supriya Mondal	Technician ‘F’
Technical	Workshop	384	Sri Biplab Kr. Dey	Technician ‘E’
Technical	Workshop	386	Sri Partha Sarathi Karmakar	Technician ‘F’ (Turner)
Technical	Workshop	1048	Sri Narayan Chandra Dey	Scientific Assistant-A (CNC Operator)
Technical	Workshop	387	Sri Tarun Tapan Biswas	Technician ‘E’ (Fitter)
Technical	Workshop	596	Sri Gopal Kr. Chatterjee	Technician ‘E’(Eng.Stores)
Technical	Workshop	388	Sri Ramkrishna Roy	Technician ‘E’ (Machinist)
Technical	Workshop	389	Sri Himangsu Bhusan Dhar	Technician ‘E’
Technical	Workshop	767	Sri Bhairab Ch. Nath	Technician ‘D’ (Mil. Fitter)
Technical	Workshop	766	Sri Sunil Das	Technician ‘D’ (Mil. Fitter)
Technical	Workshop	829	Sri Durlav Tudu	Technician ‘D’ (Turner)
Technical	Workshop	597	Sri Sadip Patra	Technician ‘C’ (Welder)
Technical	Workshop	874	Sri Himadri Chakraborty	Technician ‘C’ (Machinist)
Technical	Workshop	875	Sri Subrata Baidya	Technician ‘D’ (Machinist)
Technical	Workshop	363	Sri Subal Ch. Bindi	Technician ‘C’
Technical	Workshop	1000	Sri Adhir Sarkar	Technician ‘B’
Auxiliary	Workshop	391	Sri Santosh Kr. Barman	Caretaker
Auxiliary	Workshop	362	Sri Deb Prasad Sardar	Helper ‘E’
Auxiliary	Workshop	281	Sri Gopal Das	Helper ‘B’
Scientific	AstroParticle Physics & Cosmology (APC)	1053	Prof. Pijushpani Bhattacharjee	Sr. Professor ‘H’ & HOD
Scientific	AstroParticle Physics & Cosmology (APC)	847	Prof. Parthasarathi Majumdar	Sr. Professor ‘H+’
Scientific	AstroParticle Physics & Cosmology (APC)	19	Prof. Debades Bandyopadhyay	Professor ‘G’
Scientific	AstroParticle Physics & Cosmology (APC)	1009	Prof. Debasish Majumdar	Professor ‘F’
Scientific	AstroParticle Physics & Cosmology (APC)	1010	Prof. Ambar Ghosal	Professor ‘F’
Scientific	AstroParticle Physics & Cosmology (APC)	1232	Dr. Mala Das	Associate Professor ‘E’
Scientific	Theory Division	6	Prof. Kamales Kar	Sr. Professor ‘H’ & Head
Scientific	Theory Division	3	Prof. Radhey Shyam	Sr. Professor ‘H+’
Scientific	Theory Division	9	Prof. Anjan Kundu	Sr. Professor ‘H+’
Scientific	Theory Division	11	Prof.Parthasarathi Mitra	Sr. Professor ‘H+’

