Saha Institute of Nuclear Physics

Annual Report 2010-2011

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Saha Institute of Nuclear Physics

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Contents

Foreword

We started celebration of Diamond Jubilee Year of our institute when President of India visited us in December 2009 and we have concluded the celebration on 21st August, 2011 in presence of Prime Minister of India, Governor of West Bengal, Chief Minister of West Bengal and Union Finance Minister. In my mind these visits signifies the importance of the basic research in the planned activities of the Government of India. Significant increase in funding for research has happened in recent years and that is becoming evident in the growth of number of scientific publication from India. But the number of publications may not mean much in bringing prestige and recognition to our country in Basic Science and Technology. The Basic Science should be internationally competitive and path-breaking that improves our living conditions, for example Faraday's discovery of electricity and its production that changed human society forever, J.C. Bose's discovery of microwave communication that we use in mobile phones, Fleming's discovery of Penicillin that changed the human life-expectancy and Meghnad Saha's discovery Saha equation of Thermal ionisation that changed the way research is done in Astrophysics and Cosmology - the subject that connects human being to the universe. But we all know, to have an Everest in Indian Science we need Himalaya to grow and the general growth of publication number indicate that Himalaya is getting formed. To place India at the top, significant development of scientific infrastructure is required and institute like ours have to take responsibility for this to happen so that Nobel prizes again start coming to India as we become developed country technologically and otherwise.

Over six glorious decades this autonomous research institute, funded by the Department of Atomic Energy, has celebrated and practiced Professor Meghnad Saha's legacy: a global quest for scientific truth at fundamental levels. During these sixty years SINP has scaled new heights in a number of areas, not only in physics but also in chemistry and the life sciences, setting up firsts, nationally as well as internationally. Its ambit has covered the fundamental building blocks of matter, the atomic nucleus, the plasma state, atoms and molecules, condensed matter and nanomaterials, exotic matter and phenomena in the cosmos, the structures of genomes and proteomes, and the genetic origin of diseases.

Some early feathers in its cap were building the first cyclotron and the first electron microscope in India both were only third in the world. This tradition has been reflected in recent years in building, among others, a detector that lies at the heart of experiments being carried out at the Large Hadron Collider (LHC) in collaboration with CERN at Geneva, an achievement that has been further consolidated through closer collaboration in ALICE and CMS experiments at LHC. Saha Institute of Nuclera Physics has signed a Memorandum of Understanding with CERN for these collaborations during the visit of Director General, CERN, Geneva. The Indian National Gamma Array has been st up for probing nuclear structures, and the Facility for Research in Experimental Nuclear Astrophysics is being set up to extend Professor Saha's pioneering investigations on the inner workings of stars. On behalf of Saha Institute, it was my privilege to sign a milestone Memorandum of Understanding with DESY of Germany on 31st May, 2011 in presence of our Prime Minister and Chancellor of Germany to make our institute the nodal institute of India for nanoscience research using PETRA-III Synchrotron at DESY. Only four such high energy high brilliance synchrotron exist in the world, apart from DESY, Germany other three are in France, Japan and USA. We are proposing a second campus of SINP to built a high energy and high brilliance 6GeV and 200 mA Synchrotron - The Indian Synchrotron for Materials and Energy Research (ISMER) - the fifth such facility in the world. This campus will strengthen basic research in Energy Materials, Disease Biology and Theoretical and Computational Physics. At the completion of our Diamond Jubilee Year, the Institute looks back with pride and looks forward with hope and confidence.

Prof Milan K Sanyal
Director
January 11, 2012

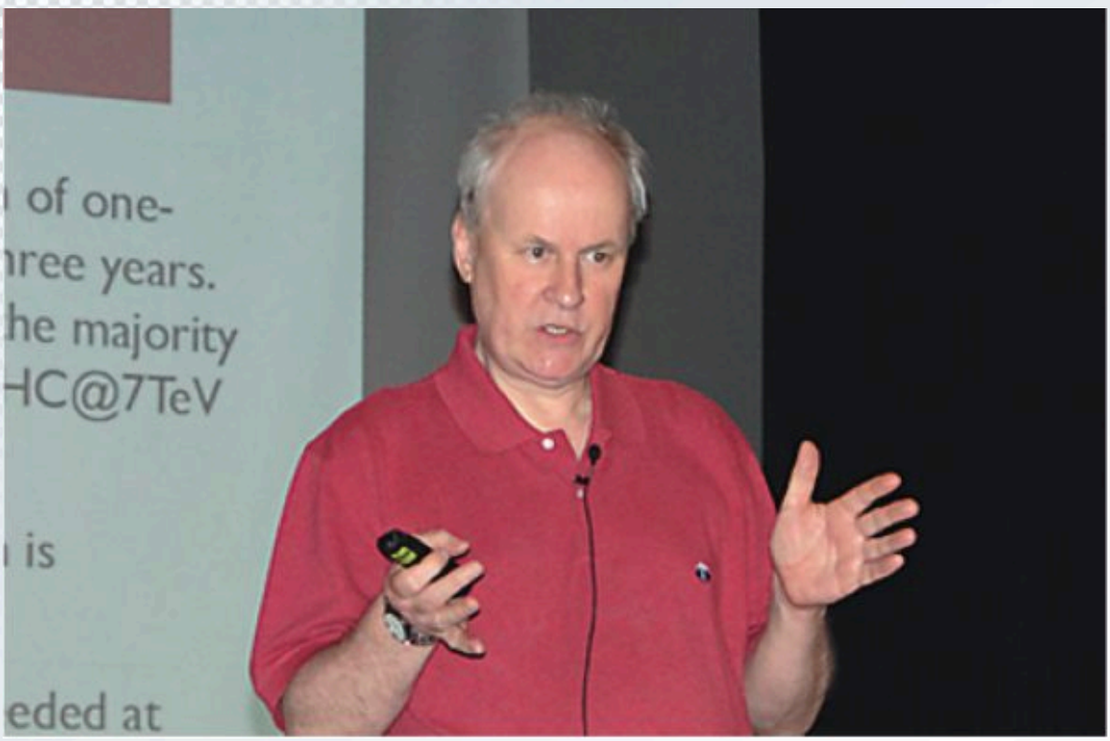
From the Desk of the Editorial Team

This annual report contains activities of Saha Institute of Nuclear Physics (SINP) from April 2010 till March 2011. The nature of research work and developmental activities carried out during this period for a multi-disciplinary institute like ours is wide in spectrum. Like in the triennial report, we stuck to the policy of accommodating the accomplished research work, by collecting the research papers published by our institute members during this period 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 in the Institute contains title of the paper, summary of the work as described in the abstract, and list of authors for each paper. This time, we have been also able to publish research highlights from the voluntary inputs of each willing faculty members. Towards this, a short summary of on-going research and / or developmental work, not published anywhere, have been included in the report. The list of publication appended for each research area, have been made from the corresponding reference along with other publications appeared in established journals. 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. At the end of the report, names and affiliations of collaborators have been enlisted. For convenience of reference, the names of external collaborators are marked with dagger (†) in the research activities section. Honourable Prime Minister of India, Dr. Manmohan Singh, visited our Institute on August 21, 2011 on the occasion of the closing ceremony of the Diamond Jubilee celebration. We have kept few photographs of the occasion in this report, which otherwise would take another year to appear in the annual report 2011-12. The editorial team wishes to thank all the institute members for their input, support and feedback.

January 11, 2012

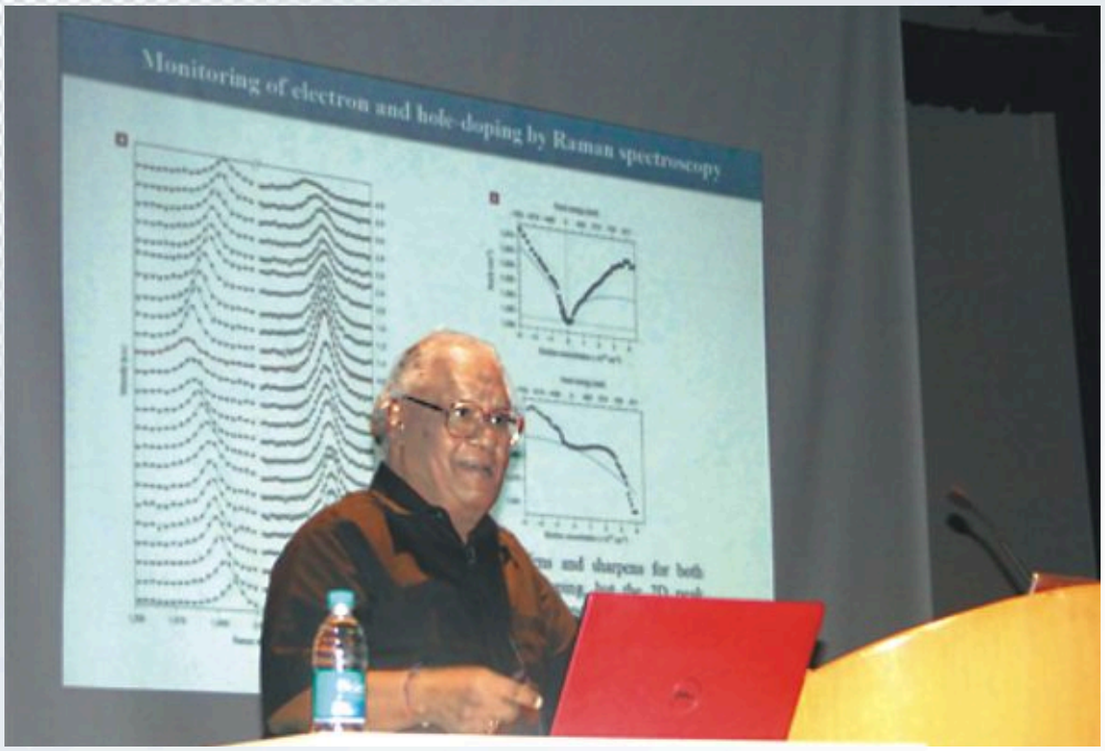
Honorable dignitaries in the closing ceremony of the Diamond Jubilee celebration of the Institute on August 21st, 2011. From left Dr. Srikumar Banerjee, Chairman, AEC & Chairman, Governing Council of SINP, Shri Pranab Mukherjee, Hon'ble Union Finance Minister, Government of India, Smt. Mamata Banerjee, Hon'ble Chief Minister of West Bengal, Shri M.K. Narayanan, Hon'ble Governor of West Bengal, **Dr. Manmohan Singh** Hon'ble Prime Minister of India, and Dr. Milan K. Sanyal, Director, SINP.

From left Dr. Milan K. Sanyal, Director, SINP, **Dr. Manmohan Singh**, Hon'ble Prime Minister of India, Smt. Mamata Banerjee, Hon'ble Chief Minister of West Bengal and Dr Srikumar Banerjee, Chairman, AEC & Chairman, Governing Council of SINP in the closing ceremony of the Diamond Jubilee celebration of SINP.



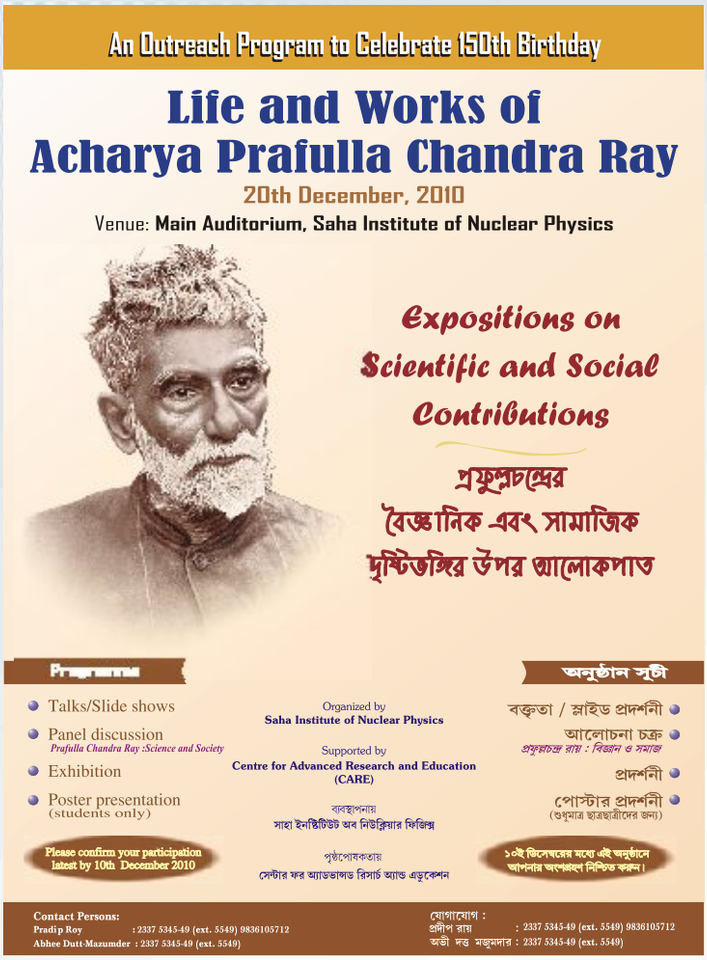
Prof. R. Keith Ellis, Fermilab, USA delivering 7th J C Bose Memorial Lecture.

Delegates of JSPS-DST Asia – 2010



Prof. C N Rao delivering lecture in JSPS-DST Asia – 2010

Prof. Klaus von Klitzing, Nobel Laureate delivering 49th Saha Memorial Lecture



An Outreach Programme organised by SINP

Prof. Suranjan Das, Vice Chancellor, University of Calcutta addressing in a discussion meeting on Crop culture, Biotechnology and Biodiversity.

Chapter 1

Biophysical Sciences including Chemistry

1.1 Summary of Research Activities of Divisions

1.1.1 Biophysics

Research activities in the last year can be classified into following broad areas: chemical biology, structural biology and biospectroscopy. In the area of chemical biology two major streams of work are as follows. The effects of small molecules with potentials as transcription inhibitors and/or epigenetic modulators upon the chromatin structure with emphasis upon remodeling have been studied. The chemical biology of the function of small molecules with use and potential as human medicine has been studied at different levels. We have also embarked upon the characterization of the self association properties of lamins especially lamin A in the light of the disease Dilated Cardiomyopathy where missense mutations of lamin A are causative factors. In this project a plethora of biophysical techniques like Fluorescence and CD spectroscopy, dynamic light scattering and isothermal titration calorimetry are being employed to address the parameters of this self association. Research in computational structural biology the emphasis has been as follows. Various base pairing motifs, as found in RNA structures, have been analyzed in detail through different ab initio quantum chemical methods and compared with crystallographic ensembles. We have characterized role of some non-Watson-Crick base pairs in double helical fragments of RNA through molecular dynamics simulations. We are also using molecular dynamics simulation to understand DNA-protein interactions, particularly where DNA deforms significantly due to complex formation.In biospectroscopy, as part of efforts to develop efficient drug delivery strategies for natural product based drugs, we explored the encapsulation of several therapeutically active plant flavonoids (which have poor solubility in water, which restricts their intrinsinsic bioavailability) in cyclodextrin based nanovehicles for drug delivery, using steady state and time resolved fluorescence, absorption and induced circular dichroism spectroscopy, combined with theoretical (molecular docking) studies. We also utilized the exquisitely sensitive two color fluorescence properties of such compounds to explore their binding to carrier proteins and phosphatidyl choline based liposomal membranes, and estimated their antioxidant activities using spectrophotometric assays. Such studies have revealed how the chemical structures of flavonoids influence their (i) nanoencapsulation properties in natural and chemically modified cyclodextrins(ii)binding characteristics in proteins/ membranes and (iii) inhibitory actions on membrane lipid peroxidation, in relation to their potential uses as drugs for free radical mediated diseases.

1.1.2 C&MB

During this period macromolecular crystallographic studies centered on the structural characterization of the industrially relevant enzymes ervatamin C, papain and also a physiologically important protein (CheY3) from *Vibrio cholereae* involved in chemotaxis. Two pathogenic organisms *Leishmania donovani* and *Entamoeba hystolytica* were also the subjects of several studies which included the characterization of a novel RNA protein (*L. donovani*) capable of both DNA/RNA endonuclease activities and a mitogen activated protein kinase (*E. hystolytica*) associated with cell survival. To identify the role of altered micro RNA (miRNA) expressions in the pathogenesis of Huntingtons disease (HD), we identified 27 miRNAs, whose expressions were altered in $STHdh^{Q111}/Hdh^{Q111}$ cells, a cell model of (HD). We also showed that among these miRNAs, decreased expression of miR-146a could general transcription factor TB.

1.1.3 Chemical Science

A Fluorescence Correlation Spectrometer (FCS) was assembled using its constituent optical and electronic components, thus providing the flexibility of easy modification of, and additions to, the setup. Calibration of the instrument using Rhodamine B yielded values of focal volume and diffusion time that indicated its capability of working in the single molecule regime. TNP-Ado, a fluorescent derivative of adenosine, was synthesized and its photophysical properties studied using fluorescence and CD spectroscopy. Studies on photoinduced host-guest interactions between biologically important molecules like 4-nitroquinoline-1-oxide, acridine and its derivatives, etc and proteins, DNA, organic bases etc in a number of confined media like micelles, reverse micelles and cucurbit[n]urils were carried out by steady-state and nanosecond time-resolved absorption associated with a small magnetic field ($\sim$0.08 Tesla) and fluorescence techniques. Gold nanoparticles (AuNP) incorporated polyaniline nanowires (PAn-NW) were used for fabrication of a novel biosensing platform. A new and label-free impedimetric biosensor for detection of *E.Coli 0157:H7* was fabricated using antigen-antibody binding method on conducting polyaniline film surface. Polyaniline-MnO_2 nanocomposite was used for fabricating an electrochemical capacitor having good specific capacitance value. The effects of different physico-chemical parameters of both the participating drugs and membranes on NSAIDs induced membrane fusion were deciphered. The influence of different base sequences on the binding of Cu(II) complexes of oxicam NSAID to the nucleic acid backbone were also elucidated. Introduction of fluorescent probes to smart supramolecular assemblies was done to investigate biochemical microenvironments. This provided unique and critical information about the response of the assemblies to single or multiple external stimuli. New production routes and separation methodologies were developed for production of clinically import radionuclides, like ^{97}Ru from ^{7}Li-activated natural niobium and proton rich $^{93-96}$Tc radionuclides from ^{7}Li- and ^{9}Be-activated zirconium and yttrium. There was active participation in the superheavy elements experiment carried out at GSI, Germany in collaboration with an international team. Neutron dosimetry in heavy ion reactions revealed that angular distribution of neutron dose is largely anisotropic even in the energy range of 7.512 MeV/amu. Analysis of the energy dependent distribution of absorbed dose D for different organs suggested a quality factor between 8.1 and 9.1 for neutrons produced in these beam energies.

1.1.4 Structral Genomics

This Division is primarily carrying out research in two major areas - hematological disorders and neurodegenerative diseases. The widely prevalent disease of eastern India, HbE-thalassemia along with, sickle cell anemia, hereditary spherocytosis and leukemia are being studied as a model for

hematological disorders while Alzheimers, Huntingtons, and the prion diseases are being studied for the neurodegenerative diseases. 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. Differential interactions of HbE and HbA with erythroid spectrin have been shown to be implicated in β- & HbEβ-thalassemia. Drastic loss of PS asymmetry has been found in sickle cell disease, leading 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 hundreds of proteins from the erythrocytes, serum and other types of blood cells. New initiative are taken to characterize proteins from platelets and urine samples using two dimensional gel electrophoresis based separation followed by MALDI/ToF/ToF tandem mass spectrometry. 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. Among the various diseases that affect the nervous system, some of the most debilitating are neurodegenerative disorders such as Alzheimers, 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 Alzheimers 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.

1.2 Research Activities

1.2.1 Biophysics Division

1.2.1.1 Human telomere d[(TTAGGG)$_4$] undergoes a conformational transition to the Na^+-form upon binding with sanguinarine in presence of K^+

Guanine-rich telomeric sequences fold into G-quadruplex conformation and are known to bind a variety of ligands including potential drug candidates. By means of CD spectroscopy and fluorescence lifetime measurements we demonstrate that putative anticancer therapeutic sanguinarine (SGR) exhibits two distinct interactions with human telomere d[(TTAGGG)$_4$] (H24) in presence of K^+. Up to about 1:2 M ratio of H24:SGR (10 μM H24), 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 SGR-induced conformational transition in a G-quadruplex formed by

a human telomeric sequence could provide new insights into interaction of drugs with quadruplex DNA structure.

Suman Kalyan Pradhan, Dipak Dasgupta, Gautam Basu

1.2.1.2 Mechanism of interaction of small transcription inhibitors with DNA in the context of chromatin and telomere

Small molecules from natural and synthetic sources have long been employed as human drugs. The transcription inhibitory potential of one class of these molecules has paved their use as anticancer drugs. The principal mode of action of these molecules is via reversible interaction with genomic DNA, double and multiple stranded. In this article we have revisited the mechanism of the interaction in the context of chromatin and telomere. The established modes of association of these molecules with double helical DNA provide a preliminary mechanism of their transcription inhibitory potential, but the scenario assumes a different dimension when the genomic DNA is associated with proteins in the transcription apparatus of both prokaryotic and eukaryotic organisms. We have discussed this altered scenario as a prelude to understand the chemical biology of their action in the cell. For the telomeric quadruplex DNA, we have reviewed the mechanism of their association with the quadruplex and resultant cellular consequence.

Saptaparni Ghosh, Parijat Majumder, Suman Kalyan Pradhan, Dipak Dasgupta

1.2.1.3 Encapsulation of serotonin in beta-cyclodextrin nano-cavities: Fluorescence spectroscopic and molecular modeling studies

Serotonin is a physiologically important biogenic amine, deficiency of which leads to mental disorders such as Alzheimer's disease, schizophrenia, infantile autism, and depression. Both beta-cyclodextrin (beta-CD) and its chemically substituted synthetic varieties (often possessing enhanced aqueous solubility and improved drug complexing abilities) are finding wide applications as drug delivery vehicles. Here we have studied the encapsulation of serotonin in beta-CD and succinyl-2-hydroxypropyl p-cyclodextrin (SHP-beta-CD) by exploiting the intrinsic serotonin fluorescence. Enhanced fluorescence emission intensity (which increases by similar to 18% and 34% in beta-CD and SHP beta-CD respectively) and anisotropy (r) (r = 0.075 and 0.1 in beta-CD and SHP beta-CD respectively) are observed in presence of the cyclodextrins. From the fluorescence data host-guest interaction with 1:1 stoichiometry is evident, the association constants (K) being 126.06 M-1 and 461.62 M-1 for beta-CD and SHP beta-CD respectively. Additionally, molecular docking and semiempirical calculations have been carried out which provide, for the first time, detailed insights regarding the encapsulation process. In particular, it is evident that the indole ring is inserted within the beta-CD cavity with the aliphatic amine side chain protruding towards the primary rim of the beta-CD cavity. Docking calculations reveal that hydrogen bonding interactions are involved in the formation of the inclusion complex. Semiempirical calculations indicate that formation of the 1:1 inclusion complex is energetically favorable which is consistent with the fluorescence data.

Sudip Chaudhuri, Sandipan Chakraborty†, Pradeep K Sengupta

1.2.1.4 Protonation of Base Pairs in RNA: Context Analysis and Quantum Chemical Investigations of Their Geometries and Stabilities

Base pairs involving protonated nucleobases play important roles in mediating global macromolecular conformational changes and in facilitation of catalysis in a variety of functional RNA molecules. Here we present our attempts at understanding the role of such base pairs by detecting possible protonated base pairs in the available RNA crystal structures using BPFind software, in their specific structural contexts, and by the characterization of their geometries, interaction energies, and stabilities using advanced quantum chemical computations. We report occurrences of 18 distinct protonated base pair combinations from a representative data set of RNA crystal structures and propose a theoretical model for one putative base pair combination. Optimization of base pair geometries was carried out at the B3LYP/cc-pVTZ level, and the BSSE corrected interaction energies were calculated at the MP2/aug-cc-pVDZ level of theory. The geometries for each of the base pairs were characterized in terms of H-bonding patterns observed, rmsd values observed on optimization, and base pair geometrical parameters. In addition, the intermolecular interaction in these complexes was also analyzed using Morokuma energy decomposition. The gas phase interaction energies of the base pairs range from -24 to -49 kcal/mol and reveal the dominance of Hartree-Fock component of interaction energy constituting 73% to 98% of the total interaction energy values. On the basis of our combined bioinformatics and quantum chemical analysis of different protonated base pairs, we suggest resolution of structural ambiguities and correlate their geometric and energetic features with their structural and functional roles. In addition, we also examine the suitability of specific base pairs as key elements in molecular switches and as nucleators for higher order structures such as base triplets and quartets.

Mohit Chawla, Purshotam Sharma, Sukanya Hader, Dhananjay Bhattacharyya, Abhijit Mitra

1.2.1.5 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.

Aditi Borkar†, Indira Ghosh, Dhananjay Bhattacharyya

1.2.1.6 Why pyridine containing pyrido[2,3-d]pyrimidin-7-ones selectively inhibit CDK4 than CDK2: Insights from molecular dynamics simulation

Designing selective cyclin-dependent kinase 4 (CDK4) inhibitors is an area of intense research to develop potential anticancer drugs. The molecular basis governing the selective inhibition of CDK4 by lig17 (6-bromo-8-cyclopenty1-2-(5-piperazin-1-yl-pyridin-2-ylamino)-8H-pyrido[2,3-d]pyrimidin-7-one) has been investigated using molecular dynamics simulation. The positive charge on the ligand was determined to be an important contributor for CDK4 selectivity due to the electronegative nature of its active site. Similar studies on CDK2 indicated that Lys89 intrudes into the active site displacing the positive charge on lig17 away from the active center. This intrusion was observed to propel a drastic conformational change in lig17, weakening its binding interactions with the protein. The pyridine nitrogen (N-AR) of lig17 was capable of interacting with His95 (CDK4) through hydrogen bonding. N-AR also showed a strong tendency to mediate protein-ligand interactions through a bridged water molecule, only when bound to CDK4. The G-loop of CDK4 was observed to fluctuate extensively when complexed with lig17 and a novel "flipping-out" mechanism exhibited by Tyr17(CDK4/CDK4-17) 17 is reported in this study. Although these proteins have similar folds, the results from principal component analysis (PCA) indicate that CDK4 and CDK2 follow an anti-correlated behavior towards the accessibility of the active site.

Nahren Manuel Mascarenhas†, Dhananjay Bhattacharyya, Nanda Ghoshal†

1.2.1.7 Structural Stability of Tandemly Occurring Noncanonical Basepairs within Double Helical Fragments: Molecular Dynamics Studies of Functional RNA

Noncanonical basepairs have gained importance over the past few years because of their various functions in RNA biochemistry. These basepairs appear quite frequently in different double helical stems also, but whether they are stabilized by contextual pressure or act as seeds of folding is not yet clear. We have used all-atom molecular dynamics simulations to characterize the stability and functional features of a few noncanonical basepairs within two RNA double helical fragments obtained from ribosome crystal structures. It is anticipated that the noncanonical basepairs would open up spontaneously if they had appeared due to contextual pressure, However, we have found from MD simulations that the noncanonical basepairs occurring in tandem at the central regions of double helical stretches are quite stable. Analysis of basepairing parameters carried out in terms of H-bonding edge-specific axis system indicates that dynamics of the noncanonical basepairs are very similar to those of the canonical ones. The stacking parameters for dinucleotide steps consisting of noncanonical basepairs are rather unusual, but the variability patterns indicate their significant stability. The stacking free-energy values as presumed from the distributions of structural parameters also appear to be similar for both canonical and noncanonical basepair steps.

Sukanya Halder, Dhananjay Bhattacharyya

1.2.2 Chemical Science Division

1.2.2.1 Inclusion of chrysin in beta-cyclodextrin nanocavity and its effect on antioxidant potential of chrysin: A spectroscopic and molecular modeling approach

Chrysin is a naturally occurring flavone that possesses a wide range of important biological activities. beta-Cyclodextrin (beta-CD) on the other hand due to its property of encapsulating

molecules that are hydrophobic in nature is widely applied as drug delivery vehicle. Here, we have investigated the inclusion of chrysin within beta-CD in aqueous solution using spectroscopic and theoretical methods. The stoichiometry of this inclusion complex was established to be equimolar (1:1) and its equilibrium constant was determined. Estimation of the thermodynamic parameters of the inclusion complex showed that it is an enthalpy driven process. Our observations also inferred that van der Waal's interaction and hydrogen bonding are the key interactions that prevail in the complex. The process of inclusion not only increased the solubility of chrysin but also its antioxidant potential, as inferred from ABTS radical scavenging assay. Theoretical calculations show that destabilization of HOMO energies account for the higher antioxidant potential of chrysin upon inclusion. Molecular docking of chrysin with beta-CD followed by molecular modeling of the obtained complexes yielded results consistent with our experimental observation. Combining our studies on solvatochromicity with cluster and interaction analyses, we suggest the preferred mode of inclusion to be through the A-ring of chrysin.

Sandipan Chakraborty†, Soumalee Basu†, Ansuman Lahiri†, Soumen Basak

1.2.2.2 Sensing of E.coli bacteria on modified Polyaniline Electrode using Electrochemical Impedance Spectroscopy

A new and simple method for label free, rapid and inexpensive impedimetric sensing of E.coli O157:H7 using antibodyantigen binding method based on covalently linked antibody on a Conducting Polyaniline (PANI) film surface is reported. The sensor electrode is fabricated by covalent immobilization of E.coli O157:H7 antibody onto electrochemically synthesized polyaniline substrate using glutaraldehyde as the cross-linker. Cyclic voltammetry is used to standardize the synthesis procedure of polyaniline matrix and FTIR spectroscopy for characterization. Electrochemical impedance spectroscopy (EIS) was used to test the sensitivity and effectiveness of the sensor electrode by measuring the change of the impedance between the bare antibody electrodes and after incubation with different concentration of bacteria. An equivalent electrical circuit model has also been proposed to explain the sensing mechanism. As few as 103 CFU of E. coli O157:H7 were successfully detected on the Au/PANI/Glu/antibody sensor where the upper detection limits up to 105 CFU. The assay requires approximately 90 min from sampling to detection. Potential applications include area-based pathogen detection for food and water safety, environmental monitoring and healthcare.

A Dutta-Chaudhuri, A De, K Bandyopadhyay, C RoyChoudhuri, P Sen

1.2.2.3 Studies on stabilities of some human chorionic gonadotropin complexes with beta-emitting radionuclides

Human chorionic gonadotropin (hCG) is a peptide hormone, whose one of the structural subunits is identical to that of thyroid-stimulating hormone (TSH). As a consequence, the receptors of TSH also act as receptor for hCG hormone. Keeping in mind this interesting property of hCG we have studied the complex formation ability of various no-carrier-added beta-emitting isotopes of Cu-61 (3.3 h), Zn-62 (9.2 h), Nb-90 (14.60 h) and Mo-99 (66.02 h) with hCG molecule. Stability of the hCG-M (M = metal ions) complexes was investigated by dialysis with respect to triple distilled

water and ringer lactate solution, which has the same composition as extracellular fluid.

Moumita Maiti, Kamalika Sen, Souvik Sen, Susanta Lahiri

1.2.2.4 Installation of Integrated Compton Suppression System

A CANBERRA made high performance Compton suppression system (CSS) has been installed, optimized, calibrated and made fully operational for the analysis of small size sample containing extreme low radioactivity. The compact CSS is a combination of ultra-low background HPGe, large annular guard with plug NaI(Tl) detectors housed inside a huge lead assembly with graded shielding. We achieved the detection limit as lows as tens of pCi.

Susanta Lahiri, Moumita Maiti, Ajoy Mandal

1.2.2.5 Influence of Heterogeneity of Confined Water on Photophysical Behavior of Acridine with Amines: A Time-Resolved Fluorescence and Laser Flash Photolysis Study

The photophysical behavior of acridine (Acr) shows facilitated water-assisted protonation equilibrium between its deprotonted (Acr^* $\sim$ 10 ns) and protonated forms ($AcrH^{+*}$ $\sim$ 28 ns) within confined region of ordered water molecules inside AOT/H_2O/n-heptane reverse micelles (RMs). The time-resolved-area-normalized-emission spectra confirm both Acr^* and $AcrH^+*$, while time-resolved-emission spectra depict time evolution between them. Quenching of $AcrH^+*$ with N,N-dimethylaniline (DMA) is a purely diffusion-controlled bimolecular quenching with linear Stern-Volmer (S-V) plot, while nonlinearity arises with triethylamine (TEA) that forms ground state complex with $AcrH^+$ ($AcrH^+$..H_2O..TEA) indicating both static and dynamic quenching. Transient intermediates, $DMA^{\cdot+}$ and $AcrH^{\cdot}$ infer photoinduced electron transfer from DMA to Acr, while those from $AcrH^+$..H_2O..TEA complex suggest water mediated excited-state proton transfer (ESPT) between $AcrH^+$ and TEA. The ESPT becomes faster in larger RMs due to enhanced mobility of hydronium ions in $AcrH^+$..H_2O..TEA, which reduces in smaller RMs as water becomes much more constrained owing to stronger complexation by excess confinement.

Manas Kumar Sarangi†, Debarati Dey†, Samita Basu

1.2.2.6 Magnetic field effect on electron transfer reactions of acridine yellow with amines of varied structures in homogeneous medium

Interaction of acridine yellow (AY) with three amines, viz., dimethylaniline (DMA), 4,4'-bis(dimethylamino) diphenylmethane (DMDPM) and triethylamine (TEA) in homogeneous medium is explored. DMA and DMDPM participate only in photoinduced electron transfer (PET) with AY whereas TEA is found to be involved in both PET and charge-transfer complex formation. The novelty of the present work lies in the fact that all the three AY-amine systems exhibit magnetic field effect on PET reactions in homogeneous medium due to inter-radical hydrogen bond mediated by intervening water molecules, which sustain the geminate characteristics as well as the

spin correlation of radical ion pairs, that are formed as primary intermediates through PET.

Brotati Chakraborty, Samita Basu

1.2.2.7 Sodium 1, 4-dihydroxy-9, 10-anthraquinone-2-sulphonate interacts with calf thymus DNA in a way that mimics anthracycline antibiotics: an electrochemical and spectroscopic study

The anthracycline drugs, adriamycin and daunorubicin, efficient in the treatment of various human cancers, form strong intercalation complexes with DNA. The therapeutic efficiency and toxic properties of the drugs are associated with electron transfer processes, which correlate well with the redox behaviour of the compounds. Sodium 1,4-dihydroxy 9,10-anthraquinone-2-sulphonate (sodium quinizarin-2-sulphonate, NaLH2) (Na-Qz-2S) is a molecule that resembles anthracycline drugs and has a simpler structure in comparison to these drugs. Two electrons in the course of chemical action reduce this molecule like the anthracyclines. Electrochemical methods were used to identify this process. UV-Vis and fluorescence spectroscopy were used to analyse binding of the compound to calf thymus DNA. The binding constant and site size were evaluated for Na-Qz-2S and the same compared to that of the anthracyclines. Such comparisons are essential in order to understand whether the simpler hydroxy-anthraquinones can be a substitute for anthracycline drugs in cancer chemotherapy.

Partha Sarathi Guin, Saurabh Das, PC Mandal

1.2.2.8 Electrochemical performances of poly(3,4-ethylenedioxythiophene)-$NiFe_2O_4$ nanocomposite as electrode for supercapacitor

Poly 3,4-ethylenedioxythiophene (PEDOT)-based $NiFe_2O_4$ conducting nanocomposites were synthesized and their electrochemical properties were studied in order to find out their suitability as electrode materials for supercapacitor. Nanocrystalline nickel ferrites (5-20 nm) have been synthesized by sol-gel method. Reverse microemulsion polymerization in n-hexane medium for PEDOT nanotube and aqueous miceller dispersion polymerization for bulk PEDOT formation using different surfactants have been adopted. Structural morphology and characterization were studied using XRD, SEM, TEM and IR spectroscopy. Electrochemical performances of these electrode materials were carried out using cyclic voltammetry at different scan rates (2-20 mV/s) and galvanostatic charge-discharge at different constant current densities (0.5-10 mA/cm(2)) in acetonitrile solvent containing 1 M $LiClO_4$ electrolyte. Nanocomposite electrode material shows high specific capacitance (251 F/g) in comparison to its constituents viz $NiFe_2O_4$ (127 F/g) and PEDOT (156 F/g) where morphology of the pore structure plays a significant role over the total surface area. Contribution of pseudocapacitance (C-FS) arising from the redox reactions over the electrical double layer capacitance (C-DL) in the composite materials have also been investigated through the measurement of AC impedance in the frequency range 10 kHz-10 mHz with a potential amplitude of 5 mV. The small attenuation (similar to 16%) in capacitance of PEDOT-NiFe2O4 composite over 500 continuous charging/discharging cycles suggests its excellent electrochemical stability.

Pintu Sen, Amitabha De

1.2.2.9 Magnetic Field Effect Corroborated with Docking Study to Explore Photoinduced Electron Transfer in Drug-Protein Interaction

Conventional spectroscopic tools such as absorption, fluorescence, and circular dichroism spectroscopy used in the study of photoinduced drug-protein interactions can yield useful information about ground-state and excited-state phenomena. However, photoinduced electron transfer (PET) may be a possible phenomenon in the drug-protein interaction, which may go unnoticed if only conventional spectroscopic observations are taken into account. Laser flash photolysis coupled with an external magnetic field can be utlized to confirm the occurrence of PET and authenticate the spin states of the radicals/radical ions formed. In the study of interaction of the model protein human serum albumin (HSA) with acridine derivatives, acridine yellow (AY) and proflavin (PF+), conventional spectroscopic tools along with docking study have been used to decipher the binding mechanism, and laser flash photolysis technique with an associated magnetic field (MF) has been used to explore PET. The results of fluorescence study indicate that fluorescence resonance energy transfer takes place from the protein to the acridine-based drugs. Docking study unveils the crucial role of Ser 232 residue of HSA in explaining the differential behavior of the two drugs towards the model protein. Laser flash photolysis experiments help to identify the radicals/radical ions formed in the due course of PET (PF center dot, AY(center dot-), TrpH(center dot+), Trp(center dot)), and the application of an external MF has been used to characterize their initial spin-state. Owing to its distance dependence, MF effect gives an idea about the proximity of the radicals/radical ions during interaction in the system and also helps to elucidate the reaction mechanisms. A prominent MF effect is observed in homogeneous buffer medium owing to the pseudoconfinement of the radicals/radical ions provided by the complex structure of the protein.

Brotati Chakraborty, Atanu Singha Roy, Swagata Dasgupta†, Samita Basu

1.2.2.10 Simultaneous Occurrence of Energy Transfer and Photoinduced Electron Transfer in Interactions of Hen Egg White Lysozyme with 4-Nitroquinoline-1-Oxide

The carcinogenic drug 4-nitroquinoline-1-oxide (4NQO) has been found to bind with the protein hen egg white lysozyme as evident from fluorescence quenching experiments. The binding constant and stoichiometry have been determined. The values of the thermodynamic parameters indicate that the interaction is an enthalpy-driven spontaneous phenomenon. The experimental value of change in free energy is similar to that obtained from the docking study. The far UV circular dichroism spectra show some changes in the secondary structure of protein. The high value of bimolecular quenching constant leads to the possibility of Forster resonance energy transfer (FRET). Along with FRET, the photoinduced electron transfer (PET) from tryptophan residue of protein to 4NQO has also been evident from the transient absorption spectra obtained in laser flash photolysis experiments. The simultaneous occurrence of FRET and PET is the key factor for quenching of intrinsic fluorescence of the protein as it binds with the drug.

Mousumi Banerjee, Sourav Maiti, Ipsita Kundu, Abhijit Chakrabarti, Samita Basu

1.2.2.11 Species dependent studies of no-carrier-added Mo-93m: A green method

The present paper reports a combination of radioanalytical and green methodology for the ultra-trace scale speciation of molybdenum. The differential attitude of iron-doped calcium alginate

(Fe-CA) and chitosan biopolymers towards no-carrier-added Mo-93m radionuclide was studied to develop environmentally sustainable speciation methodology in ultra-trace scale. The affinity of Mo-93m towards the Fe-CA beads is greater than that of chitosan. Species information was obtained by comparing the adsorption profile of Mo-93m on Fe-CA and chitosan biopolymer with the software code CHEAQS PRO program. From the experimental results it is concluded that no-carrier-added Mo-93m radionuclide form mononuclear species instead of polynuclear species in aqueous solution. Use of biodegradable, nontoxic biopolymer makes this method a step forward towards green chemistry.

Swadesh Mandal, Dalia Nayak

1.2.2.12 A traditional painkiller as a probe for microheterogeneity in 1-propanol-water mixtures

Photo physical and spectral property of indomethacin has been harnessed to sense the cluster structures that exist at the microscopic level in binary mixtures of 1-propanol-water. The ability of indomethacin to switch from a fluorescent complex with alcohol self-association cluster at low water content, to a non-fluorescent complex with hydrogen-bonded water cluster at high water content, imparts the drug with its unique microheterogeneity sensing property. Similar results are obtained for methanol-water and 1-butanol-water binary mixtures.

Sreeja Chakraborty, Esha Sehanobish†, Munna Sarkar

1.2.2.13 Effect of Increase in Orientational Order of Lipid Chains and Head Group Spacing on Non Steroidal Anti-Inflammatory Drug Induced Membrane Fusion

Membrane fusion is a key event in many biological processes. The fusion process, both in vivo and in vitro, is induced by different agents which include mainly proteins and peptides. For protein- and peptide-mediated membrane fusion, conformational reorganization serves as a driving force. Small drug molecules do not share this advantage; hence, drug induced membrane fusion occurring in absence of any other fusogenic agent and at physiologically relevant concentration of the drugs is a very rare event. To date, only three drugs, namely, meloxicam (Mx), piroxicam (Px), and tenoxicam (Tx), belonging to the oxicam group of non steroidal anti-inflammatory drugs (NSAIDs), have been shown by us to induce fusion at very low drug to lipid ratio without the aid of any other fusogenic agent. In our continued effort to understand the interplay of different physical and chemical parameters of both the participating drugs and the membrane on the mechanism of this drug induced membrane fusion, we present here the effect of increase in orientational order of the lipid chains and increase in head group spacing. This is achieved by studying the effect flow concentration cholesterol (< 10 mol%) at temperatures above the chain-melting transition. Low concentration cholesterol (< 10 mol%), above the gel to fluid transition temperature, is mainly known to increase orientational order of the lipid chains and increase head group spacing. To isolate the effect of these parameters, small unilameller vesicles (SUVs) formed by dimyristoylphosphatidylcholine (DMPC) with an average diameter of 50-60 nm were used as simple model membranes. Fluorescence assays were used to probe the time dependence of lipid mixing, content mixing, and leakage and also used to determine the partitioning of the drugs in the membrane bilayer. Differential scanning calorimetry (DSC) was used to study the effect of drugs in the presence of cholesterol on the chain-melting

temperature which reflects the fluidization effect of the hydrophobic tail region of the bilayer. Our results show contradictory effect of low concentration cholesterol on the fusion induced by the three drugs, which has been explained by parsing the effect of orientational order and increase in head group spacing on the fusion process.

Sutapa Mondal Roy, Amol S Bansode, Munna Sarkar

1.2.2.14 Directional distribution of the ambient neutron dose equivalent from 145-Mev ^{19} F projectiles incident on thick al target

The directional distribution of the ambient neutron dose equivalent from 145-MeV ^{19}F projectiles bombarding a thick aluminium target is measured and analysed. The measurements are carried out with a commercially available dose equivalent meter at 0^o, 30^o, 60^o and 90^o with respect to the beam direction. The experimental results are compared with calculated doses from EMPIRE nuclear reaction code and different empirical formulations proposed by others. The results are also compared with the measured data obtained from an earlier experiment at a lower projectile energy of 110 MeV for the same target projectile combination.

C Sunil†, AA Shanbhag†, Maitreyee Nandy, T Bandyopadhyay†, SP Tripathy†, C Lahiri, DS Joshi†, PK Sarkar†

1.2.2.15 Neutron dose distribution from C-12 induced reactions on Ti and Ag using proton recoil scintillator

We measured the double differential neutron yield at 0^o, 30^o, 60^o and 90^o from $^{12}C^{12}$ induced reactions on thick targets of Ti and Ag at 12 MeV/amu at the Cyclotron at National Institute of Radiological Sciences, lnage, Japan, with 5ẍ5p̈roton recoil scintillation detectors BC-501. The measured neutron spectra were unfolded using pulse height unfolding algorithm and energy and angular distribution obtained. Energy distribution of neutron ambient dose equivalent, H*(10) and absorbed dose, D at different angles was determined from double differential neutron spectra using ICRP recommended fluence to dose conversion coefficients.

Maitreyee Nandy, PK Sarkar†, T Sanami†, T Shibata†, M Takada†

1.2.2.16 Radiation environment in low energy accelerator for astrophysical studies

Transmitted dose through different thicknesses of ordinary concrete placed at different distances from the target has been evaluated using simple Moyer model. It has been observed that though the projectile energy is low, significant neutron and gamma doses are produced at beam currents as high as 500 μA for protons. Some radioisotopes with half-lives of the order of a few months are produced with activities of the order $10^{10} - 10^{11}$ Bq.

Maitreyee Nandy, Chirashree Lahiri, PK Sarkar†

1.2.2.17 Neutron dose from 612C induced reactions on Ti, Ag and effective quality factor

Energy-angle distribution of neutron ambient dose equivalent, $H^*(10)$ and absorbed dose, D was determined fr om the double differential neutron yield at different directions from $^{12}C^{5+}$ induced reactions on thi ck targets of Ti and Ag at 12 MeV/amu, measured at National Institute of Radiological Sciences, Inage, Japan, Analysis of the measured data showed that preequilibrium emission of neutrons has significant contribution to $H^*(10)$ which resulted in anisotropic distribution of the dose. Evaporation of neutrons contributed to the lower energy distribution of $H^*(10)$, while preequilibrium formalism gave satisfactory results for higher energy. Analysis of the energy dependent distribution of D for different organs suggested a quality factor be tween 8.1 and 9.1 for neutrons in the two reactions.

Maitreyee Nandy

1.2.3 C&MB Division

1.2.3.1 Altered microRNAs in STHdh(Q111)/Hdh(Q111) cells: miR-146a targets TBP

We studied expression of 90 miRNAs in STHdhQ(111)/Hdh(Q111) cells, a model for Huntington's disease and compared with that obtained in STHdh(Q7)/Hdh(Q7) cells. Fifteen miRNAs were down regulated and 12 miRNAs were up regulated more than 2-fold. Such changes were statistically significant. One hundred and forty-two genes are experimentally known targets of these altered miRNAs. It has been predicted that miR-146a may target Tata Binding Protein (TBP). Using luciferase reporter assays with 3'-UTRs of TBP, over-expression and inhibition of miR-146a, we showed that miR-146a targets TBP. Regulation of TBP by miR-146a may contribute to HD pathogenesis.

