National Level Academic Review

A Report for the period 2012-2017

- APPLIED NUCLEAR PHYSICS DIVISION (ANPD)
- HIGH ENERGY NUCLEAR AND PARTICLE PHYSICS (HENPP) DIVISION
- NUCLEAR PHYSICS DIVISION (NPD)
- PLASMA PHYSICS DIVISION (PPD)

National Level Academic Review

APPLIED NUCLEAR PHYSICS DIVISION (ANPD)

A Report for the period 2012-2017

APPLIED NUCLEAR PHYSICS DIVISION (ANPD)

Present staff of the division:

Scientific		Technical		Adm / Auxiliary	
Satyajit Saha	Senior Professor	Shaibal Saha	Scientific Officer	Suparna Das	Superintendent
Supratik Mukhopadhyay	Senior Professor	Pradipta Kumar Das	Scientific Officer	Kuntal Sarkhel	Helper
P.M.G. Nambissan	Senior Professor	Chandranath Marick	Scientific Assistant	Prabir Das	Helper
Chandi Charan Dey	Professor	Soma Roy	Scientific Assistant		
Nayana Majumdar	Professor	Dilip Kumar Sardar	Technician		
Sandip Sarkar	Professor				
Sankar De	Associate Professor				

Present Post Doctoral and Visiting Scientists / Fellows:

Shrabana Chakrabarti, DST Woman Scientist

Ph D degrees awarded and their present positions:

Name	Ph D Supervisor	Degree from	Year degree awarded	Present position
Subhajit Karmakar	Sandip Sarkar	Calcutta University	2013	Faculty at Burdwan University
Debasmita Kanjilal	Satyajit Saha	Jadavpur University	2013	Faculty at Raiganj College
Purba Bhattacharya	Supratik Mukhopadhyay	Calcutta University	2015	Post-doctoral Fellow at Weizmann Institute, Israel.
Ajanta Kundu	Sandip Sarkar	Calcutta University	2015	Faculty at a college in Kolkata
Meghna K K (INO-GTP student)	Satyajit Saha (Joint supervisor)	HBNI	2016	Post-doctoral Fellow at NISER
Hitesh V Rahangdale	Satyajit Saha	HBNI	2016	Post-doctoral Fellow at Racah Institute of Physics, Hebrew Univerity of Jerusalem, Israel.
Rajani Raman	Sandip Sarkar	HBNI	2017	Post-doctoral Fellow at ATR Institute International, Japan.
Deb Sankar Bhattacharya (project student)	Supratik Mukhopadhyay (Joint supervisor)	Jadavpur University	2017	Post-doctoral Fellow at IoP, Bhubaneswar (Received PDF offer from Wuerzburg University, Germany)

List of Present Research Fellows / Ph D students:

Name	Ph D Supervisor	Year of Post M Sc / Graduate Training	Enrolled / Registered in
Sourav Kumar Dey	Chandi Charan Dey Satyajit Saha	2013-14	HBNI
Bankim Chandra Das	Sankar De	2014-15	HBNI
Prasant Kumar Rout	Supratik Mukhopadhyay	2015-16	HBNI
Sridhar Tripathy	Nayana Majumdar	2015-16	HBNI
Arpita Das	Sankar De	2015-16	HBNI
Abhik Jash (INO GTP student)	Nayana Majumdar	2011-12	HBNI
Joydeep Dutta (INO GTP student)	Nayana Majumdar	2015-16	HBNI

Important Equipment and resources in the division:

1. Time Dependent Perturbed Angular Correlation (TDPAC) Spectrometers, one consisting of four Barium Fluoride scintillation detectors and a second station with Lanthanum Bromide [$LaBr_3$(Ce)] scintillation detectors. The laboratory is equipped with sample temperature controller, adjustable between 193 ^{0}K and 1000 ^{0}K, radioactive probe insertion and sample annealing set up under inert atmosphere.
2. Gamma-gamma coincidence set-up using HPGe detectors for Doppler broadening measurements.
3. Positron lifetime spectrometer consisting of Barium Fluoride scintillation detectors.
4. Gaseous ionization detector laboratory, equipped with detectors, gas mixing system, gas analyzer, electronics, data acquisition system, laminar flow table, portable x-ray generator, precision positioning system.
5. Cosmic muon test bench for characterizing resistive plate chamber (RPC) and other detectors, with large area plastic scintillators, indigenously made 4-component gas mixing system, related electronics and data acquisition system.
6. Server laboratory consisting of Blade servers with multiple computing blades and on multiple platforms.
7. Two Vision Research Setup (Cambridge) for conducting Cognitive Science Experiments with human participants.
8. Electron and Xray spectroscopy laboratory equipped with vacuum mounted X-ray detectors, 50 kV DC and pulsed electron beam generator coupled to a large volume UHV chamber.
9. Sample preparation and characterization laboratory consisting of vacuum furnace, UV-VIS-NIR fluorescence and phosphorescence life time spectrometer, dry nitrogen generator for pr samples .
10. Laser spectroscopy and quantum optics laboratory consisting of pump-probe spectroscopy setup to study electromagnetically induced phenomena in atomic Rubidium. The laboratory is equipped with state-of-art facilities like active vibration isolation optical table, external cavity diode lasers, NexTorr getter pump, demountable micro-channel plate and phosphor detector, etc.
11. In-house developed scintillator characterization set-up for dark matter search experiment, consisting of photomultipliers, large area Silicon photomultipliers, temperature controlled environment using Peltier cooler stacks and cryogen based systems.

APPLIED NUCLEAR PHYSICS DIVISION (ANPD):

Research summary / highlights:

Research carried out at the Applied Nuclear Physics Division involves probing the atomic, nuclear, molecular and nanocrystalline systems applying nuclear probes and techniques, lasers, X-rays, electron and ion beams. Molecules of biological importance, intermetallic alloys of technological importance and low-dimensional systems, such as nano-crystalline materials are also being studied to explore their properties. Our members are working on dark matter search experiment, cosmic muon based tomography and developing instruments, experimental techniques and simulation of various aspects for these applications involving interdisciplinary areas of Physics. Development, characterization and optimization of radiation detectors for next generation high energy physics experiments, model based simulation and cognitive science research to understand the details of visual perception are also being carried out in our laboratories.

Laser Spectroscopy and Quantum Optics laboratory is set up at SINP to perform spectroscopic studies on neutral Rubidium atoms using pump-probe spectroscopic techniques. Experiments on Electromagnetically Induced Transparency (EIT) and Electromagnetically Induced Absorption (EIA) in room temperature Rb atoms were carried out, and results are interpreted by assuming V- and Λ-type multi-level systems for ^{85}Rb and ^{87}Rb atoms in D2 and D1 transitions. The results can be used to render the medium opaque and transparent in a controlled way for optical switching applications. Laguerre-Gaussian (LG) beams (optical Vortex beam) were set up using external cavity diode lasers Narrowing of the line shapes of hyperfine transitions were observed for higher orders of the LG beam in comparison to the Gaussian beam. Spatially dependent Rabi frequency plays a significant role behind these narrowing phenomena. Variation of group velocity of light in a coherently prepared atomic medium was observed. Dispersive properties of the ^{87}Rb in D2 transition was studied using balanced homodyne detection technique. Variation of the time delay as well as the group velocity with the intensity of the pump laser was observed.

Using time-differential perturbed angular correlation (TDPAC) technique, studies of point defects, structural and magnetic phase transitions in metallic and inter-metallic systems, thin films and nano-crystalline materials are carried out. Four-detector TDPAC spectrometers with ultrafast BaF_2 and $LaBr_3$(Ce) detectors have been developed for the above purpose. Numerous technological applications of Ni-based Zr and Hf intermetallic alloys have prompted comprehensive studies in Zr_8Ni_{21}, Zr_7Ni_{10}, Zr_9Ni_{11}, Hf_8Ni_{21}, Hf_7Ni_{10} and Hf_9Ni_{11} alloys by perturbed angular correlation (PAC) spectroscopy which were not studied earlier. The different phases produced in the samples have been identified by PAC and X-ray diffraction (XRD) measurements. Using ^{181}Hf probe, various non-equivalent Zr/Hf sites have been observed in these compounds from PAC measurements. Density functional theory (DFT) based calculations of electric field gradient (EFG) and asymmetry parameter (η), at ^{181}Ta probe nucleus allowed us to assign the observed EFG fractions to the various lattice sites in the compounds.

Applying nuclear tools and techniques, the structure and dynamics of crystals, composites, nano-materials and soft condensed matter systems have been probed. Positron annihilation spectroscopy (PAS) was used for the studies of properties and processes related to defects in nanomaterials including metals, alloys, ferrites and semiconductors. An interesting aspect of these studies has been to look for the effect of doping and surface modification by defects and other substitutional elements in a nanocrystalline system. Investigation on several polymeric samples are also carried out for characterization of free volume defects in them and estimating their concentration.

Monte Carlo simulation of electron transport and its effects on inner shell ionization in heavy elements, such as Thorium and Uranium, by electron impact at near threshold energies was done using GEANT4 and PENELOPE. The simulation results are applied to account for systematic effects, such as self-absorption and backscattering of electrons in the elemental media, thereby improving the results on estimation of inner shell ionization cross sections in heavy elements at 15 - 40 keV electron energy. The simulation results are also utilised in the determination of detection efficiency of the X-ray detectors (SDD or Si-PIN diode) using the bremsstrahlung photon spectra. This method is advantageous over the radioactive X-ray emitting source based efficiency measurements as it gives rise to continuous efficiency data points as function of energy.

Our members have successfully implemented the nearly exact Boundary Element Method (neBEM) to solve for potential and flux field in a non-dissipative system governed by Laplace's equation. In an important break-through, we have been able to carry out analytic integration of Green's function (and derivative) for singularities uniformly distributed over typical rectangular and triangular elements through the use of symbolic mathematics. Owing to the exact closed-form foundation expressions, the new method can provide nominally exact results and hence the name. Based on these expressions, a program library, namely Inverse Square Law Exact Solutions (ISLES), has been developed to compute the influences of singularities. Several recent improvements have been made to the solver, including formulating and implementing an algorithm for charging up computations. The efficiency of the solver has been greatly enhanced by implementing OpenMP parallelization, adaptive meshing and fast volume algorithms. The solver has been applied to study the physical as well as weighting field configurations of a diverse group of detectors that includes a few wire chambers, TPC, RPC and several new generation micro-pattern gaseous detectors (MPGD) such as Micro-Wire, Micro MEGAS, THGEM etc. Experimental efforts to study various physics issues in detector dynamics have been initiated with several developments taking place in a brief period of time. A set-up including gas handling system, necessary electronics, data acquisition, several test chambers and couple of simple time projection chambers have been in operation in our Micropattern Gas Detector (MPGD) laboratory. Since last couple of years, we are working on the application-oriented field of cosmic ray muon tomography. Both experimental and numerical simulation tools are being used to explore various possibilities. A stack of position sensitive cosmic muon detectors forming a muon telescope for prototyping cosmic muon tomography is under development.

One of our members is working on computational neuroscience which is an interdisciplinary area involving computational science, cognitive science and various aspects of visual perception. Computational mechanism of filling in at the blind spot of the retina and its associated properties can be understood by taking into account the statistics of natural scene and the computational architecture (Hierarchical Predictive Coding) of the cortex, and demonstrated that several experimentally observed properties of filling-in at the blind-spot could be accommodated under the same computational framework. The findings, in this work, offer new insights into the role of natural scene statistics in our perception and suggest, what is possibly, the first systematic bridge linking anisotropy in three levels: natural environment, visual cortex, and perceptual filling-in at the blind spot. Another related aspect was investigation of the role of noise in visual perception related to contrast sensitivity and orientation selectivity. We have examined the performance of human participants in perpetual tasks with visual stimuli in a noisy environment (stimulus plus noise). Human participants exhibited an increase in sensitivity to increasing noise that attained a maximum for an intermediate noise, which is a typical signature of Stochastic Resonance. Moreover, it was also found that the basic nature of contrast sensitivity and orientation selectivity remained the same in the presence of noise. These results can be utilised for the study of visual impairments in human vision.

Our members, in collaboration with Astroparticle Physics and Cosmology (APC) Division, are working on the development of an underground laboratory in India for dark matter search experiment using scintillation based detectors. The experiment was originally proposed to be placed inside a cavern at the proposed INO laboratory. A scaled down version of the experiment, named as miniDINO is proposed now. This will be set up with a few scintillation crystals as active detectors to be placed at 555 m level of Jaduguda mine of UCIL. The experiment evolved as active collaboration between SINP, BARC, NISER and UCIL (and also INO). First phase of the experiment is to establish the laboratory, measure the radiation background and devise methods of reducing the effects of radiation background. Parallel development of scintillation detectors, their characterization for operation at cryogenic temperatures and optimizing the pulse shape discrimination to distinguish between electron and nuclear recoil events is in progress. Significant work has been done on simulation of the radiation background at the laboratory site by considering penetrating cosmic rays and residual rock radioactivity. Simulation of the detector response to background neutrons and gamma rays is also in progress. Experiments to validate the simulation results will also be done at the underground laboratory and also using radiation sources and beams in the near future.

Year-wise List of Publications of Applied Nuclear Physics Division (since 2012)

2017

1. *Electric field gradients in Zr_8Ni_{21} and Hf_8Ni_{21} intermetallic compounds; results from perturbed angular correlation measurements and first-principles density functional theory*: S. K. Dey, C. C. Dey, S. Saha and J. Belosevic-Cavor, Intermetallics, **84**, 112 (2017).
2. *Identification of phase components in Zr-Ni and Hf-Ni intermetallic compounds; Investigations by perturbed angular correlation spectroscopy and first principles calculations*: S. K. Dey, C. C. Dey, S. Saha, J. Belošević-Čavor and D. Toprek, J. Alloys and Compounds **723**, 425 (2017).
3. *Detecting supernova neutrinos with iron and lead detectors*, Abhijit Bandyopadhyay, Pijushpani Bhattacharjee, Sovan Chakraborty, Kamales Kar and Satyajit Saha, Physical Review D **95**, 065022 (2017).
4. *Positron annihilation studies and complementary experimental characterization of xAg2O-(1-x)(0.3CdO-0.7MoO3) metal oxide glass nanocomposites:* Ranadip Kundu, Sanjib Bhattacharya, Debasish Roy and P.M.G. Nambissan, *RSC Advances* **7,** 8131 (2017).
5. *Experimental and numerical simulation of a TPC like set up for the measurement of ion backflow:* Deb Sankar Bhattacharya, Purba Bhattacharya, Prasant Kumar Rout, Supratik Mukhopadhyay, Sudeb Bhattacharya, Nayana Majumdar, Sandip Sarkar, Paul Colas, David Attie, Serguei Ganjour, Aparajita Bhattacharya, *Nuclear Instruments and Methods in Physics Research A **861,** 64-70 (2017).*
6. *Overview of Large Area Triple-GEM Detectors for the CMS Forward Muon Upgrade:* N. Majumdar, S.Mukhopadhyay in CMS Muon Collaboration author-list, *Nuclear Instruments and Methods in Physics Research A **845,** 298-303 (2017).*
7. *R&D on a new type of micropattern gaseous detector: The Fast Timing Micropattern detector:* N. Majumdar, S.Mukhopadhyay in CMS Muon Collaboration author-list, *Nuclear Instruments and Methods in Physics Research A **845,** 313-317 (2017).*
8. *Studies on GEM modules for a Large Prototype TPC for the ILC:* Deb Sankar Bhattacharya, Purba Bhattacharya, Sudeb Bhattacharya, Nayana Majumdar, Supratik Mukhopadhyay in LCTPC collaboration, *Nuclear Instruments and Methods in Physics Research A **845,** 309-212 (2017).*
9. *A time projection chamber with GEM-based readout*: Deb Sankar Bhattacharya, Purba Bhattacharya, Sudeb Bhattacharya, Nayana Majumdar, Supratik Mukhopadhyay in LCTPC collaboration, *Nuclear Instruments and Methods in Physics Research A **856B,** 109-118 (2017)*
10. *The Triple GEM Detector Control System for CMS Forward Muon Spectrometer Upgrade:* N. Majumdar, S.Mukhopadhyay in CMS Muon Collaboration author-list, Journal of Instrumentation **12,** P02003 (2017).
11. *A new design using GEM-based technology for the CMS experiment:* Nayana Majumdar, S.Mukhopadhyay in CMS Muon Collaboration author-list, Journal of Instrumentation **12,** P02003 (2017).
12. *Significance of Natural Scene Statistics in Understanding the Anisotropies of Perceptual Filling-in at the Blind Spot:* R Raman and S Sarkar, Scientific Reports **7**, 3586 (2017).

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13. *Simultaneous observations of Electromagnetically Induced Transparency (EIT) and Absorption (EIA) in a multi-level V-type system of ^{87}Rb and theoretical simulation of the observed spectra using a multi-mode approach* Bankim Chandra Das, Dipankar Bhattacharyya, Arpita Das, Shrabana Chakrabarti, and Sankar De, Journal of Chemical Physics, 145, 224312 (2016).
14. *Narrowing of Doppler and hyperfine line shapes of Rb - D2 transition using a Vortex beam:* Bankim Chandra Das, Dipankar Bhattacharyya and Sankar De, Chemical Physics Letters, 644, 212 (2016).
15. *Ionic conductivity and free volume related microstructural properties of LiClO4/PVA/NaAlg polymer composites: Positron annihilation spectroscopic studies:* T. Sheela, R.F. Bhajantri, P.M.G. Nambissan, V. Ravindrachary, Blaise Lobod, Jagadish Naik and Sunil G. Rathod, *Journal of Non-Crystalline Solids* **454,** 19 (2016).
16. *Diverse spectroscopic studies and first-principles investigations of the zinc vacancy mediated ferromagnetism in mn-doped zno nanoparticles:* Rajeswari Ponnusamy, Selva Chandrasekaran Selvaraj, Meera Ramachandran, Palanichamy Murugan, Padinharu Madathil Gopalakrishnan Nambissan, and Dhanuskodi Sivasubramanian, *Cryst. Growth and Des.* **16,** 3656 (2016).
17. *Synthesis and characterization of magnesium oxide nanocrystallites and probing the vacancy-type*

defects through positron annihilation studies: Anjan Das, Atis Chandra Mandal, Soma Roy, Pendem Prashanth, Sk Izaz Ahamed, Subhrasmita Kar, Mithun S.Prasad, P.M.G.Nambissan, *Physica E* **83,** 389 (2016).