Scientific	Theory Division	12	Prof. Avaroth Harindranath	Sr. Professor ‘H+’
Scientific	Theory Division	14	Prof. Polash B. Pal	Sr. Professor ‘H+’
Scientific	Theory Division	8	Prof. Gautam Ghosh	Professor ‘G’
Scientific	Theory Division	15	Prof. Tarun Kanti Roy	Professor ‘G’
Scientific	Theory Division	16	Prof. Asit Kr. De	Professor ‘G’
Scientific	Theory Division	21	Prof. Kumar Sankar Gupta	Professor ‘G’
Scientific	Theory Division	18	Prof. Sibaji Roy	Professor ‘G’
Scientific	Theory Division	17	Prof. Gautam Bhattacharyya	Professor ‘G’
Scientific	Theory Division	20	Prof. Munshi Golam Mustafa	Professor ‘G’
Scientific	Theory Division	13	Prof. Debabrata Mukhopadhyay	Professor ‘F’
Scientific	Theory Division	696	Prof. Bireswar Basu Mallick	Professor ‘G’
Scientific	Theory Division	963	Prof. Prakash Mathews	Professor ‘F’
Scientific	Theory Division	1004	Prof. Harvendra Singh	Professor ‘F’
Scientific	Theory Division	452	Prof. Bijay Kr. Agrawal	Professor ‘F’
Scientific	Theory Division	895	Prof. Amit Ghosh	Professor ‘F’
Administrative	Theory Division	25	Sm. Dola Mallick	Superintendent
Technical	Theory Division	22	Sri Prodyut Kr. Mitra	Technician ‘E’
Technical	Theory Division	23	Sri Sudarshan Hazra	Technician ‘A’
Auxiliary	Theory Division	26	Sri Arun Kr. Bose	Helper ‘E’
Scientific	Plasma Physics Division	30	Prof. A.N.S. Iyengar	Sr. Professor ‘H’ & In-ChargeChairman, Housing Allotment Committee
Scientific	Plasma Physics Division	32	Prof. Rabindra Nath Pal	Sr. Professor ‘H’
Scientific	Plasma Physics Division	33	Prof.Santwana Roychowdhury	Professor ‘G’
Scientific	Plasma Physics Division	36	Prof. Nihar Ranjan Ray	Professor ‘G’
Scientific	Plasma Physics Division	35	Prof. Sujit Kr. Saha	Professor ‘G’
Scientific	Plasma Physics Division	39	Prof. Mylavarapu Sita Janaki	Professor ‘G’
Scientific	Plasma Physics Division	728	Prof. Nikhil Chakraborty	Professor ‘F’
Technical	Plasma Physics Division	34	Sri Shantanu Chowdhury	Engineer ‘F’
Technical	Plasma Physics Division	40	Sri Parthasarathi Bhattacharya	Scientific Officer ‘C’
Technical	Plasma Physics Division	42	Sri Subhasish Basu	Scientific Officer ‘C’
Technical	Plasma Physics Division	43	Sri Monobir Chattopadhyay	Scientific Officer ‘C’
Technical	Plasma Physics Division	41	Sri Amalendu Bal	Scientific Assistant-E
Technical	Plasma Physics Division	44	Sri Abhijit Betal	Scientific Assistant-D
Administrative	Plasma Physics Division	438	Sri Dulal Chatterjee	Superintendent
Technical	Plasma Physics Division	46	Sri Sib Sankar Sil	Technician ‘E’
Technical	Plasma Physics Division	47	Sri Dipankar Das	Technician ‘C’
Auxiliary	Plasma Physics Division	882	Sri Ashok Kr. Ram	Helper ‘B’
Scientific	Surface Physics Division	196	Prof. Milan Kr. Sanyal	Sr. Professor ‘I’ & Head
Scientific	Surface Physics Division	451	Prof. Purushottam Chakraborty	Sr. Professor ‘H’
Scientific	Surface Physics Division	199	Prof. Debabrata Ghosh	Sr. Professor ‘H’