Mithun Sinha, Jayeeta Ghose, Eashita Das, Nitai P Bhattarcharyya

1.2.3.2 Heterologous expression of a thermostable plant cysteine protease in Escherichia coli both in soluble and insoluble forms

Ervatamin-C is a stable papain-like cysteine protease from a tropical plant Ervatamia coronaria. Proteases in this family have numerous industrial applications. Thus protein engineering to create tailor-made variants of them for biotechnological and other applications will be highly desirable. A prerequisite for such an approach is a recombinant expression system. The cDNA encoding pro-ervatamin-C (mature protease domain together with the N-terminal prodomain) has therefore been cloned and expressed in Escherichia coil using two T7 based expression vectors pET-28a(+) and pET-39b(+). The recombinant pro-ervatamin-C was expressed as inclusion body using pET-28a(+) vector and the protease Was solubilized, purified and successfully refolded to its functionally active form. To express the recombinant protease in a soluble form, a DsbA (disulphide oxidoreductase) tag was placed before pro-ervatamin-C using pET-39b(+) vector to obtain folded active ervatamin-C without going through any in vitro refolding step. A comparison of the two procedures has been presented. The recombinant enzyme shows a similar enzymatic activity, specificity and thermal

stability pattern like its native counterpart.

Sruti Dutta, Raka Ghosh, JK Dattagupta, Sampa Biswas

1.2.3.3 Improving thermostability of papain through structure-based protein engineering

Papain is a plant cysteine protease of industrial importance having a two-domain structure with its catalytic cleft located at the domain interface. A structure-based rational design approach has been used to improve the thermostability of papain, without perturbing its enzymatic activity, by introducing three mutations at its interdomain region. A thermostable homologue in papain family, Ervatamin C, has been used as a template for this purpose. A single (K174R), 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 compared to the wild type (WT). The temperature of maximum enzymatic activity (T-max) and 50% maximal activity (T-50) for the triple mutant increased by 15 and 4 degrees C, respectively. Moreover, the triple mutant exhibits a faster inactivation rate beyond T-max which may be a desirable feature for an industrial enzyme. The values of t(1/2) and T-max for the double mutant lie between those of the WT and the triple mutant. The single mutant however turns out to be unstable for biochemical characterization. These results have been substantiated by molecular modeling studies which also indicate highest stability for the triple mutant based on higher number of interdomain H-bonds/salt-bridges, less interdomain flexibility and lower stability free-energy compared to the WT. In silico studies also explain the unstable behavior of the single mutant.

Debi Choudhury, Sampa Biswas, Sumana Roy, JK Dattagupta

1.2.3.4 Hydrogen peroxide-induced apoptosis-like cell death in Entamoeba histolytica

The microaerophilic intestinal parasitic protozoan Entamoeba histolytica has been previously shown to be highly susceptible to oxidative stress induced by hydrogen peroxide. However the mechanism of cell death was not investigated. Studies presented in this paper demonstrate several morphological features in the parasite when exposed to H_2O_2 which are identical to metazoan apoptotic phenotype indicating a possible apoptosis-like cell death exhibited by E. histolytica in response to H_2O_2 treatment. Trophozoite cell shrinkage, DNA fragmentation, phosphatidyl serine externalization and increased endogenous reactive oxygen species level have been observed in the protozoan parasite when exposed to 2.0 mM H_2O_2 for different time periods. Although the parasite genome is completely devoid of any of the homologues of mammalian caspases it still codes for a huge number of cysteine proteases which may take over the apoptotic function of the caspases. But the present study indicates the existence of a cysteine protease independent programmed cell death in the parasite since E-64 the specific cysteine protease inhibitor could not rescue the cells from H_2O_2 induced apoptosis-like cell death.

Anupama Sardar Ghosh, Suman Dutta, Sanghamitra Raha

1.2.3.5 Cloning, overexpression, purification, crystallization and preliminary X-ray analysis of CheY3, a response regulator that directly interacts with the flagellar 'switch complex' in Vibrio cholerae

Vibrio cholerae is the aetiological agent of the severe diarrhoeal disease cholera. This highly motile organism uses the processes of motility and chemotaxis to travel and colonize the intestinal epithelium. Chemotaxis in V. cholerae is far more complex than that in Escherichia coli or Salmonella typhimurium, with multiple paralogues of various chemotaxis genes. In contrast to the single copy of the chemotaxis response-regulator protein CheY in E. coli, V. cholerae contains four CheYs (CheY1-CheY4), of which CheY3 is primarily responsible for interacting with the flagellar motor protein FliM, which is one of the major constituents of the 'switch complex' in the flagellar motor. This interaction is the key step that controls flagellar rotation in response to environmental stimuli. CheY3 has been cloned, overexpressed and purified by Ni-NTA affinity chromatography followed by gel filtration. Crystals of CheY3 were grown in space group R3, with a calculated Matthews coefficient of 2.33 A3 Da-1 (47% solvent content) assuming the presence of one molecule per asymmetric unit.

Susmita Khamrui, Maitree Biswas, Udayaditya Sen, Jhimli Dasgupta

1.2.3.6 Ubiquitination of mRNA cycling sequence binding protein from Leishmania donovani (LdCSBP) modulates the RNA endonuclease activity of its Smr domain

In trypanosomatid parasites, an octanucleotide sequence (C/A)AUAGAA(G/A) in the UTRs primarily determines the stability of S-phase specific mRNAs. A multi-domain protein LdCSBP from Leishmania donovani interacts with the UTR of an S-phase RNA containing the octanucleotide sequence through its unique CCCH-type Zn-finger motifs. Interestingly, the RNA binding protein contains a previously characterized DNA endonuclease domain - Smr. It has been demonstrated here that the LdCSBP Smr domain independently possesses both DNA and RNA endonuclease activities, but the full-length LdCSBP exhibits only riboendonuclease activity. Moreover, LdCSBP protein has been shown to be ubiquitinated, resulting in the down-regulation of its riboendonuclease activity. In conclusion, the results described here suggest a novel regulatory mechanism of mRNA degradation through ubiquitination in eukaryotes.

Dipankar Bhandari, Kasturi Guha, Nipa Bhaduri, Partha Saha

1.2.3.7 EhMAPK, the Mitogen-Activated Protein Kinase from Entamoeba histolytica Is Associated with Cell Survival

Mitogen Activated Protein Kinases (MAPKs) are a class of serine/threonine kinases that regulate a number of different cellular activities including cell proliferation, differentiation, survival and even death. The pathogen Entamoeba histolytica possess a single homologue of a typical MAPK gene (EhMAPK) whose identification was previously reported by us but its functional implications remained unexplored. EhMAPK, the only mitogen-activated protein kinase from the parasitic protist Entamoeba histolytica with Threonine-X-Tyrosine (TXY) phosphorylation motif was cloned, expressed in E. coli and functionally characterized under different stress conditions. The expression profile of EhMAPK at the protein and mRNA level remained similar among untreated, heat

shocked and hydrogen peroxide-treated samples in all cases of dose and time. But a significant difference was obtained in the phosphorylation status of the protein in response to different stresses. Heat shock at 43 degrees C or 0.5 mM H_2O_2 treatment enhanced the phosphorylation status of EhMAPK and augmented the kinase activity of the protein whereas 2.0 mM H_2O_2 treatment induced dephosphorylation of EhMAPK and loss of kinase activity. 2.0 mM H_2O_2 treatment reduced parasite viability significantly but heat shock and 0.5 mM H_2O_2 treatment failed to adversely affect E. histolytica viability. Therefore, a distinct possibility that activation of EhMAPK is associated with stress survival in E. histolytica is seen. Our study also gives a glimpse of the regulatory mechanism of the protein under in vivo conditions. Since the parasite genome lacks any typical homologue of mammalian MEK, the dual specificity kinases which are the upstream activators of MAPK, indications of the existence of some alternate regulatory mechanisms of the EhMAPK activity is perceived. These may include the autophosphorylation activity of the protein itself in combination with some upstream phosphatases which are not yet identified.

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

1.2.3.8 Molecular mechanisms of stress survival in Entamoeba histolytica, a human enteric pathogen

As survival strategies of this disease-causing parasite are vital for the propagation of the disease, we exami ned the effects of several stress conditions in Entamoeba histolytica. We characterized the cell death mechani sm of this parasite which resembled higher eukaryotic physiological cell death or apoptosis in some aspects. E hMAPK, the sole typical MAPK of the Entamoeba genome was earlier characterized by us. Now experiments were do ne to characterize its activation mechanisms namely phosphorylations on certain residues. Also, the role of Eh MAPK in stress survival of Entamoeba histolytica was determined.

Sanghamitra Raha

1.2.4 Structural Genomics Division

1.2.4.1 Differential expression of red cell proteins in hemoglobinopathy

Red blood cell proteome has not been studied well until recently, as the large abundance of hemoglobin posed challenge to the detection of other cytosolic proteins in the linear dynamic range. However, in the last couple of years, due to emergence of various novel hemoglobin depletion strategies and more state-of-the-art detection techniques, a number of works on erythrocyte proteome have appeared in the literature. As a result, we now have much deeper information about both the membrane as well as the cytosolic proteins of erythrocytes. In this review, we have discussed the role of red cell proteome on the two most well-studied hemoglobin disorders, sickle cell disease and thalassemia, emphasizing on the differential expression of the redox regulator proteins and chaperones, in particular. We have also touched upon the importance of the association of the varying levels of hemoglobin variants, particularly HbE on the clinical manifestation of composite diseases like HbE beta thalassemia.

Abhijit Chakrabarti; Dipankar Bhattacharya; Avik Basu, Sumanta Basu, Sutapa Saha, Suchismita Halder

1.2.4.2 Eryptosis in hereditary spherocytosis and thalassemia: role of glycoconjugates

The present work is aimed to study the mechanism of faster erythrocyte clearance in hereditary spherocytosis (HS), a heterogeneous disorders characterized by alterations in the proteins of the red cell membrane skeleton along with different kinds of thalassemia. The maximum exposure of phosphatidylserine (PS) is found in HS compared to those in both alpha- and beta-thalassemia. Interestingly, in HS more PS exposed cells were found in younger erythrocytes compared to normal and the thalassemics where aged cells showed higher loss of PS asymmetry. Loss of sialic acid and GlcNAc bearing glycoconjugates, presumably the glycophorins, was also found upon aging. The loss of PS asymmetry together with the cell surface glycoproteins mediated by membrane vesiculation, seemed to play key role in early clearance of erythrocytes from circulation following a mechanism similar to HbE beta-thalassemia.

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

1.2.4.3 A large, systematic molecular-genetic study of G6PD in Indian populations identifies a new non-synonymous variant and supports recent positive selection

Malaria has been endemic in India. G6PD deficiency is known to confer resistance to malaria. Many G6PD deficiency variants, some of which are India-specific, are known to occur in high frequencies in India. This is the first systematic molecular-genetic study in multiple populations from India drawn from diverse ethnic, socio-cultural and geographical backgrounds. Resequencing of the G6PD gene was carried out in 80 males and then the polymorphic variants were genotyped in 400 individuals of both genders, drawn from 10 ethnic groups of India. Our study has identified one new exonic variant (M159I; exon-5), occurring in multiple populations, that is predicted to result in G6PD deficiency. A strong geographical sub-structuring of known G6PD variants has also been established. We have compared all available data from public-domain resources with those generated in this study to identify the nature and extent of natural selection. Our results (a) provide indication of weak negative selection, and (b) reveal signals of recent positive selection for the G6PD Orissa and G6PD Coimbra mutation bearing haplotypes. These inferences have been interpreted in the light of malarial protection to the populations that have been long exposed to plasmodium infection.

Somosree Sarkar, Nidhan K Biswas, Badal Dey, Debashis Mukhopadhyay, Partha P Majumder

1.2.4.4 DNA binding domain of RFX5: Interactions with X-box DNA and RFXANK

Regulatory factor X (RFX) is a heterotrimeric protein complex having RFX5, RFXANK and RFXAP as its three subunits. It is involved in the regulation of the transcription of MHCII molecules in antigen presenting cells. The RFX complex binds to X-box DNA, using the DNA binding domain, present in RFX5. The DNA binding domain (DBD) of RFX5 (12 kD) and intact RFXANK (35 kD) were subcloned, expressed and purified. The associations of RFX5DBD with the X-box DNA and between RFX5DBD and RFXANK were measured in this study. The interaction of RFX5DBD and X-box DNA was studied using steady state fluorescence quenching and circular dichroism. The binding dissociation constant (K-d) of the DNA-protein complex was determined

from fluorescence measurements. The van't Hoff plot was linear over the temperature range 10-25 degrees C and the binding was found to be entropy-driven and enthalpy-favorable. The effect of electrolytes in RFX5DBD-DNA association was also studied. Molecular association between RFX5DBD and RFXANK has been observed by fluorescence resonance energy transfer (FRET) measurements, changes in the ratio of the two vibronic intensities of pyrene labeled RFX5DBD in presence of RFXANK and chemical cross-linking followed by tandem mass spectrometry. Results showed that the two proteins could interact in the absence of the third subunit RFXAP, in vitro with an apparent dissociation constant (K-d) of 128 nM.

Madhumita Chakraborty, Amitava Sengupta, Dipankar Bhattacharya, Subrata Banerjee, Abhijit Chakrabarti

1.2.4.5 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.

Sumanta Basu, Debasis Banerjee†, Malay Ghosh, Abhijit Chakrabarti

1.2.4.6 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 H_2O_2/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

Madhumita Chakraborty, Dipankar Bhattacharya, Chaitali Mukhopadhyay†, Abhijit Chakrabarti

1.2.4.7 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. Experimental design: 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.

Dipankar Bhattacharya, Sutapa Saha, Sumanta Basu, Sudipa Chakravarty†, Amit Chakravarty†, Debashis Banerjee†, Abhijit Chakrabarti

1.2.4.8 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.

Mithu Raychaudhuri, Debashis Mukhopadhyay

1.2.4.9 Mechanistic insight into the physiology of disrupted protein trafficking in late-onset neurodegenerative diseases

We plan to simultaneously pursue two broad facets of late-onset neurodegenerative diseases: first, understandi ng the significance of the ESCRT machinery and the endo-lysosomal pathway in PrP-mediated (Prion protein) neur odegenerative diseases. This will aim to provide a molecular explanation for how the loss of function mutation of Mahogunin, an E3-ubiquitin ligase, results in Prion disease like phenotype of spongiform neurodegeneration , affects biogenesis and functions of the endo-lysosomal pathway. Incidentally, functional loss of Mahogunin d ue to its sequestration by mislocalized PrP disrupts lysosomal morphology. This cell-biological approach relie s primarily on high resolution live cell imaging and analyses. Secondly, we also aim to explore how the various essential molecular components of the endo-lysosomal pathways are regulated themselves during aging and perturbations in these ultimately manifests in late onset neurodege nerative diseases. The microRNA (miRNA) profile of the key controllers of the endocytic pathway will be identi fied to better understand how functions of the endo-lysosomal machinery are regulated during health and neurod egenerative diseases.

Oishee Chakrabarti

1.3 Publications

1.3.1 Publications in Books/Monographs & Volumes Edited

Application of Radiotracers in Chemical, Environmental and Biological Sciences, Vol 3, Eds: Susanta Lahiri, Moumita Maiti, SK Das, Saha Institute of Nuclear Physics (2010)

Debi Choudhury, Sampa Biswas, Sumana Roy and JK Dattagupta, Improving thermostability of Papain through structure-based protein engineering, in Protein Engineering, Design and Selection **23** (2010) 657p

Sruti Dutta, Raka Ghosh, JK Dattagupta and Sampa Biswas, Heterologous expression of a thermostable plant cysteine protease in Escherichia coli both in soluble and insoluble forms, in Process Biochemistry **45** (2010) 1307p

Debarati Dey, Manas Kumar Sarangi and Samita Basu, Hydrogen bonding on photoexcitation in Hydrogen bonding and transfer in the excited state, Eds Ke-Li Han and Guang-Jiu Zhao, (WILEY publishers, Part I, 2010, 288p)

Susanta Lahiri, Moumita Maiti, Methods of Cosmochemical Analysis, in Handbook of Nuclear Chemistry (2nd ed), Vol: 5, Eds A Vrtes, S Nagy, Z Klencsr (Springer, 2010)

1.3.2 Journal Publication

Biophysics

Aditi Borkar†, Indira Ghosh†, Dhananjay Bhattacharyya, Structure and Dynamics of Double Helical DNA in Torsion Angle Hyperspace: A Molecular Mechanics Approach, J Biomol Struct Dynam **27** (2010) 695

Nahren Manuel Mascarenhas†, Dhananjay Bhattacharyya, Nanda Ghoshal†, Why pyridine containing pyrido[2,3-d]pyrimidin-7-ones selectively inhibit CDK4 than CDK2: Insights from molecular dynamics simulation, Journal of Molecular Graphics & Modelling **28** (2010) 695

Saptaparni Ghosh, Parijat Majumder, Suman Kalyan Pradhan, Dipak Dasgupta, Mechanism of interaction of small transcription inhibitors with DNA in the context of chromatin and telomere, Biochem Biophys Acta **1799** (2010) 795

Sudip Chaudhuri, Sandipan Chakraborty, Pradeep K Sengupta , Encapsulation of serotonin in beta-cyclodextrin nano-cavities: Fluorescence spectroscopic and molecular modeling studies, J Mol Struc **975** (2010) 160

Suman Kalyan Pradhan, Dipak Dasgupta, Gautam Basu†, Human telomere d[$(TTAGGG)_4$] undergoes a conformational transition to the Na^+-form upon binding with sanguinarine in presence of K^+, Biochem Biophys Res Commun **404** (2011) 139

Chemical Science

Brotati Chakraborty, Atanu Singha Roy†, Swagata Dasgupta†, Samita Basu, Magnetic Field Effect Corroborated with Docking Study to Explore Photoinduced Electron Transfer in Drug; Protein Interaction, J Phys Chem **A114** (2010) 13313

Brotati Chakraborty, Samita Basu, Magnetic field effect on electron transfer reactions of acridine yellow with amines of varied structures in homogeneous medium, Chem Phys Lett **493** (2010) 76

Ch E Dllmann†, M Schdel†, A Yakushev†, A Trler†, K Eberhardt†, JV Kratz†, D Ackermann†, L-L Andersson†, M Block†, W Brchle†, J Dvorak†, HG Essel†, PA Ellison†, J Even†, JM Gates†, A Gorshkov†, R Graeger†, KE Gregorich†, W Hartmann†, R-D Herzberg†, FP Heberger†, D Hild†, A Hbner†, E Jger†, J Khuyagbaatar†, B Kindler†, J Krier†, N Kurz†, S Lahiri, D Liebe†, B Lommel†, M Maiti, H Nitsche†, JP Omtvedt†, E Parr†, D Rudolph†, J Runke†, B Schausten†, E Schimpf†, A Semchenkov†, J Steiner†, P Thrle-Pospiech†, J Uusitalo†, M Wegrzecki†, N Wiehl†, Production and Decay of Element 114: High Cross Sections and the New Nucleus 277Hs, Phys Rev Lett **104** (2010) 252701

Manas Kumar Sarangi, Debarati Dey†, Samita Basu, Influence of Heterogeneity of Confined Water on Photophysical Behavior of Acridine with Amines: A Time-Resolved Fluorescence and Laser Flash Photolysis Study, J Phys Chem **A115** (2011) 128

Maitreyee Nandy, Chirashree Lahiri, PK Sarkar†, Radiation environment in low energy accelerator for astrophysical studies, Ind J Pure Appl Phys **48** (2010) 478

Maitreyee Nandy, PK Sarkar†, T Sanami†, T Shibata†, M Takada†, Neutron dose distribution from C-12 induced reactions on Ti and Ag using proton recoil scintillator, Radiation Measurements **45** (2010) 1276

Moumita Maiti, Kamalika Sen†, Souvik Sen†, Susanta Lahiri, Studies on stabilities of some human chorionic gonadotropin complexes with β-emitting radionuclides, Applied Radiation and Isotopes **69** (2011) 316

Moumita Maiti, Susanta Lahiri, New routes for production of proton-rich Tc isotopes, Phys Rev **C81** (2010) 024603

Mousumi Banerjee, Sourav Maiti, Ipsita Kundu, Abhijit Chakrabarti, Samita Basu, Simultaneous Occurrence of Energy Transfer and Photoinduced Electron Transfer in Interactions of Hen Egg White Lysozyme with 4-Nitroquinoline-1-Oxide, Photochem Photobiol **86** (2010) 1237

Partha Sarathi Guin, Saurabh Das, PC Mandal, Sodium 1, 4-dihydroxy-9, 10-anthraquinone-2-sulphonate interacts with calf thymus DNA in a way that mimics anthracycline antibiotics: an electrochemical and spectroscopic study, Journal of Physical Organic Chemistry **23** (2010) 477

Pintu Sen†, Amitabha De, Electrochemical performances of poly(3,4-ethylenedioxythiophene)-NiFe2O4 nanocomposite as electrode for supercapacitor, Electrochimica Acta **55** (2010) 4677

Sandipan Chakraborty†, Soumalee Basu†, Ansuman Lahiri†, 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 Struc **977** (2010) 180

Sreeja Chakraborty, Esha Sehanobish†, Munna Sarkar, A traditional painkiller as a probe for microheterogeneity in 1-propanol-water mixtures, Chem Phys Lett **501** (2010) 118

Sutapa Mondal Roy, Amol S Bansode and Munna Sarkar, Effect of increase in orientational order of lipid chains and head group spacing on Non Steroidal Anti-Inflammatory Drug Induced Membrane Fusion, Langmuir **26** (2010) 18967

Swadesh Mandal, Dalia Nayak, Species dependent studies of no-carrier-added ^{93m}Mo: A green method, Applied Radiation And Isotopes **68** (2010) 1892

C Sunil†, AA Shanbhag†, M Nandy, T Bandyopadhyay†, SP Tripathy†, C Lahiri, DS Joshi†, PK Sarkar†, Directional distribution of the ambient neutron dose equivalent from 145-mev f-19 projectiles incident on thick al target, Radiation Protection Dosimetry **143** (2011) 4

C&MB

Anupama Sardar Ghosh, Suman Dutta, Sanghamitra Raha, Hydrogen peroxide-induced apoptosis-like cell death in Entamoeba histolytica, Parasitology International **59** (2010) 166

Anupama Sardar Ghosh, Doel Ray, Suman Dutta, Sanghamitra Raha, EhMAPK, the Mitogen-Activated Protein Kinase from Entamoeba histolytica Is Associated with Cell Survival, Plos One

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Debi Choudhury, Sampa Biswas, Sumana Roy, JK Dattagupta, Improving thermostability of papain through structure-based protein engineering, Protein Engineering Design & Selection **23** (2010) 457

Dipankar Bhandari, Kasturi Guha, Nipa Bhaduri, Partha Saha, Ubiquitination of mRNA cycling sequence binding protein from Leishmania donovani (LdCSBP) modulates the RNA endonuclease activity of its Smr domain, FEBS Lett **585** (2011) 809

Mithun Sinha, Jayeeta Ghose, Eashita Das, Nitai P Bhattarcharyya, Altered microRNAs in STHdhQ111HdhQ111 cells: miR-146a targets TBP, Biochem Biophys Res Commun **396** (2010) 742

S Khamrui, M Biswas, U Sen, J Dasgupta, Cloning, overexpression, purification, crystallization and preliminary X-ray analysis of CheY3, a response regulator that directly interacts with the flagellar 'switch complex' in it Vibrio cholera, Acta Cryst **F66** (2010) 944

Sruti Dutta, Raka Ghosh, JK Dattagupta, Sampa Biswas, Heterologous expression of a thermostable plant cysteine protease in Escherichia coli both in soluble and insoluble forms, Biochem **45** (2010) 1307

Structural Genomics

Abhijit Chakrabarti, Dipankar Bhattacharya, Avik Basu, Sumanta Basu, Sutapa Saha, Suchismita Halder, Differential expression of red cell proteins in hemoglobinopathy, Proteomics Clinical Applications **5** (2011) 98

Mithu Raychaudhuri, Debashis Mukhopadhyay, rb2-Mediated Alteration in the Trafficking of A beta PP: Insights from Grb2-AICD Interaction, Journal of Alzheimers Disease **20** (2010) 275

Amy B Emerman, Zai-Rong Zhang, Oishee Chakrabarti, Ramanujan S Hegde, Compartment-Restricted Biotinylation Reveals Novel Features of Prion Protein Metabolism in Vivo, Molecular Biology of the Cell **21** (2010) 4325

Dipankar Bhattacharya, Sutapa Saha, Sumanta Basu, Sudipa Chakravarty†, Amit Chakravarty†, Debashis Banerjee†, Abhijit Chakrabarti, Differential regulation of redox proteins and chaperones in HbE beta-thalassemia erythrocyte proteome, Proteomics Clinical Applications **4** (2010) 480

Madhumita Chakraborty, Amitava Sengupta, Dipankar Bhattacharya, Subrata Banerjee, Abhijit Chakrabarti, DNA binding domain of RFX5: Interactions with X-box DNA and RFXANK, Biochem Biophys Acta **1804** (2010) 2016

Madhumita Chakraborty, Dipankar Bhattacharya, Chaitali Mukhopadhyay†, Abhijit Chakrabarti, Structure and conformational studies on dityrosine formation in the DNA binding domain of RFX5, Biophysical Chem **149** (2010) 92

Sumanta Basu, Debasis Banerjee†, Malay Ghosh†, Abhijit Chakrabarti, Erythrocyte membrane defects and asymmetry in paroxysmal nocturnal hemoglobinuria and myelodysplastic syndrome,

Hematology **15** (2010) 236

Sumanta Basu, Debasis Banerjee†, Sarmila Chandra†, Abhijit Chakrabarti, Eryptosis in hereditary spherocytosis and thalassemia: role of glycoconjugates, Glycoconjugate Journal **27** (2010) 717

1.4 Ph D Awarded

Dipankar Bhandari [Partha Saha], Studies on Regulation of Differential Gene Expression in Leishmania Parasites, Jadavpur University, December 2010

Soumyajit Banerjee Mustafi [Sanghamitra Raha], Characterization of stress response: Involvement of the Cellular Communication Networks, Jadavpur University, May 2010

1.5 Seminars/Lectures given in Conference/Symposium/Schools

Dipak Dasgupta

Chemical Biology: a burgeoning area as a sequel to knowledge sharing among Chemists and Biologists, Endowment Lecture in Cotton College, Guahati, December 8, 2010

How do DNA-binding anticancer agents bind to chromatin?, Nanobiology Forum of Technical University of Hosei, Tokyo, Japan, December 2, 2010

Additional therapeutic potential of Aureolic Acid Group of antibiotics due to their bivalent metal ion(s) binding ability, Institute of Protein Research Annual Retreat, Osaka, Japan, November 30, 2010

Effect of DNA binding drugs upon Chromatin Structure, Protein Profiling and Proteomics Department of Institute of Protein Research, Osaka Japan on December 1, 2011

Revisit of the DNA binding properties of small ligands in the perspective of chromatin structure, International Chromatinasia meeting in JNCASR, Bangalore, December 6, 2010

High Affinity GTP Association Affects The Promoter Melting In Presence of T7 RNA POLYMERASE, XII th Transcription Assembly Meeting in CDFD, Hyderabad

Chemical Biology of two anticancer antibiotics with additional therapeutic potential, University of Rome, Tor Vergata, October 24, 2010

Chemical Biology a burgeoning area as a sequel to knowledge sharing among Chemists and Biologists, JBNSTS Summer School, March 17, 2011

Dhananjay Bhattacharyya

Theoretical Investigation of Properties of Double Helical DNA: Oligomeric vs Polymeric DNA,

International Conference on Natural Polymers, Kerala, September 24-26, 2010

Molecular Dynamics Simulation: Applications to understand Nucleic Acid Conformational Features, Workshop on Molecular Modeling and Drug Design, University of Hyderabad, August 2-7, 2010

Sequence Dependent DNA Flexibility and its role in Protein-DNA Recognition, National Workshop on DNA Physics, Benaras Hindu University, August 11-13, 2010

(1)Nucleic Acid Structural Analysis and (2)DNA flexibility and Protein DNA interaction through induced fit mechanism, Workshop on Biomolecular Simulations and its Applications in Biology, JNU, August 1-6, 2010

DNA Flexibility and Induced Fit Mechanism for Protein-DNA Recognition, International Symposium on Accelerating Biology, CDAC, Pune, December 14-16, 2010

Structural Studies of Double Helical DNA: Effect of Terminal Basepairsi, Symposium on Biomolecular Simulation, Algorithms and Application, JNU, March 15-16, 2011

Structural features of Nucleic Acids: What to look for, Kalyani University, March 17, 2011

Sanghamitra Raha

Resveratrol targets key survival elements in cancer cells and causes apoptosis, International Symposium on Signaling Networks and Cancer held concurrently with the 30thAnnual Convention of the Indian Association for Cancer research to commemorate the 75thyear of the Indian Institute of Chemical Biology (IICB), Kolkata, India, February 6-9, 2011

The allergenecity of NP24-I, a thaumatin-like protein from tomatoes, studied from its three-dimensional structure, The 39th National Seminar on Crystallography, University of Jammu, October 25-27, 2010

Sampa Biswas

Designing collagenolytic activity in a plant cysteine protease, 39th National Seminar on Crystallography, Department of Physics & Electronics, University of Jammu, Jammu Tawai, October 25-27, 2010

Partha Saha

Ubiquitination mediated inhibition of riboendonuclease activity of a RNA binding protein LdCSBP from Leishmania implication of mRNA turnover regulation through the posttranslational modification, DAE-BRNS Life Science Symposium (LSS-2010), Bhabha Atomic Research Centre, Mumbai, December 22-24, 2010

Susanta Lahiri

Green Chemistry: Responsibilities of chemists (Keynote address), National seminar on green and

environmental chemistry, Mizoram University, Aizawl, March 30, 2011

Separation of No-carrier-added 149Gd from the Natural Praseodymium, 13th International Conference on Modern Trends in Activation Analysis (MTAA-13), Texas A & M University College Station, Texas, USA, March 13-18, 2011

Studies on the production cross sections of 149,150,151Tb from 12C induced reaction on natural praseodymium, Nuclear and Radiochemistry Symposium, NUCAR-2011, GITAM University, Visakhapatnam, February 22-26, 2011

Heavy ion induced production of proton rich clinical radionuclides, Bangladesh Chemical Congress 2010, Jahangirnagar University, Bangladesh, December 10-12, 2010

Investigation on the production and isolation of 149Tb for targeted therapy, Fourth International Symposium on Nuclear and Analytical Chemistry (NAC-IV), Bhabha Atomic Research Centre, Mumbai, India, November 15-19, 2010

Aqueous biphasic extraction: a powerful analytical tool probed through radiotracer technique, Fourth International Symposium on Nuclear and Analytical Chemistry (NAC-IV), Bhabha Atomic Research Centre, Mumbai, India, November 15-19, 2010

Recent Developments in Nuclear and Chemical Data of Astatine and Technetium Radionuclides, Second International Conference on Application of Radiotracers in Chemical, Environmental and Biological Sciences (ARCEBS-10), Saha Institute of Nuclear Physics, Kolkata, India, November 7-13, 2010

Moumita Maiti, Susanta Lahiri, Separation of No-carrier-added 97Ru from Heavy Ion Activated Natural Niobium

Ajoy Mandal, Susanta Lahiri, Separation of 134Cs and 133Ba radionuclides by calcium alginate beads

Recent Trends in Nuclear Chemistry Research at the Saha institute of Nuclear Physics, Technical University of Munich, Munich, Germany, June 28, 2010

Recent Trends in Nuclear Chemistry Research at the Saha institute of Nuclear Physics, Leipzig University, Leipzig, Germany, June 16, 2010

Green Chemistry Research at the Saha Institute of Nuclear Physics, Forschungszentrum Dresden-Rossendorf, June 14, 2010

Green chemistry- commitment to the society, UGC Refresher Course for College and University Teachers, Calcutta University, December 7, 2010

A fundamental course on nuclear chemistry, UGC Refresher Course for College and University Teachers, University of Burdwan, September 14, 2010

Amitabha De

Conducting Pedot and its Nanocomposites: Transport & Magnetic properties, Application as Electrochemical Capacitor, International Conference on Nanomaterials: Synthesis, Characterization and Application, Center for Nanoscience & Nanotechnology Mahatma Gandhi University, Kottayam, Kerala, April 27-29, 2010

Magnetic Properties and Electrochemical Performances of Poly (3,4-ethylenedioxithiophene)-$NiFe_2O_4$ Nanocomposite, 2nd International Conference on Nanomechaqnics and Nanocomposites, Technical Institute of Physics and Chemistry, Chinise Academy of Sciences, Chinise Society for Composite Materials, Beijing, China, October 10-13, 2010

Magnetic Properties and Electrochemical Performances of Poly (3,4-ethylenedioxithiophene)-$NiFe_2O_4$ Nanocomposite, National Seminar on Current Trends in Polymer Science and Technology (Prof Sukumar Maity Polymer Award Foundation, Kolkata and the Department of Chemistry, Jadavpur University, Kolkata), Jadavpur University, Kolkata, January 28-29, 2011

Samita Basu

Magnetic field effect: a unique tool for elucidation of reaction pathways involving radicals as transient intermediates, 3rd Asia-Pacific Symposium on Radiation Chemistry (APSRC-2010) incorporating 10th Trombay Symposium on Radiation & Photochemistry (TSRP-2010) (Bhabha Atomic Research Centre under the auspices of the Indian Society for Radiation and Photochemical Sciences (ISRAPS)), Lonavala, September 14-17, 2010

Application of Magnetic Field on Photoinduced electron transfer, Academic Staff College, University of Calcutta, Kolkata, December 6, 2010

Magnetic field effect as a tool for identification of pathways of photoinduced reactions with radical pairs as transient intermediates in organized assemblies, Pacifichem 2010, Convention Center, Honolulu, Hawaii, USA, December 15-20, 2010

Application of a low magnetic field associated with UV-visible spectroscopic techniques for elucidation of pathways of photoinduced reactions involving radical pairs as transient intermediates, Modern Trends in Spectroscopy: Its Application in Chemistry & Biology, organized by Departments of Chemistry and Microbiology, Moulana Azad College in association with The Indian Association for the Cultivation of Science, Kolkata, India, February 3-4, 2011

A study highlighting spectroscopic changes of Merocyanine 540 (MC540) in presence of Serum Albumins (HSA & BSA), National Symposium on Radiation & Photochemistry (NSRP - 2011), JNV University, Jodhpur, Rajasthan, March 10-12, 2011

Exploring the host-guest chemistry of Acridine Yellow and Cucurbit[7]uril, International Year of Chemistry: Design, Synthesis, Interaction, Chemical and Biological Activities of Different Functional Molecules,the Department of Chemistry, University of Burdwan, Burdwan, March 15-17, 2011

Photoinduced electron transfer, Academic Staff College, Burdwan University, West Bengal, September 9, 2010

Importance of magnetic field effect in understanding structural behaviour of chemical species in photoinduced reactions, Department of Chemistry, IIT Bombay, September 13, 2010

Photoinduced electron transfer probed by magnetic field, Academic Staff College, Jadavpur University, Kolkata, January 6, 2011

Science Beyond School inspire in association with Jagadis Bose National Science Talent Search, Kolkata Molecular Photochemistry: an overview, DST-Inspire Intership Science Camp 2010, February 2, 2011

Munna Sarkar

Application of fluorescence spectroscopy in monitoring membrane fusion, Workshop on New Arena of Photoscience, Saha Institute of Nuclear Physics, Kolkata, August 24-27, 2010

Application of Fluorescence Spectroscopy in Monitoring Membrane Fusion, UGC-Academic Staff College Jadavpur University, Refresher Course on Chemistry Fundamentals and Advances January 03-22, 2011

Maitreyee Nandy

Neutron and gamma dose distribution in a 3 MV tandem accelerator facility, School cum Workshop on Low Energy Nuclear Astrophysics (SLENA2010), Saha Institute of Nuclear Physics, Kolkata, November 15-19, 2010

Aggregation of multi-model generated nuclear data using the probability-box approach in random set theory, International Conference on Modeling, Optimization and Computing (ICMOC 2010), National Institute of Technology, Durgapur, West Bengal, October 28-30, 2010

Electromagnetic waves: Strength & Hazards, Short Term Training Programme on Electromagnetic Waves & its Various Applications, National Institute of Technical Teachers' Training & Research (NITTTR), Kolkata, July 26-30, 2010

Space Radiation, 14 day Workshop on Fundamental Space Science and Technology, Vivekananda Research Centre, Kolkata, May 9-22, 2010

Abhijit Chakrabarti

Red cell death in hemoglobin disorders, Biochemistry Department, Indian Institute of Science, Bangalore, April 9, 2010

Footprints of Life, DST Sponsored INSPIRE camp on Basic Science for high school students of West Bengal organized by Nation Institute of Technology, Durgapur, June 25, 2010

DNA binding domain of RFX5: Structure, Function & Interactions, National Symposium on Trends in Cellular Biochemistry & Biophysics, to celebrate golden jubilee of University of Kalyani, Department of Biochemistry and Biophysics, October 6, 2010

Clinical Proteomics in Haematological Disoders, in Lectures cum Demonstrations for Teachers and Graduate Students on Clinical Proteomics-Technology and Beyond, ACTREC, Mumbai, November 26, 2010

Interactions of a membrane skeletal protein, spectrin with hemoglobin and phospholipids, in International Conference on Facets of Weak Interactions in Chemistry (celebrating the International Year of Chemistry), Department of Chemistry, University of Calcutta, January 13, 2011

Eryptosis in hemoglobinopathy: a mechanistic view, in 9th International Symposium on Biochemical Roles of Eukaryotic Cell Surface Macromolecules (9th ISCSM), Central University of Kerala and the Rajiv Gandhi Centre for Biotechnology Trivandrum, Poovar Island, Trivandrum, January 28, 2011

Oishee Chakrabarti

Detecting novel protein-protein interactions by high-resolution imaging, One day discussion meeting on Common Themes in Biomaterial and Nanomaterials Sciences, Saha Institute of Nuclear Physics, Kolkata, October 2010

Understanding neurodegeneration, Indian Institute of Chemical Biology, Kolkata, August 2010

1.6 Honours and Distinctions

Moumita Maiti

Young Scientist Award-2011 bestowed by the International Committee on Activation Analysis (ICAA) & Texas A & M University, College Station, Texas, USA

Samita Basu

Elected Fellow of the West Bengal Academy of Science and Technology in the year 2010 for her notable contributions in the field of Molecular Spectroscopy

1.7 Teaching elsewhere

Samita Basu

M Sc (Inorganic Chemistry special), University of Calcutta
M Sc (4th Semester of Chemistry), Spectroscopy, Midnapore college, Midnapore

Sampa Biswas

Macromolecular Crystallography, M Sc, Biophysics and Mol Biology Department, University of Calcutta

Partha Saha

DNA Replication (10 Lectures), M Sc (Biotechnology, Microbiolgy, Genetics, Neurobiology) 1st year, University of Calcutta, Kolkata, September-December, 2010

1.8 Miscellany

Fourth International Symposium on Nuclear Analytical Chemistry (NAC-IV), November 15-19, 2010, Bhabha Atomic Research Centre, Mumbai, India
Moumita Maiti, BS Tomar and Susanta Lahiri, Investigation on the production and isolation of 149Tb for targeted therapy
Moumita Maiti, Best oral presentation award

National Symposium on Radiation & Photochemistry (NSRP - 2011), JNV University, Jodhpur, Rajasthan, March 10-12, 2011
Mousumi Banerjee, Uttam pal, Arijita Subudhhi, Abhijit Chakrabarti, Samita Basu, A study highlighting spectroscopic changes of Merocyanine 540 (MC540) in presence of Serum Albumins (HSA & BSA)
Best poster award

Asian Biophysics Association (ABA) Symposium and Annual Meeting of the Indian Biophysical Society (IBS), India Habitat Center, New Delhi, January 30th February 2nd, 2011
Abhijit Chakrabarti, Madhumita Chakrabarti, Subrata Banerjee, Chaitali Mukhopadhyay, DNA binding domain of RFX5: Structure, Function & Interactions
Abhijit Chakrabarti received the NN Dasgupta best poster Award

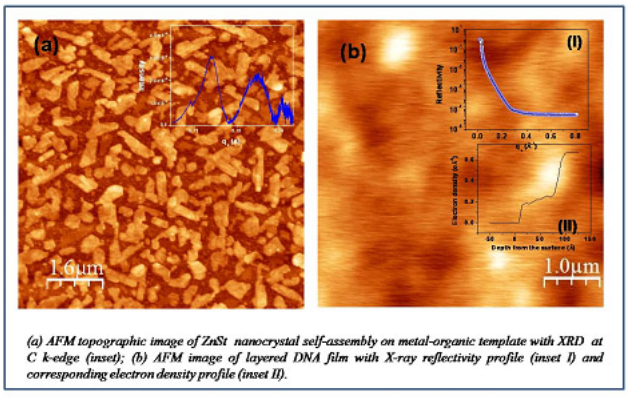
Chapter 2

Condensed Matter Physics including Surface Physics and NanoScience

2.1 Summary of Research Activities of Divisions

2.1.1 Applied Material Science

Supramolecular interactions form a crucial link between morphology, structure and bonding in complex molecular systems. The hierarchy of structures and, consequently, dynamics of such systems are governed by relative str engths of different supramolecular forces active in them. Complementing microscopy and laboratory x-ray facili ties with VUV to soft x-ray spectroscopic facility at Elettra synchrotron, we probed two kinds of supramolecul ar interactions in soft materials, both emerging due to confinement. First, forces between amphiphilic molecul es and metal ions confined to the air-water interface that control growth of super-molecular assemblies of the metal-organics through specific molecular conformations. The other class of supramolecular forces emerges in fluids, especially polymers, and lead to spontaneous one-dimensional ordering and other granular behavior.



(a) AFM topographic image of ZnSt nanocrystal self-assembly on metal-organic template with XRD at C k-edge (inset); (b) AFM image of layered DNA film with X-ray reflectivity profile (inset I) and corresponding electron density profile (inset II).

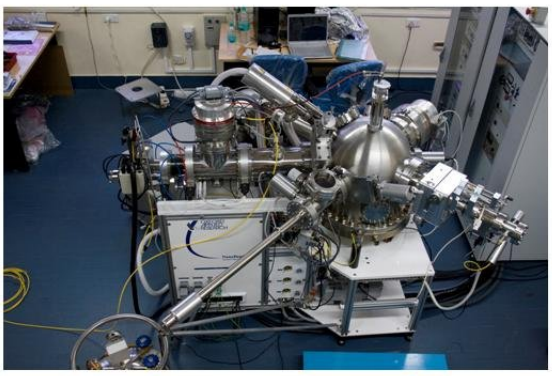
2.1.2 Experimental Condensed Matter Physics

During the period 2010-11, new equipments have been installed like physical property measurements systems for thermoelectric power, sp. heat for the investigation of SC oxides, High curie temperature intermetallic alloys, the installation of 9T for transport studies, 9T room temperature bore, XRD at 18KW with temperature variation 10K-1700K.

Magnetization and ^{63}Cu NMR studies on granular FeCu alloys, ^{75}As NMR study of oriented CeFeAsO and $CeFeAsO_{0.84}F_{0.16}$,^{11}B and ^{195}Pt NMR study of heavy fermion compound $CePt_2B_2C$, Effect of Interfacial Hydrogen Bonding on the Freezing/Melting behaviour of Nanoconfined Liquids, ^{27}Al and ^{63}Cu NMR studies on intermetallic Kondo compound CeCu3Al2 have been investigated using 7T NMR magnet system. The critical behaviour of $La_{1-x}Sr_xCoO_3(0.21 \leq x \leq 0.33)$ single crystals has been investigated from the bulk magnetic measurements in order to shed some light on the nature of magnetization. Studies of critical current density of $PrFeAsO_{0.60}F_{0.12}$, observation of large MR in PrFeAsO, are some of the work based on superconducting materials. New intermetallic alloys of RT_XSn_2 have been studied.

2.1.3 Surface Physics

This Division has primarily been engaged in the research on diversified inter-related front-line areas of surfaces and interfaces of low-dimensional materials. The main features of the activities are the development of fundamentally new bottom-up physical and chemical methods of growing nanoparticles with tunable morphology and optical/mechanical properties, growth of semiconductor quantum structures and applications in micro-nano technology. In addition, the division has been involved in fabricating decorated and modified surfaces as growth templates through medium and low-energy ion-bombardment, growth of magnetic and photonic structures through nano-manipulation and self-assembly and the development of polymer-based photovoltaics and other molecular electronic systems and study of their morphology-transport correlations.



Nanocluster Deposition System (SPD, CENSUP)

Thin films and nanomaterials from various sources such as semiconductors, metals and polymers are being synthesized using our various sophisticated techniques such as DC/RF magnetron sput-

tering, Molecular Beam Epitaxy (MBE), Metal Organic Vapour Phase Epitaxy (MOVPE), ion-implantation, nanocluster deposition, etc. along with simple chemical and self-assembled routes. Versatile microscopic and spectroscopic methods are being employed to study the structure and the range of physical properties of the grown materials. Efforts are made to correlate the structure with the novel properties of the nanomaterials for the purpose of basic understanding and to have control over the desired material properties.

Following are the glimpses of current research activities: structural evolution during controlled degradation of ultrathin polymer films; spin vortices in Gd-based Langmuir-Blodgett (LB) films; iron sulphide formation in the ferric stearate LB films; hydrophobic to hydrophilic transition of HF-treated Si surface during LB film deposition; magnetic properties of Co^{2+}-doped TiO_2 nanoparticles; anomalous magnetic behavior of CuO nanoparticles; thermal fragmentation of nano-sized silver clusters; Ar^+- induced nanocavities/bubbles in silicon; photoluminescence of ion-beam synthesized Ge/Si core/shell nanocrystals; resistivity of polymer nanowires; temperature/substrate effect on ZnO nanorod flower structures in modified chemical vapor condensation growth; MBE growth of Si/Ge superlattice and $Si_{1-x}Ge_x$ alloy structures; nonlinear optical behaviour of ion-beam synthesized metal-glass /sapphire nanocomposites, etc.

2.1.4 Theoretical Condensed Matter Physics

Major works in Quantum Annealing and Failure Dynamics in Fibre Bundles have been completed and reviewed. Kinetic Exchange Models of markets to Social Opinion formation have been extended. A textbook on Econophysics have been published from Wiley-VCH & the Monograph on Econophysics, to be published by the Cambridge Univ. Press, is on the verge of completion. Study on the effect of strongly anisotropic harmonic trap on the dynamics of bosons and fermions, moving in an optical lattice are underway. A two-step condensation occurs for lattice bosons at much reduced harmonic potential anisotropy is when compared to the case of an ideal Bose gas in an anisotropic harmonic confinement. Considering a Holstein model with nearest- and next-nearest neighbour hopping, the energy and the wave function of the ground and first excited band states are obtained by applying conjugate-gradient technique on the variational Hilbert space of the electron-phonon (e-ph) system to achieve high accuracy. The study reveals that the effect of next nearest neighbour hopping is the most prominent at the physically interesting crossover regime of the e-ph coupling and in the adiabatic regime. Studies on the Supersolidity for hard-core-bosons coupled to optical phonons are being done. The coexistence of diagonal long-range order (DLRO) and off-diagonal long-range order (ODLRO), manifested in some systems, is still a theoretical enigma. A novel microscopic mechanism is presented for supersolidity or the homogeneous coexistence of charge-density-wave state (an example of DLRO) and superfluidity/superconductivity (a realization of ODLRO). An effective d-dimensional Hamiltonian has been derived for a system of hard-core-bosons coupled to optical phonons in a lattice. At non-half-fillings, a superfluid/superconductor to a supersolid transition occurs at intermediate bosonphonon couplings, while at strong-couplings the system phase separates. That the presence of next-nearest-neighbor hopping and nearest-neighbor repulsion leads to supersolidity has been explicitly demonstrated. Attention has been focussed on nanoscience, studying electron and spin transport through nanoscale systems, persistent current through mesoscopic rings, behaviour of Dirac fermions in graphene in the presence of electron-electron interaction, etc. Development of a method to solve a class of non-equilibrium models; the method when applied to several driven diffusive systems, reveals novel spatial correlations.