18. *Mn-doping in NiO nanoparticles: Defects-modifications and associated effects investigated through positron annihilation spectroscopy and other techniques:* Anjan Das, Atis Chandra Mandal, Soma Roy and P.M.G. Nambissan, *J. Nanosci. Nanotech.* **16** 4153 (2016).
19. *Effects of variation of environmental parameters on the performance of Resistive Plate Chamber detectors:* Meghna K. K., S. Biswas, A. Jash, S. Chattopadhyay, and S. Saha, Nuclear Instruments and Methods in Physics Research Section A **816**, 1-8 (2016).
20. *Low temperature structural phase transition in hafnium and zirconium tetrafluoride trihydrates:* S K Dey, C C Dey and S Saha, Journal of Physics and Chemistry of Solids, **91**, 18-24 (2016).
21. *Low temperature structural modification in Rb2ZrF6: Investigations by perturbed angular correlation spectroscopy:* S K Dey, C C Dey and S Saha, Journal of Physics and Chemistry of Solids, 93, 145-156 (2016).
22. *Effects of Zr impurity on microscopic behavior of Hf metal:* S K Dey, C C Dey and S Saha, Journal of Physics and Chemistry of Solids, **95**, 98-105 (2016).
23. *Spectroscopic investigations of L-shell ionization in heavy elements by electron impact:* H V Rahangdale, D Mitra, P K Das, S De, M Guerra, J P Santos and S Saha, Journal of Quantitative Spectroscopy and Radiative Transfer **174**, 79-87 (2016).
24. *Effect of water vapor on the performance of glass RPCs in avalanche mode operation:* K. Raveendrababu, P. K. Behera, B. Satyanarayan, S. Mukhopadhyay, N. Majumdar, Journal of Instrumentation 11, C08001 (2016).
25. *Numerical study on the effect of design parameters and spacers on RPC signal and timing properties:* A. Jash, N. Majumdar, S. Mukhopadhyay, S. Saha, S. Chattopadhyay, Journal of Instrumentation **11,** C09014 (2016).
26. *Effect of Plate Roughness on the field near RPC plates:* A. Jash, N. Majumdar, S. Mukhopadhyay, S. Chattopadhyay, Journal of Instrumentation **11**, C06010 (2016).
27. *Test Beam and irradiation Test Results of Triple-GEM Detector Prototypes for the Upgrade of Muon System of the CMS Experiment:* N. Majumdar, S.Mukhopadhyay in CMS-GEM Collaboration author-list, *Nuclear Instruments and Methods in Physics Research A **824,** 586-588 (2016).*
28. *Status Report of the Upgrade of the CMS Muon System with Triple-GEM Detectors:* N. Majumdar, S.Mukhopadhyay in CMS-GEM Collaboration author-list, Nuclear Instruments and Methods in Physics Research A **824** 521-525 (2016).
29. *Design of a constant fraction discriminator for the VFAT3 front-end ASIC of the CMS GEM detector:* N. Majumdar, S.Mukhopadhyay in the CMS-GEM author-list, *Journal of Instrumentation* **11**, C01023 (2016).
30. *Fiber Bragg Grating (FBG) sensors as flatness and mechanical stretching sensors:* N. Majumdar, S.Mukhopadhyay in CMS-GEM Collaboration author-list, *Nuclear Instruments and Methods in Physics Research A **824,** 493-495 (2016).*
31. *Detailed 3D Simulation of GEM-based Detector:* P. Bhattacharya, S. Biswas, B. Mohanty, N. Majumdar, S. Mukhopadhyay Journal of Physics: Conference Series **759**, 012071 (2016).
32. *Effect of surface roughness on the electrostatic field of an RPC:* A. Jash, N. Majumdar, S. Mukhopadhyay, S. Chattopadhyay, Journal of Physics: Conference Series **759,** 012072 (2016).
33. *Exact solutions to model surface and volume charge distributions:* S. Mukhopadhyay, N. Majumdar, P. Bhattacharya, A. Jash, D. S. Bhattacharya, Journal of Physics: Conference Series **759,** 012073 (2016).
34. *Track distortion in the Large prototype of a Time Projection Chamber for the International Linear Collider:* Deb Sankar Bhattacharya, Purba Bhattacharya, Supratik Mukhopadhyay, Nayana Majumdar, Sudeb Bhattacharya, Sandip Sarkar, Paul Colas, David Attie, Serguei Ganjour, Aparajita Bhattacharya, Journal of Physics: Conference Series **759**, 012075 (2016).
35. *Predictive Coding: A Possible Explanation of Filling-In at the Blind Spot:* R Raman and S Sarkar, PLOS ONE **11(3)**, e0151194 (2016).
36. *Systemic study of a natural feedback loop in Huntington's disease at the onset of neurodegeneration:* Baksi S, Bagh S, Sarkar S, Mukhopadhyay D, BioSystems **150**, 46–51 (2016).

2015

37. *Positron annihilation spectroscopic studies of Mn-substitution-induced cubic to tetragonal transformation in $ZnFe_{2-x}Mn_xO_4$ (x = 0.0–2.0) spinel nanocrystallites*: Jincemon Cyriac, Rahul Mundiyaniyil Thankachan, B. Raneesh, P.M.G. Nambissanc, D. Sanyal and Nandakumar Kalarikkal, *Philos. Mag.* **95,** 4000 (2015).
38. *Cr^{3+}-substitution induced structural reconfigurations in the nanocrystalline spinel compound $ZnFe_2O_4$ as revealed from x-ray diffraction, positron annihilation and Mössbauer spectroscopic studies*: Rahul Mundiyaniyil Thankachan, Jincemon Cyriac, B. Raneesh, Nandakumar Kalarikkal, D. Sanyal and P.M.G. Nambissan, *RSC Advances* **5,** 64966 (2015).
39. *Effect of size on momentum distribution of electrons around vacancies in NiO nanoparticles*: Anjan Das, Atis Chandra Mandal and P.M.G. Nambissan, *Chinese Physics B* **24**, 046102 (2015).
40. *Positron annihilation and other experimental studies on polycarbonate/MPDMAPP nanocomposite:* T. Sheela, R. F. Bhajantri, P.M.G. Nambissan, V. Ravindrachary, Sunil G. Rathod and Boja Poojary, *J. Appl. Polymer Sci.* **132,** 42053 (11pp) (2015).
41. *Positron annihilation studies of defects and fine size effects in nanocrystalline nickel oxide:* Anjan Das, Atis Chandra Mandal, Soma Roy and P.M.G. Nambissan, *Journal of Experimental Nanoscience* **10,** 622 (2015).
42. *Investigation of in-depth and surface properties of polyethyleneterephthalate thin films after SHI and gamma radiation treatment by means of PALS and AFM studies:* Paramjit Singh, Rajesh Kumar and P.M.G. Nambissan, *Vaccum* **115,** 31 (2015).
43. *Positron annihilation spectroscopic studies of multiferroic $Bi_{1-x}Pr_xFeO_3$ nanocrystalline compounds*: Jincemon Cyriac, M.T. Rahul, Nandakumar Kalarikkal and P.M.G. Nambissan, Journal of Physics: Conference Series **618,** 012012 (6pp) (2015).
44. *Selective breaking of bonds in water with intense, 2-cycle, infrared laser pulses*: D. Mathur, K. Dota, D. Dey, A. K. Tiwari, J. A. Dharmadhikari, A. K. Dharmadhikari, S. De, and P. Vasa, Journal of Chemical Physics **143**, 244310 (2015).
45. *Do linear molecules always dissociate along their axis? Intra-molecular scattering within Diiodoacetylene*: Sankar De, H. Tezuka, P. Bhatt, G. Veshapidze, C. P. Safvan, J. Matsumoto and H. Shiromaru, Journal of Physics: Conference Series **635**, 032061 (2015).
46. *Comparison of electromagnetically induced transparency (EIT) spectra for six-level lambda (Λ) and five-level V-type systems:* Dipankar Bhattacharyya, Arindam Ghosh, Amitava Bandyopadhyay, Satyajit Saha and Sankar De, J. of Atomic, Molecular, Condensate & Nano Physics **2**, 93 (2015).
47. *Observation of electromagnetically induced transparency in six-level Rb atoms and theoretical simulation of the observed spectra:* Dipankar Bhattacharyya, Arindam Ghosh, Amitava Bandyopadhyay, Satyajit Saha and Sankar De, J. Physics B: At. Mol. Opt. Phys. **48**, 175503 (2015).
48. *Electric field gradients at ^{181}Ta probe in ZrNi: Results from perturbed angular correlation and first principles calculations*: C. C. Dey, Rakesh Das and S. K. Srivastava, J. Phys. Chem. Solids **82**, 10 (2015).
49. *An unusual structural phase transition in Rb_2HfF_6:* C. C. Dey, J. Phys. Chem. Solids **78**, 12 (2015).
50. *Anomalous magnetic moment at Ba in Au:* A.K. Bhati, J. Kaur, N. Bansal, D. Negi, R. Kumar, R. K. Bhowmik, V. Kumar, C. C. Dey, Nucl. Instrum. Meth. In Phys. Res. B **349**, 125 (2015).
51. *Subshell resolved inner shell ionization cross-sections of High Z elements by electron impact:* H. V. Rahangdale, D. Mitra, M. Guerra, J. P. Santos, S. Saha, Journal of Physics: Conference Series **635**, 052001 (2015).
52. *Observation of a rare cosmic ray event at mountain altitude:* B Basu, S Raha, S Biswas, S Dey, A Maulik, A Mazumdar, S Saha and D Syam, Astroparticle Physics 61, 88 (2015).
53. *Quality control and beam test of GEM detectors for future upgrades of the CMS muon high rate region at the LHC:* S.Mukhopadhyay in the CMS-GEM Collaboration author-list, *Journal of Instrumentation* **10**, C03039 (2015).
54. *Simulation of Efficiency and Time Resolution of Resistive Plate Chambers and Comparison with Experimental Data:* M. Salim, A. Jash, R. Hasan, B. Satyanarayana, N. Majumdar, S. Mukhopadhyay, Journal of Instrumentation **10,** C04033 (2015).
55. *The effect of spacers on the performance of Micromegas: a numerical investigation*: P. Bhattacharya, S. Mukhopadhyay, N. Majumdar, S. Bhattacharya, Nuclear Instrumentation & Methods in Physics Research, **793**, 41-48 (2015).
56. *Measurement and simulation of two-phase CO2 cooling in Micromegas modules for a Large*

Prototype of Time Projection Chamber: Deb Sankar Bhattacharya, David Attie, Paul Colas, Supratik Mukhopadhyay, Nayana Majumdar, Sudeb Bhattacharya, Sandip Sarkar, Aparajita Bhattacharya and Serguei Ganjour, Journal of Instrumentation **10**, P08001 (2015).

57. *Investigation of Ion Backflow in Bulk Micromegas Detectors:* Purba Bhattacharya, Deb Sankar Bhattacharya, Supratik Mukhopadhyay, Sudeb Bhattacharya, Nayana Majumdar, Sandip Sarkar, Paul Colas and David Attie, Journal of Instrumentation **10**, P09017 (2015).
58. *Numerical studies on electrostatic field configuration of resistive plate chambers for the INO-ICAL experiment:* A.Jash, N.Majumdar, S.Mukhopadhyay, S.Chattopadhyay, Journal of Instrumentation **10**, P110009 (2015).
59. *Stochastic Resonance in Visual Sensitivity:* A Kundu, S. Sarkar, Biological cybernetics 109, 241-254 (2015).

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101. *Oxidation of hafnium and diffusion of hafnium atoms in hexagonal close-packed hafnium; microscopic investigations by perturbed angular correlations:* Chandi C. Dey, Z. Naturforsch. 67a, 633 (2012).
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105. *Precipitation behavior investigated through positron annihilation in Sc-doped Al-6Mg followed by the effects of Zr-addition*, R. Sen, P.M.G. Nambissan, M.K. Mitra and M.K.Banerjee, *Physics Procedia* **35,** 34 (2012).
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1. Name – Sankar De

Division – Applied Nuclear Physics

Educational background:

- B. Sc. (Hons. in Physics) 1997 – Dinabandhu Andrews College, University of Calcutta
- M.Sc. (Physics) 1999 – Rajabazar Science College, University of Calcutta, India
- Ph.D. 2007, University of Calcutta (Work done at Inter-University Accelerator Centre, New Delhi)

2. Academic profile including earlier appointments, awards etc.

- Present position – **Associate Professor – E** (from November 2011)
- Postdoctoral Fellow: November 2010 – October 2011, Aarhus University, Denmark
- Research Associate: November 2007 – October 2010, Kansas State University, Manhattan, Kansas, USA

Award:

- **5th ISUILS** (International Symposium of Ultrafast Intense Laser Science) **Award for Young Researchers, 2014.** The award is sponsored by Japan Intense Light Field Science Society (JILS) and presented by the International Committee on Intense Laser Sciences (ICILS)

Visiting positions abroad:

- **Invitation fellowship** (short term) from **Japan Society for the Promotion of Science (JSPS)** to perform research in **Tokyo Metropolitan University, Japan**, November – December, 2013

3. Essential strength of research/development output

1) Laser Spectroscopy of Rubidium atoms

A Laser Spectroscopy Laboratory is newly setup at SINP to perform spectroscopic studies on neutral Rubidium atoms. We have setup multiple optical paths for pump-probe spectroscopy to perform a number of experiments.

a) Study of **Electromagnetically Induced Transparency (EIT) and Electromagnetically Induced Absorption (EIA)** in room temperature Rb atoms have been our major research area till now. We study EIT phenomenon for V and Λ-type multi-level systems with ^{85}Rb and ^{87}Rb atoms in D_2 and D_1 transitions. Recently, we observed the **simultaneous formation of the EIT and the EIA** in a multi-level V-type system **in ^{87}Rb -D_2 transition**. We have simulated the observed spectra theoretically using a multi-mode approach for the coherence terms which enable us to study all the frequency contribution of the pump and the probe individually. Since we can precisely tune our system and render the medium opaque and transparent simultaneously, it can be useful in optical switching applications.

b) **Laguerre-Gaussian (LG) beams** (optical Vortex beam) are characterized by a doughnut-shaped intensity distribution with zero field amplitude at the center. In our first attempt, we tried to understand the effects of the **LG beam on the Doppler and hyperfine line shapes**. We observed narrowing of the line shapes when we used higher orders of the LG beam in comparison to the Gaussian beam. We found out that the spatially dependent Rabi frequency plays a significant role behind these narrowing phenomenon.

c) We observed the **variation of group velocity of light in a coherently prepared atomic medium**. We experimentally investigated the dispersive properties of the ^{87}Rb in D_2 transition using balanced homodyne detection technique. We found out that the time delay as well as the group velocity varies with the intensity of the pump laser. The typical value of the reduced group velocity is recorded as c/130 m/s with a time delay of 21.73 ns.

d) **Optical cooling and trapping of neutral atoms** is the most effective and elegant experimental method in today's atomic physics. With a number of applications in mind, we designed a **Magneto optical trap (MOT) in SINP**. In our MOT, the combination of opposite helicity polarizations of six 'off resonant' laser beams and the splitting of energy levels due to the anti-Helmholtz magnetic field will create a position dependent force which will push the atoms towards the center, thereby cooling and trapping a group of Rb atoms both in the velocity space and the position space. After assembling the MOT chamber on the vibration isolated optical table, we have achieved ultra-high vacuum and have drawn multiple optical paths for the cooling laser beams.

e) Ultrafast AMO physics with Femtosecond lasers

In collaboration with TIFR, we have developed the SINP–TIFR Velocity map imaging (VMI) apparatus. This multi-electrode VMI is capable of imaging both electrons and ions with good energy resolution by using a MCP + Phosphor detector. Recently we have reported bond-selective molecular fragmentation upon application of intense, 2-cycle (~ 5 fs) pulses of 800 nm laser light and demonstrated that up to three-fold enhancement is possible for preferential bond breaking in isotopically substituted water (HOD).

f) Dissociation of polyatomic molecules due to low energy highly charged ion impact

Determination of the structures and bond rearrangements of multiply charged molecules lead to a wealth of knowledge about the nature of interatomic interactions within molecules. Using collisions with low energy highly charged ions and by measuring the coincidence ion fragments with time-of-flight (TOF) multi-hit imaging setup at Inter University Accelerator Centre, New Delhi and Tokyo Metropolitan University, Japan, we have studied the breakup dynamics of diiodoacetylene (C_2I_2) molecules. We observed that the C and I ions preferentially emit at 90^o with respect to each other whereas C-C and I-I ions dissociate almost parallel to each other in C_2I_2.

4. Future research/development plan

(a) EIT makes the medium highly dispersive to a probe beam, thereby affecting the propagation of the probe pulse through the medium. Hence it is possible to manipulate the group velocity of the pulse. We are working towards **developing methods for controlled localization (slowing down and stopping) and storage of light pulses in a hot or cold atomic vapor**. The potential application of this effect will be in optical data storage and retrieval devices, optical delay generators, all optical switches, etc.