Scientific	Surface Physics Division	201	Prof. S. R. Bhattacharyya	Professor ‘G’
Scientific	Surface Physics Division	722	Prof. Tapas Kr. Chini	Professor ‘F’
Scientific	Surface Physics Division	203	Prof. Sangam Banerjee	Professor ‘F’
Scientific	Surface Physics Division	657	Prof. Manabendra Mukherjee	Professor ‘F’
Scientific	Surface Physics Division	202	Prof. Srinanda Kundu	Professor ‘F’
Scientific	Surface Physics Division	730	Prof. Satyajit Hazra	Professor ‘F’
Scientific	Surface Physics Division	991	Dr. Satyaban Bhunia	Associate Professor ‘E’
Scientific	Surface Physics Division	993	Dr. Krishnakumar S.R. Menon	Associate Professor ‘E’
Technical	Surface Physics Division	206	Sri Avijit Das	Scientific Officer ‘C’
Technical	Surface Physics Division	204	Sri Subir Roy	Scientific Officer ‘C’
Technical	Surface Physics Division	205	Sri Susanta Bandyopadhyay	Scientific Officer ‘C’
Technical	Surface Physics Division	715	Sri Souvik Banerjee	Scientific Assistant-C
Technical	Surface Physics Division	1020	Sri Goutam Sarkar	Scientific Assistant ‘A’
Administrative	Surface Physics Division	207	Sri Mukul Ch. Das	Superintendent
Auxiliary	Surface Physics Division	209	Sri Harendra Nath Jana	Caretaker
Auxiliary	Surface Physics Division	903	Sri Gobardhan Jana	Helper ‘B’
Scientific	Applied Nuclear Physics Div.	129	Prof. Satyajit Saha	Professor ‘G’ & HOD
Scientific	Applied Nuclear Physics Div.	50	Prof. Sudeb Bhattacharya	Sr. Professor ‘H+’
Scientific	Applied Nuclear Physics Div.	53	Prof. (Smt.) Bichitra Ganguly	Professor ‘G’
Scientific	Applied Nuclear Physics Div.	55	Prof. P. M. G. Nambissan **	Professor ‘G’
Scientific	Applied Nuclear Physics Div.	130	Dr. Mihir Baran Das	Scientist ‘G’
Scientific	Applied Nuclear Physics Div.	37	Prof. Supratik Mukhopadhyay	Professor ‘G’
Scientific	Applied Nuclear Physics Div.	131	Prof. Chandi Charan Dey	Professor ‘F’
Scientific	Applied Nuclear Physics Div.	499	Prof. (Sm.) Nayana Majumdar	Professor ‘F’
Scientific	Applied Nuclear Physics Div.	500	Prof. Sandip Sarkar	Professor ‘F’
Scientific	Applied Nuclear Physics Div.	72	Prof. Manoj Sharan	Professor ‘F’
Technical	Applied Nuclear Physics Div.	133	Sri Amal Ghosal	Scientific Officer-C
Technical	Applied Nuclear Physics Div.	60	Sri Pradipta Kumar Das	Scientific Officer-C
Technical	Applied Nuclear Physics Div.	145	Sri Saibal Saha	Scientific Officer ‘C’
Technical	Applied Nuclear Physics Div.	134	Sri Haradhan Dhar	Scientific Assistant-E
Administrative	Applied Nuclear Physics Div.	86	Sri Nitish Ch. Sarkar	Officer-In-Charge
Technical	Applied Nuclear Physics Div.	725	Sri Chandra Nath Marik	Scientific Assistant-C
Technical	Applied Nuclear Physics Div.	724	Smt. Soma Roy	Scientific Assistant-C
Technical	Applied Nuclear Physics Div.	136	Sri Dilip Kr. Sardar	Technician ‘C’
Auxiliary	Applied Nuclear Physics Div.	842	Sri Kuntal Sarkhel	Helper ‘B
Auxiliary	Applied Nuclear Physics Div.	902	Sri Prabir Das	Helper ‘B’
Scientific	Nuclear Physics Division	75	Prof. Polash Banerjee	Professor ‘G’ & HOD
Scientific	Nuclear Physics Division	73	Prof. Chhanda Samanta	Sr. Professor ‘H’
Scientific	Nuclear Physics Division	76	Prof. Padmanava Basu	Professor ‘G’
Scientific	Nuclear Physics Division	56	Prof. Maitreyee Saha Sarkar	Professor ‘G’