It has been also 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. Inspired by the physics of magnetohydrodynamics (MHD), a simplified coupled Burgers-like model in one dimension (1d) to describe 1dMHD has been proposed. In addition to MHD, this model serves as a 1d reduced model for driven binary fluid mixtures, determining the scaling exponents and the amplitude-ratios of the relevant correlation functions. Studies on semi-classical RRTN (Random Resistor cum Tunneling-bond Network) model continued including (i) nonlinear response, (ii) breakdown, (iii) two early power-law dynamics; and (iv) very strong memory (associated hysteresis). A pedagogical review on the RRTN, was written.

2.2 Research Activities

2.2.1 Applied Material Science Division

2.2.1.1 Nanoparticle Surface as Activation Site

The immense surface-to-volume (S/V) ratio in nanoparticles leads to large surface energy density. These high densities play the role of sites for activities that are not triggered in bulk materials. Here we present some examples of such distinctive activities taking place at nanoparticle surfaces. Our first example involves the morphological changes in silkworm (Bombyx mori L.) nuclear polyhedrosis virus (BmNPV) brought about by lipophilic amorphous silica nanoparticles (LASN). Microscopy studies show that nanoparticles severely alter the structure of the virus envelope by a 'deflation' of the viral polyhedron and formation of elongated structures. The second example shows the spatial variation in aggregation potential with temperature, for dodecanethiol-capped Au nanoparticles on an amorphous polystyrene film surface. We find that on increasing the temperature from 32 degrees C to 50 degrees C the aggregating potential becomes almost completely confined to the film surface, whereas going over to 100 degrees C the confining potential is overcome and out-of-plane growth takes place. A tentative and qualitative explanation has been attempted.

Nupur Biswas, Ayesha Rahman†, Alokmay Datta, Arunava Goswami†, Ratan Lal Bramhachary†

2.2.1.2 Microstructural and magnetic characterization of dusts from a stone crushing industry in Birbhum, India

Stone dust sample collected from a stone crushing industry situated at Muhammad Bazar in Birbhum, India, is studied for its physical characterization using various techniques. Morphology and compositional analysis of the stone dust by scanning electron microscopy (SEM) reveal that the dust is an agglomeration of many tiny particles (0.32- 2.12 μm), mostly having sharp edges, as well show microstructure heterogeneity. Elements present in the sample are detected by energy dispersive X-ray spectrometry (EDX). The X-ray diffraction (XRD) pattern analysis shows that the sample mainly contains minerals like anorthite, augite, esseneite and albite. An overall antiferromagnetic interaction in this sample has been indicated by the nature of the thermal dependence of magnetization. The remnant magnetization study apparently indicates two magnetic transitions at low temperatures. $_{57}Fe$ Mossbauer spectroscopy has been employed to detect different possible iron sites as well as to estimate the respective site population. In general, Mossbauer spectroscopic

results corroborate the observations made through XRD analysis ingeneral.

A Bhattacharjee, H Mandal†, M Roy, J Kusz†, M Zubko†, P Gutlich

2.2.1.3 Rod-like ferrites obtained through thermal degradation of a molecular ferrimagnet

This paper presents the characteristics of iron oxides obtained through thermal degradation of a molecular ferrimagnet, N(n-C4H9)(4)[(FeFeIII)-Fe-II(C2O4)(3)](infinity) and sheds light on the reaction pathways of degradation. The powder XRD pattern and the IR spectra of the degraded material reveal the formation of hematite. The SEM study exhibits that the degraded material consists of rod-like crystals of average length and diameter being 350 and 140 nm, respectively. But the mean crystallite size as estimated from the XRD pattern analysis is 169(2)nm. The magnetization study of the degraded material by SQUID shows the presence of Morin and Verwey transitions. Formation of ferrites through thermal degradation of the molecular magnetic precursor is further established by thermogravimetric study of the precursor. This is the first ever report of synthesis of nano-ferrites from a molecular magnet precursor, which underlines a new route for synthesis of ferrites.

A Bhattacharjee, D Roy, M Roy, S Chakraborty, A De, J Kusz†, W Hofmeister†

2.2.2 Experimental Condensed Matter Physics Division

2.2.2.1 ^{27}Al and ^{63}Cu NMR studies on intermetallic Kondo compound $CeCu_3Al_2$

Detailed ^{27}Al and ^{63}Cu nuclear magnetic resonance (NMR) experiments have been performed in between 4.5 and 295 K on a polycrystalline sample of $CeCu_3Al_2$ which has a Kondo temperature $\sim$ 11 K. The NMR spectral features and Knight shift measurements show that in this compound, Cu occupy both c and g lattice sites, while Al occupy only the g sites. From the temperature dependence of Knight shift (K), the hyperfine fields for ^{63}Cu and ^{27}Al at the g sites have been estimated as 2.02(5) and 1.67(5)kOe/μ_B, respectively, and that for ^{63}Cu at c sites as -3.83(5) kOe/μ_B. Nuclear spin-lattice relaxation time (T_1) measurements indicate that though the relaxation process is governed by fluctuations of magnetic interaction, nuclear quadrupolar interaction also has a significant contribution, especially towards relaxation of ^{63}Cu in both c and g sites. For ^{27}Al, K and T_1 have yielded the effective 4f-spin correlation rate $1/\tau_{4f}$. The behavior of its temperature dependence indicates that at low temperatures in $CeCu_3Al_2$, the valence state of cerium might not be stable.

B Bandyopadhyay, M Majumder, A Ghoshray, K Ghoshray

2.2.2.2 Low noise constant current source for bias dependent noise measurements

A low noise constant current source used for measuring the $1/f$ noise in disordered systems in ohmic as well as nonohmic regime is described. The source can supply low noise constant current starting from as low as 1 μA to a few tens of milliampere with a high voltage compliance limit of around 20 V. The constant current source has several stages, which can work in a standalone manner or together to supply the desired value of load current. The noise contributed by the current source

is very low in the entire current range. The fabrication of a low noise voltage preamplifier modified for bias dependent noise measurements and based on the existing design available in the MAT04 data sheet is also described.

D Talukdar, RK Chakraborty, Suvendu Bose, KK Bardhan

2.2.2.3 Enhanced ferromagnetism in nano-sized $Zn_{0.95}Mn_{0.05}O$ grains

The present work reports ferromagnetism by doping magnetic Mn atoms in the diamagnetic ZnO matrix and the ferromagnetism has been extended up to 640 K in nano-grained $Zn_{0.95}Mn_{0.05}O$ samples. The bulk and nano-grained samples were stabilized in hexagonal crystal structure with space group p63mc. The grain size and lattice strain of the samples were estimated from room temperature XRD spectrum. Surface morphology of the samples was examined at room temperature using SEM picture and EDX spectrum. The ferromagnetism of the bulk material shows enhancement in nano-grained samples, which was mainly due to the solution of Mn atoms into the lattice sites of ZnO by mechanical milling. The enhancement of magnetic moment and ferromagnetic ordering temperature with reduction in grain size has been understood in terms of the core-shell structure and existing theoretical models. The present work also demonstrated the role of surface spin disorder on the enhancement of ferromagnetism in $Zn_{0.95}Mn_{0.05}O$ nanograins.

RN Bhowmik†, Asok Poddar, A Saravanan†

2.2.2.4 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 ($\sim$ 6.5 K) and relative cooling power ($\sim$ 320 J/kg) for a field change of 7 T are also appreciable to consider $HoMnO_3$ as a magnetic refrigerant at low temperature.

A Midya†, P Mandal, S Das, S Banerjee, LSSharath Chandra†, V Ganesan, SR Barman

2.2.2.5 Disorder induced magnetism and electrical conduction in La doped Ca_2FeMoO_6 double perovskite

We report the magnetism and electrical transport properties of La doped Ca_2FeMoO_6 double perovskite. Reduction in magnetic moment, nonmonotonic variation in magnetic ordering temperature (T_C), increasing magnetic hardness, low temperature resistivity upturn, and loss of metallic conductivity are some of the major changes that we observed due to La doping induced disorder in double perovskite structure. The increase in magnetic disorder in La doped samples and its effect on T_C is more consistent with the mean field theory. The modification in electronic band structure due to La doping is understood by establishing a correlation between the temperature dependence

of electrical conductivity and thermoelectric power.

Asok Poddar, RN Bhowmik†, I Panneer Muthuselvam†

2.2.2.6 Synthesis and study of electroactive nanoparticles and their polymer composites for novel applications

Polymer ceramic composites using a polymer binder, nanosized $BaTiO_3$ and metal particles were developed for radiation shielding in the microwave region. From X-ray Diffraction (XRD) the crystallinity and nanosize of $BaTiO_3$ was confirmed in the composite. Interesting changes in Differential Scanning Calorimetry (DSC) were observed before and after ball milling of $BaTiO_3$. Shielding Efficiency (SE) of microwave radiation has been measured from transmitted fraction (TF) of electromagnetic waves (EM) at different frequencies. The changes in TF were assigned to reflection and absorption of EM waves in different composites.

N DuttaGupta, KR Sahu, I Das, Abhijit De, Udayan De

2.2.2.7 UHV Versatile Sputtering Set-up

New science in the field of condensed matter physics are now driven by artificially created complex materials and nano-structures. Keeping this in mind, several hundreds of man hours have been spend for planning the various components, preparation of specialize design of various parts and to finalize the design configuration, of a customized UHV versatile sputtering set-up. Presently M/s Omicron Nano-Technology, Germany is fabricating the set-up as per our requirements and design. Using the set-up we are planning to fabricate high performance magnetic/nonmagnetic nano-structure for the research on various emerging fields like- (1) (a) Spin polarize transport in Magnetic tunnel junction (TMR) / GMR, (b) Quantum-well oscillation, (c) Spin-dependent coulomb blockade effect, (d) Spin-dependent resonant tunneling etc. The set-up is also specially design by us for (2) Combinatorial sputter deposition, which can give us tremendous speed and high standard in research for the creation of (a) Co-deposited composition spread, (b) Phase diagram composition spread, (c) Discrete materials library (d) Preparation of gradient or wedge film etc.

Indranil Das

2.2.2.8 Spin glass-like behaviour in Fe-rich phases of Sr2Fe1-xMnxMoO6 (0.1⇐x⇐0.4)

Below their respective ferromagnetic Curie temperatures (T-C), Sr_2Fe_1-xMnxMoO_6 (0.1⇐x⇐0.4) undergo a spin glass-like transition owing to the electronic phase segregation process that creates highly spin disordered regions. At low temperatures, an additional short range magnetic interaction is observed due to large differences in volumes of FeO6 and MnO6 octahedra. The magnetoelastic structural change is also reflected in the lattice parameters.

Asok Poddar, Chandan Mazumdar

2.2.2.9 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, $|\Delta S_M|$ decreases and its thermal distribution becomes more symmetric as compared to P=0.

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

2.2.2.10 Exchange bias in $LaFeO_3$ nanoparticles

Nanoparticles of antiferromagnetic $LaFeO_3$ were prepared by the sol-gel method. An exchange bias effect has been observed and is attributed to the exchange coupling between the ferromagnetic shell and antiferromagnetic core of the particles. The results provide clear evidence of the presence of spontaneous exchange bias in this system. After field cooling from room temperature, the exchange bias increases while the coercivity decreases with decreasing temperature. Taking into account the role of thermal activation, the temperature dependence of exchange bias and coercivity has been interpreted in terms of the spontaneous exchange bias mechanism proposed recently.

Hossein Ahmadvand†, Hadi Salamati†, Parviz Kameli†, Asok Poddar, Mehmet Acet†, Khalil Zakeri†

2.2.2.11 Electron spin dynamics in grain-aligned LaCoPO: An itinerant ferromagnet

^{139}La NMR study was performed in grain-aligned ($c^{\rightarrow} \parallel H_0^{\rightarrow}$) sample of LaCoPO and polycrystalline LaFePO. Knight shift is isotropic and temperature independent in LaFePO. It is strongly temperature dependent and anisotropic in LaCoPO. The spin-lattice relaxation rate in LaCoPO clearly reveals the existence of three-dimensional spin fluctuations both in the paramagnetic and ferromagnetic state over and above the dominant two-dimensional spin fluctuations in the paramagnetic state, observed earlier from ^{31}P NMR measurements in the same oriented sample [M. Majumder, K. Ghoshray, A. Ghoshray, B. Bandyopadhyay, B. Pahari, and S. Banerjee, Phys. Rev. B 80, 212402 (2009)]. The spin fluctuation parameters in LaCoPO determined from ^{139}La NMR relaxation and magnetization data, using the self-consistent renormalization theory, are in close agreement and follow the universal Rhodes-Wohlfarth curve.

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

2.2.2.12 Interplay between Co 3d and Ce 4f magnetism in CeCoAsO

We have investigated the ground-state properties of polycrystalline CeCoAsO by means of magnetization, specific heat, and solid-state NMR. Susceptibility and specific-heat measurements suggest a ferromagnetic order at about, T_C=75 K. No further transitions are found down to 0.5 K. At 6.5 K a complex Schottky type of anomaly shows up in the specific-heat results. The interplay

between Ce 4f and Co 3d magnetism being responsible for that anomaly is discussed. Furthermore ^{75}As-NMR investigations have been performed to probe the magnetism on a microscopic scale. As-NMR spectra are analyzed in terms of first and second-order quadrupolar interaction. The anisotropic shift component K_{ab} and K_c could be derived from the $^{As}75$ powder spectra. Towards lower temperature a strong shift anisotropy was found. Nonetheless K_{iso} tracks the bulk susceptibility down to T=50 K very well. Furthermore the presence of weak correlations among the Ce ions in the ferromagnetic state is discussed. The observed increase in C/T towards lower temperatures supports this interpretation.

Rajib Sarkar, Anton Jesche†, Cornelius Krellner†, Michael Baenitz†, Cristoph Geibel†, Chandan Mazumdar, Asok Poddar

2.2.2.13 Magnetism and transport studies in off-stoichiometric metallic perovskite compounds $GdPd_3B_x$ (x=0.25, 0.50 and 0.75)

We report the magnetic and transport properties of the off-stoichiometric metallic perovskite like compounds $GdPd_3B_x$ (x = 0.25, 0.50 and 0.75). Our results show that doping with boron in the lattice of parent binary-compound $GdPd_3$ leads to lattice expansion. Which in turn manifests in contrasting magnetic and transport behaviors of the doped compounds in comparison with the undoped $GdPd_3$. An attempt has been made to compare and correlate the results of magnetic and transport measurements of $GdPd_3B_x$ with that of stoichiometric compositions $GdPd_3B_xC_{1-x}$. The comparative study of $GdPd_3B_x$ and $GdPd_3B_xC_{1-x}$ confirms that there is a strong correlations between the structural, magnetic and transport properties of these compounds.

Abhishek Pandey, Chandan Mazumdar, R Ranganathan

2.2.2.14 Critical behavior in single-crystalline $La_{0.67}Sr_{0.33}CoO_3$

The critical behavior of $La_{0.67}Sr_{0.33}CoO_3$ single crystal has been investigated from the bulk magnetization measurements around the Curie temperature (T_C). The detailed analysis of the magnetization indicates the occurrence of a continuous ferromagnetic to paramagnetic phase transition at 223.0 K. The critical exponents $\beta = 0.361 \pm 0.007, \gamma = 1.31 \pm 0.001, and \delta = 4.64 \pm 0.01$ characterizing this second order phase transition, have been estimated using different techniques such as the Kouvel-Fisher plot, the Arrott-Noaks plot, and critical isotherm analysis. With these values of $T_C, \beta, and \gamma$, one can scale the magnetization below and above T_C following a single equation of state. The consistency in the values of the critical exponents obtained from different methods and the well-obeyed scaling behavior confirm that the calculated exponents are unambiguous and purely intrinsic to the system. These values of the exponents match well with those theoretically predicted for the three-dimensional Heisenberg model with nearest-neighbor interaction.

N Khan†, A Midya†, K Mydeen†, P Mandal, A Loidl†, D Prabhakaran†

2.2.2.15 Spin glasslike behavior and magnetic enhancement in nanosized Ni-Zn ferrite system

The effects of particle size, structure, microstrain, and cation distribution on magnetic property of nanosized $Ni_{0.35}Zn_{0.65}Fe_2O_4$ prepared through high-energy ball milling have been explored by a

wide variety of experimental technique namely, x-ray diffraction, high-resolution transmission electron microscopy, dc magnetization measurement, and Mossbauer spectroscopy. The sample exhibits mixed magnetic behavior with a collective magnetic state between 300 and 60 K while spin glasslike freezing of magnetic moments has taken place below 60 K. The sample has displayed enhancement in magnetization, magnetic hyperfine field, coercivity, and anisotropy energy. The inherent superparamagnetic relaxation of ferrite nanoparticles has significantly reduced and it shows evidence of magnetic hysterisis at room temperature. These properties could be profitably used to overcome the inherent instability of magnetic nanoparticles. The intersublattice interaction (J(AB)) in the sample has strengthened due to migration of $^{F}e^{3+}$ ions from octahedral (B) site to tetrahedral (A) site and this accounts for the genesis of counterintuitive magnetic enhancement in the sample.

B Ghosh, S Kumar, A Poddar, C Mazumdar, S Banerjee, VR Reddy†, A Gupta

2.2.3 Surface Physics Division

2.2.3.1 Significant third-order optical susceptibility of colloidal silver nanoclusters in sapphire

Silver ion implantations in single-crystalline sapphire has given rise to the formation of silver nanoparticle-sapphire composites which have been imaged using transmission electron microscopy, and confirmed using linear optical absorption and Rutherford backscattering spectrometry. Nonlinear refractive index and two-photon absorption of these nanocomposites have been observed using a combination of Z-scan and Anti-Resonant Interferometric Nonlinear Spectroscopy (ARINS) techniques in the close proximity of Surface Plasmon Resonance (SPR) frequency of silver nanoclusters. Both sign and values of the nonlinear parameters have been determined and the thirdorder optical susceptibility (3) of the nanocomposites has been found to be significant. Such metal nanocomposites in glasses and sapphires having appreciable (3) with temporal responses in pico to femto second time domain have great relevance in switching applications in nanophotonics.

Anna Kozakiewicz†, Binita Ghosh, Purushottam Chakraborty, Trevor Derry†, SR Naidoo†, Paul Franklyn†

2.2.3.2 Iron sulphide formation in the ferric stearate Langmuir-Blodgett films

Ferric stearate (FeSt) Langmuir-Blodgett (LB) films have been reacted chemically with H2S gas for making iron sulphide within the organic matrix. Films, before and after the reaction with H2S, have been analyzed with the X-ray reflectivity (XRR), atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS) studies. After sulphidation, more 'pinhole' defects form which changes the film morphology and the number of layers increases due to the rearrangement of the molecules. Formation of less ordered iron sulphide within the stearic acid multilayers after sulphidation increases the interfacial roughness that decreases the reflectivity. XPS analysis shows that polysulphide forms within the microenvironment of the FeSt LB films after reaction with H2S whereas both mono and polysulphide are produced when the reaction occurs with FeSt in bulk.

S Kundu, AKM Maidul Islam, M Mukherjee

2.2.3.3 Alumina-Supported Cu(II), A Versatile and Recyclable Catalyst for Regioselective Ring Opening of Aziridines and Epoxides and Subsequent Cyclization to Functionalized 1,4-Benzoxazines and 1,4-Benzodioxanes

An easily accessible catalyst, alumina-supported copper(II), efficiently catalyzes the ring opening of aziridines and epoxides followed by cyclization of the corresponding intermediate to produce a variety of functionalized 1,4-benzoxazines and 1,4-benzodioxanes, respectively, in one pot without any ligand in high yields. The ring cleavages of aziridines and epoxides are highly regioselective. The catalyst is inexpensive, non-air-sensitive, environmentally friendly, and recyclable. The function of the catalyst and the reaction pathway are postulated. This protocol is successfully utilized for the formation of three carbon-heteroatom bonds, namely, C-O, C-N, and C-S, in one pot.

Sukalyan Bhadra†, Laksmikanta Adak†, Subhas Samanta†, AKM Maidul Islam, Manabendra Mukherjee, Brindaban C Ranu†

2.2.3.4 Polarized neutron reflectivity study of spin vortices formed in Gd-based Langmuir-Blodgett films

Results are reported of a polarized neutron reflectivity (PNR) study of Gd-based Langmuir-Blodgett films in the temperature range of 55 mK to 15 K, representing two-dimensional magnets. A model based on in-plane spin vortices can explain the low-field as well as high-field PNR data. The branching of zero-field-cooled and field-cooled magnetization curves are explained by reconfiguration of the vortex structure. The low-field magnetization data is found to follow a power-law behavior as predicted by the Berezinskii-Kosterlitz-Thouless (BKT) transition for a finite-size system. We have also observed that a field of 15 kOe annihilates vortex-antivortex pairs completely to produce a homogeneous phase with saturation moment $\sim 7\mu_B$ per Gd ion below the BKT transition temperature $\simeq 600mK$.

S Gayen, MK Sanyal, A Sarma, M Wolff†, K Zhernenkov†, H Zabel†

2.2.3.5 Effect of oxygen vacancy and dopant concentration on the magnetic properties of high spin Co_2^+ doped TiO_2 nanoparticles

Co doped TiO_2 nanoparticles have been synthesized by a simple sol-gel route taking 7.5, 9.5 and 10.5 mol% of cobalt concentration. Formation of nanoparticles is confirmed by XRD and TEM. Increase in d-spacing occurs for (0 0 4) and (2 0 0) peak with increase in impurity content. Valence states of Co and its presence in the doped material is confirmed by XPS and EDX. The entire vacuum annealed samples show weak ferromagnetism. Increased magnetization is found for 9.5 mol% but this value again decreases for 10.5 mol% due to antiferromagnetic interactions. A blocking temperature of 37.9 K is obtained, which shows shifting to high temperature as the dopant concentration is increased. The air annealed sample shows only paramagnetic behavior. Temperature dependent magnetic measurements for the air annealed sample shows antiferromagnetic behavior with a Curie-Weiss temperature of - 16 K. Here we report that oxygen vacancy and cobalt aggregates are a key factor for inducing ferromagnetism-superparamagnetism in the vacuum annealed sample. Appearance of negative Curie-Weiss temperature reveals the presence of antiferromagnetic Co_3O_4, which is the oxidation result of metallic Co or cobalt clusters present on the host TiO_2.

B Choudhury†, A Choudhury†, AKM Maidul Islam, P Alagarsamy†, M Mukherjee

2.2.3.6 Characterization of RF Sputter-Deposited Ultra Thin PZT Films and Its Interface With Substrate

Lead Zirconate Titanate [Pb(Zr,Ti)O-3, PZT] thin films have been extensively studied due to their possible applications in ferroelectric and piezoelectric devices. This work deals with the synthesis and characterization of ultra thin PZT films of thickness similar to 100 nm deposited on Si/SiO2/TiO2/Pt(111) by RF Magnetron Sputtering under optimized deposition and post-annealing conditions. Various techniques like XRD, XPS, SIMS, SEM and TEM, have been employed to characterize the film nanostructure and the interface quality in the post-annealed films. Though the XRD results showed the formation of similar to 87 vol% perovskite phase with 111 orientation, the films failed to show good electrical and ferroelectric properties. In XPS study of annealed PZT films, Pb was found to exist in both oxidised and metallic states. Both SIMS depth profiling and STEM-EDX line profile results showed that there is an enrichment of Pb along the PZT/Pt interface. This suggests interdiffusion of the elements in the film during post-annealing. It is concluded that interdiffusion of the chemical species during annealing results in Pb enrichment at the film substrate interface. In addition, the presence of similar to 13% non-ferroelectric pyrochlore phase as well as some amount of Pb species present in metallic state further degrades the film quality.

A Bose, Sandip Bysakh, M Mukherjee, AKM Maidul Islam, AK Balamurugan†, Suchitra Sen†

2.2.3.7 Study of structural evolution during controlled degradation of ultrathin polymer films

The structural aspects of polyacrylamide thin films annealed at degradation threshold temperature have been studied as a function of annealing time using in situ X-ray reflectivity technique in vacuum. We observe significant decrease of thickness and increase of density with annealing time for all the films. The dynamical behavior of the changes was modeled in terms of two distinct exponential decay functions, following our earlier observation of two different time scales for the chemical modification pathways, and was found to be in excellent agreement with the data. The diffusion coefficients of the polymer chains corresponding to the two modes are found to be different by an order of magnitude. It was found that the two dynamical modes correspond to the formation of two degradation products at two different rates. The larger time constants for both the modes in case of thickness reduction compare to the chemical changes was explained in terms of inter-chain entanglement and attachment of the polymer with the substrate.

Mojammel H Mondal, M Mukherjee

2.2.3.8 Hydrophobic to hydrophilic transition of HF-treated Si surface during Langmuir-Blodgett film deposition

HF-treated Si surface, which is hydrophobic in nature and quite stable in air and inside pure water, can become completely hydrophilic during nickel arachidate Langmuir-Blodgett film growth. Such transition is clearly evident from the structures of films deposited by different number of strokes and can be understood by considering partial oxidation of Si surface inside subphase water and further or complete oxidation in air, in presence of Ni head-groups. Attached Ni head-groups weaken the nearby Si-Si covalent bonding and easily oxidize those Si atoms. Depending upon the amount of

those head-groups and its distribution, oxidation or transition can even complete.

JK Bal, S Kundu, S Hazra

2.2.3.9 A Novel Attempt to Calculate the Velocity Correlation Coefficients in Ternary Electrolyte Solution

This work gives estimated values of the velocity correlation coefficients VCCs for ternary electrolyte solutions (the system may have a tracer ion as one of the components), utilizing available measured transport coefficients. The VCCs originate from linear response theory and give a deeper insight into the microdynamic structure of complex ionic solutions. By assuming Onsager's relation to be valid, ten sets of velocity correlation coefficients were calculated for a ternary system and were used to calculate the VCCs for Cs-134(+) ion (present in trace amount) transport in aqueous solutions of CsCl and KCl at 25 (au <)C.

Haimanti Chakrabarti†, Shreekantha Sil†, Srinanda Kundu

2.2.3.10 Effect of ionic environment on the transport of cesium ion in alkali chloride solutions from radio tracer studies

The rate of transport (diffusion) of cesium ion in aqueous solutions of all the alkali metal chlorides together with cesium iodide and cesium fluoride (generalized name MX) at 25 degrees C temperature has been measured by the radioactive tracer technique using ^{134}Cs as tracer, over the 0.0 < concentration > 4 0 M These diffusion data along with other transport data in the literature ale used to calculate the velocity correlation coefficients (VCC) for Cs-M. $Cs - H_2O$ and Cs-X. which actually represent the ensemble average time integrals of the velocity correlation functions of the referred pair of species The concentration dependence of VCC gives a quantitative estimate of the influence of environment and its dynamics on the transport of cation cesium in a highly correlated system like aqueous solutions of 1-1 electrolytes

Haimanti Chakrabarti†, Srinanda Kundu

2.2.3.11 Correlation between local structure and refractive index of e-beam evaporated ($HfO_2 - SiO_2$) composite thin films

In the present work we have reported the results of investigations on local structures of e-beam evaporated ($HfO_2 - SiO_2$) composite thin films by synchrotron based extended x-ray absorption fine structure measurements. It has been observed that for the composite film with 10% SiO_2 content, both Hf-O and Hf-Hf bond lengths are less than their values in pure HfO_2 film. However the bond lengths subsequently increase to higher values as the SiO_2 content in the composite films is increased further. It has also been observed that at the same composition of 10% SiO_2 content, the films have smallest grain sizes (as obtained from atomic force microscopy measurements) and highest refractive index (as obtained from spectroscopic ellipsometry (SE) measurements) which suggests that the e-beam evaporated $HfO_2 - SiO_2$ composite films with 10% SiO_2 content leads

to the most compact amorphous thin film structure.

NC Das, NK Sahoo†, D Bhattacharyya, S Thakur†, NM Kamble†, D Nanda†, S Hazra, JK Bal, JF Lee†, YL Tai†, CA Hsieh†

2.2.3.12 Thermal fragmentation of nano-size clusters on surfaces

Nano-size silver clusters deposited on a silicon surface with a native-oxide layer undergo rapid thermal annealing, and after fast cooling a partial fragmentation into smaller clusters is observed. The observations are explained by a simple model where the behavior of a liquid droplet on a surface is characterized by the surface tension for a free droplet and the surface tension at the interface with the silicon surface. A method is suggested for the determination of the ratio of these parameters. Within the framework of this model cluster fragmentation into several smaller droplets is caused by thermal fluctuations due to droplet oscillations. The model could prove useful for controlling the size of nano-particles on a surface.

PV Kashtanov†, R Hippler†, BM Smirnov†, SR Bhattacharyya

2.2.3.13 Probing Ar ion induced nanocavities/bubbles in silicon by small-angle x-ray scattering

Small-angle x-ray scattering (SAXS) measurements have been performed to investigate the nanocavities/bubbles and the amorphous silicon surrounding the cavities/bubbles generated after high fluence medium-energy (60 keV) Ar ion implantation in single crystalline Si as a function of incidence angle (with respect to the surface normal of the sample). The measurements were carried out using a high flux/high transmission laboratory scale SAXS set up with Mo-K alpha radiation in transmission geometry. The scattering data have been used to calculate the average size (D-ave), number density (d(N)), and volume fraction (V-f) of cavities/bubbles in ion induced amorphous layer of the crystalline Si substrate. The novelty of the SAXS technique applied in the present case lies on its ability to detect ultrafine defect features of size even less than 1 nm, which is otherwise impossible from the transmission electron microscopy measurements usually employed for inert gas ion induced cavities/bubbles in amorphous silicon.

Koppoju Suresh†, M Ohnuma†, Y Oba†, N Kishimoto†, P Das, TK Chini

2.2.3.14 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.

Vijay Bisht†, KP Rajeev†, Sangam Banerjee

2.2.3.15 Bias dependent crossover from variable range hopping to power law characteristics in the resistivity of polymer nanowires

The electronic transport properties of ultra-low doped conducting polymer nanowires exhibit characteristics of a pinned one-dimensional Wigner crystal (1D WC) due to the long range electron-electron interaction at low temperature (<30 K). These wires also show characteristics of three-dimensional variable range hopping (3D VRH) at higher temperature. Here we report a resistivity study of these nanowires as a function of the bias around and above 30 K, to show that a crossover takes place from 3D VRH to power law behavior as the bias voltage or current is increased from a low to a relatively high value. The experimental results for this temperature range show several similarities to the theoretically predicted properties of disordered Luttinger liquid, though at lower temperature the characteristics of the 1D WC are obtained for these nanowires.

Atikur Rahman, Milan K Sanyal

2.2.3.16 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.

SR Haldar, A Nayak, TK Chini, S Bhunia

2.2.3.17 Glassiness in charge dynamics of half-doped manganite: A study on oxygen-deficient charge-ordered $R_{0.5}Ca_{0.5}MnO_{3-\delta}$ (R = Pr, Nd and Sm)

We report signature of glassiness in charge dynamics for oxygen-deficient charge-ordered manganites, $R0.5Ca_{0.5}MnO_{3-\delta}$, where R = Pr, Nd and Sm. Structural investigation reveals strong orthorhombic distortion in the oxygen-deficient specimens. Excellent agreement of the experimental data with the defect model, scaling of the complex dielectric plot as well as critical slowing-down behaviour of the freezing temperature suggest a charge-glass-like state at low temperature. The appearance of charge-glass state is proposed to be a consequence of frozen ionic and defect charges in the lattice triggered by oxygen deficiency in the charge-ordered compounds.

A Karmakar†, S Majumdar†, S Banerjee, S Giri†

2.2.3.18 Photoluminescence studies of Ge/Si core/shell nanocrystals synthesized by ion implantation and annealing

Si/Ge nanocrystals or quantum dots (QDs) embedded in a suitable matrix have attracted considerable attention due to their unique luminescence properties as well as wide potential applications in optoelectronic and non-volatile memory devices. Among the various techniques, ion implantation offers greater flexibility in the QDs formation through the control of process parameters. We have synthesized SiGe surface alloys by implanting 26 keV Si- ions in a Ge (100) wafers at different fluencies from our low energy negative ion implanter. The implanted specimens were treated rapid thermal annealing (RTA) at 7000C for 3 mins in Ar atmosphere. The Pl spectra of the annealed samples were measured at room temperature using He-Cd laser excitation at 325nm. The result shows a band emission peaked around 490nm, which possibly originates from the Ge(core)/Si(shell) QDs. The luminescence intensity was found to increase with increasing Si fluence upto 2 x 1017 ions/cm2 and then decreases with further increase of fluence. GISAX and XRD characterizations of the samples were also carried out using X-ray photons of wavelength, λ=0.1238nm at Indo-Japan beamline (18B) of the Photon factory, KEK, Japan. The results indicate the formation Ge nanoclusters in the annealed samples.

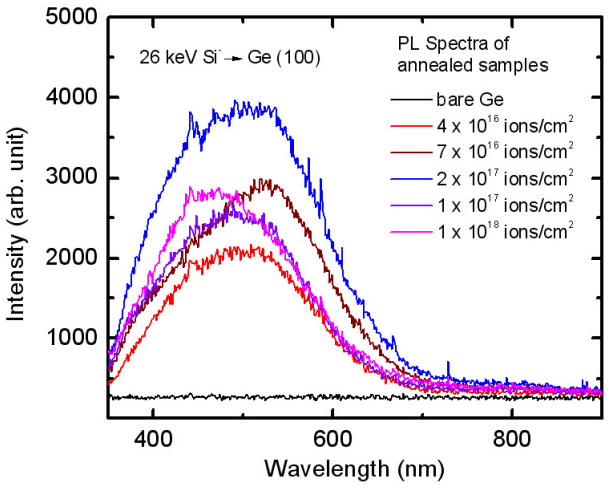


Fig. 1: PL spectra of the annealed Ge (100) samples implanted with 26 Si- ions at different fluencies.

D Ghose, SA Mollick, SR Haldar, SR Bhattacharyya and S Bhunia

2.2.4 Theoretical Condensed Matter Physics Division

2.2.4.1 Effect of fractal disorder on static friction in the Tomlinson model

We propose a modified version of the Tomlinson model for static friction between two chains of beads. We introduce disorder in terms of vacancies in the chain, and distribute the remaining beads in a scale invariant way. For this we utilize a generalized random Cantor set. We relate the static

friction force to the overlap distribution of the chains, and discuss how the distribution of the static friction force depends on the distribution of the remaining beads. For the random Cantor set we find a scaled distribution which is independent on the generation of the set.

Jon Alm Eriksen†, Soumyajyoti Biswas, Bikas K Chakrabarti

2.2.4.2 Opinion formation in kinetic exchange models: Spontaneous symmetry-breaking transition

We propose a minimal multiagent model for the collective dynamics of opinion formation in the society by modifying kinetic exchange dynamics studied in the context of income, money, or wealth distributions in a society. This model has an intriguing spontaneous symmetry-breaking transition to polarized opinion state starting from nonpolarized opinion state. In order to analyze the model, we introduce an iterative map version of the model, which has very similar statistical characteristics. An approximate theoretical analysis of the numerical results is also given, based on the iterative map version.

Mehdi Lallouache†, Anindya S Chakrabarti†, Anirban Chakraborti, Bikas K Chakrabarti

2.2.4.3 Supersolidity for hard-core-bosons coupled to optical phonons

The coexistence of diagonal long-range order (DLRO) and off-diagonal long-range order (ODLRO), manifested in some systems, is still a theoretical enigma. Here, we present a novel microscopic mechanism for supersolidity or the homogeneous coexistence of charge-density-wave state (an example of DLRO) and superfluidity/superconductivity (a realization of ODLRO). We derive an effective d-dimensional Hamiltonian for a system of hard-core-bosons coupled to optical phonons in a lattice. At non-half-fillings, a superfluid/superconductor to a supersolid transition occurs at intermediate boson-phonon couplings, while at strong-couplings the system phase separates. We demonstrate explicitly that the presence of next-nearest-neighbor hopping and nearest-neighbor repulsion leads to supersolidity.

Sanjoy Datta, Sudhakar Yarlagadda

2.2.4.4 Magnetic response in mesoscopic Hubbard rings A mean field study

The present work proposes an Idea to remove the long standing controversy between the calculated and measured current amplitudes carried by a small conducting ring upon the application of an Aharonov-Bohm (AB) flux empty set Within a mean field Hartree-Fock (HF) approximation we numerically calculate persistent current Drude weight low-field magnetic susceptibility and related Issues Our analysis may be inspiring for studying magnetic response in nano-scale loop geometries

Santanu K Maiti

2.2.4.5 Distribution of persistent currents in a multi-arm mesoscopic ring

We propose an idea to investigate persistent current in individual arms of a multi-arm mesoscopic ring. Following a brief description of persistent current in a traditional Aharonov-Bohm (AB) ring, we examine the behavior of persistent currents in separate arms of a three-arm mesoscopic ring. Our analysis may be helpful in studying magnetic response of any complicated quantum network.

Santanu K Maiti, Srilekha Saha, SN Karmakar

2.2.4.6 Electron transport through a quantum interferometer with side-coupled quantum dots: a theoretical study

We study electron transport through a quantum interferometer with side-coupled quantum dots. The interferometer, threaded by a magnetic flux ϕ, is attached symmetrically to two semi-infinite one-dimensional metallic electrodes. The calculations are based on the tight-binding model and the Green's function method, which numerically compute the conductance-energy and current-voltage characteristics. Our results predict that under certain conditions this particular geometry exhibits anti-resonant states. These states are specific to the interferometric nature of the scattering and do not occur in conventional one-dimensional scattering problems of potential barriers. Most importantly we show that, such a simple geometric model can also be used as a classical XOR gate, where the two gate voltages, viz, V-a and V-b, are applied, respectively, in the two dots those are treated as the two inputs of the XOR gate. For $\phi = \phi_0/2\phi_0 = \mathrm{ch/e}$, the elementary flux-quantum), a high output current (1) (in the logical sense) appears if one, and only one, of the inputs to the gate is high (1), while if both inputs are low (0) or both are high (1), a low output current (0) appears. It clearly demonstrates the XOR gate behavior and this aspect may be utilized in designing an electronic logic gate.

Santanu K Maiti

2.2.4.7 Spin transport through a quantum network: Effects of Rashba spin-orbit interaction and Aharonov-Bohm flux

We address spin dependent transport through an array of diamonds in the presence of Rashba spin-orbit (SO) interaction where each diamond plaquette is penetrated by an Aharonov-Bohm (AB) flux ϕ. The diamond chain is attached symmetrically to two semi-infinite one-dimensional nonmagnetic metallic leads. We adopt a single particle tight-binding Hamiltonian to describe the system and study spin transport using Green's function formalism. After presenting an analytical method for the energy dispersion relation of an infinite diamond chain in the presence of Rashba SO interaction, we study numerically the conductance-energy characteristics together with the density of states of a finite sized diamond network. At the typical flux $\phi = \phi_0/2$, a delocalizing effect is observed in the presence of Rashba SO interaction, and, depending on the specific choices of SO interaction strength and AB flux the quantum network can be used as a spin filter. Our analysis may be inspiring in designing spintronic devices.

Moumita Dey, Santanu K Maiti, SN Karmakar

2.2.4.8 Dynamical percolation transition in the Ising model studied using a pulsed magnetic field

We study the dynamical percolation transition of the geometrical clusters in the two-dimensional Ising model when it is subjected to a pulsed field below the critical temperature. The critical exponents are independent of the temperature and pulse width and are different from the (static) percolation transition associated with the thermal transition. For a different model that belongs to the Ising universality class, the exponents are found to be same, confirming that the behavior is a common feature of the Ising class. These observations, along with a universal critical Binder cumulant value, characterize the dynamical percolation of the Ising universality class.

Soumyajyoti Biswas, Anasuya Kundu, Anjan Kumar Chandra

2.2.4.9 Study of the one-dimensional Holstein model with next-nearest-neighbor hopping

We present the effect of next-nearest-neighbor hopping on Holstein polarons. The energy and wavefunction of the ground state and first excited state are obtained by using a conjugate-gradient technique on the variational Hilbert space of the electron-phonon (e-ph) system. We increase the size of the variational space systematically to obtain high accuracy. With the converged wavefunction at our disposal we obtain various physical quantities and correlation functions to get a holistic insight into the physics of e-ph interaction. Our study reveals that the effect of next-nearest-neighbor hopping is most prominent at the physically interesting crossover regime of the e-ph coupling and in the adiabatic regime. We have also performed analytical strong coupling second order perturbation with a Lang-Firsov (LF) phonon basis to account for some features in the strong coupling regime.

Monodeep Chakraborty, AN Das, Atisdipankar Chakrabarti†

2.2.4.10 Two-step condensation of lattice bosons

We present a theoretical study of Bose-Einstein condensation in highly anisotropic harmonic traps The bosons are considered to be moving in an optical lattice in an overall anisotropic harmonic confining potential We find that two-step condensation occurs for lattice bosons at much reduced harmonic potential anisotropy when compared to the case of an ideal Bose gas in an anisotropic harmonic confinement We also show that when the bosons are in an isotropic harmonic confinement but with highly anisotropic hopping in the optical lattice two-step condensation does not occur We interpret some of our results using single boson density of energy states corresponding to the potentials faced by the bosons

R Ramakumar†, AN Das

2.2.4.11 Asymmetric simple exclusion process on a Cayley tree

We study the asymmetric exclusion process on a regular Cayley tree with arbitrary co-ordination number. In this model particles can enter the system only at the parent site and exit from any of the sites at the last level. In the bulk they move downward to one of the unoccupied neighbours

chosen randomly. We show that the steady state current that flows from one level to the next is independent of the exit rate, and increases monotonically with the entry rate and the co-ordination number. Unlike the TASEP, the model has only one phase and the density profile shows no boundary layers.

Mahashweta Basu, PK Mohanty

2.2.4.12 Similarity in transactios of two distinct number networks

The main objective of our study is to disclose if any network structure is hidden among the pairs of numbers obtained by splitting the consecutive integers. By adopting some preferred rule in placing the links among the pairs obtained, we have a transition from a regular to a random one through a small world one. This type of transition is also similar to the network of primes obtained by splitting the consecutive integers which indicates some general feature in both kinds of networks. We also obtained both with some numerical and analytical explanations that support the transition and also the point of transition.

Anjan Kumar Chandra, Jun-Ichi Inoue†

2.2.4.13 Statistics of the Kolkata Paise Restaurant problem

We study the dynamics of a few stochastic learning strategies for the 'Kolkata Paise Restaurant' problem, where N agents choose among N equally priced but differently ranked restaurants every evening, such that each agent tries to get dinner in the best restaurant (with each restaurant serving only one customer and the rest of the customers arriving there going without dinner that evening). We consider the learning strategies to be similar for all the agents, and assume that each follows the same probabilistic or stochastic strategy dependent on information about past successes in the game. We show that some 'naive' strategies lead to much better utilization of services than some relatively 'smarter' strategies. We also show that a service utilization fraction as high as 0.80 can result for a stochastic strategy, where each agent sticks to his past choice (independent of success achieved or not, with probability decreasing inversely in the past crowd size). The numerical results for the utilization fraction of the services in some limiting cases are analytically examined.

Asim Ghosh, Arnab Chatterjee, Manipushpak Mitra, Bikas K Chakrabarti

2.2.4.14 New possibilities for obtaining steeply nonlinear current-voltage characteristics in some semiconductor structures

Electronic processes in a semiconductor system consisting of some resonant tunnelling structures, built in the depletion region of a Schottky barrier, are investigated. It is shown that the Schottky barrier can block of unblock the resonant tunneling current effectively. Tunneling processes do reveal the coherent character. Sharply nonlinear current-voltage characteristics are observed for both the forward and the reverse branches.

DI Sheka†, OV Tretyak†, AM Korol†, AK Sen, A Mookerjee†

2.2.4.15 Electron transport through mesoscopic rings: Evidence of nano-scale rectifiers

We investigate electronic transport through mesoscopic rings and propose how such rings can be used to design nano-scale rectifiers. A single mesoscopic ring is used for half-wave rectification, while full-wave rectification is achieved by means of two such rings, and in both cases each ring is threaded by a time varying Aharonov-Bohm (AB) flux phi which plays a central role in the rectification action. Within a tight-binding framework, all the calculations are done based on the Green's function formalism. We present numerical results for the two-terminal conductance and current which support the general features of half-wave and full-wave rectifications. Our analysis may be inspiring in designing mesoscopic or nano-scale rectifiers.

Santanu K Maiti

2.2.4.16 Berry phase and fidelity susceptibility of the three-qubit Lipkin-Meshkov-Glick ground state

Berry phases and quantum fidelities for interacting spins have attracted considerable attention, particularly in relation to entanglement properties of spin systems and quantum phase transitions. These efforts mainly focus either on spin pairs or the thermodynamic infinite spin limit, while studies of the multi-partite case of a finite number of spins are rare. Here we analyze Berry phases and quantum fidelities of the ground state of a Lipkin-Meshkov-Glick model consisting of three spin-1/2 particles (qubits). We find explicit expressions for the Berry phase and fidelity susceptibility of the full system as well as the mixed-state Berry phase and partial-state fidelity susceptibility of its one-and two-qubit subsystems. We demonstrate a realization of a nontrivial magnetic monopole structure associated with local, coordinated rotations of the three-qubit system around the external magnetic field.

Erik Sjoqvist†, Ramij Rahaman†, Urna Basu, B Basu†

2.2.4.17 Quasi-one dimensional graphite ribbon structures in the presence of a magnetic field and the on-site Coulomb correlation at half-filling

We have presented the role of the Coulomb interaction (U) and the magnetic field ((B) over right arrow) on the ground state properties of the quasi-one dimensional graphite ribbon structures at half-filling. Mean field Hartree-Fock Approximation is used to study the systems. To understand the boundary effects in graphite structures, we have compared the results of these systems with those of the square lattice ribbon structures. Studying the density of states, the Drude weight and the charge gap, we have drawn the U - B phase diagrams for the zigzag and the armchair graphite ribbons.

J Chowdhury, S Sil†, SN Karmakar, B Bhattacharyya

2.2.4.18 Inequality reversal: Effects of the savings propensity and correlated returns

In the last decade, a large body of literature has been developed to explain the universal features of inequality in terms of income and wealth. By now, it is established that the distributions of

income and wealth in various economies show a number of statistical regularities. There are several models to explain such static features of inequality in a unifying framework, and the kinetic exchange models in particular provide one such framework. Here we focus on the dynamic features of inequality. In the process of development and growth, inequality in an economy in terms of income and wealth follows a particular pattern of rising in the initial stage followed by an eventual fall. This inverted U-shaped curve is known as the Kuznets Curve. We examine the possibilities of such behavior of an economy in the context of a generalized kinetic exchange model. It is shown that under some specific conditions, our model economy indeed shows inequality reversal.