(b) We plan to extend our studies with the LG beam on the modification of EIT, EIA and Electromagnetically Induced Grating (EIG) phenomenon. We are also thinking about **investigation with the Vortex beam in the transfer of orbital angular momentum from the photon to the atom**.

(c) We are developing our MOT for studying coherent optical interactions like EIT with cold atoms. We are looking at mediums which can slow down and store information in the form of stationary light pulses in a tight confinement of atoms and radiation fields over a long interaction length. Our plan is to **guide cold atoms from a MOT inside a hollow core photonic crystal fiber (HCPCF).** Having fiber as the atomic guide, tight confinement of both photons and atoms inside will result in an increased probability of single-photon – single-atom interaction.

5. Recent Publications (Total Publications - 44)

1)‘Transformation of electromagnetically induced absorption to electromagnetically induced transparency in a five-level V-type atomic system: experimental findings and theoretical model’ - Khairul Islam, Amitava Bandyopadhyay, Satyajit Saha, **Sankar De** and Dipankar Bhattacharyya (Submitted to JOSA B).

2)‘Simultaneous observations of Electromagnetically Induced Transparency (EIT) and Absorption (EIA) in a multi-level V-type system of ^{87}Rb and theoretical simulation of the observed spectra using a multi-mode approach’ - Bankim Chandra Das, Dipankar Bhattacharyya, Arpita Das, Shrabana Chakrabarti, and **Sankar De**, **Journal of Chemical Physics, 145**, 224312 (2016).

3) ‘Narrowing of Doppler and hyperfine line shapes of Rb - D_2 transition using a Vortex beam’ – Bankim Chandra Das, Dipankar Bhattacharyya and **Sankar De, Chemical Physics Letters, 644**, 212 (2016).

4)‘Selective breaking of bonds in water with intense, 2-cycle, infrared laser pulses’ - D. Mathur, K. Dota, D. Dey, A. K. Tiwari, J. A. Dharmadhikari, A. K. Dharmadhikari, **S. De**, and P. Vasa, **Journal of Chemical Physics**, **143**, 244310 (2015).

5)‘Comparison of electromagnetically induced transparency (EIT) spectra for six-level lambda (Λ) and five-level V-type systems’ - Dipankar Bhattacharyya, Arindam Ghosh, Amitava Bandyopadhyay, Satyajit Saha and **Sankar De, J. of Atomic, Molecular, Condensate & Nano Physics 2,** 93 (2015).

6)‘Do linear molecules always dissociate along their axis? Intra-molecular scattering within Diiodoacetylene’ - **Sankar De**, H. Tezuka, P. Bhatt, G. Veshapidze, C. P. Safvan, J. Matsumoto and H. Shiromaru, **Journal of Physics: Conference Series**, **635**, 032061 (2015).

7)‘Observation of electromagnetically induced transparency in six-level Rb atoms and theoretical simulation of the observed spectra’ - Dipankar Bhattacharyya, Arindam Ghosh, Amitava Bandyopadhyay, Satyajit Saha and **Sankar De, J. Physics B:** At. Mol. Opt. Phys. **48,** 175503 (2015).

Name: Nayana Majumdar

Education:

Degree/Diploma	*University/Institute*	*Year*
B.Sc	Visva Bharati	1988
M. Sc	Visva Bharati	1990
Post M.Sc.	Saha Institute of Nuclear Physics	1991
Ph.D.	Calcutta University	1998

Academic Profile:

Post	*Institute*	*Period*
Post-doctoral	SINP	1998 - 2000
Reader D	-do-	2000 - 2006
Associate Professor E	-do-	2006 - 2008
Professor F	-do-	2008 - 2014
Professor G	-do-	2014 -

Research/Development Output:

- ***Characterization of triple-GEM detector for upgrading the forward Muon System of the CMS experiment:*** With the luminosity upgrade of LHC, the high rapidity region of forward Muon System of the CMS experiment is proposed to be equipped with triple-GEM detectors which are proved to be capable of handling high rate. The characterization of this detector leads to optimization of its design, gas mixture, operation, for achieving the trigger and tracking goals of the CMS experiment. Detailed experimental measurements of the gain, electron transparency, energy resolution, were carried out with a triple-GEM prototype for different gas mixtures to produce an extensive characterization database. To complement the experimental data, numerical simulation of the performance of the triple-GEM was done using GARFIELD, a CERN-based simulation framework, to facilitate interpretation of the experimental findings and the optimization of the said detector for its application in the CMS setup.
- ***Characterization of Micromegas detector for its application in a Time Projection Chamber (TPC) in International Linear Collider (ILC) experiment*:** ILC is a future-generation collider with energy scale upto 1 TeV, proposed for studying physics beyond standard model. The detector system for the experiments at ILC will require a large TPC for which Micromegas detector is one of the choice to populate its readout scheme. This requires extensive characterization of the detector to optimize its performance based on its design, gas mixture and operation. Several Micromegas prototypes with different designs were studied for their characteristic gain, ion backflow fraction, energy resolution following detailed measurements using different gas mixtures. Extensive numerical simulations were carried out to compare to the experimental observations which explained several issues of ion backflow in the TPC setup and track distortion observed in a test run of a Micromegas-based large prototype TPC at DESY.
- ***Performance studies of RPC for its application in INO-ICAL experiment:*** The Iron Calorimeter (ICAL) in India-based Neutrino Observatory (INO) is designed to study the neutrino oscillation parameters. Large number of RPCs will be used for tracking the muons produced in the interaction of the atmospheric neutrino with the iron plates present in the ICAL setup. The position and timing information from these RPC detectors will be used to study the track of muons and determine their directionality. To study the effect of design, gas mixture and geometrical artifacts on the timing performance of RPC which is necessary to predict and interpret the ICAL performance, several Bakelite-based RPCs were fabricated and tested for their characteristic performances with cosmic muons. The experimental measurements were complemented by detailed numerical simulation which was used to interpret the observed data.
- ***Studies on the use of eco-friendly gas mixture in RPC operation for INO-ICAL experiment:*** The ICAL setup uses several tens of thousands of RPC running with a gas mixture which has a high value of global warming potential (GWP). In view of Kyoto protocol of reduced usage of high-GWP gases, a study has

been initiated to judge the suitability of Argon-based gas mixtures in operating RPCs without compromising the physics goals of INO-ICAL experiment. Numerical simulations are in progress to study the properties of several such eco-friendly gas mixtures for identifying the suitable composition. The qualification of the gas mixtures for avalanche-mode operation of RPCs is under study by estimating their streamer probability fraction.

- ***Imaging with cosmic-ray muons:*** Cosmic muons can be used for non-destructive imaging of any structure using their absorption and scattering within the target object. In order to develop a imaging setup, numerical simulation using GEANT, a CERN-based software package, is in progress to study the interaction of muon with the given matter. The results of the muon hits as estimated from the simulation will be used for optimizing the design of a hodoscope and choice of muon detectors. To begin with, RPC is being considered for detecting the muons and the relevant hardware development has been started.
- ***Upgrade of the field solver, neBEM:*** The field solving software based on a novel approach of analytic integration of Green's function, neBEM, was developed and integrated to a CERN-based simulation framework GARFIELD, widely used for simulating the performance of gaseous detectors. The solver is distributed and maintained at CERN website. It has been upgraded and optimized for its efficiency by introducing parallelization, fast volume and adaptive meshing techniques. The solver has been readied to address the charging-up issues of the dielectrics in any gaseous detector.

Future Research/Development Plan:

- ***Cosmic-ray muon imaging setup:*** An extensive plan for developing a muon hodoscope using RPCs as muon detectors are in progress. Several other micropattern gaseous detectors are planned to be used for imaging. In future, the setup may be upgraded for application of muon tomography in detecting high density contraband materials for portal security.
- ***Quality control of triple-GEM chambers of CMS Muon System upgrade:*** The infrastructure of monitoring the quality control of the assembled triple-GEM chambers for populating the CMS Muon System will be set up. The measurement of high voltage supply, gas tightness and the gain uniformity of the chambers will be carried out before their commissioning. The necessary hardware development and procurement of components are in progress.
- ***Qualification of the eco-friendly gas mixture for RPC:*** RPCs will be tested for their performance with eco-friendly gas mixtures. Several compositions of Argon and CO2 are planned to be studied for avalanche mode operation of RPCs. A new test bench will be setup to pursue this kind of measurement.
- ***Space charge simulation:*** The space charge is a critical issue in the operation of gaseous detectors which requires detailed simulation to explain the detector performance. For this, a formulation based on the surface distribution of charges on the voxels is under development.

List of Important Publications:

1. **Journal of Instrumentation 7 P11027 (2012), N. Majumdar,** S. Mukhopadhyay, P. Bhattacharya, S. Biswas, S. Bhattacharya, S. Saha, S. Chattopadhyay, *"A numerical study on surface asperities in Bakelite-RPC",*
2. **Journal of Instrumentation 7 P09007 (2012),** P. Bhattacharya, S. Mukhopadhyay, **N. Majumdar**, S. Bhattacharya, *"A Comparative Numerical Study on GEM, MHSP and MSGC"*
3. **Nuclear Instruments & Methods A732 208 (2013),** P. Bhattacharya, S. Bhattacharya, **N. Majumdar**, S. Mukhopadhyay, S. Sarkar, P. Colas, D. Attie, *"Comparison of Bulk Micromegas of Different Amplification Gaps"*
4. **Journal of Instrumentation 9 C04037 (2014),** P. Bhattacharya, S. Bhattacharya, **N. Majumdar**, S. Mukhopadhyay, S. Sarkar, P. Colas, D. Attie, *"Performance Studies of Bulk Micromegas of Different Design Parameters"*
5. **Journal of Instrumentation 9 C10036 (2014), N. Majumdar** in CMS-GEM Collaboration, "*Upgrade of the CMS Muon system with triple-GEM detectors"*
6. **Journal of Instrumentation 10 P11009 (2015),** A. Jash, **N. Majumdar,** S. Mukhopadhyay, S. Chattopadhyay, *"Numerical studies on electrostatic field configuration of Resistive Plate Chambers for the INO-ICAL experiment"*
7. **Journal of Instrumentation 10 P08001 (2015),** D. S. Bhattacharya, D. Attie, P. Colas, S. Mukhopadhyay, **N. Majumdar**, S. Bhattacharya, S. Sarkar, A. Bhattacharya, S. Ganjour, *"Measurement and simulation of two-phase CO2 cooling in Micromegas modules for a Large Prototype of Time Projection Chamber"*
8. **Journal of Instrumentation 11 C09014 (2016),** A. Jash, **N. Majumdar**, S. Mukhopadhyay, S. Chattopadhyay, *"Numerical study on the effect of design parameters and spacers on RPC signal and timing properties"*
9. **Nuclear Instruments & Methods A824 586 (2016), N. Majumdar** in CMS-GEM Collaboration, *"Test beam and irradiation test results of triple GEM detector prototypes for the upgrade of Muon System of the CMS experiment"*
10. **Nuclear Instruments & Methods A845 313 (2017), N. Majumdar** in CMS-GEM Collaboration, *"R&D on a new type of micropattern gaseous detector: The Fast Timing Micropattern detector"*

Sandip Sarkar

Professor
Applied Nuclear Physics Division
Saha Institute of Nuclear Physics
1/AF Bidhannagar
Kolkata-700064

Ph: **+91 33 2337 5345 (O)**
Fax: **+91 33 2337 4637 (O)**
e-mail: **sandip.sarkar@saha.ac.in**

Education:

B.Sc. (Physics)	Kolkata University	1983
M.Sc. (Physics)	Madras University	1987
Post M.Sc.	Saha Institute of Nuclear Physics	1988
Ph.D. (Science)	Jadavpure University	1998

Academic Profile:

Post doctoral	Saha Institute of Nuclear Physics	1998
Reader 'D'	-do-	2000
Associate Professor 'E'	-do-	2003
Professor 'F'	-do-	2007
Professor 'G'	-do-	2016

Research Interests:

Computational Neuroscience

The goal of Computational Neuroscience (also theoretical neuroscience) is to study brain function in terms of the information processing properties of the nervous system. In this paradigm, mental processes are considered as 'computations' defined over representations. Computational neuroscience attempts to find the bridge between the principles of computation, its representation, and their neural correlates. It is an interdisciplinary computational science that links the diverse fields of cognitive phenomena with electrical engineering, computer science, mathematics, and physics.

Computational neuroscience is different from conventional theories like machine learning, neural network and so on in that it emphasizes biological plausibility of neural correlates, its physiology including dynamics and attempts to model the essential features of biological systems at multiple spatial and temporal scales. These computational models are used to frame testable hypotheses that can be directly verified by psychophysical and physiological experimentations.

Since the year 2012, the main focus of our investigations are the following:

1. Computational mechanism of filling-in at the blind spot

Everyone has a hole (called Blind-Spot which is devoid of any photoreceptors) in the retina through which optic nerves carry the visual information to the cortex. However, the region of the visual field corresponding to this blind-spot is never perceived as a gap in our perception (even in monocular viewing) because our brain somehow fills-in the informational void introduced by the blind-spot. Various propositions were put forward to explain several experimentally observed properties of the blind-spot. However, a general mechanism of filling-in was absent. In this work, we proposed a general neural computational mechanism for filling-in operation. We hypothesized that filling-in at the blind spot and its associated properties could be understood by taking into account the statistics of natural scene and the computational architecture (Hierarchical Predictive Coding) of the cortex; and demonstrated that several experimentally observed properties of filling-in at the blind-spot could be accommodated under the same computational framework. The findings, in this work, offer new insights into the role of natural scene statistics in our perception and suggest, what is possibly, the first systematic bridge linking anisotropy in three levels: natural environment, visual cortex, and perceptual filling-in at the blind spot.

2. Role of Stochastic Resonance in Human Visual Perception

The beneficial role of noise in neural computations has been observed at all levels from lower psychological to higher cognitive ones. Increase in the detectability of weak signals by the process of stochastic resonance (SR) has been observed, for example, in human brain waves, ambiguous pattern detection, human tactile sensation and also in human visual perception. It has been demonstrated in many experiments that brain can perceive details consistently and quantitatively in a stationary sub-threshold stimulus obscured with additive noise, where the noise strength strongly influenced the perceptual ability. To study the role of noise in visual perception related to contrast sensitivity and orientation selectivity, we examined the performance of human participants in perpetual tasks with visual stimuli in a noisy environment (stimulus plus noise). Human participants exhibited an increase in sensitivity to increasing noise that attained a maximum for an intermediate noise, which is a typical signature of Stochastic Resonance. Moreover, it was also found that the basic nature of contrast sensitivity and orientation selectivity remained the same in the presence of noise. These results can be utilised for the study of visual impairments in human vision.

Future Research Plan:

I will continue to work in the field of "Computational Neuroscience" with special emphasis on generalized computational aspects of the cortex that will be useful for studying various superficially disparate perceptual phenomena including illusions and cognitive disabilities in a common computational framework. Moreover, I will be involved in developing a Muon Tomography Setup useful for screening high Z materials, which is useful for homeland security.

Important Publications:

1. Raman R, Sarkar S (**2017**) Significance of Natural Scene Statistics in Understanding the Anisotropies of Perceptual Filling-in at the Blind Spot, **Scientific Reports 7, Article number: 3586 (2017),** doi:10.1038/s41598-017-03713-w.

2. Raman R, Sarkar S (**2016**) Predictive Coding: A Possible Explanation of Filling-In at the Blind Spot. **PLOS ONE 11(3): e0151194.** doi:10.1371/ journal.pone.0151194.

3. Kundu A, Sarkar S (**2015**) Stochastic Resonance in Visual Sensitivity, A Kundu, S. Sarkar, **Biological cybernetics 109(2), 241-254.**

4. Kundu A, Sarkar S (**2014**) Effect of oriented surround mask on contrast sensitivity of zero-crossing images in presence of noise**. Journal of Biomedical Image Processing 1(1), 12-19, 2014.** http://www.bowenpublishing.com/jbip/CurrentIssue.aspx?Abstr=false

5. Kundu A, Sarkar S (**2014**) Role of noise in human visual perception: A psychophysical study. **IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) 9 (3) Ver. II (May -Jun. 2014), 93-100.**

6. Karmakar S, Sarkar S (**2013**), Orientation enhancement in early visual processing can explain time course of brightness contrast and White's illusion. **Biological cybernetics 107 (3), 337-354.**

1.Name – Chandi Charan Dey

Division – Applied Nuclear Physics

Educational background:

B. Sc. (Physics Hons.) 1983 – Bankura Christian College (Burdwan University)
M.Sc. (Physics) 1985 – Burdwan University, West Bengal (ranked 1st)
Ph.D.(Jadavpur University) – March 1995, Saha Institute of Nuclear Physics

2. Academic profile including earlier appointments, awards etc.

Present position – Professor G (from January 2015)
Professor F: Feb. 2007 – Dec. 2014, SINP, Kolkata
Associate Professor E: Feb. 2004 – Jan. 2007, SINP, Kolkata
Reader D: February 2000 – Jan. 2004, SINP, Kolkata
Lecturer SC: Aug. 1997 – Jan. 2000, SINP, Kolkata
Post doctoral fellow: April 1995 – Aug. 1997, SINP, Kolkata

Visiting positions abroad:

Göttingen University, Germany: Oct. 2000 – Dec. 2000
Pennsylvania State University, USA: Oct. 2001- Sept. 2002
University of Bonn, Germany: Aug. 1, 2004 – August 31, 2004
University of Leipzig, Germany: Aug. 2005 – Nov. 2005
University of Leipzig, Germany: 26 March, 2007 – May 25, 2007

3. Essential strength of research/development output

My main research interest is on the applications of time-differential perturbed angular correlation (TDPAC) technique in Material Science. The TDPAC is a nuclear technique based on the interaction of electromagnetic moments (electric quadrupole or magnetic dipole) of a specific nuclear level with the electric field gradient or the magnetic field generated at the nuclear level by the surrounding environment of the nucleus.