Scientific	Nuclear Physics Division	77	Prof. Subinit Roy	Professor ‘G’
Scientific	Nuclear Physics Division	57	Prof. Ashimananda Goswami	Professor ‘G’
Scientific	Nuclear Physics Division	485	Prof. Ushasi Datta Pramanik	Professor ‘F’
Scientific	Nuclear Physics Division	490	Prof. Chinmay Basu	Professor ‘F’
Scientific	Nuclear Physics Division	484	Prof. (Smt.) Anjali Mukherjee	Professor ‘F’
Technical	Nuclear Physics Division	61	Sri Sujib Ch. Chattopadhyay	Scientific Officer-C
Technical	Nuclear Physics Division	139	Sri Kaushik Chatterjee	Scientific Officer-C
Technical	Nuclear Physics Division	82	Smt. Jonaki Panja	Scientific Officer-C
Technical	Nuclear Physics Division	83	Sri Ajoy Kr. Mitra	Scientific Officer-C
Technical	Nuclear Physics Division	81	Smt. Rita Ghosh	Scientific Assistant-E
Technical	Nuclear Physics Division	62	Sri Dilip Sil	Scientific Assistant-D
Administrative	Nuclear Physics Division	64	Sri Jeevan Kr. Shaw	Senior Assistant
Technical	Nuclear Physics Division	66	Sri Pradip Barua	Technician ‘C’
Technical	Nuclear Physics Division	67	Sri Sankar Prasad Singh	Technician ‘C’
Auxiliary	Nuclear Physics Division	88	Sri Dulal Ch. Ghoshal	Caretaker
Auxiliary	Nuclear Physics Division	1002	Sri Siladitya Chakraborty	Helper ‘A’
Scientific	High Energy Nuclear & Particle Physics Division	1274	Prof. Sunanda Banerjee	Professor & Head
Scientific	High Energy Nuclear & Particle Physics Division	128	Prof. Pratap Bhattacharya	Professor ‘G’
Scientific	High Energy Nuclear & Particle Physics Division	58	Prof. Sukalyan Chattopadhyay	Professor ‘G’
Scientific	High Energy Nuclear & Particle Physics Division	629	Prof. Pradip Kr. Roy	Professor ‘F’
Scientific	High Energy Nuclear & Particle Physics Division	458	Prof. Abhee Kanti Dutt-Mazumdar	Professor ‘F’
Scientific	High Energy Nuclear & Particle Physics Division	769	Dr. (Smt.) Tinku Sinha	Scientist ‘E’
Technical	High Energy Nuclear & Particle Physics Division	720	Sri Dipankar Das	Scientific Assistant-C
Technical	High Energy Nuclear & Particle Physics Division	719	Smt. Lipy Das Bose	Scientific Assistant-C
Administrative	High Energy Nuclear & Particle Physics Division	772	Sri Sanjib Kr. Mondal	Upper Division Clerk
Auxiliary	High Energy Nuclear & Particle Physics Division	892	Sri Rakesh Kr. Ram	Helper ‘B’
Auxiliary	High Energy Nuclear & Particle Physics Division	910	Sri Sudam Bagdi	Helper ‘B’
Scientific	Applied Material Science Div.	198	Prof. Alokmay Datta	Professor ‘G’ & HOD
Scientific	Applied Material Science Div.	844	Dr. Madhusudan Roy	Associate Professor ‘E’
Scientific	Applied Material Science Div.	800	Dr. Supratic Chakraborty	Associate Professor ‘E’
Technical	Applied Material Science Div.	132	Sri Abhijit Sanyal	Engineer ‘G’
Technical	Applied Material Science Div.	148	Sri Avedenanda Bhattacharya	Scientific Assistant-C

Technical	Applied Material Science Div.	147	Sri Shyama Prasad Mallick	Technician 'F'
Administrative	Applied Material Science Div.	149	Sri Subhasish Sanyal	Superintendent
Auxiliary	Applied Material Science Div.	150	Sri Provash Halder	Helper 'D'
Scientific	Electronics Workshop Facility	137	Dr. Suvendu Nath Bose	Sr. Scientist 'H' & In-Charge
Technical	Electronics Workshop Facility	138	Sri Debasish Bandyopadhyay	Scientific Assistant-E
Technical	Electronics Workshop Facility	794	Sri Dwijendra Das	Scientific Assistant-C
Technical	Electronics Workshop Facility	135	Sri Dulal Das	Technician 'G'
Auxiliary	Electronics Workshop Facility	873	Sri Singh Bahadur Thapa	Helper 'B'
Scientific	Theoretical Condensed Matter Physics Division	181	Prof. B. K. Chakraborty	Sr. Professor 'I' & HOD
Scientific	Theoretical Condensed Matter Physics Division	184	Prof. Atindra Nath Das	Sr. Professor 'H'
Scientific	Theoretical Condensed Matter Physics Division	185	Prof. Asok Kr. Sen	Professor 'G'
Scientific	Theoretical Condensed Matter Physics Division	163	Prof. S. N. Karmakar	Professor 'G'
Scientific	Theoretical Condensed Matter Physics Division	162	Prof. Sudhakar Yarlagadda	Professor 'G'
Scientific	Theoretical Condensed Matter Physics Division	1050	Prof. Pradeep Kr. Mohanty	Professor 'F'
Scientific	Theoretical Condensed Matter Physics Division	1068	Prof. Abhik Basu	Professor 'F'
Administrative	Theoretical Condensed Matter Physics Division	175	Sri Ashoke Kumar Nayak	Officer-In-Charge
Administrative	Theoretical Condensed Matter Physics Division	176	Sri P. S. Bhattacharya	Sr. Superintendent
Technical	Theoretical Condensed Matter Physics Division	801	Sri Kausik Das	Scientific Assistant-C
Auxiliary	Theoretical Condensed Matter Physics Division	878	Sri Jhantu Mallick	Helper 'B'
Auxiliary	Theoretical Condensed Matter Physics Division	877	Sri Asish Ram	Helper 'B'
Scientific	Experimental Condensed Matter Physics Division	157	Prof. Amitabha Ghosh Ray	Sr. Professor 'H' & HOD
Scientific	Experimental Condensed Matter Physics Division	182	Prof. R. Ranganathan	Sr. Professor 'H'
Scientific	Experimental Condensed Matter Physics Division	183	Prof. Kamal Kr. Bardhan	Sr. Professor 'H'
Scientific	Experimental Condensed Matter Physics Division	156	Prof. Abu Ismail Jaman	Sr. Professor 'H'
Scientific	Experimental Condensed Matter Physics Division	161	Prof. (Smt.) Kajal Ghosh Ray	Professor 'G'
Scientific	Experimental Condensed Matter Physics Division	165	Prof. Chandidas Mukherjee	Professor 'G'