Anindya S Chakrabarti†, Bikas K Chakrabarti

2.2.4.19 Two-dimensional random walk in a bounded domain

In a recent letter Ciftci and Cakmak (EPL, 87 (2009) 60003) showed that the two-dimensional random walk in a bounded domain, where walkers which cross the boundary return to a base curve near the origin with deterministic rules, can produce regular patterns. Our numerical calculations suggest that the cumulative probability distribution function of the returning walkers along the base curve is a Devil's staircase, which can be explained from the mapping of these walks to a non-linear stochastic map. The non-trivial probability distribution function (PDF) is a universal feature of CCRW characterized by the fractal dimension d = 1.75(0) of the curve which bounds this distribution.

Mahashweta Basu, PK Mohanty

2.2.4.20 Dynamical properties of two-dimensional biological active matter

Motivated by the unique physical properties of biological active matter, e.g., cytoskeletal dynamics in eukaryotic cells, we set up effective two-dimensional coarse-grained hydrodynamic equations for the dynamics of thin active gels with polar or nematic symmetries. We use the well-known three-dimensional descriptions for thin active-gel samples confined between parallel plates with appropriate boundary conditions to derive the effective 2d constitutive relations between appropriate thermodynamic fluxes and generalised forces for small deviations from equilibrium. We consider three distinct cases, characterised by spatial symmetries and boundary conditions, and show how such considerations dictate the structure of the constitutive relations. We use these to study the linear instabilities, calculate the correlation functions and the diffusion constant of a small tagged particle, and elucidate their dependences on the activity or nonequilibrium drive.

Abhik Basu

2.2.4.21 Multi-terminal quantum transport through a single benzene molecule: Evidence of a molecular transistor

We explore multi-terminal quantum transport through a single benzene molecule attached to metallic electrodes. A simple tight-binding model is used to describe the system and all the calculations are done based on the Green function formalism. With a brief description of two-terminal quantum transport, we present a detailed study of three-terminal transport properties through the benzene

molecule to reveal the actual mechanism of electron transport. Here we address numerical results which describe multi-terminal conductances, reflection probabilities and current-voltage characteristics. Most significantly we observe that, the molecular system where the benzene molecule is attached to three terminals can be operated as a transistor, and we call it a molecular transistor. This aspect can be utilized in designing nano-electronic circuits and our investigation may provide a basic framework to study electron transport in any complicated multi-terminal quantum system.

Santanu K Maiti

2.2.4.22 Quantum Transport in Honeycomb Lattice Ribbons with Zigzag Edges

We explore electron transport properties in honeycomb lattice ribbons with zigzag edges coupled to two semi-infinite one-dimensional metallic electrodes. The calculations are based on the tight-binding model and the Green's function method, which numerically compute the conductance-energy and current-voltage characteristics as functions of the lengths and widths of the ribbons. Our numerical results predict that for such a ribbon an energy gap always appears in the conductance spectrum across the energy E = 0. With the increase of the size of the ribbon, the gap gradually decreases but it never vanishes. This clearly manifests that a honeycomb lattice ribbon with zigzag edges always exhibits the semiconducting behavior, and it becomes much more clearly visible from our presented current-voltage characteristics.

Santanu K Maiti

2.2.4.23 Quantum transport in an array of mesoscopic rings: Effect of interface geometry

Electron transport properties are investigated in an array of mesoscopic rings, where each ring is threaded by a magnetic flux ϕ. The array is attached to two semi-infinite one-dimensional metallic electrodes, namely, source and drain, where the rings are considered either in series or in parallel configuration. A simple tight-binding model is used to describe the system and all the calculations are done based on the Green's function formalism. Here, we present conductance-energy and current-voltage characteristics in terms of ring-to-electrode coupling strength, ring-electrode interface geometry and magnetic flux. Most interestingly it is observed that, typical current amplitude in an array of mesoscopic rings in the series configuration is much larger compared to that in parallel configuration of those rings. This feature is completely different from the classical analogy which may provide an important signature in designing nano-scale electronic devices.

Paramita Dutta, Santanu K Maiti, SN Karmakar

2.2.4.24 Multi-terminal electron transport through single phenalenyl molecule: A theoretical study

We do parametric calculations to elucidate multi-terminal electron transport properties through a molecular system where a single phenalenyl molecule is attached to semi-infinite one-dimensional metallic leads. A formalism based on the Green's function technique is used for the calculations

while the model is described by tight-binding Hamiltonian. We explore the transport properties in terms of conductance, reflection probability as well as current-voltage characteristic. The most significant feature we articulate is that all these characteristics are very sensitive to the locations where the leads are connected and also the molecule-to-lead coupling strengths. The presence of other leads also has a remarkable effect on these transport properties. We study these phenomena for two-, three-and four-terminal molecular systems. Our numerical study may be utilized in designing tailor-made molecular electronic devices.

Paramita Dutta, Santanu K Maiti, SN Karmakar

2.2.4.25 Electron transport through a quantum interferometer: a theoretical study

In the present work, we explore the properties of electron transport through a quantum interferometer attached symmetrically to two one-dimensional semi-infinite metallic electrodes, namely the source and the drain. The interferometer is made up of two sub-rings where individual sub-rings are penetrated by the Aharonov-Bohm (AB) fluxes phi(1) and phi(2), respectively. We adopt a simple tight-binding framework to describe the model, and all the calculations are done based on the single-particle Green's function formalism. Our exact numerical calculations describe two-terminal conductance and current as functions of the interferometer-to-electrode coupling strength, magnetic fluxes threaded by left and right sub-rings of the interferometer and the difference of these two fluxes. Our theoretical results reveal several interesting features of electron transport across the interferometer, and these aspects may be utilized to study electron transport in AB geometries.

Santanu K Maiti

2.3 Developmental Work

2.3.0.1 Developmental Work of AMS Division

The first technical integration of a time domain terahertz spectrometer into the setup of an imaging ellipsometer promises a new quality of understanding on the air/water interface. The basic principle of time-domain THz spectroscopy is based on a sub-picosecond pulse of electromagnetic radiation passes through a sample and gets its time profile changed compared to the one of the reference pulse. Terahertz radiation is interacting with very low frequency phenomena such as rotations in small molecules and soft lattice vibrations in dielectrics. Current applications include collective vibrational modes in biological molecules and detecting the complex conductivity of semiconductor. This instrument has been conceptualized and scientifically supported in its design by Applied Material Science Division.

Smita Mukherjee, Nupur Biswas and Alokmay Datta

2.3.0.2 Clean Room

A 700 sq ft Class 100 and Class 1000 grades Clean Room has been set up for fabrication of small devices with a minimum feature size of 1 micron using the standard Silicon-based VLSI technology

and its characterization.

Supratic Chakraborty, Madhusudan Roy and Alokmay Datta

2.3.0.3 Developmental work on the existing SIMS facility with Secondary Neutral Mass Spectrometry (SNMS) and SIMS/SNMS Imaging

The existing SIMS instrument has been upgraded by incorporating a Hiden MAXIM analyzer system which includes an integral energy filter for ion acceptance at 30o to the probe axis, high transmission SIMS extraction ion optics, triple mass filter, pulse ion counting detector, and control electronics with windows compatible massoft pc software. The analyzer includes a front end - mounted electron-impact ion source that provides for a high-sensitivity secondary neutral mass spectrometry for quantitative analysis of metallurgical thin films, alloys and dielectric materials. The SIMS in combination with the high- sensitivity SNMS will provide much better quantification in sub-parts billion concentration regime. The 3D micro-imaging of the top surfaces and interfaces of the epitaxially grown quantum structures with the new SIMS/SNMS imaging system will now be possible.

Biswajit Saha, Avijit Das and Purushottam Chakraborty

2.4 Publications

2.4.1 Publications in Books/Monographs & Volumes Edited

V Venugopal, P Das, T Basu, S Garg, S Majumdar, SN Sarangi, SR Bhattacharyya, TK Chini and T Som, Evolution of surface topography on GaAs(100) and GaAs(111) at normal and oblique incidence of Ar+-ions, AIP Conf Proc **1276** (2010) 50

R Hippler, SR Bhattacharyya and BM Smirnov, Formation and deposition of nano-size particles on surfaces in Introduction to Complex Plasmas (Springer Series on Atomic, Optical and Plasma Physics, 59, Eds: M Bonitz, N Horing and L Patrick)(2010) 299p

2.4.2 Journal Publication

Applied Material Science

A Bhattacharjee†, D Roy†, M Roy, S Chakraborty, A De†, J Kusz†, W Hofmeister†, Rod-like ferrites obtained through thermal degradation of a molecular ferrimagnet, J Alloys & Compounds **503** (2010) 449

A Bhattacharjee†, H Mandal†, M Roy, J Kusz†, M Zubko†, P Gutlich†, Microstructural and magnetic characterization of dusts from a stone crushing industry in Birbhum, India, J Magn Magn Mater **322** (2010) 3724

Nupur Biswas, Ayesha Rahman†, Alokmay Datta, Arunava Goswami†, Ratan Lal Bramhachary†,

Nanoparticle Surface as Activation Site, Journal of Nanoscience and Nanotechnology **10** (2010) 7083

Experimental Condensed Matter Physics

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Bhabesh Roy [SN Das], Study of the Transport and Magnetic Properties of Some Rare-earth Transition Metal Oxides, Jadavpur University, December 2010

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Sanjib Maji [Indranil Das], Electrical transport in Poly (3,4- Ethylene dioxythiophene), West Bengal University of Technology, 2011

Subhrangsu Mukherjee [Manabendra Mukherjee], Study of neutralization kinetics in polymer and polymer nanocomposite systems using X-ray photoelectron spectroscopy, Jadavpur University, February 2011

2.6 Seminars/Lectures given in Conference/Symposium/Schools

Alokmay Datta

Roughening of Pristine Polyhedral Viral Surface by Nanoparticles: Possible Role of Entropic Forces, 13th International Conference on Organized Molecular Films (LB13), University of Laval, Quebec, Canada, Jul 19-21, 2010

How morphology changes bonding in soft materials, Workshop on New Arena in Photosciences, SINP, August 27, 2010

Nanoscale Aggregation and Self-assembly on Soft Surfaces, International Conference on fundamental & applications of nano science & technology (ICFANT 2010) Jadavpur University, December 9-11, 2010

Why Nano?, National Symposium on Trends in Nanoscience and Related Areas, Behala College, December 9-10, 2010

A different look at Wetting & Dewetting using synchrotron X-rays, International Symposium on Accelerator and Radiation Physics (ISARP-2011), SINP, February 16-18, 2011

R Ranganathan

Advances in magnetism: Phenomena and materials, JNCASR, Bangalore and BARC, Mumbai, Manali, June 3-5, 2010

Comparsion of Anti-perovskite and Pervoskite magnetic materials, International conference on Magnetism and magnetic materials, Saha Institute of Nuclear Physics, Kolkata, October 25-28, 2010

Magnetism of small particles-role of core shell spin model, Indo-Japan JSPS-Asian Academic Seminar, Saha Institute of Nuclear Physics, Kolkata, November 29-December 2, 2010

A need for single unique mechanism of NTE in solids and a comparison with Geometrically frustrated magnet- spin-lattice interaction, International school for Condensed Matter Physics at Infoys, International Center for theoretical studies: ICTS Bangalore campus TIFR, Mysore, Dec 12-18, 2010

Magnetic instrumentation, methods and application, UGC-SAP programme- seminar, Central University of Pondicherry, January 21, 2011

AI Jaman

Millimeterwave spectrum of Methyl Acetylene (Propyne) produced by DC glow discharge and ab initio DFT calculation, Recent trends in research on Atomic, Molecular and Optical (AMO) Physics, IACS, Jadavpur, Kolkata, March 17, 2010

Chandan Mazumdar

Powder diffraction data analysis, Indo-Japan JSPS-Asian Academic Seminar, Saha Institute of Nuclear Physics, Kolkata, November 29-December 2, 2010

Indranil Das

Charge Ordering and Related Phenomena of Manganites on Nano-scales, 12th International Ceramics Congress of CIMTEC 2010, Montecatini Terme, Tuscany, Italy, June 6-11, 2010

Magnetocaloric effect: important cooling technology & powerful tool to understand various phenomena in magnetic materials, International Conference on Magnetic Materials (ICMM-2010), Saha Institute of Nuclear Physics, Kolkata, October 25-29, 2010

Charge ordering in nanocrystalline manganites and its technological importance for magnetic field sensor, National Seminar on Nanotechnology and its applications (NSM 2011), Maharajas College, Ernakilam, Kerala, Feb 1-3, 2011

Samik Dutta Gupta

Magnetotransport and realization of Multiple Memory states in Manganite Heterostructures, International Conference on Magnetic Materials (ICMM-2010), Saha Institute of Nuclear Physics, Kolkata, October 25-29, 2010

Milan K Sanyal

Neutron Reflectivity Study of Vortex Structures formed in Langmuir Blodgett Films, Advances in Magnetism: Phenomena and Materials (AMPM 2010), Ambassador Resorts, Manali, India, June 3-5, 2010

X-ray scattering studies of MBE grown Si-Ge multilayers, Australia-India Workshop on Nanotechnology, The Australian National University, Canberra, June 14-15, 2010

Structural Ordering of Hydrophobic Materials on Water Surface, Satellite Symposium at SXNS11, Chicago, USA, July 13, 2010

Ordering of Nano-structured materials on Water Surface, Laboratoire Interdisciplinaire sur l'Organisation Nanométrique et Supramoléculaire (LIONS), CEA, September 20, 2010

Novel electronic transport properties of polymer nanowires, PEEM Conf in Honor of Dr Yakhmi, BARC, Sept 22, 2010

Electronic transport properties of polymer nanowires, EU-India Workshop, Delhi, Nov 4, 2010

Formation of spin-vortex structures in gadolinium stearate Langmuir-Blodgett films : results of a polarized neutron reflectivity study, International Conference on Magnetic Materials ICMM2010, SINP, Nov 25-29, 2010

Novel physical properties of chemically grown soft nanostructures, JSPS-DST Asian Academic Seminar, SINP, Nov 29, 2010

X-ray reflectivity and diffuse scattering techniques, JSPS-DST SCHOOL, SINP, Dec 2, 2010

Application of Scattering Techniques in Nano-science, Int Symp on Advances in Nanomaterials Meghnad Saha Auditorium, CGCRI, Kolkata, Dec 7, 2010

Ordering of Nano-structured materials on Water Surface, One Day Seminar on Soft Matter Physics, SINP, Dec 22, 2010

Applications of X-rays in Nanomaterials research, 5th DST Advanced School on Nanoscience and Nanotechnology, IISc, Bangalore, Jan 18, 2011

Purushottam Chakraborty

Indian Physical Scociety (IPS) One-Day Seminar on Recent Trends on Atomic, Molecular and Optical Physics, IACS, Kolkata, India, March 17, 2010

International Conference on Metallurgical Coatings and thin Films (ICMCTF), San Diego, California, USA

18th International Conference on Inelastic Ion-surface Collisions (IISC-18), Oak Ridge National laboratory, Tennessee, USA, September 26-October 1, 2010

National Conference on Smart Nanostructure (NCSN 2011), Dept of Physics, Tezpur University, Tezpur, Assam, January 18-20, 2011

India Epitaxy Workshop 2011, delivered at the Centre for Research in Nanoscience and Nanotechnology, Kolkata, February 21, 2011

Winter School on Semiconductor Fabrication and Characterization Techniques (FAB TECH), Inst of Radio Physics & Electronics, University of Calcutta, February 14-March 4, 2011

NCERT Programme for NTS awardees of India, Birla Institute of Technology, Mesra (Ranchi), February 1-5, 2011

Understanding and applications of MCsn+ - SIMS in direct quantification, Materials Department, Imperial College, London, 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, the Physics Department, Vanderbilt University, Nashville, Tennessee, USA, October 4, 2010

Ion beam analysis of low-dimensional structures, Physics Department, Furman University, Greenville - South Carolina, USA, October 5, 2011

Colloidal metal nanoclusters in glasses as photonic materials, Dept of Electrical Engineering, Yale University, New Haven, Connecticut, USA, October 7, 2010

D Ghose

Patterning of solid surfaces by keV ion bombardment, International Conf on Ion-beam Induced Nanopatterning of Materials (IINM-2011), Institute of Physics, Bhubaneswar, Feb 0610, 2011

SR Bhattacharayya

Mixing and interface modifications of gold and nickel thin films by keV energy ions, National Workshop on Science with ECR based keV Ion Beams (VECC and UGC DAE CSR, Kolkata Centre), VECC, Kolkata, January 20-21, 2011

2.7 Honours and Distinctions

Indranil Das

Elected as a Fellow of West Bengal Academy of Science & Technology (WAST)

2.8 Miscellany

Nupur Biswas

Confinement of Polymers at Nano and Micro-scales, Bilateral International Exchange Programme (BIEP) Global Center Of Excellence (GCOE), Kyoto University, 12 January 12, 2011

SA Mollick

Pit formation on the Ge (100) surfaces by Si-ion bombardment, International Conf on Ion-beam Induced Nanopatterning of Materials (IINM-2011), Institute of Physics, Bhubaneswar, Feb 0610, 2011

Samik Dutta Gupta

Magnetotransport and realization of Multiple Memory states in Manganite Heterostructures, In-

ternational Conference on Magnetic Materials (ICMM-2010), Saha Institute of Nuclear Physics, Kolkata, October 25-29, 2010

Alokmay Datta

Discussion Meeting on "Common Themes in Biomaterials and Nanomaterials Sciences, Organized jointly with Biophysics and Structural Genomics Division, SINP, 12 October 2010
One Day Seminar on "Frontiers of Soft Matter Physics, Organized jointly with Surface Physics Division, SINP, 22 December 2010

Sudhakar Yarlagadda

Organizing an International School and Conference on Functional Materials from March 28 to April 1, 2011 at HRI, Allahabad as a joint program of HRI & SINP

Chapter 3

Experimental Nuclear and Particle Physics

3.1 Summary of Research Activities of Divisions

3.1.1 Applied Nuclear Physics

Aim of this Division is to pursue basic and applied research using nuclear tools and techniques to explore structure and dynamics of nuclei, atoms, molecules, materials in bulk and nanoscales. Related development of detectors for various physics experiments and radiation-based imaging are also given due importance. Side by side, novel pathways to simulation of expected performance of such detectors and computerized simulation of vision by drawing analogy with the human eye and its related functionalities are also done. Collaboration with scientists from within the institute, India and abroad, working on several important experiments in the areas of Experimental Nuclear Physics, Neutrino Physics, Dark Matter search, etc. are continued.

Research programmes in nuclear spectroscopic studies using Clover detector array are carried out primarily at the national accelerator facilities, opening up the possibility to do high resolution spectroscopy of the nuclei, which are produced in trace / ultra-trace quantities in heavy ion reactions, and embedded in a high background of fission residues or elastically scattered recoil nuclei.Harnessing the powerful technique of time differential perturbed angular correlation (TDPAC), intermetallic compounds and oxide materials,involving ferromagnetic elements and Hf/Zr as one of the components, the local field gradients were investigated. ^{181}Hf was used as the radioactive probe. Novel material systems like $BiFeO_3$, which is multiferroic in nature andirradiated by alpha particles, were investigated by the positron annihilationspectroscopy. Ti-6Al-4V which is a popular bio-compact material havingexcellent corrosion resistance, was subjected to different kinds of heat-treatments and mechanical deformation and the defect properties were studied. A significant work on graphene was also carried out and theresults are currently being analysed.Positron annihilation spectroscopic study in biological supra molecular structures involving hydrogen bonding has been performed. Also, chemical synthesis of nano-semiconductor crystalline particles has been carried out under the influence of bio-molecular template. The physical characteristics of these have been

studied by various methods like UV-visible, IR spectroscopy and PL studies as also with X-ray diffraction measurements and TEM studies.In the atomic and laser spectroscopy laboratory, life-times of some levels of singly ionized krypton were measured by cascade photon- coincidence (CPC) technique in which electronic bombardment excites a state, which decays by emitting photons of wavelengths occurring in cascades. These results continue to be an important input in simulating the performance of radiation monitoring devices involving noble gases as active medium.

Detailed numerical simulation involving the recently developed combination of codes, such as Garfield, neBEM, Magboltz, and Heed, has been used to simulate the performance of several micropattern detectors. As collaborating partner of the RD51 international collaboration, the neBEM three-dimensional field solver, in particular, has been formulated, coded and maintained by the members of the division. A laboratory for experiments on micro-pattern gas detectors has been set up during this year using infrastructure development fund from the Indo-French project involving collaborators from Saclay, France and funded by CEFIPRA / IFCPAR.

In the area of cognitive science, it has been demonstrated that zero-crossing of images, computed in the early visual stage, exhibits contrast sensitivity enhancement via stochastic resonance in the presence of noise. The enhanced contrast sensitivity attains a peak in the presence of intermediate amount of noise, which is in accordance with the result obtained in a psychophysical experiment with human subjects, performed elsewhere. In another work, related to the gesture based human-computer interaction, subjects were asked to perform various tasks, with a laser pointer, on a screen. Our study showed that though the subjects tend to perform the tasks at their preferred tempo, the velocity profile of all subjects exhibit a task-specific characteristic feature, and these features can be used to distinguish voluntary gestures from involuntary ones.

3.1.2 High Energy Nuclear and Particle Physics

This division is involved in two major experiments at the Large Hadron Collider at CERN. SINP has been involved in the ALICE experiment since 1997. The experiment, focused for studies of minimum bias events in proton-proton and lead-lead collisions, has started taking data since late 2009. The Large Hadron Collider has provided large amount of data during the period between 2010 and 2011. The ALICE group in the institute constructed a part of the forward muon spectrometer which worked satisfactorily during this period. Some collision data are collected with no magnetic field and these data are used to align different components of the spectrometer to the desired accuracy. The high level trigger for muons, also designed by the SINP group, performed with very high efficiency. The data showed evidence of suppression of charged particle production, jet quenching and other features which are some of the signatures of formation of very dense medium in Pb-Pb collisions. The group is actively pursuing phenomenological studies of photon production in quark gluon plasma and heavy fermion in dense and warm plasma. A new group is formed within the institute which applied for participation in the Compact Muon Solenoid (CMS) experiment. Several new faculties from India and abroad joined the institute to make this possible. The group is welcome into the CMS collaboration and the group are given two responsibilities in the offline software group to coordinate activities on simulation and data quality monitoring. Activities have started in setting up hardware activities related to the upgrade of the CMS hadron calorimeter. Members are actively involved in the analysis of collision data for search of excited leptons, evidence of extra dimension through studies of mono-photon events, search for Higgs boson through decays with τ, studies of strong interaction through multi-jet events. During this year CMS published several important papers validating various aspects of the Standard Model. Important results came

out in the observation of ridge structure in two particle correlation for high multiplicity events in proton-proton collision and also in jet quenching and suppression of some of the bottomium states in heavy ion collision.

3.1.3 Nuclear Physics

The research activities of the Nuclear Physics Division are broadly aimed at studying the structure of nuclei in different mass regions and provide an understanding of the nuclear reaction mechanism from spectroscopic data obtained from experiments carried out at the different Accelerator Centres in India and abroad. In addition, the divisional members are actively participating in the setting up of the new facility FRENA for research in Nuclear Astrophysics for which the components of the 3 MV tandem accelerator have already arrived. The members are also pursuing theoretical research, X-ray fluorescence (XRF) spectrometry and various development activities.

The highlights of Accelerator based research in nuclear structure include (i) study of high spin states in ^{35}Cl from the reaction ^{12}C+^{28}Si (E=110 MeV) in the inverse kinematics wherein a sequence of gamma-rays de-exciting very short-lived states was identified as being superdeformed, (ii) study of the evolution of nuclear structure in neutron deficient $^{151-154}$Ho isotopes from single-particle type to collective modes, (iii) investigation of high angular momentum states in ^{141}Nd up to an excitation energy of 9 MeV and spin-parity of 45/2-; (iv) identification of shears bands in ^{111}In from the bahaviour of experimental B(M1) rates as a function of level spin and (v) study of strongly coupled high-K bands in ^{113}Sb and the observation of strongly deformed states in this nucleus. Also the neutron deficient isotopes ^{121}La,^{120}Ba,^{119}Cs,^{118}Xe and ^{114}Te were attempted to be studied following fusion-evaporation reactions. Most of these studies were made at the national accelerator centres using the Indian National Gamma Array. As part of an international collaboration, hadronic matter with enhanced strangeness content was studied in order to understand the interesting behavior of highly excited strange hadronic matter, formation of multi-strange nuclei in relativistic ion-ion collisions and the existence and stability of exotic hypernuclear states near and beyond the normal drip lines. Information on the structure of the unbound nuclei ^{9}He and ^{10}He and the three-body correlations in the decay of ^{10}He and ^{13}Li have been obtained using relativistic proton beams at the ALADIN-LAND setup at GSI. Also, the study of neutron rich exotic nuclei around the N 20 Island of Inversion was undertaken following the fragmentation of ^{40}Ar pulsed beam (at 531 MeV/u) on Be and their subsequent interaction with a secondary target.

In the study of nuclear reaction mechanisms, systematic continuum discretized coupled channel (CDCC) calculations were performed to investigate the effect of breakup on elastic scattering and fusion excitation function of ^{6}Li+^{28}Si system. A systematic measurement of complete and incomplete fusion cross sections for the systems ^{6,7}Li+^{159}Tb and ^{10,11}B+^{159}Tb, at energies around the respective Coulomb barriers were done to investigate the effect of breakup of weakly bound systems on the fusion mechanism. Besides, measurement of the inclusive -yield for the reaction ^{6}Li+^{159}Tb was also studied. It is seen that apart from complete fusion, d-transfer and n-transfer are the major contributors to the observed large inclusive α-yield at near-barrier energies. The astrophysically important reaction $^{12}C(\alpha,\gamma)$ was studied using indirect method using the $^{12}C(^{7}Li,t) and ^{12}C(^{6}Li,d)$ transfer reactions respectively at above barrier energies in order to determine the reduced alpha widths of the 6.92 (2^+) and 7.12 MeV (1^-) states of ^{16}O. The reduced alpha width or the Asymptotic Normalization Constant (ANC) of these states are related to the astrophysical S-factor for the $^{12}C(\alpha,\gamma)$ reaction. The alpha cluster states of ^{212}Po have also been studied from the elastic scattering angular distribution and excitations function studies of the reaction α+^{208}Pb.

Implanted targets of ^{14}N in Ta were prepared using the ECR ion-source at TIFR and characterized using XPS, EDX and Raman Scattering. These studies revealed the presence of low Z impurities like carbon and oxygen. The energy resolution and the detection efficiency of a silicon PIN diode detector were studied to test if such detectors can be used as complementary detectors to LEPS in gamma-ray spectroscopy.

Energy dispersive X-ray fluorescence (EDXRF) and Electron probe X-ray microanalysis (EPMA) studies of soil samples contaminated by municipal solid waste showed elevated levels of Cu, Zn, and Pb in the top-soil far exceeding the ecological screening limits for soil.

Theoretical calculations were carried out within the framework of the particle-rotor model in order to understand the underlying systematic of the even-even Cd isotopes and the superdeformed (SD) band in ^{35}Cl. This SD band was also studied using large-scale shell model calculations to identify the microscopic origin of these states. Also, the experimental data on the decay of the 8 isomer in ^{136}Cs, carried out at ISOLDE, CERN were attempted to be interpreted theoretically using shell-model calculations. In addition, the nuclear potential dependence of the ANC on the incident energies was investigated for the transfer reaction $^{12}C(^{6}Li, d)^{16}O$ at near barrier energies.

A gas scintillation proportional counter, developed earlier in the division, has been tested in the ionization mode with Xenon as the working gas. The electron response of the Multi-strip Multi-gap Resistive Plate Chamber (MMRPC), developed at SINP, was studied using the single electron pulsed beam at ELBE, HZR-Rossendorf, Germany. A time resolution of 69.1±1.3 ps was measured.

3.2 Research Activities

3.2.1 Applied Nuclear Physics Division

3.2.1.1 Realistic three dimensional simulation on the performance of micromegas

The recently developed Garfield+neBEM combination has been used here to simulate the performance of the micromegas detectors with realistic dimensions. The variation of the electric field due to a change in the cross-section of the mesh opening and other physical dimensions of the detector has been investigated in details. Other three dimensional effects such as the effects of proximity of hole edge, or the end of the detector itself, have been studied. Finally, we have compared our estimations with other available numerical and experimental results.

Purba Bhattacharya, Supratik Mukhopadhyay, Nayana Majumdar, Sudeb Bhattacharya

3.2.1.2 Study on Soluble Polyaniline by Positron Annihilation Technique

The solubility, electrical conductivity, and other properties of polyaniline (PANI) are highly dependent on its oxidation state. In this work, polyaniline (PANI1) prepared by peroxodisulphate induced polymerization of aniline in acidic aqueous medium in presence of benzenediazonium chloride salt was found to exist in lower oxidation state than emeraldine form of PANI and was highly soluble in common organic solvents. This polymer was subjected to positron annihilation spectroscopic study to investigate the correlation between the oxidation state of the polymer and defect sites generated by different degrees of protonation that in turn affect its electrical conductivity. The

positron annihilation lifetime data were resolved to yield a three-component fit for PANI1 subjected to different levels of protonation. The variation of positron annihilation parameters (tau(1), I-2) and Doppler broadening parameters (R, S) as a function of protonation level of the polymer indicate the dopant sites increase initially on protonation and reach a saturation value after a certain level of acidification. The lower value of electrical conductivity and the intensity of intermediate lifetime component (I-2) for PANI1 compared to PANI in emeraldine oxidation state indicate the presence of lesser number of quinoid-imine moieties that could undergo protonation and thus yield highly enriched trapping centers.

Ananya Dan, PK Sengupta, Bichitra N Ganguly

3.2.1.3 Fluctuations of H_2O molecule in crystalline HfF_4 center dot $3H_2O$

Fluctuations of H_2O molecules in the crystallized sample HfF4 center dot $3H_2O$ have been studied in the temperature range 298-363 K by perturbed angular correlation (PAC) technique. In this crystal, apart from static components, time dependent relaxed component has been observed at these temperatures. The relaxation constants are found to increase with temperature up to 353 K following the Arrehenius equation and then decreases at 363 K where a chemical transformation in the sample has been observed. The time dependent relaxed component has been attributed to the fluctuation of H_2O molecule in HfF_4 center dot $3H_2O$. From the measured relaxation constants at different temperatures, activation energy for the H_2O molecule has been found to be 0.15(1) eV.

CC Dey

3.2.1.4 Experimental lifetimes of some levels belonging to the 4p (4)5p configuration of KrII using the cascade-photon-coincidence technique

Lifetimes of three levels belonging to the 4p (4)5p configuration of singly ionized krypton have been measured using the cascade-photon-coincidence technique. The measurements have been performed under experimental condition where pressure dependent effect as well as other systematic errors are very small. The results have been compared with other experimental and theoretical values.

S Karmakar, MB Das

3.2.1.5 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 ($\rho \sim 10^{(10} - 10^{12}\Omega cm$), 2 mm thick matt finished bakelite paper laminates with silicone coating on the inner surfaces, has been measured. The time resolution for all the modules has been found to be $\sim_{2ns}$ at the plateau region.

S Biswas, S Bhattacharya, S Bose, S Chattopadhyay, S Saha, YP Viyogi†

3.2.1.6 Characterization and calibration of a SSNTD for heavy-ion detection and strangelet search in cosmic rays

A commercially available grade of polymer was investigated for its suitability as a solid state nuclear track detector (SSNTD) to look for rare events in cosmic rays at very high mountain altitudes. It was identified to be polyethylene terephthalate (PET) and found to have a higher detection threshold compared to many other widely used SSNTDs. Hence it is particularly suited for rare event search in cosmic rays by eliminating the dominant low Z background. Systematic studies were carried out to determine the ideal etching condition. Also the charge response of PET was studied using various ion beams from accelerators. The results of such studies were combined to obtain the calibration curve for PET as SSNTD, by which one can identify and characterize charged particles.

D Bhowmik, S Dey, A Maulik†, Sibaji Raha†, S Saha, Swapan K Saha†, D Syam†

3.2.1.7 Positron annihilation lifetime and Doppler broadening study in 50 MeV Li^{3+} ion irradiated polystyrene films

Swift heavy ion (SHI) irradiation of polymeric materials results in the change of their free volume properties which have strong correlation with their macroscopic properties. The modification depends on the polymer and ion beam parameters, namely ion energy, fluence and ion species. Polystyrene films were irradiated with Li^{3+} ions of energy 50 MeV from 15 UD Pelletron accelerators at Inter University Accelerator Centre (IUAC). New Delhi, India to the fluences of 10^{11}, 10^{12} and 10^{13} ions/cm^2. Nanosized free volume parameters in the polymer have been studied by positron annihilation lifetime spectroscopy (PALS) and Doppler broadening spectroscopy (DBS). From o-Ps lifetime τ_3. free volume hole radius, mean free volume of microvoids and fractional free volume are computed and modification in free volume with the fluence is studied. Free volume parameters change slowly with ion fluence with a decrease at the highest fluence of 10^{13} ions/cm^2. The decrease in $\tau_3 and I_3$ (reflecting the number of free volume holes) may be interpreted on the process of cross-linking. S parameter obtained from DBS measurements showed a minor decrease with increasing fluence.

S Asad Ali†, Rajesh Kumar†, PMG Nambissan, F Singh†, Rajendra†Prasad

3.2.1.8 Experimental facilities for MPGD characterization

In order to carry out experiments related to the physics issues of Micro-Pattern Gaseous Detectors (MPGDs) and their characterization, a laboratory with necessary infrastructural facilities is under development. The gas handling system with a mixing unit for four gas components, installed last year, has been upgraded by adding proper purifying filters. A bulk Micromegas has been tested with a radioactive source (Am241) in a Time Project ion Chamber (TPC) filled with 95% Argon and 5% Isobutane gas mixture. Several other test boxes have been des igned and fabricated in SINP Workshop to facilitate the testing of the existing Micromegas and other MPGDs. We have participated in an experiment at CERN for testing of Triple GEM prototype to characterize it as a candid ate for future upgrade of CMS forward muon detector at high rapidity zone. We have also taken part in the inve stigation of the characteristics of Thick GEM detector and the effect of resistive anode on its response using compact readout electronics, namely Scalable Readout System

(SRS), designed by RD51 Collaboration.

Sudeb Bhattacharya, Purba Bhattacharya, Pradipta Das, Nayana Majumdar, Supratik Mukhopadhyay, Archana Sharma†, Joao Veloso†

3.2.1.9 Centre surround model for simulating the enhancement of contrast sensitivity through stochastic resonance

A biologically plausible model of retinal ganglion cell is proposed and its role in enhancing visual perceptio n through stochastic resonance is investigated. The human retinal network consists mainly of three layers of c ells, a two-dimensional array of primary photoreceptors, a layer of bipolar cells and a layer of ganglion cells. The image is extracted in successive layers through a centre-surround effect. This antagonistic center- surround effect is generally modeled by difference of Gaussians (DoG). Taking inputs from the proposition of Ernst Mach who predicted a function that is a combination of the original intensity and its rotationally symme tric second derivative, we proposed a computational model as. This also supports the recent physiological find ing of the existence of narrow foveal channels corresponding to midget ganglion cells. We demonstrate the abil ity of this centre surround model for simulating the enhancement of contrast sensitivity through stochastic re sonance observed in many psychophysical experiments. We also show that this model could be used to simulate th e contrast sensitivity function through stochastic resonance. The quality of the fit of measured contrast sens itivity function to the simulated data is very good.

Sandip Sarkar, Subhajit Karmakar, Ajanta Kundu

3.2.1.10 Ni-substitution induced inversion in $ZnFe_2O_4$ seen by positron annihilation

Positron lifetimes were measured in normal spinel structured $ZnFe_2O_4$ after successive substitution of Zn by Ni. It is known that $NiFe_2O_4$ has an inverse spinel structure. This essentially meant that the replacement of Zn by Ni should induce a transformation from the normal to inverse spinel structure. The sensitivity of positrons to structural inversion in spinel solids due to reduction of temperature or particle size has been verified in earlier studies. In this work, this sensitivity came handy to monitor the structural transformation due to cation substitution. In the normal spinel structure, as in $ZnFe_2O_4$, the Zn^+ ions occupy the A-sites (tetrahedral) and the Fe^{3+} ions the B-sites (octahedral), In the inverse spinel structure such as that of $NiFe_2O_4$, half of the Fe^{3+} ions are at the A-sites in exchange of the Ni^{2+} ions which are transported to the B-sites. Earlier measurements have indicated larger positron lifetimes in $NiFe_2O_4$ than in $ZnFe_2O_4$. The drastic variation across $[Ni^{2+}] = 0.4$ 0.6 shown in the figure below can be thus attributed to the said transformation. The reason for the exchange of positions of the cations is related to site stabilization energies whereas the positron trapping defects are the result of some sites being unoccupied by the cations during the interchange of sites. Fig.1: Positron lifetimes τ_1 and τ_2 versus Ni ion concentration (x) in $Zn1 - xNi_xFe_2O_4$.

PMG Nambissan

3.2.2 High Energy Nuclear & Particle Physics Division

3.2.2.1 Evidence of quasifission in the $^{16}O + ^{238}U$ reaction at sub-barrier energies

Mass distribution of fission fragments and neutron multiplicity in the$^{16}O + ^{238}U$ reaction were measured at near-and below-barrier energies. A sudden change in the fragment mass width, observed in the present measurement, confirmed the transition to quasifission at below-barrier energies; the same was indicated earlier from the study of fission fragment angular anisotropy. However, the present measurement of prescission neutron multiplicity as well as the earlier measurement of evaporation residue yield did not indicate any significant departure from the respective statistical model predictions throughout the energy range. It is argued that the first two probes are more sensitive for highly asymmetric systems, whereas all probes would be useful and complimentary to each other for study of quasifission in more symmetric systems, where quasifission is more dominant.

K Banerjee, TK Ghosh, S Bhattacharya, C Bhattacharya, S Kundu, TK Rana†, G Mukherjee, JK Meena†, J Sadhukhan†, S Pal, P Bhattacharya, KS Golda†, P Sugathan†, RP Singh†

3.2.2.2 High voltage characteristic of large area cathode pad chambers for muon spectrometer of ALICE

Large area Cathode Pad Chambers (CPC) with inner and outer radii of 23.7 cm and 117 cm respectively have been fabricated and tested for 2nd Tracking station of Muon Spectrometer of ALICE. The active area of this detector has a radiation length of less than 2 % and the frames are fabricated with Peek GF-30. The anode wire plane consists of 474 anode wires of which 53 % have lengths greater than 1 meter. The separation between the wire plane and the grounded cathode plane is 2.5 mm. The high voltage behaviour of the chamber have been tested under two situations. With no support below the wires to reduce sagging of long wires. With a G10 strip-support whose dimension is 950 mm x 2 mm x 2.4 mm. The High Voltage (HV) tests show that a better stability is achieved when the strip support is implemented. Therefore this solution has been adopted for operation in ALICE.

M Danish Azmi†, S Bose, S Chattopadhyay, D Das, I Das, M Irfan†, S Das, IA Khan†, S Pal, L Das, BC Sinha, T Sinha

3.2.2.3 Suppression of charged particle production at large transverse momentum in central Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV

Inclusive transverse momentum spectra of primary charged particles in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV have been measured by the ALICE Collaboration at the LHC. The data are presented for central and peripheral collisions, corresponding to 0-5% and 70-80% of the hadronic Pb-Pb cross section. The measured charged particle spectra in $|\eta|$<0.8 and$0.3 < p_T < 20$ GeV/c are compared to the expectation in pp collisions at the same $\sqrt{s_{NN}}$, scaled by the number of underlying nucleon-nucleon collisions. The comparison is expressed in terms of the nuclear modification factor R_{AA}. The result indicates only weak medium effects ($R_{AA} \approx 0.7$) in peripheral collisions. In central collisions, R_{AA} reaches a minimum of about 0.14 at p_T = 6-7 GeV/c and increases significantly at larger p_T. The measured suppression of high-p_T particles is stronger than that observed at lower collision energies, indicating that a very dense medium is formed in central Pb-Pb collisions at the

LHC.

ALICE Collaboration

3.2.2.4 Charged-Particle Multiplicity Density at Midrapidity in Central Pb-Pb Collisions at $\sqrt{s_{NN}}$=2.76 TeV

The first measurement of the charged-particle multiplicity density at midrapidity in Pb-Pb collisions at a center-of-mass energy per nucleon pair $\sqrt{s_{NN}}$= 2.76 TeV is presented. For an event sample corresponding to the most central 5% of the hadronic cross section, the pseudorapidity density of primary charged particles at midrapidity is 1584±4(stat)±76(syst), which corresponds to 8.3±0.4(syst) per participating nucleon pair. This represents an increase of about a factor 1.9 relative to pp collisions at similar collision energies, and about a factor 2.2 to central Au-Au collisions at $\sqrt{s_{NN}}$= 0.2 TeV. This measurement provides the first experimental constraint for models of nucleus-nucleus collisions at LHC energies.

ALICE Collaboration

3.2.2.5 Elliptic Flow of Charged Particles in Pb-Pb Collisions at $\sqrt{s_{NN}}$=2.76 TeV

We report the first measurement of charged particle elliptic flow in Pb-Pb collisions at $\sqrt{s_{NN}}$ p = 2.76 TeV with the ALICE detector at the CERN Large Hadron Collider. The measurement is performed in the central pseudorapidity region ($vert\eta| < 0.8$) and transverse momentum range 0.2< p_t < 5.0 GeV/c. The elliptic flow signal v_2, measured using the 4-particle correlation method, averaged over transverse momentum and pseudorapidity is 0.087±0.002(stat)±0.003(syst) in the 40%-50% centrality class. The differential elliptic flow $v_2(p_t)$ reaches a maximum of 0.2 near p_t=3 GeV/c. Compared to RHIC Au-Au collisions at root s(NN) = 200 GeV, the elliptic flow increases by about 30%. Some hydrodynamic model predictions which include viscous corrections are in agreement with the observed increase.

ALICE Collaboration

3.2.2.6 Centrality Dependence of the Charged-Particle Multiplicity Density at Midrapidity in Pb-Pb Collisions at $\sqrt{s_{NN}}$=2.76 TeV

The centrality dependence of the charged-particle multiplicity density at midrapidity in Pb-Pb collisions at$\sqrt{s_{NN}}$= 2:76 TeV is presented. The charged-particle density normalized per participating nucleon pair increases by about a factor of 2 from peripheral (70%-80%) to central (0%-5%) collisions. The centrality dependence is found to be similar to that observed at lower collision energies. The data are compared with models based on different mechanisms for particle production in nuclear collisions.

ALICE Collaboration

3.2.2.7 Possibility of antimagnetic rotation in odd-A Cd isotopes

The classical particle-plus-rotor model for antimagnetic rotation (AMR) is used to investigate the possibility of observing AMR in the high-spin levels of $^{105,107,109}Cd$. The calculated $I\omega$ plot and B(E2) values are compared with the available experimental data.

Santosh Roy, S Chattopadhyay

3.2.2.8 Two-pion Bose-Einstein correlations in central Pb-Pb collisions at $\sqrt{S_{NN}}$=2.76 TeV

The first measurement of two-pion Bose-Einstein correlations in central Pb-Pb collisions at $\sqrt{S_{NN}}$= 2.76 TeV at the Large Hadron Collider is presented. We observe a growing trend with energy now not only for the longitudinal and the outward but also for the sideward pion source radius. The pion homogeneity volume and the decoupling time are significantly larger than those measured at RHIC.

ALICE Collaboration

3.2.2.9 Photons from jet - plasma interaction in collisional energy loss scenario

We calculate photons from jet plasma interaction in a collisional energy loss scenario. It is shown that the Phenix photon data is well reproduced when photons from initial hard collisions are taken into account.

Lusaka Bhattacharya, Pradip K Roy

3.2.2.10 Photons from jet-plasma interaction in relativistic heavy ion col lisions

We expose the role of collisional energy loss on high p (T) photon data measured by PHENIX collaboration by calculating photon yield in jet-plasma interaction. The phase-space distribution of the participating jet is dynamically evolved by solving Fokker-Planck equation. It is shown that the data are reasonably well re produced when contributions from all the relevant sources are taken into account. Predictions at higher beam energies relevant for LHC experiment have been made.

Lusaka Bhattacharya, Pradip Roy

3.2.2.11 Alidaggnment of the ALICE Inner Tracking System with cosmic-ray tracks

ALICE (A Large Ion Collider Experiment) is the LHC (Large Hadron Collider) experiment devoted to investigating the strongly interacting matter created in nucleus-nucleus collisions at the LHC energies. The ALICE ITS, Inner Tracking System, consists of six cylindrical layers of silicon detectors with three different technologies; in the outward direction: two layers of pixel detectors, two layers each of drift, and strip detectors. The number of parameters to be determined in the spatial alignment of the 2198 sensor modules of the ITS is about 13,000. The target alignment precision is well below 10 μ m in some cases (pixels). The sources of alignment information include survey

measurements, and the reconstructed tracks from cosmic rays and from proton-proton collisions. The main track-based alignment method uses the Millepede global approach. An iterative local method was developed and used as well. We present the results obtained for the ITS alignment using about 10(5) charged tracks from cosmic rays that have been collected during summer 2008, with the ALICE solenoidal magnet switched off.

ALICE Collaboration

3.2.2.12 Jet-conversion photons from an anisotropic quark-gluon plasma

We calculate the p_T distributions of jet-conversion photons from a quark-gluon plasma with pre-equilibrium momentum-space anisotropy. A phenomenological model has been used for the time evolution of the hard momentum scale $p_{hard}(\tau)$ and anisotropy parameter $\xi(\tau)$. As a result of pre-equilibrium momentum-space anisotropy, we find significant modification of the jet-conversion photon p_T distribution. For example, with fixed initial condition pre-equilibrium anisotropy, we predict a significant enhancement of the jet-photon p_T distribution in the entire region, whereas for pre-equilibrium anisotropy with fixed final multiplicity (FFM), suppression of the jet-conversion photon p_T distribution is observed. The results with FFM (as it is the most realistic situation) have been compared with high p_T PHENIX photon data. It is found that the data are reproduced well if the isotropization time lies within 1.5 fm/c.

Lusaka Bhattacharya, Pradip Roy

3.2.2.13 Two-pion Bose-Einstein correlations in pp collisions at $\sqrt{s}$=900 GeV

We report on the measurement of two-pion correlation functions from pp collisions at $\sqrt{s}$=900 GeV performed by the ALICE experiment at the Large Hadron Collider. Our analysis shows an increase of the Hanbury Brown-Twiss radius with increasing event multiplicity, in line with other measurements done in particle- and nuclear collisions. Conversely, the strong decrease of the radius with increasing transverse momentum, as observed at the Relativistic Heavy Ion Collider and at Tevatron, is not manifest in our data.

ALICE Collaboration

3.2.2.14 Energy and momentum relaxation of heavy fermion in dense and warm plasma

We determine the drag and the momentum diffusion coefficients of heavy fermion in dense plasma. It is seen that in degenerate matter the drag coefficient at the leading order mediated by the transverse photon is proportional to $(E-\mu)^2$ while for the longitudinal exchange this goes as $(E-\mu)^3$. We also calculate the longitudinal diffusion coefficient to obtain the Einstein relation in a relativistic degenerate plasma. Finally, finite temperature corrections are included both for the drag and the diffusion coefficients.