Developmental output:

- With an aim to apply the TDPAC technique in different areas of material science, a new four detector TDPAC spectrometer with ultrafast BaF_2 and $LaBr_3$(Ce) detectors has been developed. This spectrometer can acquire four coincidence spectra at a time (two at 180° and two at 90°). Also, a provision of sample temperature variation up to 1100 K has been made by using a resistive furnace.
- A dedicated argon arc melting furnace to prepare intermetallic compounds with radioactive probe has been set up.

Research output (last five years):

- **Microcrystalline phase transformation from $ZrF_4.HF.2H_2O$ to ZrO_2 through the intermediate phases $ZrF_4.3H_2O$, $ZrF_4.H_2O$, $Zr_2OF_6.H_2O$ and ZrF_4:**
  [Ref. C. C. Dey, Chem. Phys. Lett. 612(2014) 8].
- **Structural phase transition in hafnium tetrafluoride tri-hydrate and zirconium tetrafluoride tri-hydrate:**
  [Ref. S. K. Dey, C. C. Dey and S. Saha, J. Phys. Chem. Solids 91 (2016) 18].
- **Structural phase transition in Rb_2ZrF_6 and Rb_2HfF_6 at room temperature:**
  [Refs. C. C. Dey, J. Phys. Chem. Solids 78 (2015) 12; S. K. Dey, C. C. Dey, S. Saha, J. Phys. Chem. Solids 91 (2016) 18; S. K. Dey, C. C. Dey, S. Saha, J. Phys. Chem. Solids 95 (2016) 98]
- **Studies in Zr-Ni intermetallic compounds:**
  The Zr-Ni and Hf-Ni intermetallics have wide technological applications. It was found that the Zr-Ni intermetallic alloys are good hydrogen absorbing materials to form interstitial metal hydrides which have application in nickel metal hydride batteries as negative electrode material. Temperature dependent TDPAC studies in several Zr-Ni and Hf-Ni intermetallic compounds have been performed to find the

different phase components produced and assign these phases. X-ray diffraction and TEM/energy dispersive X-ray spectroscopy measurements were also performed to further characterize the samples and to confirm the PAC results. These activities in intermetallic compounds are being carried out in collaboration with Dr. J. Belosevic-Cavor, Institute of Nuclear Sciences Vinca, University of Belgrade, Serbia who is mainly responsible for doing the theoretical calculation of electric field gradient (EFG) and asymmetry parameter (η) by density functional theory (DFT).

[**Refs.** C. C. Dey and S. K. Srivastava, Physica B 427 (2013) 126; C. C. Dey, Rakesh Das and S. K. Srivastava, J. Phys. Chem. Solids 82 (2015) 10; S. K. Dey, C. C. Dey, S. Saha and J. Belovic-Cavor, Intermetallics 84(2017)112 and S. K. Dey, C. C. Dey, S. Saha, J. Belovic-Cavor and D. Toprek, J. Alloys. Comp. 723 (2017) 425]

4. Future research/development plan:

- PAC studies in intermetallic Zr-Pd, Ti-Pd systems have been planned due to their technological applications.
- PAC studies in magnetic samples (Zr-Co, Hf-Co and many other systems).
- Participation in developmental work for dark matter search experiment to be carried out at UCIL, Jadugoda.

5. Selected Publications from 2012:

1. Investigatoins of Zr-Ni intermetallic compounds by perturbed angular correlations – **C. C. Dey**, J. Mag. Mag. Mat. 342 (2013) 87.
2. Electric quadrupole and magnetic dipole interactions at ^{181}Ta impurity in Zr_2Ni_7 intermetallic compound: Experiment and first-principles calculations – **C. C. Dey** and S. K. Srivastava, Physica B 427 (2013) 126.
3. Recoil Induced Room Temperature Stable Frenkel Pairs in α-Hafnium upon Thermal Neutron Capture - Tilman Butz[1*], Satyendra K. Das[2], **Chandi C. Dey**[3], Sandhya Dey[4] and Shamik Ghoshal[1], Z. Naturforsch. 68a (2013) 610.
4. Probe-impurity interaction in dilute alloy Zr_xHf_{1-x} (x ~ 0.98): Results from perturbed angular correlation measurements – **C. C. Dey**, Solid State Commun. 179 (2014) 43
5. Microcrystalline phase transformation from $ZrF_4.HF.2H_2O$ to ZrO_2 through the intermediate phases $ZrF_4.3H_2O$, $ZrF_4.H_2O$, $Zr_2OF_6.H_2O$ and ZrF_4 – **C. C. Dey**, Chem. Phys. Lett. 612, (2014) 8.
6. Electric field gradients at ^{181}Ta probe in ZrNi: Results from perturbed angular correlation and first principles calculations – **C. C. Dey**, Rakesh Das and S. K. Srivastava, J. Phys. Chem. Solids 82 (2015)10.
7. An unusual structural phase transition in Rb_2HfF_6 – **C. C. Dey**, J. Phys. Chem. Solids 78, (2015) 12.
8. Anomalous magnetic moment at Ba in Au – **C. C. Dey** in A.K. Bhati et al., Nucl. Instrum. Meth. In Phys. Res. B 349 (2015) 125.
9. Low temperature structural phase transition in hafnium and zirconium tetrafluoride trihydrates – S. K. Dey, **C. C. Dey** and S. Saha, J. Phys. Chem. Solids, 91 (2016) 18.
10. Low temperature structural modification in Rb_2ZrF_6: Investigations by perturbed angular correlation spectroscopy – S. K. Dey, **C. C. Dey**, S. Saha, J. Phys. Chem. Solids, 93 (2016) 145.
11. Effects of Zr impurity on microscopic behavior Hf metal – S. K. Dey, **C. C. Dey** and S. Saha, J. Phys. Chem. Solids, 95 (2016) 98.
12. Electric field gradients in Zr_8Ni_{21} and Hf_8Ni_{21} intermetallic compounds; results from perturbed angular correlation measurements and first-principles density functional theory – S. K. Dey, **C. C. Dey**, S. Saha and J. Belosevic-Cavor, Intermetallics, 84(2017) 112.
13. Identification of phase components in Zr-Ni and Hf-Ni intermetallic compounds; Investigations by perturbed angular correlation spectroscopy and first principles calculations – S. K. Dey, **C. C. Dey**, S. Saha, J. Beloševic-Čavor and D. Toprek, J. Alloys and Compounds 723 (2017) 425.

Name : P.M.G. NAMBISSAN
Designation : Senior Professor – H
Division : Applied Nuclear Physics Division

1. Academic Qualifications :

B.Sc. in Physics with first class (86.50%) from Sree Narayana College, Cannanore (under University of Calicut) in 1984 with Mathematics and Chemistry as subsidiaries.

M.Sc. in Physics with first class & second rank (73.53%) from University of Calicut in 1986 with specialization in Nuclear Physics.

Post M.Sc. Associateship Diploma in Physics (75.73%) from Saha Institute of Nuclear Physics, Calcutta in 1987 with specialization in Nuclear Physics.

Ph.D. in Science (Physics) of the University of Calcutta in 1991 for the thesis done under the guidance of Prof. Prasanta Sen at Saha Institute of Nuclear Physics, Calcutta.

2. Academic profile including earlier appointments, awards etc :

Research Associate (from 27.11.1991 to 12.08.1993)
Lecturer SC (from 13.08.1993 to 31.07.1996)
Reader SD (from 01.08.1996 to 31.07.1999)
Associate Professor E (from 01.08.1999 to 31.07.2004)
Professor F (from 01.08.2004 to 31.01.2008)
Professor G (from 01.02.2008 to 30.06.2016
Senior Professor H (from 01.07.2016 onwards)
at Saha Institute of Nuclear Physics, Kolkata.

Also served, on deputation from the institute, as **Course Director, Department of Nanoscience, Kannur University, Kerala** from 31.01.2009 to 30.01.2010.

3. Essential strength of research/development output

My main area of research comprises of positron annihilation spectroscopic studies of properties and processes related to defects in nanomaterials including metals, alloys, multiferroics, spinels and semiconductors. An interesting aspect of these studies is related to the effect of substitution by other related cations in the nanocrystalline materials. Defects play a significant role by way of aiding the doped ions to follow their prefered dynamics within the host. Positron annihilation spectroscopy has been highly successful in giving defect-specific information not available from other more popular techniques. These information help to understand the systems in greater depth and perspective. We are also currently investigating several polymeric samples, the main focus of which is the characterization of the free volume defects in them and the studies of their distribution.

4. Future research/development plan

1. Synthesis, characterization and measurements of positron lifetime and coincidence Doppler broadening in oxide semiconductor nanomaterials (Continued).
2. Optical absorption studies and estimation of band gaps.
3. Defect dynamics of high energy ion-irradiated RPC Bakelite and glass samples.
4. Positron annihilation studies on certain alloys of importance in reactors.

5. List of some recent publications starting with the most recent ones.

1. Positron annihilation studies and complementary experimental characterization of *x*Ag2O-(1-*x*)(0.3CdO-0.7MoO3) metal oxide glass nanocomposites.
   Ranadip Kundu, Sanjib Bhattacharya, Debasish Roy and P.M.G. Nambissan.
   RSC Advances **7** 8131 (2017).

2. Ionic conductivity and free volume related microstructural properties of LiClO4/PVA/NaAlg polymer composites: Positron annihilation spectroscopic studies.
   T. Sheela, R.F. Bhajantri, P.M.G. Nambissan, V. Ravindrachary, Blaise Lobo, Jagadish Naik and Sunil G. Rathod.
   Journal of Non-Crystalline Solids 454 19 (2016).

3. Diverse spectroscopic studies and first-principles investigations of the zinc vacancy mediated ferromagnetism in mn-doped zno nanoparticles.
   Rajeswari Ponnusamy, Selva Chandrasekaran Selvaraj, Meera Ramachandran, Palanichamy Murugan, Padinharu Madathil Gopalakrishnan Nambissan, and Dhanuskodi Sivasubramanian.
   Cryst. Growth and Des. **16** 3656 (2016).

4. Synthesis and characterization of magnesium oxide nanocrystallites and probing the vacancy-type defects through positron annihilation studies.
   Anjan Das, Atis Chandra Mandal, Soma Roy, Pendem Prashanth, Sk Izaz Ahamed, Subhrasmita Kar, Mithun S.Prasad, P.M.G.Nambissan.
   Physica E **83** 389 (2016).

5. Positron annihilation spectroscopic studies of Mn-substitution-induced cubic to tetragonal transformation in $ZnFe_{2-x}Mn_xO_4$ (x = 0.0–2.0) spinel nanocrystallites.
   Jincemon Cyriac, Rahul Mundiyaniyil Thankachan, B. Raneesh, P.M.G. Nambissanc, D. Sanyal and Nandakumar Kalarikkal.
   Philos. Mag. **95** 4000 (2015).

6. Cr^{3+}-substitution induced structural reconfigurations in the nanocrystalline spinel compound $ZnFe_2O_4$ as revealed from x-ray diffraction, positron annihilation and Mössbauer spectroscopic studies.
   Rahul Mundiyaniyil Thankachan, Jincemon Cyriac, B. Raneesh, Nandakumar Kalarikkal, D. Sanyal and P.M.G. Nambissan.
   RSC Advances **5** 64966 (2015).

Name: Supratik Mukhopadhyay

Education:

Degree/Diploma	*University/Institute*	*Year*
B.Tech	IIT, Kharagpur	1984
Ph.D.	IIT, Kharagpur	1990

Academic Profile:

Post	*University/Institute*	*Period*
Senior Research Assistant	IIT, Kharagpur	1984 - 1986
Junior Scientific Officer	-do-	1986 - 1990
Scientist SC	Saha Institute of Nuclear Physics	1990 - 1994
Reader D	-do-	1994 - 1999
Asso Professor E	-do-	1999 - 2003
Professor F	-do-	2003 - 2008
Professor G	-do-	2008 – till date
Professor H	-do-	2016 – till date

Awards: Institute Silver Medal (first in the Department of Aeronautical Engineering, IIT, Kharagpur)

Research/Development Output:

- **Improvement and upgradation of the nearly exact BEM (neBEM) solver:** The Poisson's equation governs a large class of non-dissipative Physics processes related to electromagnetics, gravitation, inviscid fluid flows etc. Boundary Element Method (BEM), based on the Boundary Integral Equations (BIE), is one of the more elegant approaches of the solving the Poisson's equation. The method involves the use of the Green's function or its normal derivative due to singularity distributed over the boundaries of a given system in order to satisfy Dirichlet / Neumann / Robin boundary conditions. In an important break-through, we have been able to carry out analytic integration of Green's function (and derivative) for singularities uniformly distributed over typical rectangular and triangular elements through the use of symbolic mathematics. Owing to the exact closed-form foundation expressions, the new method can provide nominally exact results and hence the name. Based on these expressions, a program library, namely **Inverse Square Law Exact Solutions (ISLES)**, has been developed to compute the influences of singularities. Several recent improvements have been made to the solver, including formulating and implementing an algorithm for charging up computations. The efficiency of the solver has been greatly enhanced by implementing OpenMP parallelization, adaptive meshing and fast volume algorithms.
- **A simulation framework for gaseous ionization detectors:** The neBEM solver was modified and optimized as a toolkit in order to be interfaced with other high energy physics simulation software. One such integration, operational since 2009, with the GARFIELD code, has been extensively used to perform detailed simulation of the overall dynamics of a gaseous detector. Presently, the GARFIELD + neBEM combination is being maintained at CERN (http://nebem.web.cern.ch/nebem) as a common simulation framework for analyzing gaseous detector and being used by a number of users world-wide. This work is being pursued as a significant part of the RD51 international collaboration led by CERN to promote the development and application of micro-pattern gaseous detectors (MPGD). This framework can now simulate many of the physical processes occurring within a state-of-the-art MPGD or any gaseous ionization detectors and estimate important experimental properties such as gain, induced signal, energy, position and time resolutions, ion back-flow, effects of geometrical inhomogeneities etc.
- **Experimental efforts to study detector physics:** Experimental efforts to study various physics issues in detector dynamics have been initiated with several developments taking place in a brief period of time. A set-up including gas handling system, necessary electronics, data acquisition, several test chambers and couple of simple time projection chambers have been in operation since 2013. We have built several resistive plate chambers (RPC) and procured several MPGDs (GEMs, Micromegas). Very detailed studies on device dynamics have been carried out on characterizing the detectors.

The above experimental and numerical studies have been targeted towards:

- **Optimization of INO-ICAL RPCs**
- **Setting up of QC satellite centre for the CMS (triple GEM detectors for the forward**

muon spectrometer)
  - **Optimization of the Micromegas-based time projection chamber (ILD-TPC) for the International Linear Collider (ILC)**
  - **Development of gaseous detectors with picosecond time resolution**
  - **Identification of environment-friendly gas mixtures suitable for gaseous detectors.**
- **Visualization using Muons Atmospheric (VuMA):** Since last couple of years, we are pursuing this application-oriented field of cosmic ray muon tomography. Both experimental and numerical tools are being used to explore various possibilities. We plan to build a muon telescope that will be used to identify high-Z materials and image large structures, to begin with. A stack of gaseous detectors (RPCs and MPGDs) will be used to carry out the imaging. At present, we are concentrating on RPCs because we can build them here. Necessary electronics is also being developed.

Future Research/Development Plan:

- **Improvement and application of neBEM for simulating multi-physics multi-scale problems:** The potential of the neBEM formulation has been utilized only to a very limited area of research. We plan to use the formulation to analyze wide range of problems related to science and technology. We hope to use neBEM to study problems related to *charging up, discharge dynamics and space charge issues, gaseous and solid-state radiation detectors, impedance tomography, non-destructive testing* etc.
- **Detailed study of detector physics:** Experimental and numerical tools will be used to carry out detailed detector physics studies. In particular, we plan to focus on qualification of *environment-friendly gas mixtures, discharge dynamics, effects of using resistive layer (weakly conducting media)* on the performance of gaseous detectors. We also hope to setup the following additional experimental setups:
  a) Development of a laser setup for controlled event generation.
  b) Development of a set-up for measuring electric field.
- **Continuing optimization study for experiments:** Attempts to optimize gaseous detectors for experiments, such as the *INO, ILC, CMS*, will continue. In addition, efforts to optimize gaseous detectors for *cosmic ray muon tomography* will continue.
- **VuMA:** We hope to set up a muon telescope and use it to carry out detection of high Z materials and to image large structures.