Scientific	Experimental Condensed Matter Physics Division	164	Prof. Sailendra Nath Das	Professor 'G'
Scientific	Experimental Condensed Matter Physics Division	752	Prof. Indranil Das	Professor 'G'
Scientific	Experimental Condensed Matter Physics Division	186	Prof. Prabhat Mandal	Professor 'G'
Scientific	Experimental Condensed Matter Physics Division	166	Prof. Barnana Pal	Professor 'F'
Scientific	Experimental Condensed Matter Physics Division	189	Prof. Asok Podder	Professor 'F'
Scientific	Experimental Condensed Matter Physics Division	653	Prof. Bilwadal Bandyopadhyay	Professor 'F'
Scientific	Experimental Condensed Matter Physics Division	843	Prof. Chandan Mazumdar	Professor 'F'
Technical	Experimental Condensed Matter Physics Division	169	Sri Ajoy Kr. Bhattacharya	Scientific Officer 'C'
Technical	Experimental Condensed Matter Physics Division	191	Sri Tapan Kr. Pyne	Scientific Officer 'C'
Technical	Experimental Condensed Matter Physics Division	214	Sri Arun Kumar Pal	Technician 'G'
Technical	Experimental Condensed Matter Physics Division	170	Smt. Sankari Chakrabarti	Scientific Assistant-D
Technical	Experimental Condensed Matter Physics Division	192	Sri Arindam Chakraborti	Scientific Assistant-C
Technical	Experimental Condensed Matter Physics Division	716	Sri Dhrubajyoti Seth	Scientific Assistant-C
Technical	Experimental Condensed Matter Physics Division	193	Smt. Papia Bhowmik (Mondal)	Scientific Assistant-B
Technical	Experimental Condensed Matter Physics Division	174	Sri Anish Karmahapatra	Technician 'E'
Administrative	Experimental Condensed Matter Physics Division	194	Sri Tapan Kr. Sarkar	Superintendent
Technical	Experimental Condensed Matter Physics Division	215	Sri Sambu Hembrom	Technician 'C'
Technical	Experimental Condensed Matter Physics Division	195	Sri Prabir Das	Technician 'B'
Auxiliary	Experimental Condensed Matter Physics Division	177	Sri Patit Paban Ranjit	Helper 'E'
Auxiliary	Experimental Condensed Matter Physics Division	1275	Shri Rajeshwar Dubey	Trainee-Helper
Scientific	Crystallography & Molecular Biology Division	220	Prof. Nitai Pada Bhattacharyya	Sr. Professor 'H' & HOD
Scientific	Crystallography & Molecular Biology Division	219	Prof. (Smt.) Chandana Chakraborti	Professor 'G'