Sreemoyee Sarkar, Abhee K Dutt-Mazumder

3.2.2.15 Transverse momentum spectra of charged particles in proton-proton collisions at $\sqrt{s}$=900 GeV with ALICE at the LHC

The inclusive charged particle transverse momentum distribution is measured in proton-proton collisions at $\sqrt{s}$=900 GeV at the LHC using the ALICE detector. The measurement is performed in the central pseudorapidity region ($|\eta| < 0.8$) over the transverse momentum range $0.15 < p_T < 10 GeV/c$. The correlation between transverse momentum and particle multiplicity is also studied. Results are presented for inelastic (INEL) and non-single-diffractive (NSD) events. The average transverse momentum for $|\eta| < 0.8$ is $< p_T >_{INEL} = 0.483 \pm 0.001$ (stat.) $\pm$ 0.007 (syst.) GeV/c and $< p_T >_{NSD}$=0.489 $\pm$ 0.001 (stat.)$\pm$ 0.007 (syst.) GeV/c, respectively. The data exhibit a slightly larger $< p_T >$ than measurements in wider pseudorapidity intervals. The results are compared to simulations with the Monte Carlo event generators PYTHIA and PHOJET.

ALICE Collaboration

3.2.2.16 Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s}$=0.9 and 2.36 TeV with ALICE at LHC

Charged-particle production was studied in proton-proton collisions collected at the LHC with the ALICE detector at centre-of-mass energies 0.9 TeV and 2.36 TeV in the pseudorapidity range $|\eta|$ ¡1.4. In the central region ($|\eta| < 0.5$), at 0.9 TeV, we measure charged-particle pseudorapidity density $dN_{ch}/d\eta = 3.02 \pm 0.01(stat.)^{+0.08}_{-0.05}(syst\cdot$ for inelastic interactions, and $dN_{ch}/d\eta = 3.58 \pm 0.01(stat.)^{+0.12}_{-0.12}(syst.)$ for non-single-diffractive interactions. At 2.36 TeV, we find $dN_{ch}/d\eta = 3.77 \pm 0.01(stat.)^{+0.25}_{-0.12}(syst.)$ for inelastic, and $dN_{ch}/d\eta = 4.43 \pm 0.01(stat.)^{+0.17}_{-0.12}(syst.)$ for non-single-diffractive collisions. The relative increase in charged-particle multiplicity from the lower to higher energy is $24.7\% \pm 0.5\%(stat.)^{+5.7}_{-2.8}\%(syst.)$ for inelastic and $23.7\% \pm 0.5\%(stat.)^{+4.6}_{-1.1}\%$(syst.) for non-single-diffractive interactions. This increase is consistent with that reported by the CMS collaboration for non-single-diffractive events and larger than that found by a number of commonly used models. The multiplicity distribution was measured in different pseudorapidity intervals and studied in terms of KNO variables at both energies. The results are compared to proton-antiproton data and to model predictions.

ALICE Collaboration

3.2.2.17 Band crossing in a shears band of ^{108}Cd

The level lifetimes have been measured for a shears band of ^{108}Cd that exhibits band crossing. The observed level energies and B(M1) rates have been successfully described by a semiclassical geometric model based on shear mechanism. In this geometric model, the band crossing in the shears band has been described as the reopening of the angle between the blades of a shear.

Santosh Roy, Pradip Datta†, S Pal, S Chattopadhyay, S Bhattacharya, A Goswami, HC Jain†, PK Joshi†, RK Bhowmik†, R Kumar†, S Muralithar†, RP Singh, N Madhavan†, PV Madhusudhana Rao†

3.2.2.18 Rapidity distribution of photons from an anisotropic quark-gluon plasma

We calculate rapidity distribution of photons due to Compton and annihilation processes from quark gluon plasma with pre-equilibrium momentum-space anisotropy. We also include contributions from hadronic matter with late-stage transverse expansion. A phenomenological model has been used for the time evolution of hard momentum scale, $p_{hard}(\tau)$, and anisotropy parameter, $\xi(\tau)$. As a result of pre-equilibrium momentum-space anisotropy, we find significant modification of photons rapidity distribution. For example, with the fixed initial condition (FIC) free-streaming ($\delta = 2$) interpolating model we observe significant enhancement of photon rapidity distribution at fixed p_T, where as for FIC collisionally broadened ($\delta = 2/3$) interpolating model the yield increases till $y \sim 1$. Beyond that suppression is observed. With fixed final multiplicity (FFM) free-streaming interpolating model we predict enhancement of photon yield which is less than the case of FIC. Suppression is always observed for FFM collisionally broadened interpolating model.

Lusaka Bhattacharya, Pradip Roy

3.2.2.19 Symmetric and anti-symmetric Landau parameters and magnetic properties of dense quark matter

We calculate the dimensionless Fermi liquid parameters (FLPs), $F_{0,1}^{sym}$ and $F_{0,1}^{asym}$ for spin asymmetric dense quark matter. In general, the FLPs are infrared divergent due to the exchange of massless gluons. To remove such divergences, the hard density loop (HDL) corrected gluon propagator is used. The FLPs so determined are then invoked to calculate magnetic properties such as magnetization $<Mtextgtr$ and magnetic susceptibility χ_M of spin polarized quark matter. Finally, we investigate the possibility of magnetic instability by studying the density dependence of $<Mtextgtr$ and χ_M.

Kausik Pal, Abhee K Dutt-Mazumder

3.2.2.20 $\pi - \eta$ mixing and charge symmetry violating NN potential in matter

We construct density-dependent class III charge symmetry violating (CSV) potential caused by the mixing of pi-eta mesons with off-shell corrections. The density dependence enters through the nonvanishing $\pi - \eta$ mixing driven by both the neutron-proton mass difference and their asymmetric density distribution. The contribution of density-dependent mixing to the CSV potential is found to be appreciably larger than that of the vacuum part.

Subhrajyoti Biswas, Pradip Roy, Abhee K Dutt-Mazumder

3.2.2.21 Midrapidity Antiproton-to-Proton Ratio in pp Collisons $\sqrt{s} = 0.9$ and 7 TeV Measured by the ALICE Experiment

The ratio of the yields of antiprotons to protons in pp collisions has been measured by the ALICE experiment at $\sqrt{s} = 0.9$ and 7 TeV during the initial running periods of the Large Hadron Collider. The measurement covers the transverse momentum interval $0.45 < p_t < 1.05$ GeV/c and rapidity $|\gamma| < 0.5$. The ratio is measured to be $R_{|\gamma|<0.5} = 0.957 \pm 0.006(stat) \pm 0.0014(syst)$ at 0.9 Tev and $R_{|\gamma|<0.5} = 0.991 \pm 0.005 \pm 0.014(syst)$ at 7 TeV and it is independent of both rapidity and

transverse momentum. The results are consistent with the conventional model of baryon-number transport and set stringent limits on any additional contributions to baryon-number transfer over very large rapidity intervals in *pp* collisions.

ALICE Collaboration

3.2.2.22 Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s}$=7 TeV with ALICE at LHC

The pseudorapidity density and multiplicity distribution of charged particles produced in proton-proton collisions at the LHC, at a centre-of-mass energy $\sqrt{s}$=7 TeV, were measured in the central pseudorapidity region $|\eta| < 1$. Comparisons are made with previous measurements at $\sqrt{s}$ = 0.9 TeV and 2.36 TeV. At $\sqrt{s}$ = 7 TeV, for events with at least one charged particle in $|\eta| < 1$, we obtain $dN_{ch}/d\eta = 6.01 \pm 0.01(stat.)^{+0.20}_{0.12}(syst.)$. This corresponds to an increase of $57.6\% \pm 0.4\%(stat.)_{-1.8}\%^{+3.6}(syst.)$ relative to collisions at 0.9 TeV, significantly higher than calculations from commonly used models. The multiplicity distribution at 7 TeV is described fairly well by the negative binomial distribution.

ALICE Collaboration

3.2.2.23 Study on the performance of THGEM gas detector

The thick gas electron multiplier (THGEM) is mechanically an expansion of standard GEM, with its various dimen sions being enlarged by factors ranging from 5 to 50. The spatial resolution of THGEM is sub-millimeter. THGEM has several applications at atmospheric and low-pressure both. The PCB design of THGEM has been done at SINP and fabricated at HFL, Hyderabad. We have studied energy resolu tion and effective gain of single THGEM using 55Fe source and pre-mixed Ar/CO_2 (80:20) at atmospheric press ure. The study of both the above parameters using a drift plane has been done. To observe the improvement of effec tive gain, the data taking of two THGEMs arranging in cascade mode is going on. The energy signal is taken through a charge sensitive pre-amplifier at this stage. The incorporation of Read O ut (R/O) PCB will be done to reduce the noise. The design and fabrication of R/O PCB have been done at SINP. The future plan is to use these THGEMs to study fission reaction at low pressure in the national accelerators.

T Sinha, D Das, L Das, S Chattopadhyay, S Bose

3.2.3 Nuclear Physics Division

3.2.3.1 Systematics of antimagnetic rotation in even-even Cd isotopes

A model based on classical particle plus rotor has been used to explore the underlying systematics of even-even Cd isotopes and a self consistent picture for the observed behaviors of $^{106,108,110}Cd$ has been reported. This systematic study also helps to estimate the strengths of particle-hole and hole-hole interactions of this mass region.

Santosh Roy, S Chattopadhyay, Pradip Datta†, S Pal, S Bhattacharya, RK Bhowmik, A Goswami, HC Jain†, R Kumar†, S Muralithar†, D Negi†, R Palit†, RP Singh

3.2.3.2 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 gamma 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 $E\gamma$=194(2) keV isomeric transition, known from earlier observations, was measured to be $T_{1/2}$ = 233(18) ns. A second isomeric transition at $E\gamma$ = 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.

D Kanjilal, S Bhattacharya, A Goswami, R Kshetri†, R Raut, S Saha, RK Bhowmik†, J Gehlot†, S Muralithar†, RP Singh†, G Jnaneswari†, G Mukherjee†, B Mukherjee†

3.2.3.3 Energy levels in ^{141}Nd from fusion evaporation study

The nucleus ^{141}Nd has been investigated using two different heavy ion fusion evaporation reactions, namely $^{130}Te(^{16}O, 5\nu)$ at E_{lab}=80-85 MeV and i$^{124}Sn(^{24}Mg, \alpha 3\nu)$ at E_{lab}=107 MeV, and the de-exciting gamma rays were detected using HPGe(GDA) and Clover detector (INGA) arrays, respectively. More than 30 new gamma transitions have been placed in the proposed level scheme, which has been extended up to 9 MeV excitation energy and spin parity values of $45/2^-$. Spin parity assignments have been made to most of the newly proposed levels. The structure up to approximately 6 MeV excitation energy and spin $31/2^-$ can be explained using the shell model in a truncated basis. The levels with higher spin/energy cannot be described using even the full 50-82 shell, indicating the influence of neutron excitations across the shell gap in this mass region. One M1 band that has been observed is proposed to have a five quasiparticle configuration.

Samit Bhowal†, Chirashree Lahiri†, Rajarshi Raut, Purnima Singh, M Kumar Raju†, A Goswami, AK Singh, S Bhattacharya, T Bhattacharjee†, G Mukherjee, S Bhattacharyya, S Muralithar†, RK Bhowmik†, N Madhavan†, RP Singh†, G Gangopadhyay†

3.2.3.4 New shell closure for neutron-rich Sn isotopes

The variation of $E(2_1^+)$ of $134-140Sn$ 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 $\nu(2f_{7/2})$ 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 136-138Sn and a shell closure at ^{140}Sn.

S Sarkar†, M Saha Sarkar

3.2.3.5 Influence of projectile breakup on complete fusion

Complete fusion excitation functions for $^{11,10}B + ^{159}Tb$ and $^{6,7}Li + ^{159}Tb$ 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 $^{10}B + ^{159}Tb$ and $^{6,7}Li + ^{159}Tb$ reactions, when compared to those for $^{11}B + ^{159}Tb$. The comparison shows that the extent of suppression of complete fusion cross-sections is correlated with the α-separation energies of the projectiles. Also, the measured incomplete fusion cross-sections show that the α-particle emanating channel is the favoured incomplete fusion process. Inclusive measurement of the α-particles produced in $^{6}Li + ^{159}Tb$ reaction has been carried out. Preliminary CDCC calculations carried out to estimate the α-yield following ^{6}Li breaking up into alpha+d fail to explain the measured α-yield. Transfer processes seem to be important contributors.

A Mukherjee, MK Pradhan†

3.2.3.6 The unbound isotopes $^{9,10}He$

The unbound nuclei ^{9}He and ^{10}He have been produced in proton-knockout reactions from a 280 MeV/u ^{11}Li 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, $^{8}He + nand ^{8}He + 2n$, 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 i^{9}He 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 (Γ = 1.11(76) MeV) superimposed on a correlated background, or two overlapping resonances, a ground state at 1.54(11) MeV (Γ = 1.91(41) MeV) together with an excited state at 3.99(26) MeV (Γ = 1.64(89) MeV). The two possible interpretations are discussed.

HT Johansson†, Yu Aksyutina†, T Aumann†, K Boretzky†, MJG Borge†, A Chatillon†, LV Chulkov†, D Cortina-Gil†, U Datta Pramanik, H Emling†, C Forssen†, HOU Fynbo†, H Geissel†, G Ickert†, B Jonson†, R Kulessa†, C Langer†, M Lantz†, T LeBleis†, K Mahata†, M Meister†, G Muenzenberg†, T Nilsson†, G Nyman†, R Palit†, S Paschalis†, W Prokopowicz†, R Reifarth†, A Richter†, K Riisager†, G Schrieder†, H Simon†, K Suemmerer†, O Tengblad†, H Weick†, MV Zhukov†

3.2.3.7 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 (Λ), cascade-0 (Ξ^0) and cascade-minus (Ξ^-) drip lines. The existence of a range of

bound pure-hyperonic systems without any neutron and proton is suggested among which 6 Λ, 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 ${}^{8}_{2\Xi_0 2\Lambda}He$ to be bound. An exotic ${}_2\Xi^0 2\Xi 2\Lambda {}^{10}n$ 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.

C Samanta

3.2.3.8 Sub- and above-barrier fusion of loosely bound ^6Li with ^{28}Si

Fusion excitation functions are measured for the system ^6Li + ^{28}Li using the characteristic γ-ray method, encompassing both the sub-barrier and above-barrier regions, viz, E-lab = 7-24MeV. Two separate experiments were performed, one for the above-barrier region (E-lab = 11-24MeV) and another for the below-barrier region (E-lab = 7-10MeV). The results were compared with our previously measured fusion cross-section for the ^7Li +^{28} Si system. We observed the enhancement of the fusion cross-section at sub-barrier regions for both ^6Li and ^7Li, but the yield was substantially larger for ^{6}Li. However, for well-above-barrier regions, a similar type of suppression was identified for both the systems.

Mandira Sinha, H Majumdar, P Basu, Subinit Roy, R Bhattacharya, M Biswas, MK Pradhan†, R Palit†, I Mazumdar, S Kailas†

3.2.3.9 Channel coupling effects on the fusion excitation functions for $^{28}Si+^{90,94}Zr$ in sub- and near-barrier regions

Fusion excitation functions and angular distributions of evaporation residues (ERs) have been measured for ^{28}Si +$^{90.94}$ 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 $^{90,94}Zr$ 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.

Sunil Kalkal†, S Mandal†, N Madhavan†, E Prasad†, Shashi† Verma, A Jhingan†, Rohit Sandal†, S Nath†, J Gehlot†, BR Behera†, Mansi Saxena†, Savi Goyal†, Davinder Siwal†, Ritika Garg†, UD Pramanik, Suresh Kumar†, T Varughese†, KS Golda†, S Muralithar†, AK Sinha†, R Singh†

3.2.3.10 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.

P Roy-Chowdhury, C Samanta, DN Basu†

3.2.3.11 Experimental study of Δ/I=1 bands in ^{111}In

The two Δ/I = 1 bands in ^{111}In, built upon the 3461.0 and 4931.8 keV states, have been studied. The bands were populated in the reaction $^{1000}Mo(^{19}F, \alpha 4n\gamma)$ at a beam energy of 105 MeV. Mean lifetimes of nine states, four in the first and five in the second band, have been determined for the first time from Doppler shift attenuation data. The deduced B(M1) rates and their behavior as a function of level spin support the interpretation of these bands within the framework of the shears mechanism. The geometrical model of Machiavelli et al. has been used to derive the effective gyromagnetic ratios for the two bands.

P Banerjee, S Ganguly†, MK Pradhan, HP Sharma†, S Muralithar†, RP Singh†, RK Bhowmik†

3.2.3.12 Study of strongly coupled high-K bands in 113Sb

Strongly coupled K = 9/2+ bands in 113Sb arising due to the excitation of a 1g9/2 proton across the Z=50 closed shell have been studied using the INGA at the IUAC, New Delhi. The states were populated in the reaction 100Mo(19F, 6n) at a beam energy of 105 MeV. The band has been extended up to 7485 keV with the addition of several new transitions and a readjustment of some transitions in the existing level scheme. Spins and parities of all but the last level have been confirmed. A neutron h11/2 upbend has been observed at a rotational frequency of 0.4 MeV/. The experimental B(M1; II-1)/B(E2; II-2) ratios have been compared with the Donau-Frauendorf semiclassical model for both normal and aligned configurations, suggesting a change in the deformation following the upbend. In addition, a study of the intruder band, based on h11/2 coupled to the deformed 2p-2h 112Sn core, has established large B(E2) rates and a quadrupole deformation of 2=0.32. Total Routhian surface calculations indicate a change in shape from collective prolate at

low spin to a less deformed, triaxial shape at higher spins.

P Banerjee, S Ganguly†, MK Pradhan†, HP Sharma†, S Muralithar†, RP Singh†, Ranjan K Bhowmik†

3.2.3.13 Production of neutron-rich lambda hypernuclei at j-parc

We discuss the usefulness of the double charge-exchnage reactions (DCX) for the production of the neutron-rich Lambda-hypernuclei. We believe the (π^-, K^+) reaction is one of the most promising DCX reactions, and propose to produce the neutron-rich Lambda-hypernuclei, H-6(Lambda) and He-9(Lambda), at the J-PARC 50 Gev PS by the reaction (J-PARC E10 experiment). The design of the experiment is presented.

A Sakaguchi†, S Ajimura†, H Bhang†, L Busso†, M Endo†, D Faso†, T Fukuda†, T Kishimoto†, K Matsuda†, K Matsuoka†, Y Mizoi†, O Morra†, H Noumi†, PK Saha†, C Samanta, Y Shimizu†, T Takahashi†, TN Takahashi†, K Yoshida†

3.2.3.14 Three-body correlations in the decay of ^{10}He and ^{13}Li

The very exotic nuclear resonance systems. ^{10}He and ^{13}Li, are produced in proton-knockout reactions from relativistic beams of ^{11}Li and ^{14}Be. The experimentally determined energy and angular correlations between their decay products, $^{8}He + n + n$ and $^{11}Li + n + n$, are analyzed using an expansion of decay amplitudes in a restricted set of hyperspherical harmonics. By considering only a small number of terms it is possible to extract the expansion coefficients directly from the experimental three-body correlations. This provides a model-independent way of getting information about the decay process. on the structure of the decaying nucleus and on the quantum characteristics of the binary subsystems
The results show that the $^{8}He + n + n$ relative-energy spectrum can be interpreted as consisting of two resonances, an $/^{\pi} = 0^+$ ground state and an excited $/^{\pi} = 2^+$ state. The $^{11}Li + n + n$ relative-energy spectrum is interpreted as an $/^{\pi}$=$3/2^-$ ground state overlapping with excited states having a structure similar to the 2^+ state in ^{10}He but spread over several states due to the coupling to the $/^{\pi} = 3/2^-$ core The ^{13}Li data also give evidence for a contribution of a configuration where the two neutrons occupy the d-shell.

HT Johansson†, Yu Aksyutina†, T Aumann†, K Boretzky†, MJG Borge†, A Chatillon†, LV Chulkov†, D Cortina-Gil†, U Datta Pramanik, H Emling†, C Forssen†, HOU Fynbo†, H Geissel†, G Ickert†, B Jonson†, R Kulessa†, C Langer†, M Lantz†, T LeBleis†, K Mahata†, M Meister†, G Munzenberg, T Nilsson†, G Nyman†, R Palit†, S Paschalis†, W Prokopowicz†, R Reifarth†, A Richter†, K Riisager†, G Schrieder†, G Shulgina†, NB Shulgina†, H Simon†, K Suemmerer†, O Tengblad†, H Weick†, MV Zhukov†

3.2.3.15 Are there Superdeformed states in ^{35}Cl?

High-spin states in ^{35}Cl have been studied through ^{12}C+^{28}Si (110 MeV) reaction in the inverse kinematics using the multi-detector array of thirteen Compton suppressed Clover detectors (INGA setup) at Inter University Accelerator Centre (IUAC), New Delhi. A sequence of gamma rays decaying from very short lived states manifested through their large Doppler shifts has been proposed to belong to a band having a large deformation. Analysis of fractional Doppler shift has been done to confirm the superdeformed structure of the band. Theoretical studies using Particle rotor

model reproduces this band well. Large scale shell model calculations are being done to identify the microscopic origin of these states.

Abhijit Bisoi, Sudatta Ray, Moumita Roy Basu†, Debasmita Kanjilal, Somnath Nag†, K Selva Kumar†, A Goswami, N Madhavan†, S Muralithar†, RK Bhowmik†, S Sarkar†, M Saha Sarkar

3.2.3.16 Evolution of nuclear structure in $^{151-154}$Ho isotopes and study of nano - second isomers

The $^{151-154}$Ho isotopes are studied by $^{139}_{57}$ La(^{20}Ne, xn) reaction at a projectile energy of 139 MeV the INGA facility at VECC, Kolkata. The neutron deficient isotopes $^{151-154}$Ho encompass a very significant domain in terms of their neutron numbers. It is expected that their structural features will evolve from single particle type at ^{151}Ho to collective modes at ^{154}Ho. Moreover for each of them, how the structure evolves with increasing spins also bear important consequences. The RF-gamma TAC spectra have been used to determine the half -lives of a few nanosecond isomers in these isotopes. Total Routhian surfaces have been generated to interpret the observed features.

Dibyadyuti Pramanik†, Abhijit Bisoi, Sudatta Ray, A Chakraborty†, Gautam Dey†, Krishichayan†, R Kshetri†, I Ray, S Ganguly†, MK Pradhan, R Raut†, M Ray Basu†, G Ganguly†, SS Ghugre†, AK Sinha†, SK Basu†, A Goswami, P Banerjee, A Mukherjee, S Bhattacharya, M Saha Sarkar, S Sarkar†

3.2.3.17 Production and characterisation of ^{14}N implanted target

Measurements of nuclear reaction cross-sections relevant for astrophysical scenario require use of targets that have a high level of isotopic purity and are stable under high intensity beam bombardment. Implantation technique has been found to be one of the most effective methods to produce such targets. ^{14}N beams from ECR source at TIFR have been implanted on a tantalum backing. Its surface morphology has been characterized using XPS, EDX and Raman Scattering. Results obtained so far indicate presence of low Z impurities like carbon and oxygen. In future, special efforts will be taken to reduce them. Further investigation will be done to characterize the ^{14}N distribution within the bulk of the tantalum backing.

Abhijit Bisoi, M Saha Sarkar, CA Desai†, LC Tribedi†, J Dutta†, NR Ray

3.2.3.18 Characterisation of a Si-PIN diode detector and its usage in gamma spectroscopy

A silicon PIN diode detector has been characterized and its resolution and efficiency have been compared with a Low Energy Photon Spectrometer (LEPS): Planar HPGe detector to test whether the PIN detector can be used as a detector complementary to a LEPS in nuclear gamma spectroscopy.

Abhijit Bisoi, A Nandi†, MK Ray, NA Rather, S Ray, D Pramanik† and M Saha Sarkar

3.2.3.19 Identification of the slow E3 transition ^{136m}Cs $\rightarrow^{136}$Cs

We have interpreted theoretically the experimental data on the spectroscopy of the decay of the 8 isomer in ^{136}Cs done at ISOLDE. The excitation energy of the isomer and the multipolarity of its decay have been measured for the first time. This isomer decays by a very slow 518 keV E3 transition to the ground state. The results are discussed in comparison to shell model results. The lifetime of the isomer can be only predicted reasonably close to the observed value if the neutron effective charge is taken to be zero for the E3 transition. This feature still remains to be understood.

K Wimmer†, U Koester†, P Hoff†, Th Kroll†, R Krűcken†, R Lutter†, H Mach†, Th Morgan†, S Sarkar†, M Saha Sarkar, W Schwerdtfeger†, PC Srivastava†, PG Thirolf†, and P Van Isacker†

3.3 Developmental Work

3.3.0.20 Developmental work related to the neBEM solver

The neBEM solver and the ISLES library have been improved significantly in order to extend their range of application and also to increase their efficiency. The ISLES library, which carries out the bulk of the job by evaluating the foundation expressions unique to our approach, has been almost entirely rewritten to enhance both speed and accuracy. Several new functions have been created to allow modeling of space charge / known charge distributions. The library has been made compatible to object oriented compilers in order to allow interfacing between neBEM/ISLES and recently developed codes available in the HEP community. For example, besides the already existing interface to Garfield, interfaces to important codes such as Heed and Magboltz have been developed. The neBEM solver itself has been redesigned to add the capability of handling periodic and mirrored structures, thus allowing modeling of detectors of realistic dimensions. In addition, the wire model has been successfully implemented allowing very fast modeling of micro-pattern devices. As an application of the developed tools, elaborate physics modeling of cargo-scanning devices are being pursued at present in order to provide support to a project envisaged by the Technology Transfer Office at CERN.

Supratik Mukhopadhyay, Nayana Majumdar, Purba Bhattacharya, Sudeb Bhattacharya, Rob Veenhof†, Hatmut Hillemanns†, Marie-Pierre Vidonne†

3.4 Publications

3.4.1 Journal Publication

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3.5 Seminars/Lectures given in Conference/Symposium/Schools

Bichitra Ganguly

Exploring Structural defects in doped Sm-Zr mixed oxides, International Symposium on MOLMAT 2010, Montpellier, FRANCE July 5-8, 2010

Study of soft matter using positron Annihilation Spectroscopy, Institut fr Strahlenphysik, FORSHUNGZENTRUM Dresden-Rossendrof FZD Germany, July 9, 2010

Chhanda Samanta

Superheavy to Superstrange nuclei, Advances in Nuclear Physics in Our Time, Goa, India, November 28-December 2, 2010

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Multi-Strange Nuclei, GSI, Darmstadt, Germany, October13, 2010

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Strangeness: A New Dimension in Nuclear Physics, Johann Wolfgang Goethe Universitat, Frankfurt, Germany, Sept 30, 2010

Strange nuclei without any neutron and proton, Physics Department, Virginia Commonwealth University, Richmond, Virginia, USA, September 03, 2010

Chhanda Samanta, Discovery of the First Anti-Strange Nucleus, Saha Institute of Nuclear Physics, Kolkata, May 28, 2010

M Saha Sarkar

New Phenomenon In Exotic Neutron-Rich Sn Isotopes- Shell Model Studies, Department of Physics, University of Sao Paolo, Brazil, August 17, 2010

Evolution of intruder $1f_{7/2}$ orbital for upper sd shell nuclei, The Pan-American Advanced Study Institute on the physics and astrophysics of rare nuclear isotopes (PASI 2010), Joao Pessoa, Brazil, August 1-13, 2010

Investigation of background characteristics of gamma spectrometers, 3rd School-Cum-Workshop on Low Energy Nuclear Astrophysics, SLENA 2010, Kolkata, November 15-19, 2010

Evolution of sd-fp shell gap for upper sd shell nuclei, DAE-BRNS Symposium on Nuclear Physics, Pilani, Rajasthan, India, December 20-24, 2010

Supratik Mukhopadhyay

Estimation of Interconnect Capacitance, International Conference on Communication Computers and Devices, IIT, Kharagpur, December 10-12, 2010

Nayana Majumdar

Application of MPGD-TPCs in Exploring Neutrino-less Double Beta Decay, INO Collaboration Meeting, Madurai, January 23-26, 2011

Radiation Detectors, Regional Science Congress, Jawahar Navodaya Vidyalaya, Durgapur, November 15-20, 2010

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Investigation of high spin states of trans-Lead nuclei, DAE Symposium on Nuclear Physics, Birla

Institute of technology & Science, Pilani, December 20-24, 2010

R&D activities on ICAL active detector prototype at SINP-VECC and status report on the INO prototype at VECC, INO Collaboration Meeting, Madurai, January 23-26, 2011

PMG Nambissan

Positrons as probes for metallurgical and materials characterization, National Symposium on Micro and Nano Characterization of Materials (Metallix 2011), Jadavpur University, Jadavpur, Kolkata, January 7, 2011

Nanomaterial research using positron spectroscopic tools, Workshop on Nanoscience and Nanotechnology (ALIGARH NANO-1), Aligarh Muslim University, Aligarh, March 26-27, 2011

P Banerjee

A Facility for Research in Experimental Nuclear Astrophysics, 3rd School-Cum Workshop on Nuclear Astrophysics, Saha Institute of Nuclear Physics, Kolkata, November 15-19, 2010

3.6 Teaching elsewhere

Bichitra Ganguly

Positron Annihilation as a Chemical Probe, Bardwan University College Teachers Refreshment programme. UGC Academic Staff College, Sept 15, 2010 (two lectures)

M Sc PG II class Nuclear and Analytical Chemistry as visiting faculty CAS Programme, March 28-31, 2010 (6 lectures)

Sandip Sarkar

S N Bose Center for Basic Sciences for Integrated M Sc course. Laboratory experiments (February March 2011)

Chhanda Samanta

University of Richmond, Richmond, Virginia, USA (2010)

Chapter 4

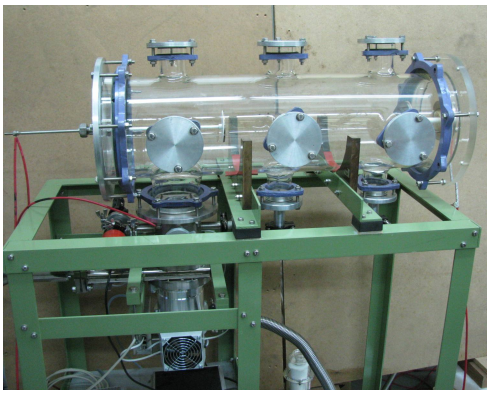
Plasma Physics

4.1 Summary of Research Activities of Divisions

4.1.1 Plasma Physics

The experimental activities of the plasma physics division mainly centre around the Tokamak, the linear magnetized plasma machine (MaPLE), the Deep Space Plasma Propulsion experiment, Diamond Nanotechnology for Biological Applications Facility(DNTBA) and Nonlinear dynamics experiments (NLDX).

Some of the interesting results from the tokamak were on the behaviour of Runaway electrons in a tokamak plasma. Thanks to the Director, SINP that with some additional funds, we were able to augment some of the subsystems of the tokamak. The Maple device has yielded some interesting results which could be attributed to drift waves and some nonlinear dynamical estimates are in progress. The DSPP experimental setup has progressed significantly, with the completion of the fabrication of most of the subsystems. In the prototype device we have able to produce double layers which are being investigated in detail. The DNTBA experiment has yielded some very interesting results and we have been able to synthesize hydrogenated diamond like carbon materials which have a lot of potential in biological applications.



On the theory front strongly coupled and correlated dusty plasmas exhibiting viscous and elastic properties have been investigated revealing the existence of new modes called magnetoelastic modes in analogy with magnetoacoustic modes. Investigations on Jeans' instability in such media suggest that elastic effects contribute to the stability of the medium against fluctuations in gravitational potential. Dusty plasma fluids also exhibit non-Newtonian shear thinning property with a power law dependence of viscosity on velocity shear that is responsible for a novel instability of the shear waves. In the presence of convective nonlinearites, sheared dusty plasma flows are shown to support time periodic radially localized arbitrary amplitude dipole vortex solutions.

4.2 Research Activities

4.2.1 Plasma Physics Division

4.2.1.1 Observation of Very Low Frequency Drift Mode Oscillations in ECR Produced Plasmas of the MaPLE Device

Study of floating potential in the plasma produced by electron cyclotron resonance method in the MaPLE device of Saha Institute of Nuclear Physics reveals the presence of a very low frequency (300 Hz) oscillation and its second harmonic at 600Hz. While moving outward radially from the axis of the cylindrical device the fluctuation changes from chaotic to periodic and then quasiperiodic at the edge. Both poloidal and radial phase shift of these oscillations are also observed. Wave number measurements indicate the oscillations at 600 Hz to be very low frequency drift mode driven by externally driven strong density oscillations at 300 Hz.

Subir Biswas, Rabindranath Pal, ANS Iyengar

4.2.1.2 Suppression of Caviton instability by quantum effect

In this work we have shown that in the electron acoustic wave the quantum effect contributing to the nonlinear Schrödinger equation where the local maxima of the potential energy may act as an effective potential well. This phenomena is explained by the high frequency electron plasma wave reflects from regions of high density and the amplitude dependent ponderomotive force digs a hole in the plasma. The electron plasma wave becomes trapped in the density depression region made by the wave itself. Formation of the depletion can be an unstable process because if a wave amplitude is trapped in a shallow well, its energy will concentrate at the bottom of this well, but this concentration of energy makes the well deeper and deeper in a small region making this energy

even larger. This process leads to an instability generally known as caviton instability. We have shown that in absence of quantum effect we recover the classical growth rate of caviton instability but for or finite quantum effect this instability is drastically reduced.

Nikhil Chakarbarti

4.2.1.3 Magnetic shield for turbomolecular pump of the Magnetized Plasma Linear Experimental device at Saha Institute of Nuclear Physics

The turbo molecular pump of the Magnetized Plasma Linear Experimental device is protected from damage by a magnetic shield. As the pump runs continuously in a magnetic field environment during a plasma physics experiment, it may get damaged owing to eddy current effect. For design and testing of the shield, first we simulate in details various aspects of magnetic shield layouts using a readily available field design code. The performance of the shield made from two half cylinders of soft iron material, is experimentally observed to agree very well with the simulation results.

Subir Biswas, Monobir Chattopadhyay, Rabindranath Pal

4.2.1.4 Jeans instability in a viscoelastic fluid

The well known Jeans instability is studied for a viscoelastic gravitational fluid using generalized hydrodynamic equations of motions. It is found that the threshold for the onset of instability appears at higher wavelengths in a viscoelastic medium. Elastic effects playing a role similar to thermal pressure are found to lower the growth rate of the gravitational instability. Such features may manifest themselves in matter constituting dense astrophysical objects.

MS Janaki, N Chakrabarti, D Banerjee

4.2.1.5 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 characterization 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.

SK Saha, AK Hui, S Chowdhury, Santwana Raychaudhuri, D Banik

4.2.1.6 Viscoelastic modes in a strongly coupled, cold, magnetized dusty plasma

A generalized hydrodynamical model has been used to study the low frequency modes in a strongly coupled, cold, magnetized dusty plasma Such plasmas exhibit elastic properties due to the strong correlations among dust particles and the tensile stresses imparted by the magnetic field It has been shown that longitudinal compressional Alfven modes and elasticity modified transverse shear mode exist in such a medium The features of these collective modes are established and discussed

Debabrata Banerjee, Janaki Sita Mylavarapu

4.2.1.7 Nonlinear interaction of quantum electron plasma waves with quantum electron acoustic waves in plasmas

An analysis of the interaction between modes involving two species with different pressures in the presence of a static-neutralizing ion background is presented using a quantum hydrodynamic model. It is shown that quantum electron plasma waves can nonlinearly interact with quantum electron acoustic waves in a time scale much longer than electron plasma oscillation response time. A set of coupled nonlinear differential equations is obtained that is similar to the Zakharov equations but includes quantum correction terms. These equations are solved in a moving frame, showing that solitary-wave-like solutions may also be possible in quantum Zakharov equations. It is also shown that quantum effects can reduce the growth rate of the usual caviton instability. Possible applications of the theory are also outlined.

Nikhil Chakrabarti, Janaki Sita Mylavarapu, Manjistha Dutta, Manoranjan Khan

4.2.1.8 Viscosity gradient-driven instability of 'shear mode' in a strongly coupled plasma

The influence of the viscosity gradient (due to shear flow) on low-frequency collective modes in a strongly coupled dusty plasma is analyzed. It is shown that for a well-known viscoelastic plasma model, the velocity shear-dependent viscosity leads to instability of the shear mode. The inhomogeneous viscous force and velocity shear coupling supply the free energy for the instability. The combined strength of the shear flow and viscosity gradient dominates over any stabilizing force and makes the shear mode unstable. The implications of this novel instability and its applications are briefly described.

D Banerjee, MS Janaki, N Chakrabarti, M Chaudhuri

4.2.1.9 Dynamics of an excitable glow-discharge plasma under external forcing

Glow discharge plasma in the excitable regime shows rich dynamical behavior under external forcing. By perturbing the plasma with a subthreshold sawtooth periodic signal, we obtained small subthreshold oscillations that showed resonance with the perturbation frequency. The resonance phenomenon can be useful to estimate characteristic of an excitable system. However, for suprathreshold perturbation, frequency entrainment was observed. In this case, the system showed harmonic frequency entrainment for the perturbation frequencies greater than the characteristic frequency of the system and the excitable behavior for the perturbation frequencies well below

the characteristic frequency. The experiments were performed in a glow-discharge plasma where excitability was achieved at a suitable discharge voltage and gas pressure.

Md Nurujjaman, AN Sekar Iyengar

4.2.1.10 Comparative study of runaway electron diffusion in the rise phase of low q(a) and normal q(a) discharges in the SINP tokamak

The behaviour of runaway electrons in the SINP tokamak, which can be operated in a normal edge safety factor (q(a)) (NQ) discharge configuration as well as in a low q(a), (LQ) configuration, was experimentally investigated, during the initial plasma generation phase. An energy analysis of the runaway electron dynamics in the rise phase of the SINP tokamak discharges was also made. A comparison of the runaway electron diffusion coefficients in NQ and LQ is carried out in this paper.

Ramesh Narayanan, AN Sekar Iyengar

4.2.1.11 Nonlinear lower-hybrid oscillations in cold plasma

In a fluid description nonlinear lower-hybrid oscillation have been studied in a cold quasineutral magnetized plasma using Lagrangian variables. An exact analytical solution with nontrivial space and time dependence is obtained. The solution demonstrates that under well defined initial and boundary conditions the amplitude of the oscillations increases due to nonlinearity and then comes back to its initial condition again. These solutions indicate a class of nonlinear transient structures in magnetized plasma.

Chandan Maity, Nikhil Chakrabarti, Sudip Sengupta†

4.2.1.12 The MaPLE device of Saha Institute of Nuclear Physics: Construction and its plasma aspects

The Magnetized Plasma Linear Experimental (MaPLE) device is a low cost laboratory plasma device at Saha Institute of Nuclear Physics 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. In the present paper, characteristics of a steady state plasma generated by electron cyclotron resonance method using 2.45 GHz microwave power are presented. Scans using simple probe drives revealed that a uniform and long plasma column having electron density similar to 3-5 X 10(10) cm(-3) and

temperature similar to 7-10 eV, is formed in the center of the plasma chamber which is suitable for wave launching experiments.

Rabindranath Pal, Subir Biswas, Subhasis Basu, Monobir Chattopadhyay, Debjyoti Basu, Manis Chaudhuri

4.2.1.13 Shear wave vortex solution in a strongly coupled dusty plasma

The properties of electrostatic transverse shear waves in a strongly coupled dusty plasma are examined using the nonlinear version of the generalized hydrodynamic equation. In the kinetic limit, it is shown that strongly coupled plasmas support localized dipolar vortexlike solutions with amplitude modulated periodically.

MS Janaki, N Chakrabarti

4.2.1.14 Covalent Immobilization of Protein onto a functionalized Hydrogenated Diamond-like Carbon Substrate

Hydrogenated diamond-like carbon (HDLC) has an atomically smooth surface that can be deposited on high-surface area substrata and functionalized with reactive chemical groups, providing an ideal substrate for protein immobilization. A synthetic sequence is described involving deposition and hydrogenation of DLC followed by chemical functionalization. These functional groups are reacted with amines on proteins causing covalent immobilization on contact. Raman measurements confirm the presence of these surface functional groups, and Fourier transform in spectroscopy (FTIR) confirms covalent protein immobilization. Atomic force microscopy (A FM) of immobilized proteins is reproducible because proteins do not move as a result of interactions with the A FM probe-tip, thus providing an advantage over mica substrata typically used in A FM studies of protein. HDLC offers many of the same technical advantages as oxidized graphene but also allows for coating large surface areas of biomaterials relevant to the fabrication of medical/biosensor devices.

Hari Shankar Biswas†, Jagannath Datta†, DP Chowdhury†, AVR Reddy†, Uday Chand Ghosh†, Arvind Kumar Srivastava†, Nihar Ranjan Ray

4.3 Developmental Work

4.3.0.15 A Plasma Experimental Set-up for Student Program and Basic Research

Recently India has joined ITER, a large international experimental project to develop a large tokamak machine for demonstrating the viability of a fusion reactor. India is thereby in need of a large pool of plasma physicists in near future, especially in the experimental side. In collaboration with Bose Institute, Kolkata a small linear plasma device (Figure 1) has been developed with primary aim of training students in the university level plasma physics. The machine is made up of a 80 cm long, 20 cm inner diameter glass chamber having 8 radial ports in addition to two end ports for diagnostic purposes. Base vacuum achieved in the chamber up is $1.3x10^{-6}$ Torr using a 250l/s turbo- molecular pump backed by a rotary pump. Plasma is created in by glow discharge method inserting two electrodes through the end plates and powering them by a 2 kV, 1 A dc power supply. The device is suitable for carrying out basic plasma physics experiments including wave launching,

instabilities and studying their nonlinear behavior. Some material research problems with plasma processing can also be tried out in the set-up.

Monobir Chattopadhyay, Subhasis Basu, Dipankar Das and Rabindranath Pal

4.3.0.16 Deep Space Plasma Propulsion Experiment (XI-th plan project)

Propulsion of a spacecraft by a plasma is far more fuel efficient than chemical means. With this objective, the above project has been initiated to study the physics involved in the generation of mechanical thrust by a plasma. 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 π configuration has been designed and constructed here. The vacuum pumping system, gauges and data acquisition system are also ready. The first part of this system is ready but could not be installed due to lack of laboratory space.

SK Saha, Santwana Raychaudhuri, S Chowdhury, AK Hui

4.3.0.17 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 maximum) provided by a Helmholtz coil pair. The plasma (n$\sim$1e11 cm^{-3}, T$_e$ $\sim$5-10 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. A Langmuir probe compensated for the RF fluctuations of plasma potential has been constructed with help from IIT, Delhi. Preliminary measurements of density and potential have been done by this Langmuir probe movable in the axial direction using stepper motor controlled drives. An emissive probe has been used to obtain the axial profile of the plasma potential. A four-grid retarding field ion energy analyser has also been constructed and used to find the distribution function of the plasma ions. The system is operational and further experiments are in progress.

SK Saha, Santwana Raychaudhuri, S Chowdhury, AK Hui, MS Janaki D Das, P Bhattacharyya, A Bal, SS Sil, S Bose and M Chattopadhyay

4.4 Publications

4.4.1 Publications in Books/Monographs & Volumes Edited

N Chakrabarti, PN Guzdar†, RG Kleva†, R Singh†, PK Kaw†, V Naulin†, JJ Rasmussen†, *Geodesic Acoustic modes mode in toroidal plasma*, International Syposium on waves, coherent structures, and turbulent plasmas, AIP conference Proceedings, Melville, New York **1308**, 108 (2010)

Subir Biswas and Rabindranath Pal, *Parametric Decay of Pump Waves into Two Linear Modes in SINP MaPLE Device*, International Symposium on waves, coherent structures, and turbulent plasmas, AIP conference Proceedings, Melville, New York 1308, 142 (2010)

4.4.2 Journal Publication

Chandan Maity, Nikhil Chakrabarti, Sudip Sengupta†, Nonlinear lower-hybrid oscillations in cold plasma, Phys Plasmas **17** (2010) 082306

D Banerjee, MS Janaki, N Chakrabarti, M Chaudhuri†, Viscosity gradient-driven instability of 'shear mode' in a strongly coupled plasma, New J Phys **12** (2010) 123031

Debabrata Banerjee, Janaki Sita Mylavarapu, Nikhil Chakrabarti, Viscoelastic modes in a strongly coupled, cold, magnetized dusty plasma, Phys Plasmas **17** (2010) 113708

Hari Shankar Biswas†, Jagannath Datta†, DP Chowdhury†, AVR Reddy†, Uday Chand Ghosh†, Arvind Kumar Srivastava†, Nihar Ranjan Ray, Covalent Immobilization of Protein onto a functionalized Hydrogenated Diamond-like Carbon Substrate, Langmuir **26** (2010) 17413

MS Janaki, N Chakrabarti, D Banerjee, Jeans instability in a viscoelastic fluid, Phys Plasmas **18** (2011) 012901

Nikhil Chakrabarti, Janaki Sita Mylavarapu, Manjistha Dutta, Manoranjan Khan, Nonlinear interaction of quantum electron plasma waves with quantum electron acoustic waves in plasmas, Phys Rev **E83** (2011) 016404

Rabindranath Pal, Subir Biswas, Subhasis Basu, Monobir Chattopadhyay, Debjyoti Basu, Manis Chaudhuri, The MaPLE device of Saha Institute of Nuclear Physics: Construction and its plasma aspects, Rev Sci Instrum **81** (2010) 073507

Ramesh Narayanan, AN Sekar Iyengar, Comparative study of runaway electron diffusion in the rise phase of low q_a and normal q_a discharges in the SINP tokamak, Pramana **75** (2010) 691

SK Saha, AK Hui, S Chowdhury, Santwana Raychaudhuri, D Banik, Hard X-ray correlation analysis as a diagnostic tool for the measurement of magnetic turbulence in tokamaks, Rev Sci Instrum **81** (2010) 123506

Subir Biswas, Monobir Chattopadhyay, Rabindranath Pal, Magnetic shield for turbomolecular pump of the Magnetized Plasma Linear Experimental device at Saha Institute of Nuclear Physics, Rev Sci Instrum **82** (2011) 013506

4.5 Ph D Awarded

Debjyoti Basu [Rabindranath Pal], Effect of Edge Biasing on SINP-TOKAMAK Plasmas, Jadavpur University, December 2010

4.6 Seminars/Lectures given in Conference/Symposium/Schools

Rabindranath Pal

Disruption Control of Tokamak Discharges by Electrode Biasing, Workshop on INDO-USA collaboration program on Magnatic Fusion Research, IPR, Gandhinagar, March 7-9, 2011

The MaPLE Device at Saha Institute of Nuclear Physics (a Plenary Talk), 25th National Symposium on Plasma Science & Technology (PLASMA - 2010), IASST, Guwahati, December 8-11, 2010

Nikhil Chakraborti

Viscosity gradient driven mode in inhomogeneous complex (dusty) plasmas, One day microseminar organized at Viswabharati University, Shantiniketan, August 27, 2010

Basic plasma physics (eight lectures), SERC school, Institute of Advanced Study in Science and Technology(IASST), Guwahati, February 7-10, 2011

S K Saha

An experiment for plasma propulsion in deep space, Nat Conf on Electric Propulsion Systems, Bangalore, India, February 23-24, 2011

NR Ray

Hydrogenated diamond like carbon HDLC-A multifunctional material for technological applications, WSU-ASM-Seminar, Wright State University, Dayton, USA, May 19, 2010

Spectroscopic Charecterization of ultrananocrystalline diamond (UNCD), Dept of Physics & Astronomy, Clemson University, USA, May 21, 2010

4.7 Teaching elsewhere

Nikhil Chakraborti

Basic Quantum Mechanics, M Sc, Narendrapur Ramkrishana Mission College (Calcutta University), 2010

Basic Plasma physics, M Sc, Narendrapur Ramkrishana Mission College (Calcutta University), 2010

4.8 Miscellany

Nikhil Chakraborti

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Chapter 5

Theoretical Physics including Mathematics

5.1 Summary of Research Activities of Divisions

5.1.1 Astroparticle Physics and Cosmology

This Division persues research in the interface areas between Astrophysics & Cosmology on the one hand and high energy nuclear and particle physics on the other. During the year, members of the Division have carried out research on a variety of topics in AstroParticle Physics. Some highlights are given below.
(i) Work has been done on the *Experimental search for WIMP Dark Matter Candidates using Superheated Drop Detectors (SDD)*, as a part of the international PICASSO Collaboration for the WIMP Dark Matter search experiment currently underway at the SNOLab underground facility in Sudbury, Canada. In particular, nucleation efficiencies of different sensitive liquids used in SDDs have been studied. Also the possibility of discriminating between neutron and gamma induced events which act as backgrounds to the possible WIMP signals has been studied. It has been shown that analysis of the pulse height of signals at the neutron and gamma-ray sensitive temperatures provides important information for identification of neutron and gamma-ray induced events.
(ii) *Theoretical research on Dark Matter*: Work has been done on various particle physics models of dark matter, analysis of experimental results from direct dark matter search experiments in order to impose bounds on dark matter mass and cross sections using different dark matter halo models, prediction of directional variation of dark matter direct detection rates, calculating the expected neutrino signals from WIMP annihilation in the Sun and constraints on the Dark Matter properties from experimental upper limits on the flux of such neutrinos from the Sun, and so on.
(iii) *Phase transitions in Neutron Star interiors*: The possible phase transition from hadronic matter to antikaon condensed matter during the cooling stage of protoneutron stars has been investigated. In particular, the effect of shear viscosity on the thermal nucleation rate of droplets of antikaon condensed matter has been studied in this connection. It is found that the prefactor in the nucleation rate, which includes the shear viscosity, is enhanced by several orders of magnitude compared with the T^4 approximation used in earlier calculations.