List of 10 Important Publications:

1. Studies on GEM modules for a Large Prototype TPC for the ILC, Supratik Mukhopadhyay in LCTPC collaboration, **NIM A 845**, 309-212 (**2017**)

2. "R&D on a new type of micropattern gaseous detector: The Fast Timing Micropattern detector", S.Mukhopadhyay in CMS Muon Collaboration author-list, **NIM A845**, 313-317 (**2017**)

3. "Numerical study on the effect of design parameters and spacers on RPC signal and timing properties", A. Jash, N. Majumdar, S. Mukhopadhyay, S. Saha, S. Chattopadhyay, **Journ of Instr 11** C09014, (**2016**)

4. The effect of spacers on the performance of Micromegas: a numerical investigation, P. Bhattacharya, **S. Mukhopadhyay**, N. Majumdar, S. Bhattacharya, **NIM A**, **793**, 41-48 (**2015**)

5. Measurement and simulation of two-phase CO2 cooling in Micromegas modules for a Large Prototype of Time Projection Chamber, Deb Sankar Bhattacharya, David Attie, Paul Colas, **Supratik Mukhopadhyay**, Nayana Majumdar, Sudeb Bhattacharya, Sandip Sarkar, Aparajita Bhattacharya and Serguei Ganjour, **Journ of Instr 10,** P08001 (**2015**)

6. Investigation of Ion Backflow in Bulk Micromegas Detectors, Purba Bhattacharya, Deb Sankar Bhattacharya, **Supratik Mukhopadhyay**, Sudeb Bhattacharya, Nayana Majumdar, Sandip Sarkar, Paul Colas and David Attie, **Jour of Instr 10** P09017, (**2015**)

7. Numerical studies on electrostatic field configuration of resistive plate chambers for the INO-ICAL experiment, A.Jash, N.Majumdar, **S.Mukhopadhyay**, S.Chattopadhyay, **Journ of Instr 10** P110009, (**2015**)

8. Performance Studies of Bulk Micromegas of Different Design Parameters, Purba Bhattacharya, S. Bhattacharya, N.Majumdar, **S.Mukhopadhyay**, S.Sarkar, P.Colas, D.Attie, **Journ of Instr 9** C04037, (**2014**)

9. Upgrade of the CMS Muon system with triple-GEM detectors, **S.Mukhopadhyay** in the CMS-GEM author-list (2013, 2014), **Journ of Instr 9** C10036, (**2014**)

10. A comparative numerical study on GEM, MHSP and MSGC, P. Bhattacharya**, S.Mukhopadhyay**, N.Majumdar, S.Bhattacharya, **Journ of Instr 7** P09007 (**2012)**

Name: SATYAJIT SAHA
Division/Section: Applied Nuclear Physics

Educational background

- B Sc (Presidency College, Calcutta University 1980)
- M Sc (Calcutta University 1982)
- M S (University of Washington (UW), Seattle, USA, 1984)
- Ph D (University of Washington, Seattle, USA 1990)

Earlier employments:

- Teaching Assistant, Dept of Physics, UW, Seattle, USA, Jan 1983 to Dec 1984
- Research Assistant, Dept of Physics, UW, Seattle, USA, Jan 1985 to Jan 1990
- Visiting Fellow, Nuclear Reactions Group, TIFR, Mumbai, July 1990 to July 1993
- Lecturer, Dept of Physics, Bose Institute, Kolkata, August 1993 to November 1993
- Reader (SD), NIS Section, SINP, December 1993 to January 1998
- Associate Professor (E), NIS Division (erstwhile N A P Division), SINP, February 1998 to January 2003
- Professor (F), Nuclear and Atomic Physics Division, SINP, February 2003 to January 2007
- Professor (G) , Nuclear and Atomic Physics Division, SINP, February 2007 to April 2010
- Professor (G) and Head, Applied Nuclear Physics Division, SINP, May 2010 till December 2012.
- Senior Professor (H) and Head, Applied Nuclear Physics Division, SINP, January 2013 till date.

Essential strength of research/development output:

- Research in nuclear reactions and spectroscopy using various types of charged particle, neutron, gamma ray and X-ray detectors, exploration of nuclear structure of proton rich and neutron rich nuclei vis a vis experiment with large Clover detector array like INGA.
- Development of different types of gas based radiation detectors, such as position sensitive multiwire proportional counter, parallel grid avalanche counter, Bragg curve and transverse ionization chamber, resistive plate chamber (RPC) detector, liquid scintillator based neutron detector, etc. These detectors are used in various experiments involving gamma spectroscopy with charged particle tagging, exploring the nuclear dynamics of a few nucleon transfer reactions, fission and fusion reactions at beam energies available from the India based Pelletron accelerators, and also for the detection of cosmic muons by RPC with an aim to develop indigenously built large area active detectors for the iron calorimeter as planned for the India based Neutrino Observatory.
- Exploration of nuclear landscape through evaluation of nuclear structure of neutron deficient trans-lead and trans-uranium nuclei with very low yield; development and utilization of gas-based residue tagging detectors for the above purpose.
- Electron impact excitation and ionization studies of heavy elements, molecular clusters using X-ray, Auger electron spectroscopic tools. Such studies are important for both fundamental and applied research. These systematic studies can help us understand the electron-atom collision processes, which are not yet understood completely in the low-energy regime. The atomic inner-shell ionization cross sections by electron impact are also needed for a number of applications, such as in materials and surface science, astrophysics, fusion plasma physics, X-ray laser and electron/positron-matter interaction modeling, and many more. In recent years, these cross section data for electron impact are needed for the study of hard X-ray production in ultrashort laser-matter interaction. Inner shell ionization in heavy elements, such as Thorium and Uranium, by electron impact at energies 15 to 40 keV was investigated using energy dispersive spectrometer at the electron spectroscopy laboratory.

These studies have their importance in establishing the predictive power of the quantitative trace element analysis based on electron impact ionization. The energy dependent inner shell ionization cross-sections, specifically that of the L-shells and sub-shells were evaluated and attempts were made to explain the results in the light of DWBA theory and related simulation.

- Development and nurturing of the research area of atomic, molecular and optical physics involving Doppler-free laser spectroscopy, collision dynamics of cold atoms, exploration of interaction of cold atoms with ions, ultrafast dynamics of molecules using short pulse lasers and the pump-probe techniques.

Future research/development plans:

- Development of an underground laboratory in India for dark matter search experiment using scintillation based detectors. The experiment was originally proposed to be placed inside a cavern at the proposed INO laboratory. A scaled down version of the experiment, named as miniDINO is proposed now, with a few scintillation crystals as active detectors proposed to be placed at the Jaduguda mine of UCIL. The experiment evolved as active collaboration between SINP, BARC, NISER and UCIL (and also INO). First phase of the experiment is to establish the laboratory, measure the radiation background and devise methods of reducing the effects of radiation background. Parallel development of scintillation detectors, their characterization for operation at cryogenic temperatures and optimizing the pulse shape discrimination to distinguish between electron and nuclear recoil events is in progress.

List of 10 (ten) recent publications in refereed journals-

1. *First observation of high spin states and isomeric decay in ^{210}Fr*: D. Kanjilal, **S Saha,** S. Bhattacharya, A Goswami, R. Kshetri, R Raut, S Muralithar, R P Singh, G Mukherjee, B. Mukherjee, Physical Review C **84**, 064321 (2011).
2. *Experimental Investigation of shell model excitations of Zr-89 up to high spin:* Saha S., Palit R., Sethi J., Trivedi T., Srivastava P. C., Kumar S., Jain H. C., Joshi P. K., Mukherjee G., Naik Z., Nag S., Nanal V., Pillay R. G., **Saha S.**, Singh A. K.; Physical Review C **86**, 034315 (2012).
3. *Measurement of electrical properties of electrode materials for the bakelite Resistive Plate Chambers*, Meghna, K. K.; Banerjee, A.; Biswas, S.; Bhattacharya, S. ; Bose, S.; Chattopadhyay, S.; Das, G.; Marick, C.; **Saha, S.**; Viyogi, Y. P.; Journal of Instrumentation **7**, P10003 (2012).
4. *Nuclear temperatures from evaporation fragment spectra and observed anomalies:* A. Ray, A. De, A. Chatterjee, S. Kailas, S. R. Banerjee, K. Banerjee, **S. Saha**; Physical Review C **87**, 064604 (2013).
5. *Observation of a rare cosmic ray event at mountain altitude:* B Basu, S Raha, S Biswas, S Dey, A Maulik, A Mazumdar, **S Saha** and D Syam, Astroparticle Physics **61**, 88 (2015).
6. *Performance simulation of a MRPC-based PET imaging system:* A Roy, A Banerjee, S Biswas, S Chattopadhyay, G Das, S Saha, Journal of Instrumentation **9**, C10030 (2014).
7. *Determination of subshell-resolved L -shell-ionization cross sections of gold induced by 15-40-keV electrons*, H V Rahangdale, M B Guerra, P K Das, S De, J P Santos, D Mitra and **S Saha**, Physical Review A **89**, 052708 (2014).
8. *Effects of variation of environmental parameters on the performance of Resistive Plate Chamber detectors:* Meghna K. K., S. Biswas, A. Jash, S. Chattopadhyay, and **S. Saha,** Nuclear Instruments and Methods in Physics Research Section A **816**, 1-8 (2016).
9. *Spectroscopic investigations of L-shell ionization in heavy elements by electron impact*, H V Rahangdale, D Mitra, P K Das, S De, M Guerra, J P Santos and **S Saha**, Journal of Quantitative Spectroscopy and Radiative Transfer **174**, 79-87 (2016).
10. *Detecting supernova neutrinos with iron and lead detectors*, Abhijit Bandyopadhyay, Pijushpani Bhattacharjee, Sovan Chakraborty, Kamales Kar and **Satyajit Saha**, Physical Review D **95**, 065022 (2017).

National Level Academic Review

High Energy Nuclear and Particle Physics (HENPP) Division

A Report for the period 2012 - June, 2017

Present Staff

Scientific/Faculties (8)	Technical/Sc. Officers/Assistants (2)
Sukalyan Chattopadhyay, Senior Prof. H+, Head	Lipy Das
Pradip Kr. Roy, Prof. G	Dipankar Das
Manoj Sharan, Prof. G	
Satyaki Bhattacharya, Prof. G	
Subir Sarkar, Prof. F	**Administrative/Auxiliary (3)**
Suchandra Dutta, Prof. F	Sanjib Kr. Mondal
Tinku Sinha, Scientist F	Rakesh Kr. Ram
Debasish Das, Asso. Prof. E	Sudam Bagdi
Engineer (1)	
Arindam Das, Engineer D	
Faculty Deceased (1)	
Abhee Kanti Dutt-Mazumder, 2013	
Faculties Superannuated (2)	
Sunanda Banerjee, 2014	
Pratap Bhattacharya, 2013	

Ramanujan Fellow

	Name	Year of joining
1	Indranil Das	2016

Postdoctoral Fellows

	Name of PDFs	Year of joining
1	Surashree Majumder	2016
2	Husnud	2016

Present Research Fellows

	Name of RFs	Year of joining	Ph.D. Supervisor
1	Ashim Roy	2013	Satyaki Bhattacharya, Manoj Sharan
2	Kuntal Mandal	2013	Suchandra Dutta, Sunanda Banerjee
3	Suvankar Roy Chowdhury	2013	Sunanda Banerjee, Subir Sarkar
4	Biswarup Das	2014	Sukalyan Chattopadhyay
5	Rajarshi Bhattacharya	2014	Suchandra Dutta, Subir Sarkar
6	Saswati Nandan	2014	Sunanda Banerjee, Subir Sarkar
7	Shamik Ghosh	2014	Satyaki Bhattacharya
8	Arnab Purohit	2014	Satyaki Bhattacharya
9	Arghya Mukherjee	2015	Pradip Kr. Roy
10	Aritra Das	2016	Pradip Kr. Roy
11	Wadut Shaikh	2016	Sukalyan Chattopadhyay
12	Jhuma Ghosh	2016	Sukalyan Chattopadhyay
13	Debabrata Bhowmik	2016	Satyaki Bhattacharya

Ph.D. Degree Awarded (2012 – till date)

	Name of RFs	Award	Ph.D. Supervisor	Present Occupation
1	Santosh Roy	2013	Sukalyan Chattopadhyay	Research Faculty, Manipal Centre for Natural Sciences,
2	Palash Khan	2015	Sukalyan Chattopadhyay	Enterpreneur
3	Biswarup paul	2015	Sukalyan Chattopadhyay	INFN Fellow, Torino
4	Niyaz A Rather	2015	Sukalyan Chattopadhyay	Assistant Prof., NIT, Srinagar
5	Lusaka Bhattacharya	2012	Pradip Kr. Roy	PDF in Ohio State University
6	Sreemoyee Sarkar	2015	Pradip Kr. Roy & Abhee Kanti Dutt-Mazumder	Inspire faculty at Centre for Excellence in Basic Sciences, University of Mumbai-DAE
7	Souvik P. Adhya	2016	Pradip Kr. Roy	RA, VECC, Kolkata
8	Mahatsab Mandal	2017	Pradip Kr. Roy	Lecturer, Kalna College
9	Atanu Modak	2017	Suchandra Dutta, Subir Sarkar	Soon join Kansas State University as PDF
10	Debarati Ray	2016	Sunanda Banerjee, Manoj Sharan	PDF at University of the Witwatersrand, Johannesburg
11	Swagata Mukherjee	2016	Sunanda Banerjee, Manoj Sharan	PDF at Physics Institute 3A, RWTH Aachen University, Aachen, Germany
12	Bhawna Gomber	2015	Satyaki Bhattacharya	PDF at University of Wisconsin-Madison
13	Raman Khurana	2015	Satyaki Bhattacharya	PDF at National Central University, Taiwan
14	Shilpi Jain	2015	Satyaki Bhattacharya	PDF at National Central University, Taiwan
15	Sandhya Jain	2015	Satyaki Bhattacharya	PDF at TIFR, Mumbai

Ph.D. Thesis Submitted

	Name of RFs	Year	Ph.D. Supervisor	Status
1	Kalyanmoy Chatterjee	2016	Suchandra Dutta, Subir Sarkar	PDF at University of Florence
2	Sourav Dey	2017	Sunanda Banerjee, Subir Sarkar	Short-term LPC fellow at Fermilab

Important equipment and facility

- A fully quipped gas detector fabrication and testing laboratory
- A large area cosmic-ray trigger bench
- A High Performance Computing (HPC) cluster delivering ~ 8 Tflops of computing power and ~ 200 TB raw storage
- A complete micro-TCA setup for testing micro-TCA based data-acquisition boards

Areas of Research

The research activities in HENPP division can be categorized in four major directions namely, Collaborative research in ALICE and CMS, phenomenological studies and nuclear structure studies at high spins.

ALICE Collaboration

The Saha-ALICE group joined the ALICE Collaboration in 1997 and has been one of the founder laboratories who developed the Muon Spectrometer. The group has made critical hardware contributions which have been fabricated indigenously. These are the Muon chambers for the Second Tracking station built entirely in the campus and the MANAS chips for the readout of the 1.1 million channels which were designed at Saha Institute and fabricated at the Semiconductor Complex Laboratory, Chandigarh. These deliverables performed exceedingly well during the Run-I & II which has led to 30 research publications in reputed journals in last five years.

During Run-II, the Pb-Pb collisions took place during November-December, 2015 at a collision rate which was 20 times higher than that in Run-I. Next year, during the Pb-p collisions, ALICE experienced the highest trigger rate (~320 kHz of V0 trigger). These increased collision rates poised a challenge to the Muon Chambers and also to the MANAS chip. The technical team from Saha Institute carried out detail service works during the shutdown periods to ensure the smooth functioning of our deliverables during these critical periods.

The members of the SAHA-ALICE team have participated in the physics analysis of the data collected by the Muon Spectrometer in p-p, p-Pb and Pb-Pb collisions. The team have made significant contributions in hardware and its maintenance, data collection and data quality monitoring and MC productions for all the data-sets. The physics highlights have been listed in the next section.

The team currently have the following responsibilities in the collaboration: Responsible for Station 2 of Muon Tracker, Shift participation, System Run Coordinator of Muon Tracker during heavy-ion collisions, Deputy project leader of Muon Tracker, Co-Convener of PWG-PP Monte Carlo group and Co-Convener of quarkonia-to-mumu-Physics Analysis Group.

CMS Collaboration

The Saha Institute of Nuclear Physics joined the CMS collaboration in April, 2011. The members of the CMS group have significantly contributed to Physics analysis, operation of the experiment, detector upgrade and computing.

Physics Analysis: Search for the Higgs boson as well as study of the properties in $WH \rightarrow \tau\tau$, $H \rightarrow \gamma\gamma$ (both SM and low mass BSM), and $H \rightarrow ZZ^* \rightarrow 4$ leptons channels is a major involvement of the group. Search for new physics, e.g extra-dimensions in γ + MET final state (mono-photon), search for excited leptons are other fields where the members are deeply involved. The group members have made major contribution to the study of Quantum Chromodynamics using different event shape variables and exploring multi-jet production at the LHC. We have also been working on di-Higgs production at the LHC in the $HH \rightarrow bb\,\tau\,\tau$ and $\tau\,\tau\,\mu\,\mu$ channels. We have performed a Trigger level study on the prospects of triggering the rare track only $Bs \rightarrow \varphi\,\varphi \rightarrow 4K$ physics process with the proposed PhaseII Detector.

SINP members also bear major responsibilities in the collaboration by carrying out basic tasks like Tracker & HCAL Calibration, prompt feedback on data quality, offline remote shifts, Data validation & certification all of which are very crucial for successful data-taking. SINP members have served as Data Quality Monitoring coordinator, HCAL Detector Performance Group co-convenor, HCAL backend electronics coordinator.

Detector Development: The group activity includes the CMS HCAL backend electronics upgrade during LS1, GEM GE1/1 for PhaseI and R&D work for GE2/1, HGCal and tracker for PhaseII.

Phenomenological studies

We have mainly concentrated on two aspects of phenomenology of heavy ion collisions. Firstly, we calculated electromagnetic probes (photons and dileptons) from anisotropic quark gluon plasma (AQGP) and compared it with the RHIC data. In addition, we have also investigated two-photon interferometry and gluon dissociation of J/psi dissociation in AQGP. Secondly, we have studied the effect of momentum space anisotropy on the jet induced collective oscillations of plasma which leads to instability of the plasma. The wake in the potential and charge density due to the passage of energetic jets has also been studied both in collision-less and collisional plasma.

For the last two years we have started to investigate the properties of hadrons in magnetic field at finite temperature and density. In this context, we studied the pion and rho meson properties in magnetized medium.

The production ratio of Y(3S) to Y(1S) and Y(2S) to Y(1S) via pp collisions at the LHC energies is an important preliminary to the research on QGP which has been studied for forward rapidities along with J/psi(1S),Psi(2S) and compared with experimental results to understand both the hot and cold nuclear matter produced at LHC energies.