Scientific	Crystallography & Molecular Biology Division	221	Prof. Sanghamitra Raha	Professor 'G'
Scientific	Crystallography & Molecular Biology Division	222	Prof. Rahul Banerjee	Professor 'F'
Scientific	Crystallography & Molecular Biology Division	223	Prof. Sampa Biswas	Professor 'F'
Scientific	Crystallography & Molecular Biology Division	224	Prof. Partha Saha	Professor 'F'
Scientific	Crystallography & Molecular Biology Division	770	Prof. Udayaditya Sen	Professor 'F'
Technical	Crystallography & Molecular Biology Division	230	Sri Utpal Basu	Scientific Officer 'C'
Technical	Crystallography & Molecular Biology Division	232	Sri Abhijit Bhattacharya	Scientific Assistant-D
Technical	Crystallography & Molecular Biology Division	717	Sri Bikram Nath	Scientific Assistant-C
Technical	Crystallography & Molecular Biology Division	785	Sri Sushanta Debnath	Scientific Assistant-C
Technical	Crystallography & Molecular Biology Division	787	Sri Saikat Mukhopadhyay	Scientific Assistant-C
Technical	Crystallography & Molecular Biology Division	231	Sri Ashis Kumar Dutta	Scientific Assistant-B
Administrative	Crystallography & Molecular Biology Division	234	Smt. Durga Hazra	Superintendent
Technical	Crystallography & Molecular Biology Division	235	Sri Samir Kr. Majumdar	Technician 'C'
Auxiliary	Crystallography & Molecular Biology Division	236	Sri Chinmoy Chatterjee	Helper 'D'
Auxiliary	Crystallography & Molecular Biology Division	237	Sri Sakal Dev Ram	Helper 'C'
Auxiliary	Crystallography & Molecular Biology Division	885	Sri Bipin Bose	Helper 'B'
Scientific	Structural Genomics Division	246	Prof. Subrata Banerjee	Professor 'G' & HOD
Scientific	Structural Genomics Division	1005	Dr. Debashis Mukhopadhyay	Associate Professor 'E'
Scientific	Structural Genomics Division	1227	Dr. (Smt.) Oishee Chakrabarti	Associate Professor 'E'
Auxiliary	Structural Genomics Division	554	Shri Madhu Sudan Samal	Asstt. Halwai-cum-Cook
Scientific	Structural Genomics Division	245	Prof. Abhijit Chakrabarti	Professor 'G'
Technical	Structural Genomics Division	957	Sri Raju Dutta	Technician 'B'
Auxiliary	Structural Genomics Division	886	Sri Sanjay Shaw	Helper 'B'
Technical	Electron Microscope Facility	242	Sri Pulak Krmar Roy	Engineer 'G' & Head
Scientific	Electron Microscope Facility	1279	Dr. Biswarup Satpati	Scientist 'E'
Technical	Electron Microscope Facility	248	Sri Tapan Kr. Roy	Scientific Officer 'D'
Technical	Electron Microscope Facility	249	Sri Ajay Chakrabarty	Scientific Assistant-D
Scientific	Biophysics Division	239	Prof. Dipak Dasgupta	Sr. Professor 'H' & HOD