(iv) *Neutrino mass and leptogenesis*: A particular structure of neutrino mass matrix, known as four zero Yukawa textures, has been studied in connection with mechanisms of generating the baryon asymmetry of the Universe through supersymmetric leptogenesis.
(v) *Black Hole spacetimes*: A number of fundamental issues associated with Black Hole spacetimes have been investigated, including (a) the differences between the extremal limit of a generic Reissner-Nordstrom spacetime and the exactly extremal geometry, (b) the physical equivalence of seemingly disparate approaches on characterization of the horizon theory for the Schwarzschild black hole (as well as spherical isolated horizons in general), and (c) a detailed study of the decade-old formulation of the isolated horizon classically and within loop quantum gravity, and the extraction of the microcanonical entropy of such a horizon from this formulation.

5.1.2 Theory

Research in this Division branches out in several areas of theoretical physics. This has created various subgroups within the division, which are, theoretical nuclear physics, high energy phenomenology, mathematical physics, quantum field theories and strings & gravity. Summarise of the important results obtained during this period is given below.

a) Theoretical Nuclear Physics:

Dileptons (e+ e-) provide a valuable tool to investigate the properties of the strongly interacting matter at high temperature and density formed in the relativistic and ultra-relativistic nuclear collisions because after their production they travel to the detectors almost undisturbed by the surrounding baryonic matter. A recurring feature of the dilepton spectra measured in such collisions at lower beam energies (1-2 GeV/nucleon) energies has been the significant enhancement observed in the intermediate dilepton mass region as compared to the predictions of various transport models which has been attributed to some inherent problems in the theory. The insufficiently known cross sections for the dilepton production in elementary proton-proton (pp) and proton-neutron (pn) collisions, are an important reason behind this. A theory developed by us within the effective Lagrangian framework now predicts that the dilepton production in proton-neutron collisions is indeed 3-4 times larger than the corresponding rate in of the proton-proton collisions. This fact that was not known before, is now able to solve the long standing puzzle of the larger dilepton yields as mentioned above.
The main aim of ongoing ultra relativistic heavy ion collisions is to study the properties of nuclear or hadronic matter at extreme conditions. A particular goal lies in the identification of a new state of matter formed in such collisions, the quark-gluon plasma (QGP), where the quarks and gluons are deconfined from the nucleons and move freely over an extended space-time region. An extensive amount of theoretical study is being carried out on QGP and heavy-ion phenomenology.
The symmetry energy coefficients of dilute clusterized nuclear matter are evaluated in the S-matrix framework. Employing a few different definitions commonly used in the literature for uniform nuclear matter, it is seen that the different definitions lead to perceptibly different results for the symmetry coefficients for dilute nuclear matter. They are found to be higher compared to those obtained for uniform matter in the low density domain. The calculated results are in reasonable consonance with those extracted recently from experimental data.

b) Mathematical Physics:

Successful application of the integrable perturbation is achieved for a wide range of nonlinear

systems generating new nonlinear models, including N-wave deformation and hidden possibilities in the integrable structure of the deformed nonlinear Schrödinger equation in controlling the optical soliton in fiber optic communication. Applying braided Yang-Baxter equation developed by us we have found new quantum integrable 1D anyonic lattice and field models, discovering the missing link to the well known anyon gas models.
It is shown that the partition functions for a class of Haldane-Shastry like 1-dimensional quantum spin chains with long-range interactions are equivalent to those of some 1-dimensional classical vertex models. Spectrum of spin Sutherland model associated with the D_N root system is derived by applying periodic boundary condition on the opposite faces of a N-dimensional generalization of the rhombic dodecahedron. The partition function of the corresponding Haldane-Shastry type spin chain is obtained by using the freezing trick.
Noncommutative geometry and noncommutative quantum field theories, including the analysis of twisted statistics and derivation of the twisted oscillator algebra for scalar field theories have been studied. Noncommutative black holes and the behaviour of scalar fields in such backgrounds have been investigated. Effect of topological defects of the quantum dynamics of lower dimensional systems such as graphene has been explored.

c) High Energy Phenomenology:

Investigations on lepton number violation in R-parity violating supersymmetric models, on consequences of CPT violation, and on the formulation of Majorana fermions have been carried out. The effects of R-parity violation (RpV) in several flavor observables by studying correlated enhancements in different channels by triggering only one or two RpV couplings have been studied. A reappraisal of Spontaneous RpV has also been under attention. Some phenomenological implications of 5-dimensional supersymmetric models have been analysed and flavor models which give unconventional Higgs decays signatures have been explored.
The impact of next-to-leading-order (NLO) QCD radiative corrections to the associated production of weak gauge boson and the graviton in theories with large extra dimensions is studied at the LHC. The QCD corrections enhances the cross section and they are sensitive to both transverse momentum distribution and the number of extra dimensions. We find that the uncertainty resulting from the choice of the factorization scale at leading order is reduced significantly after the inclusion of NLO QCD corrections thus making our predictions more reliable for the collider searches of large extra dimensions.
In the very high density region of a collapsed star leading to supernova explosions, the neutrino-neutrino interaction gives rise to collective neutrino oscillations. This non-linear effect results in partial or complete swaps of the spectra of electron and mu/tau type neutrinos and anti-neutrinos. The fact that r-process nucleosynthesis can take place only in neutron-rich environment and this mechanism of collective oscillations are shown to put constraints on the unknown fluxes of neutrinos emitted in supernovae.

d) Quantum Field Theory:

Work has mainly progressed in nonperturbative aspects like quantum fields on the lattice as given below.
With the Cray XT5 supercomputer starting operation in early 2010, the lattice QCD investigations with 2 degenerate light dynamical flavours of Wilson quarks and plaquette gauge action got a real boost. Gauge configurations were generated for two different lattice spacings, 3 different volumes and a host of quark masses corresponding to pion masses in the range below 300 MeV to about

700 MeV. The chiral regime of lattice QCD was primary goal of this investigation. Low lying spectrum including the pion and the rho meson masses and their decay constants were investigated and their consistency with chiral perturbation theory to NLO was checked. In addition, a study of the topological sectors of the QCD vacuum, and especially dependence of the topological susceptibility with decreasing quark mass was studied. Analytically, the effect of averaging of the Wilson parameter was studied on the emergence of the flavor-singlet chiral anomaly. The averaging produced remarkably better results when compared with many other improved lattice fermion formulations.

e) Strings and Gravity:

The thermodynamics and phase structure of asymptotically flat non-dilatonic as well as dilatonic black branes (in canonical ensemble) are studied in a cavity in arbitrary dimensions. While for the zero charge case an analog of Hawking-Page phase transition is found for these black branes, when the charge is non-zero, it is found that below a critical value of the charge, the phase diagram has a line of first-order phase transition in a certain range of temperatures which ends up at a second order phase transition point as the charge attains the critical value. The critical exponents are calculated at that critical point. The standard technique of Null Melvin Twist has been applied to the non-extremal (D1, D3) bound state configuration of type IIB string theory. Under a particular decoupling limit, such configuration represents the gravity dual of the non-relativistic, non-commutative Yang-Mills theory at a finite temperature. The AdS/CFT and the string probe approach has been used to compute the drag force on an external quark moving through such a hot non-relativistic, non-commutative YM plasma.
A very special type vanishing horizon (double) limit of 'boosted' black D3-branes, with compact light-cone direction, has been studied. The type IIB string solutions obtained by taking such double limits are found to be describing non-relativistic Lifshitz-like solutions with dynamical exponent 3. Similar double limits for boosted black M2-branes case also have been studied. Interestingly, in M2-brane case the dynamical exponent of the Lifshitz background has a fractional value.
Holography and application of Sullivan's theorem to the warped AdS_3 black holes and other geometries have been investigated. Black hole entropy using the holographic principle has also been studied.
Black hole state counting in loop quantum gravity: The two ways of counting microscopic states of black holes in the U(1) formulation of loop quantum gravity, one counting all allowed spin network labels j,m and the other only m labels, are discussed in some detail. The constraints on m are clarified and the map between the flux quantum numbers and m discussed. Configurations with —m—=j, which are sometimes sought after, are shown to be important only when large areas are involved. The discussion is extended to the SU(2) formulation.

5.2 Research Activities

5.2.1 AstroParticle Physics Division

5.2.1.1 Nucleation efficiency of R134a as a sensitive liquid for superheated drop emulsion detector

Superheated emulsion detector is known to detect neutrons, γ-rays and other charged particles. The present work includes the study of nucleation efficiency of superheated drops of one of the CFC-free liquids, R134a (C2H2F4), to fast neutrons, its response to γ-rays from ^{241}Am and ^{137}Cs and compare its nucleation efficiency with that of R12. The observation indicates that because of

the presence of hydrogen, the nucleation efficiency is less in R134a than in R12 in the present neutron energy range of consideration. R134a is one of the most environment-friendly, commercially available liquid that is suitable for superheated drop detector, specially in neutron dosimetry and one needs to investigate it in detail.

Mala Das, R Sarkar, PK Mondal, S Saha, BK Chatterjee, SC Roy

5.2.1.2 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 similar 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 distribution of the WIMPs in our model is non-Maxwellian with a cut-off at a maximum velocity that is self-consistently determined by the model itself. For our halo 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 similar to 5.3 x 10(-8) pb at a WIMP mass of similar to 71GeV. We also find, 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 similar to 2-16GeV, 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 (less than or similar to 10GeV) WIMPs as a candidate for dark matter as indicated by several earlier studies performed within the context of the SIIM. A more rigorous analysis using DAMA bins over smaller intervals should be able to better constrain the "DAMA regions" in the WIMP parameter space within the context of our model.

Soumini Chaudhury, Pijushpani Bhattacharjee, Ramanath Cowsik†

5.2.1.3 Interpreting the bounds on solar dark matter induced muons at super-kamiokande in the light of cdms results

We consider the recent limits on dark matter-nucleon elastic scattering cross-section from the analysis of CDMS II collaboration using the two signal events observed in CDMS experiment. With these limits we try to interpret the super-Kamiokande (SK) bounds on the detection rates of up-going muons induced by the neutrinos that are produced in the sun from the decay of annihilation products of dark matter (WIMP's) captured in the solar core. Calculated rates of up-going muons for different annihilation channels at SK using CDMS bounds are found to be orders below the predicted upper limits of such up-going muon rates at SK. Thus there exists room for enhancement (boost) of the calculated rates using CDMS limits for interpreting SK bounds. Such a feature is expected to represent the PAMELA data with the current CDMS limits. We also show the

dependence of such a possible enhancement factor (boost) on WIMP mass for different WIMP annihilation channels.

Abhijit Bandyopadhyay†, Sovan Chakraborty, Debasish Majumdar

5.2.1.4 Baryon asymmetry from leptogenesis with four zero neutrino Yukawa textures

The generation of the right amount of baryon asymmetry. of the Universe from supersymmetric leptogenesis is studied within the type-I seesaw framework with three heavy singlet Majorana neutrinos N-i (i = 1, 2, 3) and their superpartners. We assume the occurrence of four zeroes in the neutrino Yukawa coupling matrix Y-v, taken to be mu t symmetric, in the weak basis where N-i (with real masses M-i > 0) and the charged leptons l(α) (α = e, μ, t) are mass diagonal. The quadrant of the single nontrivial phase, allowed in the corresponding light neutrino mass matrix m(v), gets fixed and additional constraints ensue from the requirement of matching η with its observed value. Special attention is paid to flavor effects in the washout of the lepton asymmetry. We also comment on the role of small departures from high scale μ t symmetry due to RG evolution.

Biswajit Adhikary, Ambar Ghosal, Probir Roy

5.2.1.5 Effect of shear viscosity on the nucleation of antikaon condensed matter in neutron stars

We investigate a first-order phase transition from hadronic matter to antikaon condensed matter during the cooling stage of protoneutron stars. The phase transition proceeds through the thermal nucleation of antikaon condensed matter. In this connection we study the effect of shear viscosity on the thermal nucleation rate of droplets of antikaon condensed matter. Here we adopt the same equation of state for the calculation of shear viscosity and thermal nucleation time. We compute the shear viscosity of neutron star matter composed of neutrons, protons, electrons, and muons using the relativistic mean field model. The prefactor in the nucleation rate, which includes the shear viscosity, is enhanced by several orders of magnitude compared with the T^4 approximation of earlier calculations. Consequently the thermal nucleation time in the T^4 approximation overestimates our result. Further, the thermal nucleation of an antikaon droplet might be possible in our case for surface tension smaller than 20 MeV fm^{-2}.

Sarmistha Banik†, Debades Bandyopadhyay

5.2.1.6 Circular orbits in extremal Reissner-Nordstrom spacetime

Circular null geodesic orbits, in extremal Reissner-Nordstrom spacetime, are examined with regard to their stability, and compared with similar orbits in the near-extremal situation. Extremization of the effective potential for null circular orbits shows the existence of a stable circular geodesic in the extremal spacetime, precisely on the event horizon which coincides with the null geodesic generator. Such a null orbit on the horizon is also indicated by the global minimum of the effective potential for circular timelike orbits. This type of geodesic is of course absent in the corresponding near-extremal spacetime, as we show here, testifying to differences between the extremal limit of a

generic RN spacetime and the exactly extremal geometry.

Parthapratim Pradhan, Parthasarathi Majumdar

5.2.1.7 Schwarzschild horizon dynamics and SU(2) Chern-Simons theory

We discuss the effect of different choices in partial gauge fixing of bulk local Lorentz invariance, on the description of the horizon degrees of freedom of a Schwarzschild black hole as an SU(2) Chern-Simons theory with specific sources. A classically equivalent description in terms of an ISO(2) Chern-Simons theory is also discussed. Further, we demonstrate that both of these descriptions can be partially gauge fixed to a horizon theory with U(1) local gauge invariance, with the solder form sources being subject to extra constraints in directions orthogonal to an internal vector field left invariant by U(1) transformations. Seemingly disparate approaches on characterization of the horizon theory for the Schwarzschild black hole (as well as spherical isolated horizons in general) are thus shown to be equivalent physically.

Romesh K Kaul†, Parthasarathi Majumdar

5.2.1.8 Constraining scalar singlet dark matter with CDMS, XENON and DAMA and prediction for direct detection rates

We consider a simplest extension of the Standard Model (SM) through the incorporation of a real scalar singlet and an additional discrete Z(2) symmetry. The model admits the neutral scalar singlet to be stable and thus, a viable component of dark matter. We explore the parameter space of the model keeping in view the constraints arise from different dark matter direct detection experiments through WIMP-nucleon scattering. First of all, we have utilised the data obtained from CDMS, XENON-10 and XENON-100 collaborations. We further constraint the parameter space from the DAMA collaboration results (both with and without channelling) and CoGeNT collaboration results. Throughout our analysis, the constraint arises due to the observed relic density of dark matter reported by WMAP experiment, is also incorporated. Utilising all those constraints, on the model parameter space, we calculate the event rates and the annual variation of event rates in the context of a Liquid Argon Detector experiment.

Ambar Ghosal, Debasish Majumdar

5.2.1.9 Neutron-gamma discrimination by pulse analysis with superheated drop detector

Superheated drop detector (SDD) consisting of drops of superheated liquid of halocarbon is irradiated to neutrons and gamma-rays from Cf^{252} fission neutron source and Cs^{132} gamma source, respectively, separately. Analysis of pulse height of signals at the neutron and gamma-ray sensitive temperature provides significant information on the identification of neutron and gamma-ray induced events.

Mala Das, S Seth, S Saha, S Bhattacharya, P Bhattacharjee

5.2.1.10 Entropy of isolated horizons revisited

The decade-old formulation of the isolated horizon classically and within loop quantum gravity, and the extraction of the microcanonical entropy of such a horizon from this formulation, is reviewed, in view of recent renewed interest. There are two main approaches to this problem: one employs an SU(2) Chern-Simons theory describing the isolated horizon degrees of freedom, while the other uses a reduced U(1) Chern-Simons theory obtained from the SU(2) theory, with appropriate constraints imposed on the spectrum of boundary states "living" on the horizon. It is shown that both these ways lead to the same infinite series asymptotic in the horizon area for the microcanonical entropy of an isolated horizon. The leading area term is followed by an unambiguous correction term logarithmic in area with a coefficient -3/2, with subleading corrections dropping off as inverse powers of the area.

Rudranil Basu†, Romesh K Kaul†, Parthasarathi Majumdar

5.2.2 Theory Division

5.2.2.1 Phase transitions and critical behavior of black branes in canonical ensemble

We study the thermodynamics and phase structure of asymptotically flat non-dilatonic as well as dilatonic black branes in a cavity in arbitrary dimensions (D). We consider the canonical ensemble and so the charge inside the cavity and the temperature at the wall are fixed. We analyze the stability of the black brane equilibrium states and derive the phase structures. For the zero charge case we find an analog of Hawking-Page phase transition for these black branes in arbitrary dimensions. When the charge is non-zero, we find that below a critical value of the charge, the phase diagram has a line of first-order phase transition in a certain range of temperatures which ends up at a second order phase transition point (critical point) as the charge attains the critical value. We calculate the critical exponents at that critical point. Although our discussion is mainly concerned with the non-dilatonic branes, we show how it easily carries over to the dilatonic branes as well.

JX Lu†, Shibaji Roy, Zhiguang Xiao†

5.2.2.2 Effect of topology on the critical charge in graphene

We show that the critical charge for the Dirac excitations in gapless graphene depends on the spatial topology of the sample. In particular, for graphene cones, the effective value of the critical charge can tend toward zero for a suitable angle of the conical sample. We discuss the nature of the scattering phase shifts, quasibound state energies, and local density of states for a gapless graphene cone and determine the dependence of these physical quantities on the sample topology.

Baishali Chakraborty, Kumar S Gupta, Siddhartha Sen†

5.2.2.3 Infrared chiral anomaly at finite temperature

We study the Schwinger model at finite temperature and show that a temperature dependent chiral anomaly may arise from the long distance behavior of the electric field. At high temperature this anomaly depends linearly on the temperature T and is present not only in the two point function,

but also in all even point amplitudes.

Ashok Das, J Frenkel†

5.2.2.4 Generalization of Gunion-Bertsch formula for soft gluon emission

We generalize the most extensively used Gunion-Bertsch formula for the soft gluon emission in a perturbative QCD. We show that the corrections arising due to this generalization could be very important for the phenomenology of the hot and dense matter produced in the heavy-ion collisions.

Raktim Abir, Carsten Greiner†, Mauricio Martinez†, Munshi G Mustafa

5.2.2.5 Special limits and nonrelativistic solutions

We study special vanishing horizon limit of 'boosted' black D3-branes having a compact light-cone direction. The type IIB solution obtained by taking such a zero temperature limit is found to describe a nonrelativistic system with dynamical exponent 3. We discuss about such limits in M2-branes case also where the dynamical exponent of the Lifshitz background is rather fractional.

Harvendra Singh

5.2.2.6 Binding of hypernuclei, and photoproduction of lambda-hypernuclei in the latest quark-meson coupling model

We study the binding of hypernuclei based on the latest version of quark-meson coupling model, and estimate the photoproduction cross sections for the C-12(γ, K^+)(Λ)12 B reaction using the bound Lambda spinors obtained in the model.

K Tsushima†, PAM Guichon†, R Shyam, AW Thomas†

5.2.2.7 Baryonic loop in the ρ-meson self-energy

A relativistic formula is derived for the self-energy of rho meson in nuclear matter from a baryonic loop graph containing nucleon and $\Delta(1232)$. After identifying the Lindhard function, we find another term in it that contributes appreciably to the real part of the self-energy. We also note small errors that may appear in the numerical calculation owing to the use of incorrect Δ coupling with other fields and presence of quadratic distribution functions in the self-energy formula.

Sabyasachi Ghosh†, Sourav Sarkar, S Mallik

5.2.2.8 A pedagogical review of electroweak symmetry breaking scenarios

We review different avenues of electroweak symmetry breaking explored over the years. This constitutes a timely exercise as the world's largest and the highest energy particle accelerator, namely, the Large Hadron Collider (LHC) at CERN near Geneva, has started running whose primary mission is to find the Higgs or some phenomena that mimic the effects of the Higgs, i.e. to unravel the mysteries of electroweak phase transition. In the beginning, we discuss the Standard Model Higgs mechanism. After that we review the Higgs sector of the minimal supersymmetric Standard Model. Then we take up three relatively recent ideas: little Higgs, gauge-Higgs unification and Higgsless scenarios. For the latter three cases, we first present the basic ideas and restrict our illustration to some instructive toy models to provide an intuitive feel of the underlying dynamics, and then discuss, for each of the three cases, how more realistic scenarios are constructed and how to decipher their experimental signatures. Wherever possible, we provide pedagogical details, which beginners might find useful.

Gautam Bhattacharyya

5.2.2.9 Exotic Higgs boson decay modes as a harbinger of $S-3$ flavor symmetry

Discrete symmetries employed to explain flavor mixing and mass hierarchies can be associated with an enlarged scalar sector which might lead to exotic Higgs decay modes. In this paper, we explore such a possibility in a scenario with $S-3$ flavor symmetry which requires three scalar SU(2) doublets. The spectrum is fixed by minimizing the scalar potential, and we observe that the symmetry of the model leads to tantalizing Higgs decay modes potentially observable at the CERN Large Hadron Collider.

Gautam Bhattacharyya, Philipp Leser, Heinrich Pas

5.2.2.10 Dilepton production in proton-proton and quasifree proton-neutron reactions at 1.25 GeV

We investigate the $pp \to ppe^+e-$ and quasifree $pn \to pne^+e-$ reactions within an effective Lagrangian model at a laboratory kinetic energy of 1.25 GeV for which experimental data have recently been reported by the HADES Collaboration. The model uses a meson-exchange approximation to describe the initial nucleon-nucleon NN scattering. Contributions to the reaction amplitudes are included from the NN bremsstrahlung as well as from the excitation, propagation, and radiative decay of the $\Lambda(1230)$ isobar state. It is found that the HADES data on the e^+e^- invariant mass distribution in the $pp \to ppe^+e^-$ reaction are excellently reproduced by our model where the Δ isobar term dominates the spectrum. In the case of the quasifree $pn \to pne^+e^-$ reaction, a strong sensitivity to the pion electromagnetic form factor is observed which helps to bring the calculated cross sections closer to the data in the higher dilepton mass region.

R Shyam, U Mosel†

5.2.2.11 Low-mass dilepton rate from the deconfined phase

We discuss low-mass dilepton rates ($\leq$1 GeV) from the deconfined phase of QCD using both perturbative and nonperturbative models and compare them with those from lattice gauge theory and

in-medium hadron gas. Our analysis suggests that the rate at very low invariant mass (M $\leq$200 MeV) using the nonperturbative gluon condensate in a semiempirical way within the Green function approach dominates over the Born rate, independent of any uncertainty associated with the choice of the strong coupling in perturbation theory. On the other hand, the rate from rho-q interaction in the deconfined phase is important at 200 MeV $\leq$M $\leq$1 GeV as it is almost of same order as the Born rate as well as the in-medium hadron gas rate. Also, the higher order perturbative rate, leaving aside its various uncertainties, from the hard-thermal-loop approximation becomes reliable at M $\geq$200 MeV and also becomes comparable with the Born rate and the lattice rate for M $\geq$500 MeV, constraining on the broad resonance structures in the dilepton rate at large invariant mass. We also discuss the lattice constraints on the low-mass dilepton rate. Furthermore, we discuss a realistic way to advocate the quark-hadron duality hypothesis based on the dilepton rates from quark-gluon plasma and hadron gas.

Carsten Greiner†, Najmul Haque, Munshi G Mustafa, Markus H Thoma†

5.2.2.12 Non-minimally coupled scalar fields, Holst action and black hole mechanics

The paper deals with the extension of the Weak Isolated Horizon (WIH) formulation of black hole horizons to the non-minimally coupled scalar fields. In the early part of the paper, we introduce an appropriate Hoist type action to incorporate scalar fields non-minimally coupled to gravity and construct the covariant phase space of the theory. Using this phase space, we proceed to prove the laws of black hole mechanics. Further, we show that with a gauge fixing, the symplectic structure on the horizon reduces to that of a $U(1)$ Chern-Simons theory. The level of the Chern-Simons theory is shown to depend on the non-minimally coupled scalar field.

Ayan Chatterjee

5.2.2.13 One-Dimensional Vertex Models Associated with a Class of Yangian Invariant Haldane-Shastry Like Spin Chains

We define a class of $Y(sl_{(m|n)})$ Yangian invariant Haldane-Shastry (HS) like spin chains, by assuming that their partition functions can be written in a particular form in terms of the super Schur polynomials. Using some properties of the super Schur polynomials, we show that the partition functions of this class of spin chains are equivalent to the partition functions of a class of one-dimensional vertex models with appropriately defined energy functions. We also establish a boson-fermion duality relation for the partition functions of this class of supersymmetric HS like spin chains by using their correspondence with one-dimensional vertex models.

Bireswar Basu-Mallick, Nilanjan Bondyopadhaya†, Kazuhiro Hikami†

5.2.2.14 Analytic structure of ρ meson propagator at finite temperature

We analyse the structure of one-loop self-energy graphs for the ρ meson in real time formulation of finite temperature field theory. We find the discontinuities of these graphs across the unitary and the Landau cuts. These contributions are identified with different sources of medium modification discussed in the literature. We also calculate numerically the imaginary and the real parts of the

self-energies and construct the spectral function of the ρ meson, which are compared with an earlier determination. A significant contribution arises from the unitary cut of the $\pi\omega$ loop, that was ignored so far in the literature.

Sabyasachi Ghosh†, S Mallik, Sourav Sarkar

5.2.2.15 Relativistic expansion of electron-positron-photon plasma droplets and photon emission

The expansion dynamics of hot electron-positron-photon plasma droplets is dealt with within relativistic hydrodynamics. Such droplets, envisaged to be created in future experiments by irradiating thin foils with counterpropagating ultraintense laser beams, are sources of flashes of gamma radiation. Warm electron-positron plasma droplets may be identified and characterized by a broadened 511 keV line.

R Yaresko†, Munshi G Mustafa, B Kampfer

5.2.2.16 The spin Sutherland model of D_N type and its associated spin chain

In this paper we study the su(m) spin Sutherland (trigonometric) model of D_N type and its related spin chain of Haldane-Shastry type obtained by means of Polychronakos's freezing trick. As in the rational case recently studied by the authors, we show that these are new models, whose properties cannot be simply deduced from those of their well-known BC_N counterparts by taking a suitable limit. We identify the Weyl-invariant extended configuration space of the spin dynamical model, which turns out to be the N-dimensional generalization of a rhombic dodecahedron. This is in fact one of the reasons underlying the greater complexity of the models studied in this paper in comparison with both their rational and BC_N counterparts. By constructing a non-orthogonal basis of the Hilbert space of the spin dynamical model on which its Hamiltonian acts triangularly, we compute its spectrum in closed form. Using this result and applying the freezing trick, we derive an exact expression for the partition function of the associated Haldane-Shastry spin chain of D_N type.

B Basu-Mallick, F Finkel†, A Gonzalez-Lopez†

5.2.2.17 Constraints on the quantum gravity scale from κ-Minkowski spacetime

We compare two versions of deformed dispersion relations (energy vs. momenta and momenta vs. energy) and the corresponding time delay up to the second-order accuracy in the quantum gravity scale (deformation parameter). A general framework describing modified dispersion relations and time delay with respect to different noncommutative kappa-Minkowski spacetime realizations is firstly proposed here and it covers all the cases introduced in the literature. It is shown that some of the realizations provide certain bounds on quadratic corrections, i.e. on quantum gravity scale, but it is not excluded in our framework that the quantum gravity scale is the Planck scale. We also show how the coefficients in the dispersion relations can be obtained through a multiparameter fit

of the gamma-ray burst (GRB) data.

A Borowiec, Kumar S Gupta, S Meljanac, A Pacho

5.2.2.18 The response of laser interferometers to a gravitational wave

Laser interferometer detectors are widely used in the extensive effort to detect gravitational waves. The interaction of a gravitational wave with light in the interferometer is usually explained in terms of the motion of the free mirrors that form the interferometer arms. It is instructive to show that the same result can be obtained by calculating the propagation of an electromagnetic plane wave between free mirrors in the curved space-time induced by the gravitational wave. We find that the plane wave acquires frequency modulation sidebands at the frequency of the gravitational wave. Such sidebands are equivalent to the time-dependent phase shift imposed on the plane wave, as obtained in the conventional calculation.

Adrian Melissinos†, Ashok Das

5.2.2.19 Quantum Integrable 1D anyonic Models: Construction through Braided Yang-Baxter Equation

Applying braided Yang-Baxter equation quantum integrable and Bethe ansatz solvable 1D anyonic lattice and field models are constructed. Along with known models we discover novel lattice anyonic and q-anyonic models as well as nonlinear Schrodinger equation (NLS) and the derivative NLS quantum field models involving anyonic operators, N-particle sectors of which yield the well known anyon gases, interacting through δ and derivative δ-function potentials.

Anjan Kundu

5.2.2.20 Relativistic spectral function of nucleons in hot nuclear matter

We present a simple calculation of the nucleon self-energy in nuclear matter at finite temperature in a relativistic framework, using the real-time thermal field theory. The imaginary parts of one-loop graphs are identified with discontinuities across the unitary and the Landau cuts. We find that in general both the cuts contribute significantly to the spectral function in the region of (virtual) nucleon mass usually considered, even though the unitary cut is ignored in the literature. Furthermore, our relativistic spectral function differs from the one in nonrelativistic approximation, used in some earlier calculations.

Sabyasachi Ghosh†, Sourav Sarkar, S Mallik

5.2.2.21 Anatomy of the symmetry energy of dilute nuclear matter

The symmetry energy coefficients of dilute clusterized nuclear matter are evaluated in the S-matrix framework. Employing a few different definitions commonly used in the literature for uniform nuclear matter, it is seen that the different definitions lead to perceptibly different results for the symmetry coefficients for dilute nuclear matter. They are found to be higher compared to those

obtained for uniform matter in the low density domain. The calculated results are in reasonable consonance with those extracted recently from experimental data.

JN De, SK Samaddar, BK Agrawal

5.2.2.22 Pionic contribution to relativistic Fermi liquid parameters

We calculate pionic contribution to the relativistic Fermi liquid parameters (RFLPs) using a chiral effective Lagrangian. The RFLPs so determined are then used to calculate chemical potential, exchange and nuclear symmetry energies due to pi N interaction. We also evaluate two loop ring diagrams involving sigma, omega, and pi meson exchanges and compare results with what one obtains from the relativistic Fermi liquid theory (RFLT).

Kausik Pal

5.2.2.23 Reappraisal of spontaneous R-parity violation

In this short reappraisal of spontaneous lepton number violation in a supersymmetric scenario implemented through singlet sneutrino vacuum expectation value (VEV), we contribute two new things in the context where the lepton number symmetry is global: (i) provide explicit expressions of R-parity violating couplings in terms of the neutrino Yukawa couplings and the singlet sneutrino VEV, and (ii) estimate the limit on this VEV using the current knowledge of the light neutrino mass and the astrophysical constraint on the Majoron-electron coupling. Besides, we put updated constraints on the VEV and Yukawa coupling of the singlet superfield when the lepton number is gauged.

Gautam Bhattacharyya, Palash B Pal

5.2.2.24 Dilepton production in nucleon-nucleon collisions around 1 GeV/nucleon: A theoretical update

We present a fully relativistic and gauge invariant framework for calculating the cross-sections of dilepton production in nucleon-nucleon (NN) collisions which 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 to describe this reaction. We discuss the comparison of our calculations with the old DLS and the recent HADES data

R Shyam, U Mosel†

5.2.2.25 Ab-initio Hamiltonian approach to light nuclei and to quantum field theory

Nuclear structure physics is on the threshold of confronting several long standing problems such as the origin of shell structure from basic nucleon-nucleon and three-nucleon interactions. At the same time those interactions are being developed with increasing contact to QCD, the underlying theory of the strong interactions, using effective field theory. The motivation is clear - QCD offers the promise of great predictive power spanning phenomena on multiple scales from quarks and gluons

to nuclear structure. However, new tools that involve non-perturbative methods are required to build bridges from one scale to the next. We present an overview of recent theoretical and computational progress with a Hamiltonian approach to build these bridges and provide illustrative results for the nuclear structure of light nuclei and quantum field theory

JP Vary, H Honkanen, Jun Li, P Maris, AM Shirokov, SJ Brodsky, A Harindranath, GF De-Teramond, EG Ng, C Yang, M Sosonkina

5.2.2.26 The Central charge of the warped ads(3) black hole

The AdS/CFT conjecture offers the possibility of a quantum description for a black hole in terms of a CFT. This has led to the study of general AdS_3 type black holes with a view to constructing an explicit toy quantum black hole model. Such a CFT description would be characterized by its central charge and the dimensions of its primary fields. Recently, the expression for the central charges (C$-L$,C$-R$) of the CFT dual to the warped AdS_3 have been determined using asymptotic symmetry arguments. The central charges depend, as expected, on the warping factor. We show that topological arguments, used by Witten to constrain central charges for the BTZ blackhole, can be generalized to deal with the warped AdS_3 case. Topology constrains the warped factor to be rational numbers while quasi-normal modes are conjectured to give the dimensions of primary fields. We find that in the limit when warping is large or when it takes special rational values,the system tends to Witten's conjectured unique CFTs with central charges that are multiples of 24.

Kumar S Gupta, E Harikumar†, Siddhartha Sen†, M Sivakumar†

5.2.2.27 Collective flavor oscillations of supernova neutrinos and r-process nucleosynthesis

Neutrino-neutrino interactions inside core-collapse supernovae may give rise to collective flavor oscillations resulting in swap between flavors. These oscillations depend on the initial energy spectra, and relative fluxes or relative luminosities of the neutrinos. It has been observed that departure from energy equipartition among different flavors can give rise to one or more sharp spectral swap over energy, termed as splits. We study the occurrence of splits in the neutrino and antineutrino spectra, varying the initial relative fluxes for different models of initial energy spectrum, in both normal and inverted hierarchy. These initial relative flux variations give rise to several possible split patterns whereas variation over different models of energy spectra give similar results. We explore the effect of these spectral splits on the electron fraction, Ye, that governs r-process nucleosynthesis inside supernovae. Since spectral splits modify the electron neutrino and antineutrino spectra in the region where r-process is postulated to happen, and since the pattern of spectral splits depends on the initial conditions of the spectra and the neutrino mass hierarchy, we show that the condition Y-e$<$0.5 required for successful r-process nucleosynthesis will lead to constraints on the initial spectral conditions, for a given neutrino mass hierarchy.

Sovan Chakraborty, Sandhya Choubey†, Srubabati Goswami†, Kamales Kar

5.2.2.28 Geometric finiteness, holography and quasinormal modes for the warped AdS_3 black hole

We show that there exists a precise kinematical notion of holography for the Euclidean warped AdS_3 black hole. This follows from the fact that the Euclidean warped AdS_3 black hole spacetime is a geometrically finite hyperbolic manifold. For such manifolds a theorem of Sullivan provides a one-to-one correspondence between the hyperbolic structure in the bulk and the conformal structure of its boundary. Using this theorem we obtain the holographic quasinormal modes for the warped AdS_3 black hole.

Kumar S Gupta, E Harikumar†, Siddhartha Sen†, M Sivakumar†

5.2.2.29 Turbulent flow in graphene

We demonstrate the possibility of turbulent flow of electrons in graphene in the hydrodynamic region, by calculating the corresponding turbulent probability density function. This is used to calculate the contribution of the turbulent flow to the conductivity within a quantum Boltzmann approach. The dependence of the conductivity on the system parameters arising from the turbulent flow is very different from that due to scattering.

Kumar S Gupta, Siddhartha Sen†

5.2.2.30 A relativistic description of the A $(\pi^+, K^+)\Lambda$ A reaction

We investigate the A$(\pi^+, K^+)\Lambda$A reaction within a covariant model. We consider those amplitudes which are described by creation, propagation and decay into the relevant channel of N*(1650), N*(1710), and N*(1720) intermediate baryonic resonance states in the initial collision of the incoming pion 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. Expressions for the reaction amplitudes are derived taking continuum particle wave function in the plane wave approximation. Numerical calculations are presented for reactions on ^{12}C,^{40}Ca,$^{51}Vand^{89}Y$ target nuclei. The predictions of our model are in reasonable agreement with the available experimental data.

S Bender†, R Shyam, H Lenske†

5.2.2.31 A phenomenological study of 5d supersymmetry

Supersymmetry and extra dimension need not be mutually exclusive options of physics for the TeV scale and beyond. Intrinsically higher dimensional top-down scenarios, e. g. string models, often contain supersymmetry at the weak scale. In this paper, we envisage a more phenomenological scenario by embedding the 4d constrained minimal supersymmetric standard model in a flat 5d S-1/Z(2) orbifold, with the inverse radius of compactification at the TeV scale. The gauge and Higgs supermultiplets are placed in the bulk. We assume that only the third generation matter multiplet accesses the bulk, while the first two generations are confined to a brane on an orbifold fixed point. From a 4d perspective, the bulk has $N = 2$ supersymmetry which entails a special non-renormalization theorem giving rise to a significant numerical impact on the renormalization

group running of various parameters. The brane supersymmetry corresponds to $N = 1$ which we assume to be broken in an unspecified but phenomenologically acceptable way. Given this setup, we study how the gauge and Yukawa couplings and the $N = 1$ brane supersymmetry breaking soft masses run through the energy scale exciting the Kaluza-Klein states at regular interval. In the process, we ensure that electroweak symmetry does break radiatively. We confront our low energy parameters with the experimental measurements or limits of different observables, e.g. LEP lower limits on the lightest Higgs boson and the chargino, the (g - 2) of muon, the branching ratio of $b \to s\gamma$, and the WMAP probe of relative dark matter abundance. We present our results by showing the allowed/disallowed zone in the plane of the common scalar mass (m(0)) and common gaugino mass (M-1/2) for both positive and negative mu parameter. Our plots are the first 5d versions of the often displayed 4d m(0)-M-1/2 plots, and we provide reasons behind the differences between the 4d and 5d plots.

Gautam Bhattacharyya, Tirtha Sankar Ray

5.2.2.32 Traveling wave solutions of nonlinear partial differential equations

We propose a simple algebraic method for generating classes of traveling wave solutions for a variety of partial differential equations of current interest in nonlinear science. This procedure applies equally well to equations which may or may not be integrable. We illustrate the method with two distinct classes of models, one with solutions including compactons in a class of models inspired by the Rosenau-Hyman, Rosenau-Pikovsky and Rosenau-Hyman-Staley equations, and the other with solutions including peakons in a system which generalizes the Camassa-Holm, Degasperis-Procesi and Dullin-Gotwald-Holm equations. In both cases, we obtain new classes of solutions not studied before.

D Bazeia†, Ashok Das, L Losano†, MJ Santos†

5.2.2.33 Drag force in a hot non-relativistic, non-commutative Yang-Mills plasma

We apply the standard technique of Null Melvin Twist to the non-extremal (D1, D3) bound state configuration of type IIB string theory. Under a particular decoupling limit, such configuration represents the gravity dual of the non-relativistic, non-commutative Yang-Mills theory at a finite temperature. We then use the AdS/CFT and the string probe approach to compute the drag force on an external quark moving through such a hot non-relativistic, non-commutative YM plasma. We discuss various limiting cases to show the interplay between the non-relativistic as well as the non-commutative effect of the general drag force expression.

Kamal L Panigrahi, Shibaji Roy

5.2.2.34 Examining the efficacy of isotope thermometry in the S-matrix approach

Isotope thermometry, widely used to measure the temperature of a hot nuclear system formed in energetic nuclear collisions, is examined in the light of the S-matrix approach to the nuclear equation of state of disassembled nuclear matter. Scattering between produced light fragment pairs, hitherto neglected, is seen to have an important bearing on extraction of the system temperature

and volume at freeze-out from isotope thermometry. Taking due care with the scattering effects and decay of the primary fragments, a more reliable way to extract the nuclear thermodynamic parameters, by exploiting the least-squares fit to the observed fragment multiplicities, is suggested.

SK Samaddar, JN De

5.2.2.35 An alternative construction of the positive inner product for pseudo-Hermitian Hamiltonians: Examples

In this paper, we build on our earlier proposal for the construction of a positive inner product for pseudo-Hermitian Hamiltonians and present examples to clarify the procedure. We focus on two detailed calculations where the method is used, namely, a simple (generalized 2 x 2 matrix) pseudo-Hermitian Hamiltonian, which can be diagonalized, and a second system where the Hamiltonian cannot be diagonalized, but can be described as a perturbation of the harmonic oscillator. When the quantum mechanical system cannot be diagonalized exactly, our construction can be carried out perturbatively and we develop the general formalism for such a perturbative calculation systematically (for real eigenvalues).

Ashok Das, L Greenwood†

5.2.2.36 Properties of static limit and rotating equilibrium sequences of compact stars: Systematic correlations and constraints

We study the properties of nonrotating and rapidly rotating configurations of compact stars (CS) by employing a representative set of equations of state (EOSs). The chosen EOSs depend upon different dense matter models of compact stars. The empirical relationships of rotating equilibrium configurations and fixed frequency configurations with the some key properties of nonrotating sequences of compact stars are investigated. We find that the maximum gravitational mass of static limit CS ranges from 1.6M$\odot$ to 2.5M$\odot$ and their canonical radius $R_{1.4}$ varies from 10 to 15 km, which is reasonably well within the available observational bounds for CS mass and radius $R_{1.4}$. We show suitable parametric relationship between the combination of observable properties of static limit sequences with the observable properties uniformally rotating equilibrium configurations. It is found that the calculated values of M_{stat}^{max} and $R_{1.4}$ of nonrotating CSs have shown empirical relationship with Ω_K. The suitable combination of $R_{1.4}$ and Ω_K is reasonably correlated with the value of δM_B. Whereas any combination of Ω_K with angular momentum J_{1122} or moment of inertia I_{1122} are weakly correlated with δM_B.

Shashi K Dhiman†, Gulshan Mahajan, BK Agrawal

5.2.2.37 Correlated enhancements in $D_s \to \ell\nu$, (g-2) of muon, and lepton flavor violating τ decays with two R-parity violating couplings

With just two R-parity violating couplings, λ'_{223} and λ'_{323}, we correlate several channels, namely, $D_s \to \ell\nu(\ell\mu\tau)$, (g-2)$_\mu$, and some lepton flavor violating tau decays. For $\lambda\prime_{223} = \lambda\prime_{323} \sim 0.3$ and for a common superpartner mass of 300 GeV, which explain the recently observed excesses in the

above D_s, decay channels, we predict the following R-parity violating contributions: $Br(\tau \to \mu\gamma) \sim 4.5.10{-}8$, $Br(\tau \to \mu\mu\mu) \sim 1.2.10_8$, $Br(\tau \to \mu\eta/\eta\prime) \sim 4.10_{10}$, $(g\mu_2)/2 \sim 4.10_{11}$. We exhibit our results through observable versus observable correlation plots.

Gautam Bhattacharyya, Kalyan Brata Chatterjee, Soumitra Nandi†

5.2.2.38 Many-body quantum chaos: Recent developments and applications to nuclei

In the last decade, there has been an increasing interest in the analysis of energy level spectra and wave functions of nuclei, particles, atoms and other quantum many-body systems by means of statistical methods and random matrix ensembles. The concept of quantum chaos plays a central role for understanding the universal properties of the energy spectrum of quantum systems. Since these properties concern the whole spectrum, statistical methods become an essential tool. Besides random matrix theory, new theoretical developments making use of information theory, time series analysis, and the merging of thermodynamics and the semiclassical approximation are emphasized. Applications of these methods to quantum systems, especially to atomic nuclei, are reviewed. We focus on recent developments like the study of "imperfect spectra" to estimate the degree of symmetry breaking or the fraction of missing levels, the existence of chaos remnants in nuclear masses, the onset of chaos in nuclei, and advances in the comprehension of the Hamiltonian structure in many-body systems. Finally, some applications of statistical spectroscopy methods generated by many-body chaos and two-body random matrix ensembles are described, with emphasis on Gamow-Teller strength sums and beta decay rates for stellar evolution and supernovae.