We are also involved in phenomenological studies of new physics in proton-proton collision.

Nuclear structure studies at high spins

This work is being carried out at the National Accelerator centers at TIFR and IUAC, Delhi using the Indian National Gamma Array (INGA). INGA is a multi-detector, multi-user facility that is transported to the major accelerator centres in India. In the last five years, we have identified a number of angular momentum generation mechanisms in nuclei of A~100 region namely, collective rotation, anti-magnetic rotation, shears mechanism and interplay of shears mechanism and collective rotation. We have also studied the 'partner bands' in ^{106,108}Ag.

Research Highlights (last 5 years)

ALICE Collaboration

- **Charmonia (J/psi and Psi(2S)) production and suppression**

The charmonia production in hadronic collisions is still not completely understood, and henceforth the data on charmonium production represent a complex and critical test for QCD-inspired models [Eur.Phys.J. C74 (2014) no.8, 2974, Eur.Phys.J. C76 (2016) no.4, 184]. Among the charmonium states, the strongly bound S-wave J/psi and the weakly bound radially excited Psi(2S) have been studied for the understanding of Quark-Gluon Plasma (QGP) [JHEP 1605 (2016) 179]. The studies in pp collisions provide a reference for the Pb–Pb data taken at the same √s per nucleon-nucleon collision [Phys.Lett. B718 (2012) 295-306]. Also these data offer the possibility of studying charmonia production at an intermediate energy between Tevatron and the present LHC top energy, and represent an interesting test for models. The measurement of charmonium production is especially promising at the Large Hadron Collider (LHC) where the high-energy density of the medium and the large number of (c-cbar) pairs produced in central Pb-Pb collisions can help to disentangle between the different suppression and regeneration scenarios [Phys.Rev.Lett. 109 (2012) 072301, Phys.Lett. B734 (2014) 314-327.]. Furthermore the study of charmonia in p-A collisions can be used as a tool for a quantitative investigation in the context of studies of the hot and dense matter [JHEP 1402 (2014) 073, JHEP 1412 (2014) 073,JHEP 1606 (2016) 050].

- **Bottomonia production and suppression**

The Bottomonia (Upsilon, 1S, 2S and 3S states) production [Eur.Phys.J. C74 (2014) no.8, 2974, Eur.Phys.J. C76 (2016) no.4, 184] is a powerful tool to investigate hadron collisions and the properties of the medium created in heavy-ion collisions. According to the color-screening model, these mesons give important information about the deconfined medium called Quark-Gluon Plasma (QGP) produced in ultrarelativistic heavy-ion collisions. The study of bottomonium production also complements the results obtained with charmonia: for the latter system an important regeneration in AA collisions might be expected at the LHC energies due to the large number of c-cbar pair produced, while this effect should be much smaller for the bottomonium [Phys.Lett. B738 (2014) 361-372]. Cold nuclear matter (CNM) effects can modify the bottomonium production [Phys.Lett. B740 (2015) 105-117] even in absence of deconfined matter: the study of p-A collisions is therefore very important to disentangle these effects from the hot ones.

- **Quarkonia(charmonia) flow**

The azimuthal distribution of particles in the transverse plane is sensitive to the dynamics of the early stages of heavy-ion collisions. In non-central collisions, the geometrical overlap region and, therefore, the initial matter distribution are anisotropic (almond-shaped). If the matter is strongly interacting, this spatial asymmetry is converted via multiple collisions into an anisotropic momentum distribution. Henceforth more differential studies, like the J/psi elliptic flow, could help to assess the assumption of charm quark thermalization in the medium [Phys.Rev.Lett. 111 (2013) 162301]. Within the transport model scenario the observed J/psi have two origins. First, primordial J/psi produced in the initial hard scatterings, traverse and interact with the created medium. During this process they may be dissociated. Second, J/psi could be regenerated from deconfined charm quarks in the QGP.

- **Photo-production of charmonia**

Exclusive photoproduction of vector mesons, where a vector meson but no other particles are produced in the event, is of particular interest. Exclusive production of J/psi in photon-proton interactions, $\gamma + p \rightarrow J/psi + p$, has been successfully modelled in perturbative QCD in terms of the exchange of two gluons with no net-colour transfer. Exclusive photoproduction of J/ψ vector mesons are presented in Pb–Pb collisions at $\sqrt{s_{NN}}$= 2.76 TeV have been measured at forward rapidities through their dimuon decay [Phys.Lett. B718 (2013) 1273-1283]. Exclusive photoproduction can be either coherent, where the photon couples coherently to all nucleons, or incoherent, where the photon couples to a single nucleon.

- **Polarization of charmonia**

The measurement of polarization clearly represents a more stringent test of the theoretical calculations, offering therefore the possibility of confirming/ruling out the current QCD approach to charmonium production. The study of the J/psi polarization at the LHC energies has therefore opened up a new testing ground for theoretical models. At present, NLO calculations for direct J/psi polarization at the LHC via the color-singlet channel predict a large longitudinal polarization in the HE frame which is in contrast with the vanishing polarization that we observe in such a transverse momentum region [Phys. Rev. Lett. 108 (2012) 082001].

- **Multiplicity dependence of charmonia production**

The charged particle multiplicities measured in high-multiplicity pp collisions at LHC energies reach values that are of the same order as those measured in heavy-ion collisions at lower energies like at RHIC, BNL. Since quarkonium yields in heavy-ion reactions are expected to be modified relative to minimum bias pp collisions it will be interesting to know whether their production rates in high-multiplicity pp collisions are already exhibiting any effects like J/psi suppression. The increase of the J/psi production with event multiplicity, as reported in Phys.Lett. B712 (2012) 165-175, might be due to Multi-Parton Interaction (MPI). In this scenario the multiplicity of charged particles is a direct measurement of the number of partonic interactions in the pp events.

- **Weak Bosons at forward rapidity**

With the large centre-of-mass energies and luminosity of the Large Hadron Collider (LHC), the W and Z boson production has become accessible now in proton-nucleus collisions at forward rapidities [JHEP 1702 (2017) 077]. The W and Z boson production occurs in hard scattering processes at the initial stage of the collision, and it is expected to scale with the number of binary nucleon-nucleon collisions. The centrality-dependent yield can be therefore used as a test bench for the centrality estimation at the LHC. Further measurements with better precision are needed to provide more stringent constraints on the nPDFs and on the binary scaling.

CMS Collaboration

- **Higgs Physics**

The most important milestone is undoubtedly the discovery of the Higgs boson with a mass of 125 GeV in various Higgs decay channels ($H \rightarrow ZZ^* \rightarrow 4l$, $H \rightarrow \gamma\gamma$, $H \rightarrow \tau\tau$, $H \rightarrow ZZ^* \rightarrow 2l2\tau$) and measurement of the properties of the newly found boson. The discovery has opened up a new window to unknown physics which crucially depends on the precise measurement of the Higgs boson properties [Ref: CMS publication - 1, 4, 7, 10, 11, 16].

- **Searches for physics Beyond Standard Model**

Search for Dark matter and Large extra dimension at the LHC in the single photon + MET (mono-photon) channel has been a clean probe for searching gravitons (as predicted by

Arkani Hamed Dimopoulos Dvali's model on spatial extra dimensions) and for direct pair production of dark matter(DM) candidates. For the simplified dark matter production models considered, the latest search excludes mediator masses of up to 700 GeV for low-mass dark matter. For an effective dimension-7 photon-dark matter contact interaction, values of up to 600 GeV are excluded. For the ADD model with extra spatial dimensions, values of the fundamental Planck scale up to 2.31–2.49 TeV, depending on the number of extra dimensions, are excluded. These are the most stringent limits to date using the monophoton final state. The bounds obtained from this analysis on the DM-nucleon scattering cross section complements the best bounds from direct-detection experiments in the DM mass region below ~200 GeV. The same final state has been used for measurement of production cross section for Z to invisible + γ final state, from which upper bounds have been set on trilinear gauge boson couplings.

SINP members have also been involved in the search for compositeness in the leptons sectors, throughout the RUN1 period. Pair production of leptons, where one lepton is produced in an excited state and radiatively comes down to ground state gives rise to l+l-γ final state. Using this final state, the first upper bound from the LHC on the compositeness scale of leptons was reported. Improved bounds, well exceeding the best limits from TeVatron, were reported in the scalar lepton mass- contact interaction scale plane, in two subsequent publications. SINP took the full responsibility of the electron channel analysis.

SINP members have played leadership roles in these searches, serving as analysis contacts and main editors [Ref: CMS publication – 2, 3, 5, 16, 17, 18, arXiv: 1706.03794v1].

A thesis work from SINP on the monophoton analysis has been highlighted in the CERN courier and received Rahul Basu Memorial best thesis award of 2016.

- **QCD**

Measurement of the double-differential inclusive jet cross section, study of hadronic event-shape variables in multijet final states and topological observables in inclusive three- and four-jet events using the CMS data have been a major achievement of the group, with SINP members being responsible for the complete analyses. [Ref: CMS publication – 8, 12, 15].

- **Detector related studies**

For the proposed PhaseII CMS upgrade, the addition of a Track Trigger at Level1, which is an integral part of the design of the proposed new silicon tracker, will help enormously to keep the trigger rate low without loosing any physics potential. It has been estimated that a rate of 750 kHz Level-1 read-out rate (compared to the current 100 kHz) and up to 12.5 μsec Latency (compared to the current 4 μsec) is achievable at PhaseII. In this context a detailed study was done to estimate the performance of electron trigger. It was shown that a reduction factor of 10 can be achieved without compromising the electron Et threshold, if Level1 Tracking information is combined with the Calorimeter information [Ref: CMS publication – 13, 14].

The capability of the L1 Track trigger was also exploited by studying whether Bs $\rightarrow$ φ φ $\rightarrow$ 4K events can be triggered at Level-1 [CMS PAS FTR-16-006].

The electronics of different components of the HCAL have been upgraded during the long shutdown 1 (LS1, 2013-14) of LHC, with SINP playing a leading role. A micro-TCA based testing system for backend electronics cards and a power module test was setup in SINP.

SINP members participated in High-granularity calorimeter (HGCAL) test beams at CERN and Fermilab in 2016, participating in data taking shifts and taking responsibilities of simulation of the test beams.

The laboratory set-up for quality control activities related to CMS Muon System upgrade, namely Gas leak test, High voltage test, and Effective gain measurement and response uniformity test is nearing completion.

- **Computing**

The CMS cluster hardware was fully installed and commissioned by 2012. The full CMS analysis framework was successfully installed. An important achievement was to successfully hold the CMS Data Analysis (CMSDas) school at SINP in 2013, the only one held in India so far. Since 2016, SINP became a member of the LHCone network.

In addition to CMS Collaboration papers published in journals, the group members have also authored several Detector Notes, Public Analysis Summary (PAS) documents and conference reports and contributed in internal reviews of several papers.

Phenomenological studies

By studying the electromagnetic probes from AQGP we have extracted the thermalization time of the QGP which matches with that extracted using other observables, such as, elliptic flow. We have shown that the wake potential in AQGP is very different from that in isotropic QGP which modifies the two-quark potential and in view of that quarkonium dissociation should be re-investigated. Using NRQCD model we have calculated the J/psi production cross-section in p-p collisions at LHC energies and showed that the data is well reproduced above certain transverse momentum. In the literature it has been argued that pion and rho mesons condense at some finite critical value of the magnetic field. However, using an effective model and the full propagator in magnetic field we conclude that infinitely large magnetic field is necessary for neutral pion to condense. In case of rho meson the mass increases with the magnetic field indicating no rho condensation.

The production ratio of Y(3S) to Y(1S) and Y(2S) to Y(1S) via pp collisions at the LHC energies is an important preliminary to the research on QGP as discussed and summarized in Modern Physics Letters A publication Vol.28, No.16, 1350067(May 2013) and further compared with the experimental results(of ALICE and LHCb) to test the validity of the calculations for quarkonia,[both charmonia(J/psi(1S),Psi(2S)) and bottomonia(Y(nS))] production at 7 TeV published in 2013 in Modern Physics Letters A Vol. 28, No.28, 1350120 (August 2013) alongwith the 8 TeV studies which was published in Modern Physics Letters A Vol.29, No.16, 1450082 (May 2014), for 13 TeV in Int. J. Mod. Phys. E 24, no. 05, 1550038 (2015), and in other review summary published in International Journal of Modern Physics A Vol. 31, 1630010 (2016, march) including the comparisons with experimental results published in Int.J.Theo.Phys. Volume 55, Issue 10, 4362-4370, October 2016. To understand and interpret the quarkonia measurements in p-Pb data-sets, which happened during the last phase of 2016, the studies of Cold Nuclear Matter(CNM) effects primarily on Y(3S) to Y(1S) ratios (denoted as RY(3S)/Y(1S)) and their suppression comparisons with [J/psi(1S),Psi(2S)] for p-Pb at 8 TeV are published in Int.J.Theor.Phys. Volume 55, Issue 12, pp 5152-5156, 2016.

HENPP members have also been involved in phenomenological studies of new physics in proton proton collision. Complementing the experimental analysis of low mass resonance in diphoton final states, it has been shown that a low mass radion can give such low mass diphoton final states produced in the LHC collisions (Phys. Rev. D 91, 016008).

Nuclear structure studies at high spins

- **Nearly Degenerate Doublet Bands in ^{106}Ag (PRL 112 (2014) 202503)**

The lifetimes of the excited levels for the two nearly degenerate bands of ^{106}Ag were measured using the Doppler-shift attenuation method. The deduced B(E2) and B(M1) rates in the two bands are found to be similar, except around the band crossing spin, while their moments of inertia are quite different. This was a novel observation for a nearly degenerate doublet band.

- **Emergence of principal axis rotation in ^{110}Ag (PLB 710 (2012) 587)**

The negative-parity yrast band of ^{110}Ag was extended significantly and the lifetimes of the high spin levels of this band have been measured. The experimentally observed level scheme and measured electromagnetic transition rates were compared with the theoretical predictions of a model with two quasiparticles coupled to a triaxially deformed core. This calculation successfully reproduced the energy spectra and electromagnetic transition rates beyond $I^{\pi} = 12^{-}$ hbar. These observations indicate that the principal axis of rotation is responsible for the generation of high angular momentum states along the yrast cascade in ^{110}Ag. In all the other lighter isotopes, these states are generated through titled axis rotation. Thus, ^{110}Ag is the first nucleus where the boundary between tilted and principal axis rotation was established.

- **Antimagnetic rotation in ^{104}Pd (PRC 89 (2014) 061303 (R))**

The electric quadrupole transition rates for the high-spin yrast states of ^{104}Pd was measured by using the Doppler-shift attenuation method. These values were found to decrease with the increase of angular momentum, which could be associated with the phenomenon of antimagnetic rotation. In this work, a numerical calculation based on the semiclassical particle plus rotor model for antimagnetic rotation was employed, giving a good description of the experimental Routhian and the transition rates and providing conclusive evidence of antimagnetic rotation in a nucleus other than cadmium.

- **Novel evolution of the positive parity shears band in ^{106}Ag(PRC95(2017)051304 (R))**

The positive-parity band of ^{106}Ag was extended up to I = 25 hbar and the lifetimes of the high spin levels of this band have been measured. The deduced transition rates decrease with increasing spin until I = 21 hbar. Beyond this spin, the observed transition rates are substantially small and remain nearly constant. This is a novel observation for a shears band. The observed features were described within the framework of the shears mechanism with a principle axis cranking calculation.

Future Plan

ALICE Collaboration

The readout of ALICE Muon Spectrometer will need a major upgrade in order to accept 50 kHz Pb-Pb collisions and 200 kHz pp and p-Pb collisions during Run III. The MANAS chip will be replaced by a self-triggered chip named SAMPA. Thus, electronic readout PCBs for all the Muon Tracking Stations need to be re-designed and re-fabricated. The SAHA-ALICE team is responsible for this upgrade for the 2nd Station. This will be the largest PCB (1.2 mt X 1.2 mt) with more than 8000 signal tracks per readout plane. The conceptual design has already been approved by the External Reviewers of ALICE. The detail electronics design is being done in-house and the first prototype is expected during 2017 which will be used for validation tests. The full production is foreseen in the second half of 2018. The new readout will be installed at CERN during 2019-20 (Long Shut down 2).

A new data concentrator card (CRU) will be produced in India and the SAHA-ALICE team will be responsible for the validation tests of these cards. We are preparing the requisite infrastructure in the division for these tests. It is also planned that the Saha team will contribute in the development of User Logic Firmware on the FPGA on CRU.

During 2019-20, the ALICE Muon Spectrometer will be augmented by a Muon Forward Tracker (MFT) which will add the vertexing capability. This MFT will have five tracking planes with Si-Pixel sensors. The SAHA-ALICE team is responsible for the cooling solution of these planes. The cooling plate made out of carbon-composites will be fabricated indigenously. In addition, the members will participate in assembly and QA testing of sensor ladders and disk of MFT and the technical team will participate in the installation of MFT disks in cavern.

In addition to these upgrade responsibilities, the team will be responsible for the regular maintenance of the detectors for the 2nd Muon Tracking station.

These augmentation and increased luminosity of the beam will substantially enhance the physics domain of the ALICE Muon Spectrometer. The MFT will improve the special resolution and a detail study of bottomonia production at forward rapidity will be possible. The exclusive charmonia studies will be possible and the J/ψ tagged B-physics at forward rapidity will be pursued.

CMS Collaboration

Physics analysis: The group plans to continue working on the measurement of properties of the Higgs boson Coupling, J^{CP}, differential cross section, mass and self-coupling (through di-Higgs production). Following the discovery of the Higgs boson in 2012, searches for new physics, in particular Super-symmetry, Dark Matter and other Exotic and beyond Standard Model (BSM) physics have become the main focus of the LHC experiments. The group is geared to pursue several such studies as more data become available.