Scientific	Biophysics Division	240	Prof. Pradip Kr. Sengupta	Sr. Professor ‘H’
Scientific	Biophysics Division	247	Prof. Dhananjay Bhattacharyya	Professor ‘G’
Scientific	Biophysics Division	241	Dr. Radha Bhattacharyya	Scientist ‘F’
Scientific	Biophysics Division	244	Prof. Arun Kr. Pal	Professor ‘F’
Scientific	Biophysics Division	1231	Dr. Kaushik Sengupta	Associate Professor ‘E’
Technical	Biophysics Division	250	Sri Sekhar Bhattacharya	Scientific Officer ‘C’
Technical	Biophysics Division	251	Sri Arijit Pal	Scientific Assistant-D
Administrative	Biophysics Division	253	Sri Bijay Kr. Das	Superintendent
Technical	Biophysics Division	257	Sri Nirmal Ch. Das	Technician ‘B’
Auxiliary	Biophysics Division	887	Sri Shyamal Ch. Digar	Helper ‘B’
Scientific	Chemical Sciences Division	90	Prof. Soumen Basak	Sr. Professor ‘H’ & HOD
Scientific	Chemical Sciences Division	93	Prof. Amitabha De	Professor ‘G’
Scientific	Chemical Sciences Division	94	Prof. Susanta Lahiri	Professor ‘G’
Scientific	Chemical Sciences Division	92	Prof. Samita Basu	Professor ‘G’
Scientific	Chemical Sciences Division	95	Prof. Maitreyee Nandy	Professor ‘F’
Scientific	Chemical Sciences Division	96	Prof. Munna Sarkar	Professor ‘F’
Technical	Chemical Sciences Division	97	Sri Ajay Das	Scientific Assistant-E
Technical	Chemical Sciences Division	98	Smt. Chitra Raha	Scientific Assistant-D
Technical	Chemical Sciences Division	645	Sri Avijit Shome	Scientific Assistant-C
Administrative	Chemical Sciences Division	100	Sri Subir Bandyopadhyay	Senior Assistant
Technical	Chemical Sciences Division	102	Sri Bablu Ram	Technician ‘C’
Auxiliary	Chemical Sciences Division	915	Sri Deepak Kr. Ram	Helper ‘C’
Auxiliary	Chemical Sciences Division	914	Sri Jitendra Nath Ray	Helper ‘C’
	Teaching	14	Prof. Palash Baran Pal	Head of Section
Scientific	Teaching	258	Dr. Bijay Bhushan Bal	Scientist ‘G’
Technical	Teaching	260	Sri Jayant Kr. Mukherjee	Scientific Assistant-C
Administrative	Teaching	261	Sri Sudarshan Mondal	Senior Assistant
Auxiliary	Teaching	262	Sri Nirmal Ch. Biswas	Helper ‘D’
	Computer	16	Prof. Asit Kr. De	Professor ‘F’ & Prof.-in-Charge
Scientific	Computer	264	Sri Gautam Garai	Scientist ‘G’
Technical	Computer	765	Sri Deeptish Dey	Engineer ‘F’
Technical	Computer	266	Sri Gautam Datta	Scientific Assistant-E
Technical	Computer	1021	Sri Sumit Basu	Scientific Assistant ‘B’
Technical	Computer	268	Sri Nanda Lal Sanpui	Technician ‘C’
Technical	Computer	1017	Sri Soumya Majumdar	Technician ‘C’
	Guest House & Hostel	201	Prof. Satya Ranjan Bhattacharya	Prof.-in-Charge, Guest House &Hostel, SINP Housing Com.(MSA-II)
Guest House & Hostel	36	Prof. Nihar Ranjan Ray		Prof.-In-Charge, Guest House & Hostel, Salt Lake Campus (MSA-I)

Auxiliary	Guest House & Hostel	837	Shri Ramesh Singh	Helper ‘B’
Auxiliary	Guest House & Hostel	889	Sri Somenath Das	Helper ‘B’
Auxiliary	Guest House & Hostel	888	Smt. Suro Mahato	Helper ‘B’
Auxiliary	Guest House & Hostel	556	Sri Suresh Ch. Das	Asst. Halwai-cum-cook
Auxiliary	Guest House & Hostel	555	Sri Sakti Pada Bisui	Asst. Halwai-cum-cook
	Canteen Staff (Salt Lake Campus)	247	Prof. Dhananjay Bhattacharyya	Chairman, Canteen Committee
Administrative	Canteen Staff (Salt Lake Campus)	635	Sri Ashok Roy	Asstt. Manager-cum-Storekeepe
Auxiliary	Canteen Staff (Salt Lake Campus)	634	Sri Shankar Panda	Halwai-cum-cook
Auxiliary	Canteen Staff (Salt Lake Campus)	633	Sri Prabhat Maity	Halwai-cum-cook
Auxiliary	Canteen Staff (Salt Lake Campus)	638	Sri Kartick Ch. Maity	Asst. Halwai-cum-cook
Auxiliary	Canteen Staff (Salt Lake Campus)	636	Sri Sujan Ch. Mistri	Asst. Halwai-cum-cook
Auxiliary	Canteen Staff (Salt Lake Campus)	637	Sri Sailen Halder	Bearer-II
Auxiliary	Canteen Staff (Salt Lake Campus)	639	Sri Nemai Ch. Das	Bearer-II
Auxiliary	Canteen Staff (Salt Lake Campus)	641	Sri Amar Das	Bearer-II
Auxiliary	Canteen Staff (Salt Lake Campus)	642	Sri Barun Kr. Barua	Bearer-II
Auxiliary	Canteen Staff (Salt Lake Campus)	663	Sri Subodh Kr. Pradhan	Bearer-I
Auxiliary	Canteen Staff (Salt Lake Campus)	890	Sri Sunil Ram	Bearer
Auxiliary	Canteen Staff (Salt Lake Campus)	891	Sri Shankar Andia	Sr. Bearer