JMG Gomez†, K Kar, VKB Kota†, RA Molina†, A Relano†, J Retamosa†

5.2.2.39 MC Realization of IR-improved DGLAP-CS Parton Showers: HERWIRI1.031

We introduce the new IR-improved Dokshitzer-Gribov-Lipatov-Altarelli-Parisi-Callan-Symanzik (DGLAP-CS) kernels recently developed by one of us into the HERWIG6.5 to generate a new MC, HERWIRI1.0 (31), for hadron-hadron scattering at high energies. We use MC data to compare the part on shower generated by the standard DGLAP-CS kernels and that generated by the new IR-improved DGLAP-CS kernels. The seamless interface to MC©NLO, MC©NLO/HERWIRI, is illustrated. We show comparisons with FNAL data and discuss some possible LHC phenomenology implications.

BFL Ward†, S Joseph†, S Majhi, SA Yost†

5.2.2.40 New approach to parton shower Monte Carlo event generators for precision QCD theory: HERWIRI1.0(31)

By implementing the new IR-improved Dokshitzer-Gribov-Lipatov-Altarelli-Parisi-Callan-Symanzik (DGLAP-CS) kernels recently developed by one of us in the HERWIG6.5 environment we generate a new Monte Carlo (MC), HERWIRI1.0(31), for hadron-hadron scattering at high energies. We use MC data to illustrate the comparison between the parton shower generated by the standard DGLAP-CS kernels and that generated by the new IR-improved DGLAP-CS kernels.

The interface to MC@NLO, MC@NLO/HERWIRI, is illustrated. Comparisons with FNAL data and some discussion of possible implications for LHC phenomenology are also presented.

S Joseph†, S Majhi, BFL Ward†, SA Yost†

5.2.2.41 Dilepton production in nuclear collisions around 1 GeV/nucleon - solution of a long standing puzzle

Dileptons (e^+e^-) provide a valuable tool to investigate the properties of the strongly interacting matter at high temperature and density formed in the relativistic and ultra-relativistic nuclear collisions because a fter their production they travel to the detectors almost undisturbed by the surrounding baryonic matter. A r ecurring feature of the dilepton spectra measured in such collisions at lower beam energies (1-2 GeV/nucleon) energies [1] has been the significant enhancement observed in the intermediate dilepton mass region as compare d to the predictions of various transport models which has been attributed to some inherent problems in the th eory. The insufficiently known cross sections for the dilepton production in elementary proton-proton (pp) and proto n-neutron (pn) collisions, are an important reason behind this. A theory developed by us [2] within the effect ive Lagrangian framework now predicts that the dilepton production in proton-neutron collisions is indeed 3-4 times larger than the corresponding rate in of the proton-proton collisions (see Fig. 1). This fact that was n ot known before, is now able to solve the long standing puzzle of the larger dilepton yields as mentioned above.

Radhey Shyam

5.2.2.42 It is shown that the partition functions for a class of Haldane-Shastry like

1-dimensional quantum spin chains with long-range interactions are equivalent to the partition functions of so me 1-dimensional classical vertex models with appropriately defined energy functions. Spectrum of $su(m)$ spin Sutherland model associated with the D_N root system is derived by applying periodic boundary condition on the opposite faces of a N-dimensional generalization of the rhombic dodecahedron. The partition function of the corresponding Haldane-Shastry type spin chain is obtained by using the freezing trick.

Bireswar Basu Mallick

5.2.2.43 Vector boson production in association with KK modes of the ADD model to NLO in QCD at LHC

Next-to-leading order (NLO) QCD corrections to the associated production of the vector boson (Z/W) with the Kaluza Klein (KK) modes of the graviton in large extra-dimensional model at the Large Hadron Collider (LHC) are presented. We have obtained various kinematic distributions using a Monte Carlo code which is based on the two-cutoff phase space slicing method that handles soft and collinear singularities appearing at the NLO level. 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 QCD corrections are included.

Prakash Mathews

5.3 Developmental Work

5.3.1 Astroparticle Physics and Cosmology

5.3.1.1 Direct detection of WIMPs: Implications of a self-consistent truncated isothermal model of the Milky Ways dark matter halo

Direct detection of Weakly Interacting Massive Particle (WIMP) candidates of Dark Matter (DM) has been studied within the context of a self-consistent truncated isothermal model of the finite-size dark halo of the Galaxy based on the King model of the phase space distribution function of collisionless DM particles. This halo model 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 distribution 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 parameter set 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 x 10^{-8}pb at a WIMP mass of∼71 GeV. It is also found, using the original 2-bin annual modulation amplitude data of the DAMA experiment, that there exists a range of small WIMP masses, typically ∼2-16 GeV, within which DAMA collaborations claimed annual modulation signal purportedly due to WIMPs is compatible with the null results of other experiments. These results strengthen the possibility of low-mass ($\lesssim$ 10GeV) WIMPs as a candidate for dark matter as indicated by several earlier studies performed within the context of the SHM. Work was also done to calculate the expected neutrino flux due to WIMP annihilations in the core of the Sun, within the context of the same self-consistent model of the Galaxys DM halo described above.

Pijushpani Bhattacharjee, Susmita Kundu, Soumini Chaudhury Ramanath Cowsik

5.3.1.2 WIMP Dark Matter detection using Superheated Droplet Detectors (SDD)

Neutron-gamma discrimination by pulse analysis with superheated drop detector (SDD) Continuing on with the programme of R&D work on Superheated Drop Detectors (SDD) began in the previous year, a small SDD fabricated in-house and consisting of drops of superheated liquid of halocarbon was irradiated with neutrons and gamma-rays from ^{252}Cf fission neutron source and ^{137}Cs gamma source separately. The analysis of pulse height of the signals in the neutron and gamma-ray sensitive temperature was shown to provide a clean way of identifying, and hence discriminating between, neutron and gamma-ray induced events. This has interesting implications for the use of SDDs in the search for WIMPs.

Mala Das, Susnata Seth, Sudeb Bhattacharya, Pijushpani Bhattacharjee, Satyajit Saha

5.3.1.3 Observational High Energy Gamma Ray Astronomy with the HAGAR Cherenkov telescope system at Hanle, Ladakh

A regular programme of observations of astronomical high energy gamma ray sources was began during the year. At SINP, simulation work to determine the telescope performance parameters (that are required as input in the analysis of the raw observational data) was continued, with SINP taking up the main responsibility of these aspects in the HAGAR Collaboration.

Pijushpani Bhattacharjee, Lab Saha, Soumini Chaudhury, Ramanath Cowsik†

5.4 Publications

5.4.1 Publications in Books/Monographs & Volumes Edited

PB Pal

Einstein-er uttoradhikar (Einstein's legacy): Nine essays in Bengali, discussing various aspects of Einstein's work, his predecessors from whom he derived inspiration, and his impact on society and science. [Bangiya Bijnan Parishad, Calcutta, 2011]

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K Kar

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5.4.2 Journal Publication

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Kumar S Gupta, E Harikumar†*, Siddhartha Sen*†*, M Sivakumar*†, Geometric finiteness, holography and quasinormal modes for the warped AdS_3 black hole, Class Quantum Grav **27** (2010) 165012

Kumar S Gupta, E Harikumar†*, Siddhartha Sen*†*, M Sivakumar*†, The central charge of the warped AdS3 black hole, Mod Phys Lett **A25** (2010) 2065

R Shyam, U Mosel†, Dilepton production in nucleon-nucleon collisions around 1 GeVnucleon: A theoretical update, Pramana **75** (2010) 185

R Shyam, U Mosel†, Dilepton production in proton-proton and quasifree proton-neutron reactions at 1.25 GeV, Phys Rev **C82** (2010) 062201(R)

R Yaresko†*, Munshi G Mustafa, B Kmpfer*†, Relativistic expansion of electron-positron-photon plasma droplets and photon emission, Phys Plasmas **17** (2010) 103302

Raktim Abir, Carsten Greiner†*, Mauricio Martinez*†*, Munshi G Mustafa*, Generalization of Gunion-Bertsch formula for soft gluon emission, Phys Rev **D83** (2011) 011501

S Bender†*, R Shyam, H Lenske*† , A relativistic description of the $A(\pi^+, \kappa^+)\Lambda$ reaction, Nucl Phys **A839** (2010) 51

Shashi K Dhiman†*, Gulshan Mahajan*†*, BK Agrawal*, Properties of static limit and rotating equilibrium sequences of compact stars: Systematic correlations and constraints, Nucl Phys **A836** (2010) 183

SK Samaddar, JN De, Examining the efficacy of isotope thermometry in the S-matrix approach, Phys Rev **C81** (2010) 041601(R)

S Joseph†*, S Majhi, BFL Ward*†*, SA Yost*†, New approach to parton shower Monte Carlo event generators for precision QCD theory: HERWIRI1.0(31) , Phys Rev **D81** (2010) 076008

Sabyasachi Ghosh†*, Sourav Sarkar*†*, S Mallik*, Relativistic spectral function of nucleons in hot nuclear matter, Phys Rev **C82** (2010) 045202

Sabyasachi Ghosh†*, Sourav Sarkar*†*, S Mallik*, Baryonic loop in the ρ-meson self-energy, Phys Rev **C83** (2011) 018201

MC Kumar, Prakash Mathews, V Ravindran, Satyajit Seth, Vector boson production in association with KK modes of the ADD model to NLO in QCD at LHC, J Phys **G38** (2011) 055001

5.5 Ph D Awarded

Sovan Chakraborty [Kamales Kar], Neutrino oscillations in supernovae, Homi Bhabha National Institute, January 2011

Tirtha Sankar Ray [Gautam Bhattacharyya], Beyond the Standard Model: some aspects of supersymmetry and extra dimension, University of Calcutta, October 2010

Sayan Kumar Chakraborti [Kumar S Gupta], Aspects of Gravity in Higher Dimensions, Jadavpur University, December 2010

Nilanjan Bondyopadhaya [Bireswar Basu-Mallick], Studies on some quantum integrable spin chains with long-range interaction, Jadavpur University, December 2010

5.6 Seminars/Lectures given in Conference/Symposium/Schools

Pijushpani Bhattacharjee

From Quarks to Cosmos: The Micro - Macro connection, Bengal Engineering & Science University (BESU), Shibpur, Howrah, 22 May 2010

Debades Bandyopadhyay

Neutron stars: from the crust to the interior, International Conference on Nucleon-nucleon interaction and nuclear many body problem Tata Institute of Fundamental Research, November 22-27, 2010

Neutron Star Crust in Strong Magnetic Fields, International Conference on Nucleon-nucleon interaction and nuclear many body problem Tata Institute of Fundamental Research, November 22-27, 2010

Shear Viscosity of Antikaon Condensed Matter in Neutron Stars, International Nuclear Physics Conference, 2010 (INPC2010), University of British Columbia, Vancouver, July 5-9, 2010

PB Pal

Summary of theoretical seminars, Conference on Dark Matter in LHC Era: Direct and Indirect Searches, Saha Institute of Nuclear Physics, Calcutta, January 4-8, 2011

Particle physics of WIMP-nucleon cross section, Conference on Dark Matter in LHC Era: Direct and Indirect Searches, Saha Institute of Nuclear Physics, Calcutta

Man and the universe, Golden Jubilee celebration conference of the Indian Anthropological Society, Indian Anthropological Society and the Anthropological Survey of India, Calcutta, November 23-26, 2010

Symmetry violation through matter effects, High Energy Physics Seminar, Technische Universitat, Dortmund, May 20, 2010

Kyalendarer rohosyo (The mystery of calendars), (i)Rajendra Smriti Vidyapith, Dec 14, 2010, (ii) 85th Orientation Course for College and University Teachers organized by Calcutta University, July 30, 2010 and 84th Orientation Course for College and University Teachers organized by Calcutta University, July 19, 2010

Doirghyer porimap (Measurements of length), (i)Physics Department seminar, Presidency College, Calcutta, September 3, 2010 and (ii) lecture at DST-INSPIRE Internship Science Camp, Kalyani University, June 24, 2010

R Shyam

Dilepton production in elementary Nucleon-Nucleon collisions, Workshop on Bremsstrahlung in Dilepton production, University of Frankfurt, Germany, May 28, 2010

Dilepton production in nucleon-nucleon collisions within OBE Model, Workshop on Electromagnetic probes of strongly interacting matter: Status and future of low mass lepton-pair spectroscopy, ECT* Trento, Italy, September 13-17, 2010 *Hadronic and Electromagnetic Interactions as Probes for Strongly interacting matter*, International workshop on Nucleon-Nucleon Interaction and Nuclear Many-Body Problem, Tata Institute of Fundamental Research, Mumbai, India, November 18-27, 2010

Institutes of Nuclear Theory around the World, Why should there be one in India too!, Interaction meeting on Nuclear Theory, Indian Institute of Technology, Roorkee, India, July 27-29, 2010

An overview of Hadron Physics with Indian perspective, Interaction meeting on Nuclear Theory, Indian Institute of Technology, Roorkee, India, July 27-29, 2010

Munshi G Mustafa

Relativistic Expansion Dynamics of Electron-Positron-Photon Plasma and Photon Production, Forschunzentrum-Dresden, Rosse

Generalisation of the Gunion-Bertsch Formula for Soft Gluon emission, Goethe University, Frankfurt, Germany, September 14, 2010

B Basu Mallick

Exactly solvable D_N type spin Sutherland model and Haldane-Shastry spin chain (Plenary talk), Colloquium on Integrable Systems and Quantum Symmetries, Prague, June 17-19, 2010

K Kar

Collective oscillations and diffuse supernova neutrino background, Advances in Nuclear Physics in Our Time, Goa, November 28- December 2, 2010

Nuclear Physics of WIMP-nucleus cross section, Workshop on Dark Matter in the LHC era: Direct and Indirect Searches, SINP, January 4-8, 2011

Harvendra Singh

Holographic flows in some non-relativistic string backgrounds, ICTP, Trieste, Italy, November 11, 2010

$z = 3$ *Lifshitz space-times in string theory*, International Conference on New Trends in Field Theories, Department of Physics, BHU, Varanasi, February 7-12, 2011

Sibaji Roy

Phase structure of black branes in canonical ensemble, International conference "ISM2011", Puri, India, January 4-11, 2011

Anjan Kundu

Construction of 1D integrable anyon models through braided YBE, Institute of Mathematical Sciences, Chennai, India, May 2-8, 2010

Modelling of recent experiment on magnetic pattern by topological skyrmion, Institute of Mathematical Sciences, Chennai, India, February 1, 2011

Coordinate and algebraic Bethe ansatz in quantum integrable systems, SERC School (DST) on Nonlinear Dynamics, Bharathidasan University, Trichy, January 16-26, 2011

Nonultralocal quantum algebra and 1D anyonic quantum integrable models, International Conf Recent Advances in Quantum Integrable Systems (RAQIS'10), Annecy, France, June 15-18, 2010

Integrable two-fold hierarchy of perturbed equations and application to optical soliton dynamics, International Conf on Nonlinear Physics: Theory & Experiment (NLPTE'10), Gallipoli, Italy, June 25- July 3, 2010

Integrable perturbation with nonholonomic constraint for AKNS and KN systems for N-wave and Painlevé equations, Integrability and Symmetry Sattelite conf. of ICM'10), Pondichery, India, August 12-18, 2010

Nonholonomic deformation of NLS and DNLS equations and application to fiber optic communication, National Conference on Nonlinear Dynamics & Integrable Systems (NCNLDIS'11), Trichy,

January 27-30, 2011

Systematic construction of integrable 1D anyon Lattice and field models, International Conference on Recent trends in field theory, VBU, Banaras, India, February 5-12, 2011

Kumar S Gupta

Spin and Statistics in Quantum Space-time, Department of Physics, Chulalongkorn University, Bangkok, Thailand, February 16, 2011

Holography and Quasinormal Modes of Black Holes, Department of Physics, Chulalongkorn University, Bangkok, Thailand, February 17, 2011

Effect of Topology on the Critical Charge in Graphene, Department of Physics, Chulalongkorn University, Bangkok, Thailand, February 21, 2011

Holography and Quasinormal Modes of Black Holes, Department of Mathematics, University of Rome "La Sapienza", Rome, Italy, October 1, 2010

Noncommutative Geometry, Symmetry and Quantum Structure of Space-Time, Fifth International Workshop DICE2010, Castiglioncello, Italy, September 13-17, 2010

Noncommutative Black Holes and Quantum Structure of Space-time, International Conference on Noncommutative Structures and (Non)-Relativistic (Super) Symmetries, LMPT, Tours, June 21-25, 2010

Gautam Bhattacharyya

Theoretical Overview of Electroweak Symmetry Breaking Scenarios, Physics Department, IISc, Bangalore, April 2010

Theoretical Overview of Electroweak Symmetry Breaking Scenarios, Physics Dept, Univ of Torino, Italy, June 2010

Phenomenology of 5d supersymmetry, Physics Department, University of Rome, La Sapienza, Rome, Italy, October 2010

Phenomenology of 5d supersymmetry, International Centre for Theoretical Physics, Trieste, Italy, October 2010

Phenomenology of 5d supersymmetry, Physics Department, University of Padova, Italy, October 2010

R parity violation: Flavor-LHC interplay, Workshop on Synergy between High Energy and High Luminosity Frontiers, TIFR, Mumbai, January 2011

P Mitra

Time-reversal and parity conservation for gravitating quarks, Workshop on Field Theoretic Aspects of Gravity VIII, HNB Garhwal University, Srinagar, Uttarakhand, April 19-23, 2010

Symmetries and Regularizations of QCD, New Trends in Field Theories, BHU, Varanasi, February 7-12, 2011

P Mathews

Perturbative QCD for the LHC physics, National Workshop on Recent Trends in Theoretical Physics, Cochin University of Science and Technology, Kochi, March 19-21, 2011

Bijay Kumar Agrawal

Some results for the Extended Relativistic mean field modles, 5th LACM-EFES-JUSTIPEN Workshop, Oak Ridge NAtional Laboratory, USA, March 15-17, 2011

Asit Kumar De

Lattice QCD with Wilson Fermions, One Day Meeting on non-perturbative aspects of Quantum Field Theory, IACS, Kolkata, December 20, 2010

5.7 Honours and Distinctions

PB Pal

Ramendra Sundar Smriti Puroskar awarded by the Bangiya Bijnan Parishad, January 2011

5.8 Teaching elsewhere

Debades Bandyopadhyay

Astrophysics course for M.Sc. students in Presidency University, Kolkata during February-March, 2011

Munshi G Mustafa

Electromagnetism in M Sc Course (2009-2010), jointly organised by J.C. Bose Institute, Kolkata and St. Xavier College, Kolkata

B Basu Mallick

Appointed as 'Honorary Collaborator' for the academic year 2010-2011 by the Faculty of Physics Department, Universidad Complutense de Madrid

Gautam Bhattacharyya

'New Physics at LHC (Part-I)', SERC main school in Theoretical High Energy Physics, Jamia Millia Islamia, New Delhi, Jan/Feb 2011 (9 lectures)

PB Pal

Vector space formalism of Quantum Mechanics (4 lectures), the Refresher Course, Physics Department, Calcutta University, July 6-7, 2010

5.9 Miscellany

Gautam Bhattacharyya

(i) Mercator Visiting Professorship at Dortmund, Germany, for 6 months (sponsored by DFG, Germany), to start in 2012.

(ii) Adjunct faculty of TIFR, Mumbai (2009-12)
(iii) Program Committee Member of International Centre for Theoretical Sciences (ICTS) TIFR, Mumbai (2010-12)

Munshi G Mustafa

i) Guest Scientist, FZ Dresden, Rossendorf, Germany, July-August, 2010
ii) Guest Scientist, Helmohltz International Center for FAIR, Goethe University, Frankfurt, Germany, September-November, 2010

B Basu Mallick

Appointed as 'Honorary Collaborator' for the academic year 2010-2011 by the Faculty of Physics Department, Universidad Complutense de Madrid

P Mathews

Member of the the National Organising Committee of the NationalWorkshop on Recent Trends in Theoretical Physics, Cochin University of Science and Technology, Kochi, India, 19 - 21 March 2011

Pijushpani Bhattacharjee

Member of DSTs Programme Advisory Committee (PAC) on Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics

Chapter 6

Teaching

6.1 The Post-M Sc Associateship Course

6.1.1 Physics

6.1.1.1 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 (PK 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 AP Patro Memorial Award

Second Term

Advance Courses (Teachers)

Quantum Field Theory (Probir Roy)
Condensed Matter Physics (Y Sudhakar)

General Relativity(Parthasarathi Majumdar and Parthasarathi Mitra)
High energy Astrophysics (Pijushpani Bhattacharjee & Debades Bandyopadhyay)
Microelectronics (Madhusudan Roy and Supratic Chakraborty)
Dynamics of Statistical Systems (Abhik Basu)
Nuclear Physics (Maitreyee Saha Sarkar, Chinmay Basu)
Plasma Physics (Nikhil Chakrabarti, MS Janaki)
Neutrino Physics (Debasish Majumdar and Ambar Ghosal)

Advanced Experiments under Teachers

ECMP: (I Das, K Bardhan, C Mukherjee) NAP: (Ushasi Datta Pramanik, B Ganguly, Maitreyee Saha Sarkar) ME: (S Sarkar) SP: (M Mukherjee) *Third Term (Review)* [Student, Review Title (Supervisor)]

1. Abhijit Bishoi, Implanted targets and their uses in Nuclear Structure and Nuclear Astrophysics experiments (Maitreyee Saha Sarkar, Nuclear & Atomic Physics Division)
2. Avirup Ghosh, Quantum Field Theory in curved Space time and Hawking Radiation (Amit Ghosh, Theory Division)
3. Protick Mohanta, Thermodynamics of Quark Gluon Plasma (Abhee K Dutta Mazumdar, HEN & PPD)
4. Atanu Kumar, Creation of universe from nothing (Amit Ghosh, Theory Division)
5. Abhishek Chowdhury, Chiral Symmetry (A Harindranath, Theory Division)
6. Abhishek Majhi, Review on entropic gravity(Parthasarathi Mitra, Theory Division)
7. Parijat Dey, Entropy and thermodynamics of black p-branes in string theory (Shibaji Roy, Theory Division)
8. Anirban Biswas, Dark matter in the universe and calculation of velic density for a specific Dark matter candidate (Debasish Majumdar, INO Section)
9. Debabrata Adak, Dark Energy from Supernova La Data (Debasish Majumdar, INO Section)
10. Mainak Chakraborty, Dark energy and mass varying neutrino (Ambar Ghoshal, INO Section)
11. Mahatsab Mondal, Characterizing the anisotropic quark gluon plasma (Pradip Roy, High Energy Physics Division)
12. Md Anisur Rahaman, Exploring New Magic number using RIB (Ushasi Datta Pramanik, Nuclear and Atomic Physics Division)
13. Palash Khan, Characterization of Ultra-relativistic Heavy Ion collisions using Event Generators (Sukalyan Chattopadhyay, High energy Physics Division)
14. Samik Dutta Gupta, Electrical transport phenomena in low dimensions (Indranil Das, ECMP division)
15. Kalipada Das, Magnetism in bulk and in low dimensional systems (Indranil Das, ECMP division)
16. Sudipta Mondal, Magnetic properties of perovskite, metallic perovskite and double perovskite and double perovskite compounds (Chandan Mazumdar, ECMP Division)
17. Suvankar Chakraborty, Growth, structure, electronic and magnetic properties of epitaxial oxide films studied by synchrotron based x-ray scattering techniques (Krishnakumar Menon, Surface Physics Division)
18. Sumana Sinha, Trends and techniques in development of organic nano-electronic devices (Manabendra Mukherjee, Surface Physics Division)
19. Arpan Bhattacharyya, Magneto-electronic transport properties of nano-structures materials (Milan K Sanyal, Surface Physics Division)

20. Ishani Roy, Scanning tunneling microscopic and spectroscopic studies of low-dimensional architectures (Satyajit Hazra, Surface Physics Division)
21. Sourish Bandyopadhyay, Particle Ordering in Zero Range Process (Pradeep Kumar Mohanty, TCMP)
22. Ravindra Pankaj, The architecture of Complex Networks (Pradeep Kumar Mohanty, TCMP)
23. Ujjal Kumar Gayen, Statistical Mechanics of Money, income and wealth (Bikas K Chakrabarti/PK Mohanty, TCMP Division)
24. Sohan Kumar Jha, coexistence of charge-density-wave and off-diagonal long range orders (Y Sudhakar, TCMP)
25. Muzaffar Qadir Lone, Quantum Entanglement around phase transition (Y Sudhakar, TCMP)

The following 25 Physics students successfully completed the course:

Abhishek Chowdhury, Abhishek Majhi, Anirban Biswas, Avirup Ghosh, Ishani Roy, Mahatsab Mandal, Mainak Chakraborty, Md Anisur Rahaman, Muzafar Qadir Lone, Parijat Dey, 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, Protick Mohanta (Complete on January 2011)

58th Session (2010-11)

The following 44 Physics students were admitted:

Dipankar Das, Abhik Mukherjee ,Debashis Saha, Rajnish Kumar, Susmita Dhara, Chandrachur Chakraborty , Mampi Dutta, Debarati Roy , Arindam Chakraborty, Kamakshya Prasad Modak , Amit Dutta Banik, Bipattaran Halder, Moumita Nandi, Kousik Bagani, Soumya Bagchi, Hitesh Vijay Rahangdale, Atanu Modak , Sutapa Ghosh Swagata Mukherjee, Kaustabh Dan , Tanmay Ghosh, Rajani Raman, Rajeswari Roy Chowdhury , Sudip Garai, Mala Mukhopadhyay , Debashree Chowdhury, Tapas Paramanik, Amit Dey, Kalyanmoy Chatterjee, Sudip Kumar Sarkar, Atanu Rajak, Bijoy, Kumar Daga , Biswarup Paul, Choudhuri Aminul Islam, Jayati Ray, Madhumita Choudhuri, Mayukh Kumar Ray, Md. Moin Shaikh, Niyaz Ahmad Rather, Prithwish Dutta, Sanchayita Mondal, Souvik Priyam Adhya, Subhendu Rajbanshi, Uttam Kumar Basak

First Term: 2010-11

Courses (Teachers)

Quantum Mechanics (Prodip Roy)
Nuclear Physics (Maitreyee Saha Sarkar)
Statistical Mechanics (Abhikanti Dutta Majumdar)
Particle Physics (Debasish Majumdar)
Plasma Physics (Nikhil Chakrabarti, & MS Janaki)
Condensed Matter Physics (Sachin Karmakar)
Basic Experiments & Techniques (Bijay Bal and Sandip Sarkar)

Mr Biswarup Paul received the Professor AP Patro Memorial Award (2010-11 Session) *Second Term:*

Advance Courses (Teachers):

Quantum Field Thory (Palash Baran Pal)
Statistical Mechanics (Bikas K Chakrabarti, Abhik Basu)
Condensed Matter Physics (Alokmay Datta)
Gravitation (Amit Ghosh)
Astroparticle Physics (Debasish Majumdar, Pijushpani Bhattacharjee)
Particle Physics (Gautam Bhattacharyya, Asit K De)
String Theory (H Singh)
Plasma Physics (MS Janaki, Nikhil Chakrabarti)
Nuclear Structure (Maitrayee Saha Sarkar)
Nuclear Reactions (Subinit Roy, C Samanta)
Exotic Probes (Bichitra Nandi Ganguly)
Nonlinear Dynamics (AN Sekar Iyengar)

Advanced Experiments under Teachers:

Tinku Sinha, Tapas Kumar Chini, Bichitra Nandi Ganguli, AN Sekar Iyenger, Purushottam Chakraborty, Prabhat Mondal, Alokmay Datta, Biwadal Banerjee, Satyajit Saha, Madhusudhan Ray, Gopal Nambissan, Mala Das, Chandi Charan De, Manabendra Mukherjee, Rabin Pal, Maitreyee Saha Sarkar

6.1.2 Biophysics

Review topics of existing Post-M.Sc (Biophysical Sciences) students **Student, Review Title (Supervisor)**

Kallol Bera, Fluorescence Correlation Spectroscopy: An Introduction to its Concepts and Application (Prof Soumen Basak)
Kaustab Ghosh, Comparative Study for Detection of Trace Scale Mercury by Different Instrumental Techniques (Prof Susanta Lahiri)
Mahan Ray, The role of Wnt/β-catenin signaling pathways in development and disease (Prof Sanghamitra Raha)
Anindita Deb, Mitochondrial Dynamics and Disease (Prof Subrata Banerjee)
Rakhi Paul, Phosphohistidine Phosphatase: Structure and Function (Prof Udayaditya Sen)
Moupriya Nag, Truncated Hemoglobins: Origin, Structure and Function (Prof Soumen Basak)
Poorna Roy, Ribozyme: Mechanism of Action (Prof Dhananjay Bhattachryya)
Sourav Kumar Dey, Single Molecule Fluorescence Spectroscopy Techniques and Their Application in Biological Sciences (Prof Soumen Basak)
Madhurima Mitra, Biology and Chemistry of Fodrin (Prof Abhijit Chakrabarti)
Anakan Dutta Chowdhury, Biosensor application using nanostructured conducting polymer and carbon nanotubes: Recent progress (Prof Amitava De)
Amrita Banerjee, Is Chromatin a Dynamic Assembly of Proteins and Nucleic Acids? (Prof Dipak Dasgupta)
Ayesha Kabir, Self Renewal Pathways and DNA Replication (Prof Subrata Banerjee)
Shilpita Karmakar, Platelet Disorders (Prof Abhijit Chakrabarti)
Shreyasi Dutta, Small Epigenetic modulators-as Potential Drugs (Prof Dipak Dasgupta)

Sujay Ghosh, Dielectric Relaxation & Solvation Dynamics of Aqueous Biomolecules & Related Organized Molecular Assemblies (Prof Samita Basu)

The following students have successfully completed the Post-M.Sc. Biophysical Sciences (2009-10)

Shilpita Karmakar, 2. Anindita Deb, 3. Ayesha Kabir, 4. Madhurima Mitra, 5. Amrita Banerjee, 6. Poorna Roy, 7. Rakhi Paul, 8. Moupriya Nag, 9. Mahan Ray, 10. Shreyasi Dutta, 11. Sujay Ghosh, 12. Ankan Datta Choudhury, 13. Kollol Bera, 14. Kaustab Ghosh.

INSTITUTE FELLOWSHIP 2010-11 STUDENTS

1. Arpita Saha 2. Angana Ray 3. Srijan Haldar 4. Supratim Ghatak 5. Pritha Bhattacharjee 6. Debashree Das 7. Arka Banerjee 8. Devika Srivastava

CSIR-UGC FELLOWSHIP 2010-11 STUDENTS

1. Piyali Mitra 2. Sayantani Ghosh 3. Banabithi Koley 4. Mohor Biplab Sengupta 5. Urbashi Basu 6. Neha Rai 7. Avinanda Banerjee 8. Priyanka Majumder 9. Anupa Majumdar 10. Subhas Chandra Bera

Modular Courses to be offered in the first semester (August to December) (All compulsory for Post M.Sc. Biophysical Sciences) along with proposed conveners of the courses

1.Cellular and Molecular Biology (Oisee Chakrabarti, Kausik Sengupta)
2.Basics of Biochemistry (Abhijit Chakrabarti)
3.Essentials of Computational Methods (Dhananjay Bhattacharyya, Pulak Ray, Debasis Mukherjee)
4.Microscopy-1 (Debasis Mukherjee)
5.Biochemical and Biophysical Methods (Partha Saha)
6.Mocribiology and Immunology (Subrata Banerjee, Arun K Pal)
7.Protein Structure and Folding (Rahul Banerjee, Soumen Basak)
8.Spectroscopy (Samita Basu, Munna Sarkar)
9.Radio Analytical Chemistry (Sushanta Lahiri)
10.Nucleic Acid and Lipid Structures (Dhananjay Bhattacharyya, Abhijit Chakrabarti)
11.Chemical Biology - 1 (Dipak Dasgupta)
12.Scientific Writing, Ethics, Safety and History of Science (Munna Sarkar, Debasis, PK Sengupta)
13.Recent Developments in Biology and Chemistry (Samita Basu)

Modular Courses for the second semester (January to March) (any five)

1.Spectroscopy - 2 (Samita Basu, Munna Sarkar)
2.Polymer Chemistry (Amitabha Dey)
3.Green Chemistry (Sushanta Lahiri)
4.Genomics (Nitai P Bhattacharyya)
5.Proteomics (Debasis Mukherjee)

6.Chemical Biology - 2 (Dipak Dasgupta)
7.Macromolecular Crystallography (Udayaditya Sen, Sampa Biswas)
8.Cellular and Molecular Biology - 2 (Oisee Chakrabarti, Kausik Sengupta)
9.Advanced Computer Programming -2 (Pulak Ray)
10.Stem Cell and Regenerative Medicine (Subrata Banerjee)
11.Cell Cycle (Partha Saha)
12.Membrane Biology (Abhijit Chakrabarti)
13.Drug Development (Munna Sarkar)
14.Cell Signaling (Sanghamitra Raha)
15.Structural Bioinformatics (Dhananjay Bhattacharyya)

6.2 Undergraduate Associateship Course

Physics (2010)

Baidarvi Guhathakurta (Mentor: Prof SR Bhattacharya)
Archisman Saha (Mentor: Prof M Saha Sarkar)
Sarbajaya Kundu (Mentor: Prof Amitabha De)
Dhruv Sharma (Mentor: Prof P Majumdar)
Sinjini Chandra (Mentor: Prof Samita Basu)
Pragati Mitra (Mentor: Prof D Majumdar)
Sourav Raha (Mentor: Prof P Mitra)
Debosmita Deb (Mentor: Prof Samita Basu)
Animik Ghosh (Mentor: Dr Mala Saha & P Bhattacharjee)
Kimberly Hsieh Sui Mee (Mentor: Dr T Sinha & S Chattopadhyay)

Biophysical Sciences

Sudip Jana (Mentor: Prof D Mukhopadhyay)
Vaibhav Jain (Mentor: Prof M Sarkar & A Chakrabarti)

6.3 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.

Table 6.1: List of summer project students for the year 2010

Sl	Name	Affiliation	Guide
1	Abhinav Kumar	IIT Roorkee	Debashis Mukhopadhyay
2	Alpha Michael Wharton	IIT Madras	Sekar Iyenger
3	Amitabha Nandi	IIT Kanpur	M Saha Sarkar
4	Amrita Sahu	Heritage Institute, WBUT	Sandip Sarkar
5	Arikta Biswas	Haldia Inst of Technology	Nitaipada Bhattacharya
6	Arnab Paul	IIT Bombay	Supratik Mukhopadhyay
7	ARPAN DE	IIT Bombay	Sangam Banerjee
8	Arundhati Das	IIT Guwahati	Chandi C Dey
9	Asim Pal	IIT Kharagpur	Debasish Majumdar
10	Aveek Chandra	IIT Bombay	Y Sudhakar
11	Avradip Pradhan	IIT Kanpur	Nihar Ranjan Ray
12	Ayan Kumar Pal	IIT Bombay	PMG Nambissan
13	Basudev Sahoo	IIT Kanpur	Munna Sarkar
14	Chayan Dutta	IIT Kanpur	Susanta Lahiri
15	Dinesh R Vernekar	BITS Pilani	Kamales Kar
16	Dwaipayan Mukhopadhyay	IIT Kanpur	Samita Basu
17	Jagriti Pal	Calcutta University	Oishee Chakrabarti
18	kaushik Mandal	Jadavpur University	Sandip Sarkar
19	Krishanu Roychowdhury	IIT KANPUR	Tinku Sinha
20	MP Revathy	CUSAT Kerala	Sujit Saha
21	Niketa Bhawsinghka	Calcutta University	Dipak Dasgupta
22	Rahul Kumar	IIT Roorkee	Sampa Biswas
23	Raisa Mondal	Calcutta University	Nihar Ranjan Ray
24	Saubhik Sarkar	IIT Kanpur	Pradeep Mohanty
25	Shreya Chakrabarti	Inst of Engg & Mgt, Kolkata	Sandip Sarkar
26	Siddharth Shekhar	IIT Delhi	Chinmay Basu
27	Sk jahiruddin	IIT BOMBAY	Alokmay Datta
28	Somik Dasgupta	Jadavpur University	Amitabha De
29	Soumendra N Bandyopadhyay	IIT Kanpur	Abhijit Chakrabarti
30	Sramana Kundu	IIT Kanpur	Chhanda Samanta
31	Timir Hajari	IIT Bombay	Dhananjay Bhattacharya

Chapter 7

Research Fellows/Visiting Fellows/Research Associates

Theory Division

Smt Bhramar Chatterjee :SRF
Shri Priti Bhajan Byakti:SRF
Shri Santanu Mondal :SRF
Shri Raktim Abir :SRF
Smt Anwesha Sarkar :JRF
Smt Sangita De Sarkar :JRF
Md Najmul Haque :JRF
Smt Baishali Chakraborty:JRF
Shri Arindam Majumdar :JRF
Shri Somdeb Chakraborty :JRF
Shri Pratyay Banerjee :JRF
Shri Avirup Ghosh :JRF
Shri Abhishek Chowdhury :JRF

Astro Particle Physics & Cosmology Division

Shri Srijit Bhattacharjee:SRF
Smt Soumini Chaudhury :SRF
Shri Rana Nandi :SRF
Smt Susmita Kundu :SRF
Smt Susnata Seth :SRF
Shri Lab Saha :SRF
Shri Mainak Chakraborty :JRF
Shri Abhishek Majhi :JRF
Shri Anirban Biswas :JRF
Shri Debabrata Adak :JRF

Plasma Physics Division

Shri Subir Biswas :SRF
Shri Debabrata Banerjee :SRF
Shri Chandan Maity :JRF

Surface Physics Division

Shri Biswajit Saha : SRF
Shri Sirshendu Gayen : SRF
Shri Suman Mandal : SRF
Shri Mojammel Haque Mandal: SRF
Shri AKM Maidul Islam : SRF
Smt Paramita Chatterjee : SRF
Md Safiul Alam Mollick : SRF
Shri Abhisakh Sarma : SRF
Shri Sanjoy Kumar Mahatha: SRF
Shri Bishnudas Ghosh : SRF
Smt Manjula Sharma : SRF
Smt Tanusree Samanta : SRF
Shri Pabitra Das : SRF
Shri Amaresh Metya : JRF
Shri Santanu Maiti : JRF
Shri Jayanta Das : JRF
Shri Shyamal Mondal : JRF
Smt Ishani Roy : JRF
Shri Suvankar Chakraborty: JRF

Applied Materials Science Division

Smt Smita Mukherjee : SRF

Nuclear Physics Division

Shri Mukesh Kr Prodhan : SRF
Md Anisur Rahaman : JRF
Shri Santosh Chakraborty: JRF

Applied Nuclear Division

Smt Debasmita Kanjilal : SRF
Shri Subhajit Karmakar : SRF
Smt Purba Bhattacharya : JRF

High Energy Nuclear & Particle Physics Division

Shri Indranil Das : SRF
Smt Lusaka Bhattacharya : SRF
Smt Sreemoyee Sarkar : JRF
Shri Mahatsab Mandal : JRF

Theoretical Condensed Matter Division

Shri Debashis Samanta : SRF
Shri Rakesh Chatterjee : SRF
Smt Mahashweta Basu : SRF
Shri Debarshee Bagchi : SRF
Shri Asim Ghosh : SRF
Smt Paramita Dutta : JRF
Shri Niladri Sarkar : JRF
Smt Moumita Dey : JRF
Smt Srilekha Saha : JRF
Shri Soumyajyoti Biswas : JRF
Shri Sourish Bondyopadhyay: JRF
Mr Muzafar Qadir Lone : JRF

Experimental Condensed Matter Division

Shri Deep Talukdar : SRF
Shri Dilip Kumar Bhoi : SRF
Md Nazir Khan : SRF
Shri Mayukh Majumder : SRF
Shri Arindam Midya : SRF
Shri Sudipta Mandal : JRF

Crystallography & Molecular Biology Division

Shri Anup Kumar Maity : SRF
Smt Moumita Datta : SRF
Smt Jayeeta Ghose : SRF
Shri Sudip Majumder : SRF
Smt Kamalika Roy Choudhury: SRF
Shri Sankar Chandra Basu: SRF
Smt Kasturi Sengupta nee Guha: SRF
Smt Eashita Das : SRF
Shri Saurav Roy : JRF
Smt Barnali Waugh : JRF
Smt Seema Nath : JRF
Shri Mahan Ray : JRF
Smt Rakhi Paul : JRF

Structural Genomics Division

Smt Sutapa Saha : SRF
Smt Madhumita Chakraborty: SRF
Shri Mithun Sinha : SRF
Smt Nandini Pal Basak : SRF
Shri Samir Das : SRF
Shri Sudip Kundu : JRF
Smt Kasturi Roy : JRF
Smt Suchismita Halder : JRF
Shri Shounak Baksi : JRF
Smt Shilpita Karmakar : JRF
Smt Madhurima Mitra : JRF

Biophysics Division

Smt Sudipta Pal : SRF
Smt Parijat Majumder : SRF
Shri Shibojyoti Lahiri : SRF
Smt Sukanya Halder : SRF
Smt Swati Panigrahi : SRF
Shri Biswapathik Pahari : SRF
Smt Sanchita Mukherjee : SRF
Smt Saptaparni Ghosh : JRF
Shri Manas Mondal : JRF
Smt Amrita Banerjee : JRF

Chemical Sciences Division

Smt Sutapa Mondal : SRF
Smt Brotati Chakraborty : SRF
Shri Manas Kumar Sarangi: SRF
Smt Mousumi Banerjee : SRF
Smt Binita Dutta : SRF
Smt Moupiya Nag : JRF

Post M Sc(Physics)

Shri Dipankar Das : SINP Fellow
Shri Abhik Mukherjee : SINP Fellow
Shri Debashis Saha : SINP Fellow
Smt Aparajita Singha : SINP Fellow
Shri Rajnish Kumar : SINP Fellow
Smt Susmita Dhara : SINP Fellow
Shri Ram Krishna Dewanjee: SINP Fellow
Shri Chandrachur Chakaraborty: SINP Fellow
Smt Mampi Dutta : SINP Fellow
Smt Anamika Pramanik : SINP Fellow
Shri Sutirtha Mukherjee : SINP Fellow
Smt Debarati Roy : SINP Fellow
Shri Arindam Chakraborty: SINP Fellow
Shri Kamakshya Prasad Modak: SINP Fellow
Shri Amit Dutta Banik : SINP Fellow
Shri Bipattaran Halder : SINP Fellow
Smt Moumita Nandi : SINP Fellow
Shri Kousik Bagani : SINP Fellow
Shri Soumya Bagchi : SINP Fellow
Shri Hitesh Vijay Rahangdale: SINP Fellow
Shri Manash Kumar Bag : SINP Fellow
Shri Atanu Modak : SINP Fellow
Smt. Sutapa Ghosh : SINP Fellow
Smt. Swagata Mukherjee : SINP Fellow
Shri Kaustabh Dan : SINP Fellow
Shri Tanmay Ghosh : SINP Fellow
Smt Rajani Raman : SINP Fellow
Smt Rajeswari Roy Chowdhury: SINP Fellow
Shri Sudip Garai : SINP Fellow
Smt Mala Mukhopadhyay : SINP Fellow
Smt Debashree Chowdhury : SINP Fellow
Shri Tapas Paramanik : SINP Fellow
Shri Sourav Dey : SINP Fellow
Shri Amit Dey : SINP Fellow
Shri Kalyanmoy Chatterjee: SINP Fellow
Shri Sudip Kumar Sarkar : SINP Fellow
Shri Atanu Rajak : SINP Fellow
Shri Ashish Bakshi : SINP Fellow
Shri Bijoy Kumar Daga : CSIR
Shri Biswarup Paul : CSIR
Smt Jayati Ray : CSIR
Smt Madhumita Choudhuri : CSIR
Md Moin Shaikh : CSIR
Shri Prithwish Dutta : CSIR
Smt Sanchayita Mondal : CSIR
Shri Subhendu Rajbanshi : CSIR
Md Choudhuri Aminul Islam: UGC
Shri Mayukh Kumar Ray : UGC
Md Niyaz Ahmad Rather : UGC
Shri Souvik Priyam Adhya: UGC
Shri Uttam Kumar Basak : UGC

Post M Sc(Biophysical Sciences)

Shri Mainak Bose : SINP Fellow
Shri Bharat Vaidyanathan: SINP Fellow
Shri Malay Ghosh : SINP Fellow
Shri Mriganka Sekhar Biswas: SINP Fellow
Shri Sumitash Jana : SINP Fellow
Shri Saurabh Bhattacharya: SINP Fellow
Smt Arpita Saha : SINP Fellow
Smt Angana Ray : SINP Fellow
Smt Sananda Chanda : SINP Fellow
Shri Srijan Haldar : SINP Fellow
Shri Supratim Ghatak : SINP Fellow
Smt Pritha Bhattacharjee: SINP Fellow
Smt Debashree Das : SINP Fellow
Smt Devika Srivastava : SINP Fellow
Smt Piyali Mitra : CSIR
Smt Sayantani Ghosh : CSIR
Shri Mohor Biplab Sengupta: CSIR
Smt Neha Rai : CSIR
Smt Priyanka Majumder : CSIR
Smt Anupa Majumdar : UGC
Shri Subhas Chandra Bera: UGC
Smt Banabithi Koley : UGC
Shri Avinanda Banerjee : UGC

CSIR

Dr JK Dattagupta : Emeritus Scientist C&MB
Dr Sruti Datta : Research Associate C&MB
Shri Srijit Das : JRF(NET) C&MB
Shri Ramanuj Banerjee : JRF(NET) C&MB
Smt Nupur Biswas : SRF(NET) AMS
Shri Satya Ranjan Halder: SRF(NET) SPD
Smt Anuradha Bhattacharya: JRF(NET) SPD
Shri Arpan Bhattacharyya: JRF(NET) SPD
Shri Atanu Kumar : JRF(NET) Theory
Sm Parijat Dey : SPM Fellow Theory
Smt Anita Roy : SRF(NET) SGD
Shri Arunabha Chakrabarti: SRF(NET) SGD
Shri Avik Basu : JRF(NET) SGD
Smt Shreyasi Dutta : JRF(NET) Biophysics
Dr Moumita Maiti : Senior Res Assoc CSD

Smt Sreeja Chakraborty : JRF(NET) CSD
Shri Kaustab Ghosh : JRF(NET) CSD
Shri Kallol Bera : JRF(NET) CSD
Shri Ankan Datta Chowdhur: JRF(NET) CSD
Shri Sujay Ghosh : JRF(NET) CSD
Shri Samik Dutta Gupta : JRF(NET) ECMP
Shri Kalipada Das : JRF(NET) ECMP
Shri Ujjal Kumar Gayen : JRF(NET) TCMP
Smt Urna Basu : SPM Fellow TCMP
Shri Sohan Kr Jha : JRF(NET) TCMP
Shri Abhijit Bisoi : JRF(NET) NPD
Smt Anindita Deb : JRF(NET) SGD

UGC

Shri Swadesh Mandal : JRF(NET) CSD
Shri Ajoy Mondal : JRF(NET) CSD
Shri Satyajit Seth : JRF(NET) Theory
Smt. Ajanta Kundu : JRF(NET) ANP
Smt. Sumona Sinha : JRF(NET) SPD
Shri Palash Khan : JRF(NET) HENPPD
Shri Rabindra Pankaj : JRF(NET) TCMP

DST

Dr(Smt) Debi Chowdhury:Principal Investigator (Women Scientist Scheme-A) C&MB
Dr(Smt) Papri Dasgupta:Women Scientist-A ECMP
Dr (Smt) Sumana Ray:Women Scientist-A C&MB
Dr Subarna Mitra:Post Doc Fellow SPD
Dr Santosh Kumar Samaddar:Principal Investigator
Dr(Smt) Lakshmishri Lahiry:Research Associate-I SGD
Md Sahinur Reja:Cavendish-Saha Research Fellow TCMP

Institute's RA/PDF

Dr Tapan Naskar:Post Doc Fellow Theory
Shri Prasanna Kumar Mondal:Post Doc Fellow APCD
Dr (Smt) Sarmistha Banik:Post Doc Fellow APCD
Dr(Smt) Sayanee Majumdar:Post Doc Fellow SPD
Dr Amulya Krishna Mahapatra:Post Doc Fellow SPD
Dr (Smt) Sucheta Adhikari:Research Associate-III NPD
Dr (Smt) Sudatta Ray:Research Associate-II NPD
Shri Dhrubajyoti Gupta:Post Doc Fellow NPD
Dr Mandira Sinha:Research Associate-I NPD
Dr Ritesh Kshetri:Post Doc Fellow NPD
Dr Sreetama Dutta:Research Associate-I ANPD
Dr Kushal Das:Post Doc Fellow HENPPD
Shri Santosh Roy:Post Doc Fellow HENPPD
Dr Anjan Kr Chandra:Research Associate-III TCMP
Dr(Smt) Anasuya Kundu:Post Doc Fellow TCMP
Dr (Smt) Rangana Bhattacharya:Research Associate-I ECMP
Dr Kausik Sengupta:Post Doc Fellow ECMP
Dr Aurkie Ray:Post Doc Fellow CSD
Dr Kuntal Chakrabarti:Research Associate-I AMSD
Dr(Smt) Alakananda Goswami(Nag):Post Doc Fellow C&MB

Chapter 8

Facilities

8.1 Centre for Advanced Research & Education

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. The Post-M.Sc. Associateship Course has become an integral part of the Ph. D. Programme of the institute. The Courses in the two streams (Ph/Bio) equip students for the Ph.D. Programme through classroom lectures at basic and advanced levels, laboratory sessions and exposure to computers. 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 organized.