The group will also continue with its long term responsibilities, namely, Tracker & HCAL Calibration, prompt feedback on data quality, Data validation & certification to serve the experiment.

Detector Development: The group plans to complete the ongoing work on HCAL backend electronics upgrade and GEM station GE1/1 production and installation in time. R&D activities for PhaseII upgrade on GEM, HGCal and Tracker have already started and further work towards deliverables on all the three detectors will be the major hardware focus of the group.

The group also has plans to expand the existing computing facility and add cpu power and storage in order to be able to cope with the increase in CMS data volume in the next few years and beyond.

Phenomenological studies

In the coming years we plan to study the measurement of production cross-sections of heavy-quark resonances at ultra-relativistic heavy ion collision. This has direct relevance to the ALICE-DIMUON spectrometer. In addition to that we would also like to investigate quasi-particle damping rate in magnetized strongly interacting matter, equation of state of warm and dense hadron gas in magnetic field which may be applied to study the properties of magnetars where moderately high magnetic field is believed to exist. We also plan to study spectral properties of hadrons in magnetic field using different effective models. Analysis of single muon from heavy flavour decay in ALICE will also be done in the coming years.

We plan to carry out phenomenological studies on new particle signatures in p-p collisions which would be possible with the high luminosity LHC.

Nuclear structure studies at high spins

The experimental investigations in A~100 region will be extended to the study of the non-yrast bands of neutron-rich isotopes of this mass region. These studies are expected to reveal a rich variety of single particle configurations and shape effects.

The band structures of ^{184}Pb will be studied through delayed alpha-tagging using the INGA-HYRA set-up at Inter University Accelerator Centre (beam-time approved).

At the upcoming FRENA, the team proposes measure fission cross-sections at deep sub-barrier energies.

List of Publications (2012-17): (Total - 82)

ALICE (substantial contribution from SAHA-ALICE team)

1) *Production of muons from heavy-flavour hadron decays in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Shreyasi Acharya et al.).
Phys.Lett. B770 (2017) 459-472.

2) *Energy dependence of forward-rapidity J/ψ and ψ(2S) production in pp collisions at the LHC*
By ALICE Collaboration (Shreyasi Acharya et al.).
Eur.Phys.J. C77 (2017) no.6, 392.

3) *W and Z boson production in p-Pb collisions at* $\sqrt{s_{NN}}$ *= 5.02 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
JHEP 1702 (2017) 077.

4) *J/ψ suppression at forward rapidity in Pb-Pb collisions at* $\sqrt{s_{NN}}$*= 5.02 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Phys.Lett. B766 (2017) 212-224.

5) *Centrality dependence of ψ(2S) suppression in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
JHEP 1606 (2016) 050.

6) *Measurement of an excess in the yield of J/ψ at very low* p_T *in Pb-Pb collisions at* $\sqrt{s_{NN}}$*=2.76 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Phys.Rev.Lett. 116 (2016) no.22, 222301.

7) *Inclusive quarkonium production at forward rapidity in pp collisions at* $\sqrt{s}$*= 8 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Eur.Phys.J. C76 (2016) no.4, 184.

8) *Coherent ψ(2S) photo-production in ultra-peripheral Pb-Pb collisions at* $\sqrt{s_{NN}}$ *=2.76 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Phys. Lett. B751 (2016) 358.

9) *Elliptic flow of muons from heavy-flavour hadron decays at forward rapidity in Pb-Pb collisions at* $\sqrt{s_{NN}}$ *=2.76 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Phys.Lett. B753 (2016) 41-56.

10) *Φ-meson production at forward rapidity in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV and in pp collisions at* $\sqrt{s}$ *= 2.76 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
Phys.Lett. B768 (2017) 203-217.

11) *Centrality dependence of inclusive J/ψ production in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
JHEP 1511 (2015) 127.

12) *Differential studies of inclusive J/ψ and ψ(2S) production at forward rapidity in Pb-Pb collisions at* $\sqrt{s_{NN}}$*=2.76 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
JHEP 1605 (2016) 179.

13) *Rapidity and transverse momentum dependence of the inclusive J/ψ nuclear modification factor in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Jaroslav Adam et al.).
JHEP 1506 (2015) 055.

14) *Production of inclusive Υ(1S) and Υ(2S) in p-Pb collisions at* $\sqrt{s_{NN}}$ *= 5.02 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Lett. B740 (2015) 105-117.

15) *Exclusive J/ψ photoproduction off protons in ultra-peripheral p-Pb collisions at* $\sqrt{s_{NN}}$ *= 5.02 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Rev.Lett. 113 (2014) no.23, 232504.

16) *Suppression of Upsilon(1S) at forward rapidity in Pb-Pb collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Lett. B738 (2014) 361-372.

17) *Suppression of psi(2S) production in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
JHEP 1412 (2014) 073.

18) *Measurement of quarkonium production at forward rapidity in pp collisions at* $\sqrt{s}$ *= 7 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Eur.Phys.J. C74 (2014) no.8, 2974.

19) *Performance of the ALICE Experiment at the CERN LHC*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Int.J.Mod.Phys. A29 (2014) 1430044.

20) *Centrality, rapidity and transverse momentum dependence of J/ψ suppression in Pb-Pb collisions at* $\sqrt{s_{NN}}$ *=2.76 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Lett. B734 (2014) 314-327.

21) *J/Psi production and nuclear effects in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*
By ALICE Collaboration (Betty Bezverkhny Abelev et al.).
JHEP 1402 (2014) 073.

22) *J/psi Elliptic Flow in Pb-Pb Collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
By ALICE Collaboration (Ehab Abbas et al.).
Phys.Rev.Lett. 111 (2013) 162301.

23) *Coherent J/psi photoproduction in ultra-peripheral Pb-Pb collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
By ALICE Collaboration (Betty Abelev et al.).
Phys.Lett. B718 (2013) 1273-1283.

24) *Production of Muons from Heavy Flavor Decays at Forward Rapidity in pp and Pb-Pb Collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
By ALICE Collaboration (Betty Abelev et al.).
Phys.Rev.Lett. 109 (2012) 112301.

25) *Inclusive J/psi production in pp collisions at* $\sqrt{s}$ *=2.76 TeV*
By ALICE Collaboration (B. Abelev et al.).
Phys.Lett. B718 (2012) 295-306, Erratum: Phys.Lett. B748 (2015) 472-473.

26) *J/psi production as a function of charged particle multiplicity in pp collisions at* $\sqrt{s}$ *=7 TeV*
By ALICE Collaboration (B. Abelev et al.).
Phys.Lett. B712 (2012) 165-175.

27) *J/psi Suppression at Forward Rapidity in Pb-Pb Collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*
By ALICE Collaboration (B. Abelev et al.).
Phys.Rev.Lett. 109 (2012) 072301.

28) *Heavy flavour decay muon production at forward rapidity in proton-proton collisions at* $\sqrt{s}$ *= 7 TeV*
By ALICE Collaboration (Betty Abelev et al.).
Phys.Lett. B708 (2012) 265-275.

29) *J/psi Polarization in pp Collisions at* $\sqrt{s}$ *= 7 TeV*
By ALICE Collaboration (Betty Abelev et al.).
Phys. Rev. Lett. 108 (2012) 082001.

30) *Rapidity and transverse momentum dependence of inclusive J/psi production in pp collisions at* $\sqrt{s}$ *= 7 TeV*
By ALICE Collaboration (Betty Abelev et al.).
Phys. Lett. B 704 (2012) 442.

In addition, the members of SAHA-ALICE team are co-authors of 120 publications by ALICE collaboration.

CMS (substantial contribution from SAHA-CMS team)

1. A New Boson with a mass of 125 GeV Observed with the CMS experiment at the Large Hadron Collider, CMS Collaboration, **Science 338(2012) 1569-1575**

2. Measurement of the production cross section for $Z\gamma \rightarrow \nu\nu\gamma$ in pp collisions at $\sqrt{s} = 7$ TeV and limits on $ZZ\gamma$ and $Z\gamma\gamma$ triple gauge boson coupling, CMS Collaboration, **JHEP 10 (2013) 164**

3. Search for Dark Matter and Large Extra Dimensions in pp Collisions Yielding a Photon and Missing Transverse Energy, CMS Collaboration, **Phys. Rev. Lett. 108, 261803 (2012)**

4. Search for a Standard Model Higgs boson produced in the decay channel H → ZZ → $2l2\tau$ with CMS detector at $\sqrt{s}$ = 7 TeV, CMS Collaboration, **JHEP03 (2012) 081**

5. Search for excited leptons in pp collision at $\sqrt{s}$ = 7 TeV
CMS Collaboration, **Phys. Lett. B. 720 (2013) 309-329**

6. Observation of the diphoton decay of the Higgs boson and measurement of its properties, CMS Collaboration, **European Physics Journal C 74, no. 10, 3076 (2014)**

7. Study of hadronic event-shape variables in multijet final states in pp collisions at $\sqrt{s}$ = 7 TeV, CMS Collaboration, **JHEP10 (2014) 087**

8. Description and performance of track and primary-vertex reconstruction with the CMS tracker, CMS Collaboration, **JINST 9, no. 10, P10009 (2014)**

9. Evidence for the direct decay of the 125 GeV Higgs boson to fermions
CMS Collaboration, **Nature Phys. 10, 557 (2014)**

10. Evidence for the 125 GeV Higgs boson decaying to a pair of τ leptons
CMS Collaboration, **JHEP 1405, 104 (2014)**

11. Distributions of topological observables in inclusive three- and four-jet events in pp collisions at $\sqrt{s}$ = 7 TeV, CMS Collaboration, **Eur. Phys. J. C (2015) 75:302**

12. Technical Proposal for the Phase 2 Upgrade of the CMS Detector
CMS Collaboration, **CERN-LHCC-2015-010**

13. CMS Phase II Upgrade Scope Document
CMS Collaboration**, CERN-LHCC-2015-019**

14. Measurement of the double-differential inclusive jet cross section in proton–proton collisions at $\sqrt{s}$ = 13 TeV, CMS Collaboration, **Eur. Phys. J. C (2016) 76:451**

15. Measurement of differential cross sections for Higgs boson production in the diphoton decay channel in pp collisions at $\sqrt{s}$ = 8 TeV, CMS Collaboration, Eur. Phys. J. C (2016) 76

16. Search for new phenomena in monophoton final states in proton-proton collisions at sqrt(s) = 8 TeV ; *The CMS Collaboration*; **Phys. Lett. B 755 (2016) 102**

17. Search for excited leptons in proton-proton collisions at $\sqrt{S}$=8 TeV *The CMS Collaboration*; **JHEP 03 (2016) 125**

18. Measurement of the $Z\gamma \rightarrow \nu\nu\gamma$ production cross section in pp collisions at sqrt(s) = 8 TeV and limits on anomalous Z-Z-g and Z-g-g trilinear gauge boson couplings; *The CMS Collaboration*; **Phys. Lett. B 760 (2016) 448**

In addition, the members of SAHA-CMS team are co-authors of 400 publications by CMS collaboration.

PHENOMENOLOGY :

1. Spectral properties of rho meson in a magnetic filed,
   S. Ghosh, A. Mukherjee, M. Mandal, S. Sarkar, and P. Roy, **Phys.Rev. D94 (2016) no.9, 094043**

2. Jet-dilepton conversion from an anisotropic quark-gluon plasma,
   A. Mukherjee, M. Mandal, and P. Roy, **Eur.Phys.J. A53 (2017) no.5, 81**

3. Pionic dispersion relations in the presence of a weak magnetic field,
   S. P. Adhya, M. Mandal, S, Biswas, and P. Roy, **Phys.Rev. D93 (2016) no.7, 074033**

4. Systematic study of charmonium production in p-p collisions at LHC energies,
   B. Paul, M. Mandal, P. Roy, and S. Chattopadhyay, **J.Phys. G42 (2015) no.6, 065101**

5. Jet induced collective modes in an anisotropic quark gluon plasma,
   M. Mandal and P. Roy, **Phys.Rev. D89 (2014) no.7, 074016**

6. Wake potential in collisional anisotropic quark gluon plasma.
   M. Mandal and P. Roy, **Phys.Rev. D88 (2013) no.7, 074013**

7. Some aspects of anisotropic quark gluon plasma,
   M. Mandal and P. Roy, **Adv.High Energy Phys. 2013 (2013) 371908**

8. Two photon correlation in anisotropic quark gluon plasma,
   P. Mohanty, M. Mandal, and P. Roy, **Phys.Rev. C89 (2014) no.5, 054915**

9. Wake in anisotropic quark gluon plasma,
   M. Mandal and P. Roy, **Phys.Rev. D86 (2012) 114002**

10. Effect of running coupling on photon emission from quark gluon plasma,
    M. Mandal, P. Roy, S. Mitra, and S. Sarkar, **Phys.Rev. C85 (2012) 067901**

11. Role of magnetic intercation in dense plasma,
    S. Sarkar, K. Pal, and A. Dutt-Mazumder, **Adv.High Energy Phys. 2013 (2013) 530895**

12. Non-Fermi liquid behaviour of thermal relaxation time in degenerate electron plasma,
    S. Sarkar and A. Dutt-Mazumder, **Phys.Rev. D87 (2013) no.7, 076003**

13. Effect of flow on the quasiparticle damping rate in hot QCD plasma,
    S. Sarkar, K. Pal, and A. Dutt-Mazumder, **Phys.Rev. D88 (2013) 054006**

14. Psi(2S) and Upsilon(3S) Suppression in p-Pb 8 TeV Collisions and Mixed Heavy Quark Hybrid Mesons
    Leonard S. Kisslinger and Debasish Das, **Int.J.Theor.Phys. 55 (2016) no.12, 5152-5156.**

15. Psi and Upsilon Production in p-p Collisions at E=5, 14 TeV; and Comparison With Experiment at E= 7 TeV
    Leonard S. Kisslinger and Debasish Das, **Int.J.Theor.Phys. 55 (2016) no.10, 4362-4370.**

16. Psi and Upsilon Production in proton–proton collisions at E = 13 TeV
    Leonard S. Kisslinger and Debasish Da, **Int.J.Mod.Phys. E24 (2015) no.05, 1550038.**

17. Review of QCD, quark–gluon plasma, heavy quark hybrids, and heavy quark state production in p – p and A – A collisions
Leonard S. Kisslinger and Debasish Das, **Int.J.Mod.Phys. A31 (2016) no.07, 1630010.**

18. J/Psi, Psi(2S) Production in pp Collisions at E=510 GeV
Leonard S. Kisslinger and Debasish Das, **Int.J.Theor.Phys. 54 (2015) no.8, 2737-2739.**

19. Psi and Upsilon Production in pp Collisions at 8.0 TeV
Leonard S. Kisslinger and Debasish Das, **Mod.Phys.Lett. A29 (2014) 1450082.**

20. Psi and Upsilon Production In pp Collisions at 7.0 TeV
Leonard S. Kisslinger and Debasish Das, **Mod.Phys.Lett. A28 (2013) 1350120.**

21. Upsilon Production in pp Collisions For Forward Rapidities At LHC
Leonard S. Kisslinger and Debasish Das, **Mod.Phys.Lett. A28 (2013) 1350067.**

NUCLEAR STRUCTURE STUDIES:

1. B. Das, N. Rather, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, P. Datta, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; *Novel evolution of the positive parity shears band in* ^{106}Ag

Phys. Rev. C95, 051301 (R) (2017).

2. S. Rajbanshi, Sajad Ali, Abhijt Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Bhattacharjee, S. Bhattacharyya, **S. Chattopadhyay,** G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, T. Trivedi and A. Goswami; *Shears mechanism and development of collectivity in* ^{141}Sm

Phys. Rev. C94, 044318 (2016)

3. B. Das, N. Rather, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, P. Datta, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; *Three proton hole structure in* ^{106}Ag

Phys. Rev. C93, 064322 (2016)

4. J Sethi, R Palit, J J Carroll, S Karamian, S Saha, S Biswas, Z Naik, T Trivedi, M S Litz, P Datta, **S Chattopadhyay**, R Donthi, U Garg, S Jadhav, H C Jain, S Kumar, D Mehta, B S Naidu, G H Bhat, J A Sheikh, S Sihotraand P M Walker; *Low-lying states near the* $\boldsymbol{I}^{\pi} = 6^{+}$ *isomer in* ^{108}Ag

J. Phys. G: Nucl. Part. Phys. 43 015103 (2016)

5. S.Rajbanshi, S.Roy, SomnathNag, Abhijit Bisoi, S.Saha, J.Sethi, T.Bhattacharjee, S.Bhattacharyya, **S.Chattopadhyay**, G.Gangopadhyay, G.Mukherjee, R.Palit, R.Raut, M.SahaSarkara, A.K.Singh, T.Trivedi, A.Goswami; *Antimagnetic rotation and sudden change of electric quadrupole transition strength in* ^{143}Eu

Physics Letters B 748, 387 (2015)

6. S. Rajbanshi, Abhijt Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Trivedi, T. Bhattacharjee, S. Bhattacharyya, **S. Chattopadhyay,** G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, and A. Goswami **(2014);** *Multiple magnetic rotational bands based on proton alignment in* ^{143}Eu

Phys. Rev. C90, 024318.

7. N. Rather, S. Roy, P. Datta, **S. Chattopadhyay,** A. Goswami, S. Nag, R. Palit, S. Pal, S. Saha, J. Sethi, T. Trivedi, and H. C. Jain **(2014);** *Antimagnetic rotation in* ^{104}Pd

Phys. Rev. C89, 061303 (R).

8. N. Rather, P. Datta, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, G. H. Bhat, J. A. Sheikh, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; (2014); *Exploring the origin of nearly degenerate doublet bands in* ^{106}Ag

Phys. Rev. Lett 112, 202503.