List of Retirement for the period from 01.04.2007 to 31.03.2010:

List of Retirement - 2007

SL. NO.	NAME & DIVISION/ SECTION	DESIGNATION ON APPT.	DATE OF JOINING	DATE OF BIRTH	DATE OF RETIREMENT
1.	Sri Sadhan Barua/ Biophysics	Bearer	09.12.69	20.04.47	30.04.2007
2.*	Prof. J.K.Dattagupta/ C&MB	Lecturer	19.02.77	01.05.45	30.04.2007
3.	Sri Dipak Banik/ PPD	Tech. 'C'	12.03.75	13.06.47	30.06.2007
4.	Sri Tapan Kr. Das/ N&AP	Tech. 'C"	07.11.78	15.06.47	30.06.2007
5.**	Prof. Bikash Sinha/ DIRECTOR		01.11.92	16.06.45	30.06.2007
6.	Sri R. K. Dubey/ BM(E)	Lab.Attdt.	01.03.68	15.08.47	31.08.2007
7.	Sri S. K. Banerjee/ Adm.	UDC	11.07.74	26.08.47	31.08.2007
8.	Sri Anarshi Ram/ ECMP	Bearer	01.09.63	15.09.47	30.09.2007
9.	Sri S.N.Dutta/ ECMP	Tech. 'C'	14.06.74	10.10.47	31.10.2007
10.	Sri Ranabir Ram/ T.U.	Bearer	01.09.68	04.12.47	31.12.2007
11.	Sri Bhamar Singh/ Security	Durwan	01.11.67	08.12.47	31.12.2007
12.	Prof. D. Bhattacharya/ N&AP	Reader	04.01.88	23.12.47	31.12.2007

* Prof. J. K. Dattagupta - Extension for two years w.e.f.01.05.2005.
** Prof. Bikash Sinha – Extension for two years w.e.f.30.06.2007.

List of Retirement - 2008

SL. NO.	NAME & DIVISION/ SECTION	DESIGNATION ON APPT.	DATE OF JOINING	DATE OF BIRTH	DATE OF RETIREMENT
1.	Sri Babulal Ram/ Library	Attendant	01.11.67	04.02.48	29.02.2008
2.	Sri Arun Roy/ T.U.	Driver-I	14.06.84	12.03.48	31.03.2008
3.	Prof. G. Bhattacharya/ Theory	Reader	01.09.84	19.05.48	31.05.2008
4.	Sri Samir Kr. Das/ Security	Tech. 'A' (Security Staff)	08.12.80	09.09.48	30.09.2008
5.	Dr. Swapan Kr. Sen/ MED	Scientist 'SB'	01.09.84	01.11.48	31.10.2008

List of Retirement - 2009

SL. NO.	NAME & DIVISION/ SECTION	DESIGNATION ON APPT.	DATE OF JOINING	DATE OF BIRTH	DATE OF RETIREMENT
1.	Sri S. K. Seal/ Adm.	Bearer	01.07.69	10.01.49	31.01.2009
2.	Sri Bhim Hari/ BM(C)	Sweeper	01.04.70	13.01.49	31.01.2009
3.	Sri R. N. Dutta/ WKS	Tech. 'D'	21.10.78	04.02.49	28.02.2009
4.	Sri B. P. Das/ N&AP	Tech. 'D'	15.09.83	29.07.49	31.07.2009
5.	Dr. P. C. Mondal/ CSD	Lecturer	12.05.88	13.09.49	30.09.2009
6.	Sri Niranjan Maity/ Canteen	Bearer/Wash Boy/ Dish Cleaner	20.05.85	04.11.49	30.11.2009
7.	Dr. Gautam Roy/TCMP (Earlier DOR-31.12.2009)	Scientist 'SB'	02.07.83	28.12.49	15.01.2009 (VRS)

List of Retirement - 2010

SL. NO.	NAME & DIVISION/ SECTION	DESIGNATION ON APPT.	DATE OF JOINING	DATE OF BIRTH	DATE OF RETIREMENT
1.	Sm. Baby Basak/ Adm.	L.D.C.	05.04.90	06.01.50	31.01.2010

12 Author Index

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D