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.

Science Day Celebration has been organized by the CARE through Seminars and Open House for undergraduate students during 2007-2010. The CARE also organized KVPY and JBNSTS scholars to visit the Science Gallery, SINP Laboratory. The CARE organized seminars, the institutes colloquium, lecture and have been conducting many schools and workshops on different disciplines of Physics, Biology and issues on social and historical aspects of Science. The CARE acts as the nodal centre of SINP for the Homi Bhabha National Institute.

The CARE published Triennial Report 2007-2010. The CARE took initiative in making a Documentary film on SINP named INSPIRATION in January 2011.

Preservation and Digitization of documents and artifacts of MN Saha Archive are also organized by the CARE. The CARE stands for helping in Research and Education on History of Science.
CARE Schools & Workshops
CARE School on Genomics and Proteomics for the Cilnicians held on March 29- Apr.2 2010
CARE School on Genomics and Proteomics for the Cilnicians held on Feb 14-19, 2011
Workshop on "New Arena in Photosciences" held on August 24th-27th, 2010
CARE Seminar & Lectures
The First PSI Seminar Series on Indian Proteomics:users perspective held on July 2-3, 2010. Jointly organized by CARE, SINP and IICB, Kolkata.
Sri Sambhu Mitra and Bengali Drama, Sri Debtosh Ghosh, 11th June,2010.
Biography, Archives and Contemporary History :the making of a Masterful Spirit, Speaker : Dr. Indira Chowdhury, 9th September, 2010.
An Illusion of Understanding, Sri Pathik Guha, 1st October, 2010.

8.2 Computer Section

The Computer Section is a facility meant for providing the general computing and networking environment for the whole Institute. The Computer Section plans, implements and maintains the central servers of the Institute for e-mail, web, network, Internet access, cyber security and also provides some general computing facilities including peripheral support for the general user.

A major activity in the year 2010-2011 of the Computer Section was to complete the tendering process for the new servers for the main Data Centre (DC) and Disaster Recovery (DR) site. The new servers will obviously replace the old servers which have been in use for the past several years but are slowly going out of term for service from the vendors due to old age. A new addition in this scheme in the new system would be the DR site which would be in different physical location from the main installation. This will ensure seamless redundancy of the system and safety in case of eventualities. The philosophy of the new system is the same as before, namely this is going to be a highly available (HA) cluster of nodes where each node performs one or more particular service(s) and on failure of that particular node the service will be automatically provided by another node of the cluster. One significant new feature of the new system is that it is designed to have more nodes than our previous system, and naturally the new system will be more redundant. It also will have more disk storage. Towards the end of the 2010-2011, the hardware was received and after a brief preparation of the primary site, actual installation began.

In the following, some of the main areas are itemized:
1. Designing and planning of the enhancement of the existing HA Cluster setup to a DC-DR setup. 2. Installation of 2 x 25 Tera Bytes of disk space for DC-DR setup. 3. Procurement and beginning of installation of RHEL based HA clustering solution for Data Center. 4. Procurement of Scalix mailing solution for users of the institute. 5. Planning of Migration of existing setup and user data to the new DC-DR infrastructure based on blades and rack servers. 6. Testing of asynchronous storage replication between DC-DR setups and LTO based enterprise class backups. 7. Installation of new router and switches for the new DC-DR project. 8. Procurement of software licenses of system and application softwares for servers and desktops.

This year also saw an MoU signed between SINP and National Knowledge Network (NKN) for bandwidth provided to our Institute from the NKN project. Subsequently an Internet bandwidth of 1 Gbps was made available to SINP through proper installation.

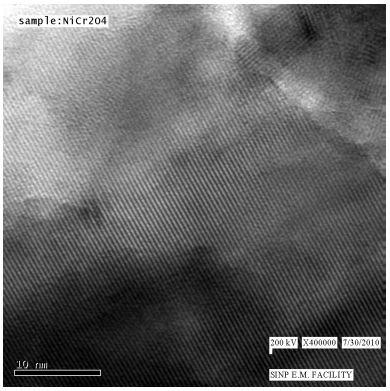
Other activities included installation of more modules for Maple and Maplesim software, addition of peripherals and general software.

Book Published

G Garai, Different Applications of Cascaded Genetic Algorithms: Data Clustering, Function Optimization and Shape Recognition, VDM Verlag Dr Muller Aktiengesellschaft & Co KG (Publisher), 2010

8.3 Electron Micorscope Facility

Transmission Electron Microscope Facility is working as a central facility and equipped with a 200kV Transmission Electron Microscope. The facility caters to the researchers from Biological Sciences and Material Sciences both Biophysics Div., Chemical Sc. Div., C & MB Div.



and Structural Genomic Div. use the facility to study biological samples like bacteria & their thin section, lipid vesicles, detergent micelles, lipid-protein complexes, peptide aggregation etc. ECMP, Surface Physics, Applied Material Sciences, Applied Nuclear Physics and Plasma Physics Div. use the facility to study material sciences samples like nanomaterials, metal oxides, nanocrystalline solids, diamond like carbon etc. More than 30 faculty members of the institute and 6 scientists from VECC use the facility on regular basis. Other research institutes and universities e.g. IACS, CGCRI, Jadavpur University, Calcutta University, Kalany University, WBUT, DAE-IUC, SNBCBS, IIT (Kgp), BESU, 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 12 publications have come out in reputed scientific journals, contributed by different scientists using the Transmission Electron Microscope during this period.

8.4 Electronics Workshop Facility

The Electronics Workshop Facility (EWF) caters to the electronics-related requirements of different experimental projects of the Institute. It could provide services in
a) Design, development and modification of electronic circuits/modules.
b) Fabrication, testing and installation of electronic gadgets as per the design.
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.

8.5 Library

Main activities: The Library of SINP is one of the major information resource centres within Eastern India in the field of Physical and Biophysical sciences and is privileged to support the institutes 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 as well as other institutions of DAE and eastern India. 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.
Collection: The library of SINP is one of the leading science-library within Eastern Region. In addition to huge collection of books on science and technology it also subscribe more than 233 leading journals in the field of physical, chemical and biophysical sciences. Library has a huge collection of books & non-book materials. The details are given below:
Books: 30829 (technical) + 3793 (non-technical) [646 books are added in this year]
Bound volumes of journals: 49753
Current subscribed journals: 233 (Foreign 174 + Indian 59)[33 titles added in this year]
Online journals: 3000 titles
Reports: 25000+
Number of CD/DVD Rom: 921

Major items/equipments available:
Library has two IBM servers where Libsys 4 (Rel 6.0 upgraded version) database is running.
32 Pcs are in the library out of 22 are for library user.
One hp Design jet plotter printer & one Canon plotter printer
One hp colour printer & 3 hp black & white printers.
Six Xerox machines cum printers.
Two lamination machines.
Three scanner & one spiral binding machine.

Membership:
In addition to our more than 805 institute members (faculties, fellows and staff), library has the privilege to serve about six hundred (610) users coming from different scientific and educational institutes of Eastern India. The list of external users includes Calcutta University, Jadavpur University, Viswa Bharati, IACS, IICB, ISI, Bengal Engineering and Science University, CMERI, Guwahati University, North East Hilly University, Patna University etc. apart from numerous Under-Graduate/Post-Graduate colleges and project students
Number of members & types of facilities are available for each category of members
(A) *SINP members (No. 805)*
(1) Borrowing facility
(2) Xerox facility
(3) Inter-library-loan
(4) Online searching & downloading.
(B) *VECC members (No. 130)*
(1) Borrowing facility
(2) Online searching & downloading
(C) *External members (No. 610)*
(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

Online facilities:
Successfully the library has implemented the online and archival facilities of various journals from XI plan project grant (LDRM). More than 3000 online journals as well as online archives are available (full-text pdf) from our site:
1. Institute of Physics, London
2. American Institute/APS
3. American Chemical Society
4. Wiley-Interscience
5. World Scientific
6. Springer
7. Taylor & Francis
8. Science Classic
9. Nature Publishing Group
10. Cambridge University Press

Library has the online e-books collection of Annual Reviews & Lecture Notes in Physics. Currently the library is subscribing Web of Knowledge & Science Citation Index from 1945 to current.

8.6 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.

8.7 Central Workshop

The Computerized Numerical Control (CNC) machine tools, installed in the workshop, are 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. Most of the components, fabricated in the workshop were designed and drafted by the design & drafting section.

8.8 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.

8.9 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 section was involved in maintenance of all R.C.C. & steel building structures, (ii) water supply, plumbing and sanitary systems, (iii) carpentry trade, (iv) gardening and landscaping, (v) housekeeping etc. in the office premises as well as in two housing complexes. The Section also renders their services in renovation, modification and extension works of various laboratories according to their requirements.

8.10 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.

8.11 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 reception counter of the Section usually attends the visitors. The Section maintains telephone lines, extensions and cables with the help of Building Maintenance Electrical Division and processes the monthly Telephone Bills of Institute through proper channel. Updating of Telephone Directory at Website is carried out routinely.

8.12 Auditorium Complex

The SINP Auditorium Complex is mainly used for holding various programmes, seminars, symposium, Conferences of national and international stature, etc. 141 Programmes Held during 2010-11.

8.13 Guest House

Guest House provides accommodation in 4 rooms with double occupancy throughout the year. Student hostel provides accommodation of 13 Girl student and 36 Boy students. There is separate canteen facility for the students only. These facilities for the students are provided throughout the year.

8.14 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.

Chapter 9

Administration

9.1 Council Members

Dr Srikumar Banerjee
Chairman, Atomic Energy Commission &
Secretary to the Government of India
Department of Atomic Energy
Anushakti Bhawan
CSM Marg, Mumbai-400 001

Smt Revathy Iyer
Joint Secretary (R&D) to the
Government of India
Department of Atomic Energy
Anushakti Bhawan
CSM Marg, Mumbai-400 001

Shri VR Sadasivam, IDAS
Joint Secretary (Finance)
Govt of India
Department of Atomic Energy
Anushakti Bhawan
CSM Marg, Mumbai-400 001

Professor PK Kaw
Director
Institute for Plasma Research
Near Indira Bridge Ghat
Gandhinagar-382242

Professor Mustansir Barma
Director
Tata Institute of Fundamental Research
Colaba, Homi Bhabha Road
Mumbai-400 005

Professor Amitava Raychaudhuri
Palit Professor of Physics
University of Calcutta
92, Acharya Prafulla Chandra Road
Kolkata-700 009

Shri Satish Chandra Tewary, IAS
Principal Secretary
Higher Education Department
Government of West Bengal
Bikash Bhavan, Room no 604, 6th Floor
Salt Lake, Kolkata-700 091

Professor Dhrubajyoti Chattopadhyay
Pro Vice-Chancellor (Academic)
University of Calcutta, Senate House
87/1, College Street
Kolkata-700 073

Prof Susanta Sen
Professor,
Institute of Radiophysics & Electronics
and
Deputy Director
Centre for Research in Nanoscience and Nanotechnology
University of Calcutta
92, Acharya Prafulla Chandra Road
Kolkata-700 009

Professor Milan K Sanyal
Director
Saha Institute of Nuclear Physics
Sector-I, Block-AF, Bidhannagar
Kolkata-700 064

Mr VV Mallikarjuna Rao (Ex-Officio Secretary)
Registrar
Saha Institute of Nuclear Physics
Sector-I, Block-AF, Bidhannagar
Kolkata-700 064

9.2 Audited Accounts

SAHA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2011

	Schedule	2010-11	2009-10
INCOME : -			
Income from Sales/Services	8	595260.00	78960.00
Grants	9	694193494.78	730731939.26
Interest Earned	10	16410804.00	8038216.00
Other Income	11	4513072.00	2700168.00
Excess of Expenditure over Income transferred to Capital Fund		516591414.30	162686054.08
		1232304045.08	**904235337.34**
EXPENDITURE : -			
Establishment Expenses	12	807647602.00	528371206.00
Administrative Expenses	13	210688498.78	163879046.26
Interest/Bank charges	14	52893.00	23846.00
Depreciation	5	213915051.30	211961239.08
		1232304045.08	**904235337.34**

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

(Milan K. Sanyal)
Director

In terms of our attached Report of even date
For Nemani Garg Agarwal & Co
CHARTERED ACCOUNTANTS

(Nirmal Kr. Pal)
Partner
Membership No. 11277
135, B R Basu Road,
2nd Floor, Kolkata - 700001
Dated :- 25th October, 2011

Nemani Garg Agarwal & Co KOLKATA Chartered Accountants

SAHA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2011

	Schedule	2010-11	2009-10
CAPITAL FUND & LIABILITIES			
CAPITAL FUND	1	471596119.37	535,279,262.02
CAPITAL RESERVE	2	7116996.30	7,116,996.30
EARMARKED FUNDS	3	24285445.00	22,482,568.00
CURRENT LIABILITIES AND PROVISIONS	4	**2652865831.69**	2,006,291,015.25
TOTAL		**3155864392.36**	**2571169841.57**
ASSETS			
FIXED ASSETS			
Gross Block	5	2781459183.90	2,346,438,382.25
Less : Accumulated Depreciation	5	1060751456.38	846836405.08
		1720707727.52	1499601977.17
INVESTMENT	6	370908556.00	212458448.00
CURRENT ASSETS, LOANS & ADVANCES	7	**1064248108.84**	859109416.40
TOTAL		**3155864392.36**	**2571169841.57**
SIGNIFICANT ACCOUNTING POLICES	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

(Milan K. Sanyal)
Director

In terms of our attached Report of even date
For Nemani Garg Agarwal & Co
CHARTERED ACCOUNTANTS

(Nirmal Kr. Pal)
Partner
Membership No. 11277
135, B R Basu Road,
2nd Floor, Kolkata - 700001
Dated :- 25th October, 2011

SAHA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Account for the year ended 31st March, 2011

Receipts	2009-10	2010-11	Payments	2009-10	2010-11
Opening Balance b/f :-					
Cash in hand	199,868.00	409,422.00	Establishment Expenses	360,475,206.00	424,330,602.00
Current Account Balances	81,577,182.12	268,304,075.73	Administrative Expenses	157,160,299.26	208,667,335.78
			Bank Charges	23,846.00	52,893.00
Grant-in-aid received from DAE :-			Assets	439,070,817.71	435,020,801.65
Recurring	526,700,000.00	469,000,000.00	Expenses paid for ongoing projects of other agencies	44,338,665.92	93,762,932.21
Non-Recurring	815,000,000.00	700,000,000.00	HBA & Other Advances paid	3,100,149.00	1,083,630.00
			Investment	202,597,165.00	158,450,108.00
Grant received from other agencies			Margin Money deposit	183,794,821.00	292,069,396.00
for on going projects	107,418,650.50	332,800,445.00	Other Deposit	60,079,760.00	348,500.00
HBA & Other Advance recovery	3,020,470.00	3,764,574.00	Advances paid	159,229,256.00	
Realisation of Margin Money Deposit	396,343,162.00	234,767,306.21	Last Year's provision paid	9,806,780.00	6,574,842.00
Realisation of other advances		6,284,804.00	Last Year's current liabilities paid	55,280,854.00	1,737,513.00
Interest Received	8,038,216.00	16,410,804.00			
Income Receipts	2,779,128.00	5,108,332.00	Closing Balance c/f :-		
Pension Fund Receipts	2,594,441.00	3,465,654.00	Cash in hand	409,422.00	198,788.00
			Current Account Balances	268,304,075.73	418,018,075.30
	1,943,671,117.62	**2,040,315,416.94**		**1,943,671,117.62**	**2,040,315,416.94**

(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
Membership No. 11277
135, B R Basu Road, 2nd Floor, Kolkata 700001
Dated :- 25th October, 2011

9.3 Purchase Section

Order Placed by Purchase Section

Year	Domestic Order
2010-11	1153
Year	Domestic Order
2010-11	????

9.4 Members of the Institute

Prof Milan Kumar Sanyal : Director

DIRECTOR'S OFFICE

1. Sri Amalesh Chandra Saha : AAO(DO)
2. Sri Jeevan Kr Shaw : AAO(DO)
3. Sri Subhasish Ghosal : UDC
4. Sri Gautam Mandal : UDC
5. Sri Ratan Lal Ram : Technician B
6. Sri Babu Rajak : Helper A

REGISTRAR'S OFFICE

1. Sri VV Mallikarjuna Rao : Registrar
2. Sri Biplab Kumar Ray : AAO (E-I)
3. Sri Bimilesh Kr Tripathi : Jr Hindi Translator
4. Sri Bibekbijay Bandyopadhyay : UDC
5. Sri Rudal Prasad Ram : Technician C
6. Sri Mahadev Das : Helper E

Academic Departments and Divisions

ASTROPARTICLE PHYSICS & COSMOLOGY (APC)

1. Prof Pijushpani Bhattacharjee : Professor 'H' & HOD
2. Prof Parthasarathi Majumdar : Sr Professor 'H+'
3. Prof Debades Bandyopadhyay : Professor 'G'
4. Prof Debasish Majumdar : Professor 'F'
5. Prof Ambar Ghosal : Professor 'F'
6. Prof Mala Das : Asso Prof 'E'
7. Shri Nilanjan Biswas : Scientific Assistance 'B'

THEORY DIVISION

1. Prof Anjan Kundu : Sr Professor 'H+' & HOD
2. Prof Kamales Kar : Sr Professor 'H+'
3. Prof Radhey Shyam : Sr Professor 'H+'
4. Prof Parthasarathi Mitra : Sr Professor 'H+'newline 5. Prof Avaroth Harindranath : Sr Professor 'H+'
6. Prof Palash B Pal : Sr Professor 'H+'
7. Prof Gautam Ghosh : Sr Professor 'H'
8. Prof Tarun Kanti Roy : Professor 'G'
9. Prof Asit Kr De : Professor 'G'
10. Prof Kumar Sankar Gupta : Professor 'G'
11. Prof Shibaji Roy : Professor 'G'
12. Prof Gautam Bhattacharyya : Professor 'G'
13. Prof Munshi Golam Mustafa : Professor 'G'
14. Prof Debabrata Mukhopadhyay : Professor 'F'
15. Prof Bireswar Basu Mallick : Professor 'G'
16. Prof Prakash Mathews : Professor 'F'
17. Prof Harvendra Singh : Professor 'F'
18. Prof Bijay Kr Agrawal : Professor 'F'
19. Prof Amit Ghosh : Professor 'F'
20. Sm Dola Mallick : Superintendent
21. Smt Sangita Pande : Scientific Assistant 'B'
22. Sri Prodyut Kumar Mitra : Technician 'E'
23. Sri Sudarshan Hazra : Technician 'A'
24. Sri Arun Kumar Bose : Helper 'E'

PLASMA PHYSICS DIVISION

1. Prof ANS Iyengar : Sr Professor 'H' & HOD
2. Prof Rabindra Nath Pal : Sr Professor 'H'
3. Prof Santwana Roychoudhury : Professor 'G'
4. Prof Nihar Ranjan Roy : Professor 'G'
5. Prof Sujit Kr Saha : Professor 'G'
6. Prof Mylavarapu Sita Janaki : Professor 'G'
7. Prof Nikhil Chakraborty : Professor 'F'
8. Sri Shantanu Chowdhury : Engineer 'F'
9. Sri Parthasarathi Bhattacharya : Scientific Officer 'C'
10. Sri Subhasis Basu : Scientific Officer 'C'
11. Sri Monobir Chattopadhyay : Scientific Officer 'C'
12. Sri Amalendu Bal : Scientific Assistant 'E'
13. Sri Abhijit Betal : Scientific Assistant 'D'
14. Sri Dulal Chatterjee : Superintendent
15. Sri Sib Sankar Sil : Technician 'E'
16. Sri Dipankar Das : Technician 'C'
17. Sri Ashok Kumar Ram : Helper 'B'

AMS DIVISION

1. Prof Alokmay Dutta : Professor 'G' & HOD
2. Prof Madhusudan Roy : Asso Prof 'E'
3. Prof Supratic Chakraborty : Asso Prof 'E'
4. Prof Mrinmay Kr Mukhopadhyay : Asso Prof 'E'
5. Sri Abhijit Sanyal : Engineer 'G'
6. Sri Shyama Prasad Mallick : Technician 'F'
7. Sri Subhasish Sanyal : Superintendent
8. Sri Provash Halder : Helper 'D'

SURFACE PHYSICS DIVISION

1. Prof Purushottam Chakraborty : Sr Professor 'H' & HOD
2. Prof D Ghosh : Sr Professor 'H'

3. Prof SR Bhattacharyya : Professor 'G'
4. Prof Tapas Kr Chini : Prof 'G'
5. Prof Sangam Banerjee : Prof 'G'
6. Prof Manabendra Mukherjee : Prof 'G'
7. Prof (Sm) S Kundu : Prof 'F'
8. Prof Satyajit Hazra : Prof 'F'
9. Prof Satyaban Bhunia : Prof 'F'
10. Prof Krishnakumar S R Menon : Prof 'F'
11. Dr Biswarup Satpati : Scientist 'E'
12. Sri Avijit Das : Scientific Officer 'C'
13. Sri Subir Roy : Scientific Officer 'C'
14. Sri Susanta Bandyopadhyay : Scientific Officer 'C'
15. Sri Souvik Banerjee : Scientific Assistant 'C'
16. Debraj Dey : Scientific Assistant 'B'
17. Sri Goutam Sarkar : Scientific Assistant 'A'
18. Sri Mukul Ch Das : Superintendent
19. Sri Harendra Nath Jana : Caretaker
20. Sri Gobardhan Jana : Helper 'B'

APPLIED NUCLEAR PHYSICS DIVISION

1. Prof Satyajit Saha : Professor 'G' & HOD
2. Prof Sudeb Bhattacharya : Sr Professor 'H+'
3. Prof (Smt) Bichitra Ganguly : Professor 'G'
4. Prof PMG Nambissan : Professor 'G'
5. Dr Mihir Baran Das : Scientist 'G'
6. Prof Supratik Mukhopadhyay : Professor 'G'
7. Prof Chandi Charan Dey : Professor 'F'
8. Prof (Smt) Nayana Majumdar : Professor 'F'
9. Prof Sandip Sarkar : Professor 'F'
10. Sri Amal Ghosal : Scientific Officer 'C'
11. Sri Pradipta Kumar Das : Scientific Officer 'C'
12 Sri Saibal Saha : Scientific Officer 'C'
13. Sri Haradhan Dhar : Scientific Assistant 'E'
14. Sri Nitish Ch Sarkar : Officer-in Charge
15. Sri Chandra Nath Marik : Scientific Assistant 'C'
16. Smt Soma Roy : Scientific Assistant 'C'
17. Sri Dilip Kr Sardar : Technician 'C'
18. Sri Kuntal Sarkhel : Helper 'B'
19. Sri Prabir Das : Helper 'B'

NUCLEAR PHYSICS DIVISION

1. Prof Polash Banerjee : Professor 'G' & HOD
2. Prof (Smt) Chhanda Samanta : Sr Professor 'H'
3. Prof Padmmanava Basu : Professor 'G'
4. Prof (Smt)Maitreyee Saha Sarkar : Professor 'G'
5. Prof Subinit Roy : Professor 'G'
6. Prof Ashimananda Goswami : Professor 'G'
7. Prof (Smt) Ushasi Datta Pramanik: Professor 'F'
8. Prof Chinmay Basu : Professor 'F'
9. Prof (Smt) Anjali Mukherjee : Professor 'F'
10. Sri Sujib Ch Chattopadhyay : Scientific Officer 'C'
11. Sri Kaushik Chatterjee : Scientific Officer 'C'
12. Smt Jonaki Panja : Scientific Officer 'C'
13. Sri Ajoy Kumar Mitra : Scientific Officer 'C'
14. Smt Rita Ghosh : Scientific Assistant 'E'
15. Sri Dilip Sil : Scientific Assistant 'D'
16. Sri Pradip Barua : Technician 'B'
17. Sri Sankar Prasad Singh : Technician 'B'
18. Sri Siladitya Chakraborty : Helper 'A'

HIGH ENERGY NUCLEAR & PARTICLE PHYSICS DIVISION

1. Prof Sunanda Banerjee : Professor & HOD
2. Prof Pratap Bhattacharya : Professor 'G'
3. Prof Sukalyan Chattopadhyay : Professor 'G'
4. Prof Pradip Kr Roy : Professor 'F'
5. Prof Abhee Kanti Dutt-Mazumder : Professor 'F'
6. Prof Manoj K Sharan : Professor 'F'
7. Dr (Smt) Tinku Sinha : Scientist 'D'
8. Prof Satyaki Bhattacharya : Asso Prof 'E'
9. Prof Subir Sarkar : Asso Prof 'E'
10 Prof Suchandra Dutta : Asso Prof 'E'
11 Prof Debasish Das : Asso Prof 'E'
12. Sri Dipankar Das : Scientific Assistant 'C'
13. Smt Lipy Paul : Scientific Assistant 'C'
14. Sri Sanjib Kr Mondal : UDC
15. Sri Rakesh Kr Ram : Helper 'B'
16. Sri Sudam Bagdi : Helper 'B'

THEORETICAL CONDENSED MATTER PHYSICS DIVISION

1. Prof BK Chakrabarti : Sr Professor 'I' & HOD
2. Prof Atindra Nath Das : Professor 'H'
3. Prof Asok K Sen : Professor 'G'
4. Prof SN Karmakar : Professor 'G'
5. Prof Sudhakar Yarlagadda : Professor 'G'
6. Prof Pradeep Kr Mohanty : Professor 'F'
7. Prof Abhik Basu : Professor 'F'
8. Prof Arti Garg : Asso Prof 'E'
9. Sri PS Bhattacharjee : Sr Superintendent
10. Sri Kausik Das : Scientific Assistant 'C'
11. Sri Jhantu Mallick : Helper 'B'
12. Sri Asish Ram : Helper 'B'

EXPERIMENTAL CONDENSED MATTER PHYSICS DIVISION

1. Prof R Ranganathan : Professor 'H' & HOD
2. Prof Amitabha Ghosh Ray : Professor 'H'
3. Prof Kamal Kr Bardhan : Professor 'H'
4. Prof Abu Ismail Jaman : Professor 'H'
5. Prof (Mrs) Kajal Ghosh Ray : Professor 'H'
6. Prof Chandidas Mukherjee : Professor 'G'
7. Prof Sailendra Nath Das : Professor 'G'
9. Prof Indranil Das : Professor 'G'
8. Prof Prabhat Kr Mondal : Professor 'G'
9. Prof (Mrs) Barnana Pal : Asso Prof 'F'
10. Prof Asok Podder : Asso Prof 'F'
11. Prof Bilwadal Bandyopadhyay : Asso Prof 'F'
12. Prof Chandan Mazumdar : Asso Prof 'F'
13. Sri Ajoy Kumar Bhattacharya : Scientific Officer 'C'
14. Sri Tapan Kr Pyne : Scientific Officer 'C'
15. Sri Arun Kumar Pal : Technician 'G'
16. Sm Sankari Chakrabarti : Scientific Assistant 'D'
17. Sri Arindam Chakraborti : Scientific Assistant 'C'
18. Sri Dhrubajyoti Seth : Scientific Assistant 'C'
19. Smt Papia Bhowmik (Mondal) : Scientific Assistant 'B'
20. Sri Anish Karmahapatra : Technician 'E'
21. Sri Tapan Kr Sarkar : Superintendent
22. Sri Sambu Hembram : Technician 'C'
23. Sri Prabir Das : Technician 'B'
24. Sri Patit Paban Ranjit : Helper 'E'
25. Sri Rajeshwar Dubey : Trainee-Helper

CRYSTALLOGRAPHY & MOLECULAR BIOLOGY DIVISION

1. Prof Nitai Pada Bhattacharyya : Professor 'H'& HOD
2. Prof (Smt) Sanghamitra Raha : Professor 'G'
3. Prof Rahul Banerjee : Professor 'F'
4. Prof (Sm) Sampa Biswas : Professor 'F'
5. Prof Partha Saha : Professor 'F'
6. Prof Udayaditya Sen : Professor 'F'
7. Sri Utpal Basu : Scientific Officer 'C'
8. Sri Abhijit Bhattacharya : Scientific Assistant 'D'
9. Sri Bikram Nath : Scientific Assistant 'C'
10. Sri Sushanta Debnath : Scientific Assistant 'C'
11. Sri Saikat Mukhopadhyay : Scientific Assistant 'C'
12. Sri Ashis Kumar Dutta : Scientific Assistant 'B'
13. Smt Durga Hazra : Superintendent

14. Sri Samir Kr Majumdar : Technician 'C'
15. Sri Chinmoy Chatterjee : Helper 'D'
16. Sri Sakal Dev Ram : Helper 'C'
17. Sri Bipin Bose : Helper 'B'

STRUCTURAL GENOMICS DIVISION

1. Prof Subrata Banerjee : Professor 'G'& HOD
2. Prof Abhijit Chakraborty : Professor 'G'
3. Prof Debashis Mukhopadhyay : Professor 'F'
4. Prof Oishee Chakrabarti : Asso Prof 'E'
5. Sri Raju Dutta : Technician 'B'
6. Sri Madhu Sudan Samal : Asstt Halwai-cum-Cook
7. Sri Sanjay Shaw : Helper 'B'

BIOPHYSICS DIVISION

1. Prof Dipak Dasgupta : Sr Professor 'H+' & HOD

2. Prof Dhananjay Bhattacharyya : Professor 'G'
3. Prof Arun Kr Pal : Professor 'F'
4. Prof Kaushik Sengupta : Asso Prof 'E'
5. Sri Sekhar Bhattacharya : Scientific Officer 'C'
6. Sri Arijit Pal : Scientific Assistant 'D'
7. Sri Bijay Kr Das : Superintendent
8. Sri Nirmal Ch Das : Technician 'B'
9. Sri Shyamal Ch Digar : Helper 'B'

CHEMICAL SCIENCES DIVISION

1. Prof Soumen Basak : Professor 'H' & HOD

2. Prof Amitabha De : Professor 'G'
3. Prof Susanta Lahiri : Professor 'G'
4. Prof (Sm) Samita Basu : Professor 'G'
5. Prof (Sm) Maitreyee Nandy : Professor 'F'
6. Prof (Sm) Munna Sarkar : Professor 'F'
7. Prof Padmaja Prasad Mishra : Asso Prof 'E'
8. Sri Ajay Das : Scientific Assistant 'E'
9. Sm Chitra Raha : Scientific Assistant 'D'
10. Sri Avijit Shome : Scientific Assistant 'C'
11. Sri Subir Bandyopadhyay : Sr Assistant
12. Sri Bablu Ram : Technician 'C'
13. Sri Deepak Kr Ram : Technician 'A'
14. Sri Jiitendra Nath Roy : Technician 'A'

TEACHING

Prof Alokmay Datta : Professor 'G' & HOD

1. Dr BB Bal : Scientist 'G'
2. Sri Jayant Kr Mukherjee : Scientific Assistant 'C'
3. Sri Sudarshan Mondal : Sr Assistant
4. Sri Nirmal Ch Biswas : Technician 'B'

Central Facilities

Computer

Prof Asit Kr De : Professor 'F' & 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 'C'

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 Singh Bahadur Thapa : Helper 'B'

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.Shri Mahesh Hembrom : Scientific Assistant 'B'
6.Smt Man Lun Ching : Scientific Assistant 'B'
7.Sri Subrata Chowdhury : Technician 'E'
8.Smt Anupama Saha : Technician 'B'
9.Sri Manoj Karmakar : Technician 'C'
10.Sri Kishori Lal Ram : Technician 'B'
11.Sri Kartick Ch Panigrahi: Helper 'B'

Centre for Advanced Research & Education (CARE)

Prof Abhijit Chakraborti: Professor 'G' & Head

1.Smt Dipa Dasgupta : Scientific Officer 'C'
2.Sri Amit Kumar Saha : 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'

Workshop

Prof Manabendra Mukherjee: Professor 'F' & Chairman

1.Dr Jisnu Basu : Engineer 'F' & Officer-In-Charge
2.Sri Asit Kr Mondal : Technician 'H'
3.Sri Sadananda Dutta : Technician 'G'
4.Sri Ramen Jana : Technician 'F'
5.Sri Sudipta Barman : Scientific Assistant 'C' (Fitter)
6.Sri Debasish Sen : Technician 'F'
7.Sri Supriya Mondal : Technician 'F'
8.Sri Biplab Kr Dey : Technician 'E'
9.Sri Partha Sarathi Karmakar: Technician 'F' (Turner)
10.Sri Narayan Chandra Dey : SA-A (CNC Operator)
11.Sri Tarun Tapan Biswas : Technician 'E' (Fitter)
12.Sri Gopal Kr Chatterjee : Technician 'E'(Eng.Stores)
13.Sri Ramkrishna Roy : Technician 'E' (Machinist)
14.Sri Bhairab Ch Nath : Technician 'D' (Mil. Fitter)
15.Sri Sunil Das : Technician 'D' (Mil. Fitter)
16.Sri Durlav Tudu : Technician 'D' (Turner)
17.Sri Subrata Baidya : Technician 'D' (Machinist)
18.Sri Sadip Patra : Technician 'C' (Welder)
19.Sri Himadri Chakraborty : Technician 'C' (Machinist)
20.Sri Subal Ch Bindi : Technician 'C'
21.Shri C Palanivel : Technician 'C' (Glass Blower)
22.Sri Adhir Sarkar : Technician 'B'
23.Sri Santosh Kr Barman : Caretaker
24.Sri Deb Prasad Sardar : Helper 'E'
25.Sri Gopal Das : Helper 'B'

Building Maintenance (Electrical)

Prof PMG Nambissan : Chairman, BM(Electrical)

1.Sri Debi Prasad Ghosh : Engineer 'G'

2.Sri Kamal Prakash Panja : Scientific Officer 'D'
3.Sri Paresh Ch Majumdar : Scientific Assistant-E
4.Sri Swapan Kr Mandal : Scientific Assistant-D
5.Sri Somenath Ghosh : Scientific Assistant-C
6.Sri Saral Guha : Technician 'G'
7.Sri Sujit Kr De : Technician 'G'
8.Sri Kali Kanto Dey : Technician 'F'
9.Sri Madhusudan Kaity : Technician 'F'
10.Sri Asok Kr Majumdar : Technician 'E'
11.Sri Kalyan Paul Roy : Technician 'D'
12.Sri Gautam Kr Sabui : Technician 'C'
13.Sri Pratap Dhanuk : Technician 'C'
14.Sri Dilip Kr Chakraborty: Technician 'C'
15.Shri Jai Prakash Tiwari : Technician 'B'
16.Sri Jagannath Mondal : Technician 'B'
17.Sri Mahendra M Khapekar : Technician 'C'
18.Sri Dilip Ram : Helper 'E'
19.Sri Bijay Ram : Helper 'C'
20.Sri Sankar Adhikari : Helper 'B'

Building Maintenance (Civil)
Prof Ashimananda Goswami: Chairman, BM(Civil)

1.Sri Rajkumar Sengupta : Engineer 'E'
2.Sri Subha Sankar 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.Shri Sujoy Halder : Scientific Assistant 'B'
7.Sri Asok Kumar Das : Technician 'F'
8.Sri Sisir Kumar Mondal : Tech 'E' (Structural Draftsman)
9.Sri Sunil Murmu : Technician 'C'
10.Sri Subir Modak : Upper Division Clerk
11.Sri Samir Kr Chakraborty: Caretaker (Mali)
12.Sri Dulal Dey : Helper 'E' (Mali)
13.Sri Shyamal Kr Bose : Helper 'E'

Administrative Departments

Establishment
1.Sri Suchintya Kumar Gupta: Establishment Officer on deputation in ISI

2.Sri Alok Mitra : AAO(Establishment)
3.Sri Prasanta Kr. Das : Sr Superintendent
4.Smt Chandana Basu : Sr Superintendent
5.Sri Biswajit Dutta : Accountant
6.Sri Asim Haldar : Upper Division Clerk
7.Sri Subhash Ch. Gayen : Technician 'B'
8.Sri Rajeswar Roy : Driver - V
Despatch 1.Smt Chandana Mitra : Sr Superintendent
2.Sri Tapan Chakraborty : Superintendent
3.Sri Swadesh Ch. Deb : Upper Division Clerk
4.Sri Tarak Nath Bhattacharya: Technician 'B'
5.Shri Pintu Ram : Helper 'B'

Accounts
1.Sri Niladri Sanyal : Dy Controller of Accounts
2.Shri Ved Prakash Mishra : Accounts Officer

Accounts (Budget & Audit)
1.Sri Mrityunjoy Dey : AAO(Budget)
2.Sri Somnath Sarkar : Accountant
3.Sri Pradip Dutta Sharma : Lower Division Clerk

Accounts (Cash)
1.Sri Swarup Kr Bose : AAO(Cash)
2.Shri Raghunath Naskar : Senior Assistant
3.Sri Avijit Saha : Upper Division Clerk
4.Smt Seethalakshmi Rath : Upper Division Clerk
5.Sri Sanat Kumar Kotal : Technician 'B'

Accounts (Salary)
1.Sri Rammohan Moitra : AAO(Salary)
2.Sri Ashoke Maity : Sr Superintendent
3.Sm Nirupama Halder : Upper Division Clerk
4.Smt Monika Bhattacharya : Lower Division Clerk
5.Sri Madhu Bose : Helper 'E'
6.Sri Kartick Hari : Helper 'E'

Accounts (Bill)
1.Sri Asit Ranjan Deb : AAO(Bills)

2.Sri Tapan Kr Bhattacharyya: Sr Superintendent
3.Smt Tultul Dutta : Superintendent
4.Sri Goutam Ghosh : Senior Assistant
5.Sri Biswanath Paul : Helper 'E'
6.Shri Pradip Ram : Asst Halwai-cum-cook

Accounts (PF & Pension)
1.Sri Niranjan Sarkar : AAO(PF & Pension)

2.Sri Ranjit Dutta : Superintendent
3Sri Pradip Kr Das : Driver - V

Purchase 1.Smt Seema Bhattacharyya : AO-III & Off-In-Charge of Purchase Cell

Purchase (Domestic Cell)
1.Sri Sanjoy Chakraborty : APO(Purchase-Domestic)
2.Sri Asim Krmar Sarkar : Sr Superintendent
3.Sri Gautam Das : Superintendent
4.Sri Ajoy Kumar Biswas : Senior Assistant
5.Ms Rekha Ram : Upper Division Clerk
6.Sri Ashoke Kr Roy : Technician 'A'

Purchase (Foreign Cell)
1.Sri JS Raychaudhuri : APO (Purchase-Foreign)

2.Sri Sankar Nath Dewan : Sr Superintendent
3.Sri Debasish Das : Sr Superintendent
4.Sri Ranjit Roy : Sr Assistant
5.Sri Gour Hari Das : Helper 'E'

Stores
1.Sri Shyamal Ch Biswas : Superintendent
2.Sri Ramesh Hari : Helper 'C'

Medical Unit
Prof Abhijit Chakrabarti: Chairman, MAC

1.Dr Sumalay Kar : Part-time Attending Physician
2.Dr Arup Kumar Sahu : Part-time Attending Physician
3.Smt Dipali Saha : Sr Superintendent
4.Sri Gautam Dutta : Technician 'E'
5.Sri Gobinda Chakraborty : Superintendent
6.Sri Dipak Kr. Das : Superintendent
7.Sm Suparna Das : Senior Assistant
8.Smt Chandana Nayak : Lower Division Clerk
9.Sri Nabin Kumar Halder : Technician 'B'

Telephone
Prof (Smt) Samita Basu : Prof & In-Charge

1.Smt Sunanda Chakraborty : Technician 'F'
2.Smt Bithi Biswas : Technician 'E'
3.Smt Pampa Bhattacharjee : Technician 'C'

Auditorium Management Section
Smt Seema Bhattacharyya : Officer-In-Charge

1.Sri Sushanta Chakraborty: Scientific Assistant-E

Security (Cosmetic)
1.Sri Badal Hari : Helper 'E' (Sweeper)
2.Sri Sakhi Chand Hari : Helper 'E' (Sweeper)
3.Sri Banarshi Mallick : Helper 'E' (Sweeper)
4.Sri Siblal Hari : Helper 'D' (Sweeper)
5.Smt Anjali Hari : Helper 'C' (Sweeper)
6.Sri Gobinda Ch Das : Helper 'C' (Sweeper)
7.Sri Santosh Hari : Helper 'B' (Sweeper)
8.Sri Ashok Mallick : Helper 'B'
9.Sri Kala Chand Hela : Helper 'B' (Sweeper)
10.Sri Amit Hari : Helper 'A'

Security (Gardener)
1.Sri Gangadhar Maity : Tech 'E' (Supervisor Mali)
2.Sri Sushil Kr De : Helper 'E' (Mali)
3.Sri Santosh Kr Sarkar : Helper 'E' (Mali)
4.Sri Kamala Kanta Sarkar : Helper 'E' (Mali)
5.Sri Santosh Kr Bachar : Helper 'E' (Mali)
6.Sri Swapan Kr Mondal : Helper 'E' (Mali)
7.Sk Mostakin : Helper 'B'

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 Chandra Nath : Security Supervisor-A
8.Sri Gobinda Ch Roy : Lower Division Clerk
9.Sri Balli Rana : Technician 'A'
10.Sri Dukha Krishna Reddy : Technician 'A'
11.Sri Subrata Kr Chowdhury: Technician 'A'
12.Sri PB Thapa : Helper 'E' (Watchman)
13.Sri Joyram Murmu : Helper 'E' (Watchman)
14.Sri Madhusudan Bhakta : Helper 'E' (Watchman)
15.Sri Sudhangsu Sekhar Mondal: Helper 'D' (Watchman)
16.Sri Swapan Mukherjee : Helper 'D'
17.Sri Mongol Oraon : Helper 'D' (Watchman)
18.Sri Sibu Oraon : Helper 'C' (Watchman)
19.Sri Tapan Kr Sinha : Helper 'C' (Watchman)
20.Sri Sudhir Kr Debnath : Helper 'C' (Watchman)
21.Md Manayar Hasan Mondal : Technician 'A'
22.Sri Ranjit Kr Roy : Helper 'C' (Watchman)
23.Sri Arun Kumar Dutta : Helper 'B' (Watchman)
24.Sri Pran Gopal Das : Helper 'C' (Watchman)
25.Sri Gopal Chandra Saren : Helper 'C' (Watchman)

Transport
Prof Subrata Banerjee : Chairman, Transport Committee
Sri Kaushik Chatterjee : Officer-in-Charge, Transport Sec

1.Sri Dharmendra Prasad : Scientific Assistant-C
2.Sri Aloke Kr Sarkar : Transport Supervisor & Driver - V
3.Sri Swapan Kumar Mondal : Technician 'G'
4.Sri Trinath Maharana : Technician 'E'(Vehi Mech)
5.Sri Surai Mandi : Technician 'C'(Vehi Mech)
6.Sri Kanai Lal Malakar : Technician 'C'
7.Sri Gouri Sankar Singh : Driver - V
8.Sri Tarak Nath Ghosh : Driver - IV
9.Sri Dilip Baidya : Driver - IV
10.Sri Madhusudan Mondal : Driver - IV
11.Sri Gopal Ch Ghosh : Driver - III
12.Sri Uttam Kr Roy : Driver - II
13.Sri Kartick Ch Pal : Driver - II
14.Sri Prabir Kr Mistri : Driver - III
15.Sri Prabir Biswas : Driver - II
16.Sri Asit Kr Mahapatra : Technician 'B'
17.Sri Mongol Ch Mondal : Helper 'E'
18.Sri Sankar Ram : Helper 'B'

Guest House & Hostel
Prof Satya Ranjan Bhattachary: Prof-in-Charge, Guest House & Hostel, SINP Housing Com.(MSA-II)
Prof Nihar Ranjan Ray : Prof-In-Charge, Guest House & Hostel, Salt Lake Campus (MSA-I)

1.Shri Ramesh Singh : Helper 'B'
2.Sri Somenath Das : Helper 'B'
3.Smt Suro Mahato : Helper 'B'
4.Sri Suresh Ch Das : Asstt Halwai-cum-cook
5.Sri Sakti Pada Bisui : Asstt Halwai-cum-cook

Canteen (Salt Lake Campus)
Prof Dhananjay Bhattacharyya : Chairman, Canteen Committee

1.Sri Ashok Roy : Asstt Manager-cum-Storekeeper
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 Mistri : Asstt Halwai-cum-cook
6.Sri Shankar Andia : Asstt Halwai-cum-cook
7.Sri Sailen Halder : Bearer-II
8.Sri Nemai Ch Das : Bearer-II

9.Sri Amar Das : Bearer-II
10.Sri Barun Kr Barua : Bearer-II
11.Sri Subodh Kr Pradhan : Bearer-I

List of Retirement 2010-2011

Sl No	*Name*	*Division/Section*	*Date of Retirement*
1	Prof Manoranjan Sarkar	NPD	31.05.2010
2	Dr Tapas Kr Mondal	Biophysics	30.06.2010
3	Shri Dulal Ch Ghosal	NPD	31.01.2011
4	Shri Nepal Ch Mitra	BM(Elec)	31.01.2011
5	Shri Tapan Kr Ray	Biophysics	28.02.2011
6	Shri Ajoy Sarkar	Transport	31.03.2011
7	Prof (Smt) Chandana Chakraborty	C&MB	31.03.2011

Chapter 10

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Index

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