9. S. Rajbanshi, Abhijt Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Trivedi, T. Bhattacharjee, S. Bhattacharyya, **S. Chattopadhyay,** G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, and A. Goswami **(2014);** *Shape coexistence in the near-spherical* ^{142}Sm *nucleus*

Phys. Rev. C89, 014315.

10. J. Sethi, R. Palit, S. Saha, T. Trivedi, G.H. Bhat, J.A. Sheikh, P. Datta, J.J. Carol, **S. Chattopadhyay**, R. Drnthi, U. Garg, S. Jadhav, H.C. Jain, S. Karamian, S. Kumar, M.S. Litz, D. Mehta, B.S. Naidu, Z. Naik, S. Sihortra, P.M. Walker, **(2013);** *Structure of nearly degenerate bands in* ^{108}Ag

Physics Letters B 725, 85.

11. Santosh Roy and **S. Chattopadhyay (2013);** *Comment on "Evidence of antimagnetic rotation in odd-A Cd-105"*

Phys. Rev. C87, 059801.

12. Santosh Roy, N. Rather, Pradip Datta, **S. Chattopadhyay**, R.A. Bark, S. Pal, S. Bhattacharya, R.K. Bhowmik, A. Goswami, H.C. Jain, R. Kumar, E. Lawrie, S. Muralithar, D. Negi, R. Palit, **(2012);** *Emergence of principal axis rotation in* ^{110}Ag

Physics Letters B 710, 587.

13. T. Trivedi, R. Palit, J. Sethi, S. Saha, S. Kumar, Z. Naik, V. V. Parkar, B. S. Naidu, A. Y. Deo, A. Raghav, P. K. Joshi, H. C. Jain, S. Sihotra, D. Mehta, A. K. Jain, D. Choudhury, D. Negi, S. Roy, **S. Chattopadhyay,** A. K. Singh, P. Singh, D. C. Biswas, R. K. Bhowmik, S. Muralithar, R. P. Singh, R. Kumar, and K. Rani **(2012);** *Small quadrupole deformation for the dipole bands in In-112*

Physical Review. C. 85, 014327.

SUKALYAN CHATTOPADHYAY, Sr. Professor H+

DoB 23 November 1963
Phone 91 33 23375346 (ext: 3405)
E-mail sukalyan.chattopadhyay@saha.ac.in

EDUCATION

1994: Ph.D. in Physics, University of Bombay (TIFR)
1988: M.Sc. in Physics, University of Poona and TIFR
1986: B.Sc. Physics Hons, University of Calcutta

AREA(S) OF RESEARCH

Angular momentum generation mechanisms in atomic nuclei.
Study of the properties of the matter produced in ultra-relativistic collisions at LHC using heavy quarks as probes.

ACADEMIC POSITIONS

2016- ...... : Senior Professor H+, Saha Institute of Nuclear Physics
2013-2016: Professor H, Saha Institute of Nuclear Physics
2008-2013: Professor G, Saha Institute of Nuclear Physics
2004-2008: Professor F, Saha Institute of Nuclear Physics
2000-2004: Associate Professor E, Saha Institute of Nuclear Physics
1998-2000: Reader D, Saha Institute of Nuclear Physics
1996-1998: Lecturer C, Saha Institute of Nuclear Physics
1995 : Research Associate, Saha Institute of Nuclear Physics
1988-1994: Research Fellow, Tata Institute of Fundamental Research

AWARDS/ HONOURS

Elected as Fellow of National Academy of Sciences, India in 2015.
Received TIFR Scholarship from 1986-'88 during post-graduation studies.
Identified as potential young scientist in nuclear physics by the Department of Science and Technology, Government of India in 1990.
Received the best thesis award in nuclear physics from the Indian Physics Association for the year 1993.

PUBLICATION Journals: 82 (for 2012-2016: 44)

SELECTED PUBLICATION (2012-2016)

B. Das, N. Rather, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, P. Datta, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; '*Novel evolution of the positive parity shears band in ^{106}Ag*' **Phys. Rev. C95, 051301 (R) (2017).**

B. Das, N. Rather, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, P. Datta, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; '*Three proton hole structure in ^{106}Ag*' **Phys. Rev. C93, 064322 (2016).**

N. Rather, S. Roy, P. Datta, **S. Chattopadhyay,** A. Goswami, S. Nag, R. Palit, S. Pal, S. Saha, J. Sethi, T. Trivedi, and H. C. Jain**;** '*Antimagnetic rotation in ^{104}Pd*' **Phys. Rev. C89, 061303 (R) (2014).**

N. Rather, P. Datta, **S. Chattopadhyay,** S. Rajbanshi, A. Gowsami, G. H. Bhat, J. A. Sheikh, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain; **(2014)**; '*Exploring the origin of nearly degenerate doublet bands in ^{106}Ag*' **Phys. Rev. Lett 112, 202503 (2014).**

Santosh Roy, N. Rather, Pradip Datta, **S. Chattopadhyay**, R.A. Bark, S. Pal, S. Bhattacharya, R.K. Bhowmik, A. Goswami, H.C. Jain, R. Kumar, E. Lawrie, S. Muralithar, D. Negi, R. Palit; '*Emergence of principal axis rotation in 110Ag*' **Phys. Lett. B 710, 587 (2012).**

S.Chattopadhyay in J. Adam et al. (ALICE Collaboration), 'Centrality dependence of ψ(2S) suppression in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, **Journal of High Energy Physics 1606 (2016) 050.**

S.Chattopadhyay in J. Adam et al. (ALICE Collaboration), '*Production of inclusive Υ(1S) and Υ(2S) in p-Pb collisions at* $\sqrt{s_{NN}}$ *= 5.02 TeV*' **Phys. Lett. B740, 105 (2014).**

S.Chattopadhyay in J. Adam et al. (ALICE Collaboration), **'***Suppression of psi(2S) production in p-Pb collisions at* $\sqrt{s_{NN}}$ *=5.02 TeV*' **Journal of High Energy Physics 12, 073 (2014).**

S.Chattopadhyay in J. Adam et al. (ALICE Collaboration), **'***Suppression of Upsilon(1S) at forward rapidity in Pb-Pb collisions at* $\sqrt{s_{NN}}$ *= 2.76 TeV*' **Phys. Lett. B738, 361 (2014)**

S.Chattopadhyay in J. Adam et al. (ALICE Collaboration), **'***Measurement of quarkonium production at forward rapidity in pp collisions at* $\sqrt{s}$ *= 7 TeV*' **Eur. Phys. J. C74, 2974 (2014)**.

SELECTED TALKS (2012-2016)

"Prof. M.S. Sinha Colloquium" for 2017 at NIT Durgapur on *"Instrumentation, detection and observation"* (03/02/17).
SINP Colloquium on *"Effects of the shape of a finite fermion system"* (13/05/15).
NSF Colloquium of TIFR on *"Shapes and symmetries of Atomic Nucleus"* (14/01/15).
Invited talk on *"ALICE-MS: The Indian Contribution"* at the National Meet on "India at Large Hadron Collider", INSA, Delhi (29/08/12).

TEACHING/ GUIDANCE

Ph.D. degree awarded: 8 [in the period 2012-2016: 4]; Thesis to be submitted: 3

ESSENTIAL STRENGTH OF RESEARCH / DEVELOPMENT OUTPUT:

I have been one of the first Indian nuclear spectroscopist who have done pioneering research work in the field of "Nuclear structure studies at high spins" using the techniques of measuring ultra short lifetimes of discrete nuclear states. Using these techniques, I have made significant contributions in the field of angular momentum generation mechanisms in atomic nuclei in mass-100 region.

Since 1997, I have been also working in the field of Ultra-relativistic heavy ion collision at CERN. Under my leadership, the Indian scientists have delivered indigenously developed state-of-art technology equipments for a CERN collaboration (ALICE) which includes the MANAS chip and the world's largest Cathode Pad Chambers; have taken the responsibility of data collection; have carried out the data analysis using the GRID facility and are exploring the properties of matter produced in ultra-relativistic collisions at the LHC using heavy quark resonances as probes. The data collected with these hardware deliverables have led to thirty research publications. I have been actively involved in the measurement of the production cross-sections of the heavy quark resonances at forward angles in nucleus-nucleus, proton-nucleus and proton-proton collisions at LHC.

FUTURE RESEARCH/DEVELOPMENT PLAN:

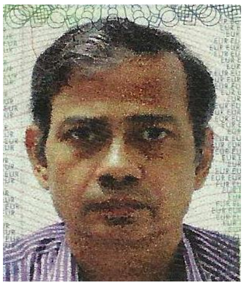
Spectroscopic study of the non-yrast bands of the neutron-rich nuclei of mass-100 region using the heavy ion beams from the Indian accelerator centres.

Measurement of fission cross-sections at deep sub-barrier energies using FRENA.

Measurement of double differential production cross-sections of heavy quark resonances at forward angles in nucleus-nuclues collisions with emphasis on the Jpsi regeneration at LHC energies.

The conceptual design of the electronic readout proposed by me for the Second Tracking Station has been accepted. I shall be responsible for the complete design, production and installation of the new readout PCBs for the high luminosity runs. I shall contribute in the hardware aspects of the Muon Forward Tracker. These two major upgrades will be carried out during 2019-2020.

I shall participate in setting up of a FPGA training centre for the students.



PRADIP KR. ROY, Professor G

DOB 5 August, 1967
Phone 91 33 23375346 (ext: 3429)
E-mail pradipk.roy@saha.ac.in

EDUCATION

1998, Ph.D. in Physics, Jadavpur University (1998).
1990, M.Sc. in Physics, Jadavpur University, Kolkata
1988, B.Sc in Physics Honors, Jadavpur University

AREA(S) OF RESEARCH

- Study of collective modes in anisotropic quark gluon plasma (AQGP)
- Study of electromagnetic probes in AQGP
- Charmonium production and suppression in QGP
- Hadronic properties in presence of magnetic field at high temperature and density.
- Study of fermionic oscillation in magnetized QGP

ACADEMIC POSITIONS

2013-………	Professor G, SINP
2007-2013	Professor F, SINP
2003-2007	Associate Professor E, SINP
2000-2003	Reader D, SINP
1998-2000	RA, SINP
1997-1998	RA, VECC

AWARDS/DISTINCTION

Received National scholarship.
Received Foundation day Award.

PUBLICATION for 2012-2017 : 40

SELECTED PUBLICATIONS (2012-2017)

Spectral properties of rho meson in a magnetic filed, S. Ghosh, A. Mukherjee, M. Mandal, S. Sarkar, and P. Roy, **Phys.Rev. D94 (2016) no.9, 094043**

Jet-dilepton conversion from an anisotropic quark-gluon plasma, A. Mukherjee, M. Mandal, and P. Roy, **Eur.Phys.J. A53 (2017) no.5, 81**

Pionic dispersion relations in the presence of a weak magnetic field, S. P. Adhya, M. Mandal, S, Biswas, and P. Roy, **Phys.Rev. D93 (2016) no.7, 074033**

Systematic study of charmonium production in p-p collisions at LHC energies, B. Paul, M. Mandal, P. Roy, and S. Chattopadhyay, **J.Phys. G42 (2015) no.6, 065101**

Jet induced collective modes in an anisotropic quark gluon plasma,
M. Mandal and P. Roy, **Phys.Rev. D89 (2014) no.7, 074016**

Wake potential in collisional anisotropic quark gluon plasma.
M. Mandal and P. Roy, **Phys.Rev. D88 (2013) no.7, 074013**

Some aspects of anisotropic quark gluon plasma,
M. Mandal and P. Roy, **Adv.High Energy Phys. 2013 (2013) 371908**

Two photon correlation in anisotropic quark gluon plasma,
P. Mohanty, M. Mandal, and P. Roy, **Phys.Rev. C89 (2014) no.5, 054915**

Wake in anisotropic quark gluon plasma,
M. Mandal and P. Roy, **Phys.Rev. D86 (2012) 114002**

Effect of running coupling on photon emission from quark gluon plasma,
M. Mandal, P. Roy, S. Mitra, and S. Sarkar, **Phys.Rev. C85 (2012) 067901**

SELECTED TALKS (2012-2017)

Invited talk in DAE-BRNS Nuclear Physics Symposium, 2016
Invited talk in Primordial QCD matter in LHC era, Cairo, 2013
Invited talk in dimuon meeting, Tuscany, Italy, 2017

TEACHING/Ph.D. GUIDANCE:

Ph. D. Degree Awarded: 4 [in the period 2012-2017: 4]. No. of present students : 2

FUTURE RESEARCH PLAN

- Measurement of production cross-sections of heavy-quark resonances at ultra-relativistic heavy ion collision.
- Quasi-particle damping rate in magnetized strongly interacting matter
- Equation of state of warm and dense hadron gas in magnetic field
- Spectral properties of hadrons in magnetic field using different effective models
- Analysis of single muon from heavy flavour decay in ALICE

SATYAKI BHATTACHARYA, Professor G

DoB 21 January 1969

Phone 91 33 23375346 (ext: 3431)

E-mail bhattacharya.satyaki@saha.ac.in

EDUCATION

1999: Ph.D. in Physics, University of Bombay (TIFR)

1993: M.Sc. in Physics, University of Calcutta; 1st class

1990: B.Sc. Physics Hons, University of Calcutta; 1st class

ACADEMIC POSITIONS

2016- ...... : Professor G, Saha Institute of Nuclear Physics

2011-2016: Associate Professor F, Saha Institute of Nuclear Physics

2010-2011: Associate Professor, IISER, Kolkata

2005-2010: Reader and Assoc. Professor, University of Delhi

1999-2005: Post Doctoral Researcher and Junior Scientist in CMS project, University of California, San Diego

AWARDS/ HONOURS

Recipient of 2007 best poster-paper award in 2007 International Lepton- Photon conference, Daegu, South Korea.

PUBLICATION

I am a signing author of CMS experiment at LHC since 2000, and L3 experiment at LEP, CERN from 1999-1996.

SELECTED PUBLICATION (2012-2016)

CMS papers where I am a primary author

1. Search for new phenomena in monophoton final states in proton-proton collisions at sqrt(s) = 8 TeV ; *The CMS Collaboration*; **Phys. Lett. B 755 (2016) 102**
2. Measurement of the Z gamma to nu nu-bar gamma production cross section in pp collisions at sqrt(s) = 8 TeV and limits on anomalous Z-Z-γ and Z-γ-γ trilinear gauge boson couplings; *The CMS Collaboration*; **Phys. Lett. B 760 (2016) 448**
3. Search for excited leptons in proton-proton collisions at √S=8 TeV *The CMS Collaboration*; **JHEP 03 (2016) 125**
4. Search for excited leptons in pp collisions at sqrt(s) = 7 TeV *The CMS Collaboration;* **Phys. Lett. B 720 (2013) 309–329**
5. Measurement of the production cross section for $Z\gamma \rightarrow \nu\nu\gamma$ in pp collisions at root(s) =7 TeV and limits on $ZZ\gamma$ and $Z\gamma\gamma$ triple gauge boson coupling, *The CMS Collaboration;* **JHEP 10 (2013) 164, CMS-SMP-12-020**
6. Search for Dark Matter and Large Extra Dimensions in pp Collisions Yielding a Photon and Missing Transverse Energy, *The CMS Collaboration;* **Phys. Rev. Lett. 108 261803 (2012).**

Other papers

7. A review of the discovery of SM-like Higgs boson in $H \rightarrow \gamma\gamma$ decay channel with the CMS detector at the LHC; *Bhattacharya S. & Jain S.*; **Pramana, 87(3), 1-30**
8. Probing the light radion through diphotons at the Large Hadron Collider.
Satyaki Bhattacharya, Mariana Frank, Katri Huitu, Ushoshi Maitra, Biswarup Mukhopadhyaya, and Santosh Kumar Rai,
Phys. Rev. D 91, 016008, 26 January 2015

GUIDANCE Ph.D. degree awarded: 4 [in 2012-2016: 4]; Thesis to be submitted: 4
Guided more than 15 under graduate and graduate level project students.

TEACHING 6 years of teaching experience in theoretical and laboratory courses in University of Delhi and IISER, Kolkata. I teach regularly in post-M.Sc. Courses of SINP. Invited lecturer in several SERC schools in Theoretical HEP and other national level workshops.

AREA(S) OF RESEARCH:

- Search for new phenomena in high energy collisions.
- Computing and machine learning in HEP.

ESSENTIAL STRENGTH OF RESEARCH / DEVELOPMENT OUTPUT:

Since 1995 my core research activity has been searching for new particles in high energy colliders. Starting with search for supersymmetry (**Phys.Lett. B471 (1999) 280-292, Phys.Lett. B456 (1999) 283-296**) in the L3 experiment, my expertise covers a broad range of searches beyond standard model. My most important work is a study of a machine learning based search strategy for Higgs discovery in diphoton mode (**CMS Physics TDR, Vol II, CMS Note-2006-112**) which was useful for the Higgs discovery at the LHC. In run 1 of LHC my team's most significant contributions have been in search for excited leptons and search for dark matter. I am one of the initiators of the searches in single photon + MET channel in CMS. Search for dark matter in this channel produced important upper bounds in the dark matter-nucleon scattering cross-sections (**Phys. Lett. B 755 (2016) 102, spires citation 82, and Phys. Rev. Lett. 108, 261803 (2012) spires citation 170, best poster paper award in international Lepton Photon conference, 2011, Mumbai**) The excited lepton and monophoton analyses have featured in CERN courier and Fermilab news.

My phenomenological work with colleagues from Univ. of Delhi (**Phys.Rev.D80:015014,2009.**) on excited quark search have been cited by both CMS and ATLAS collaborations in the first LHC searches of quark compositeness in photon + jets channel.

Between 1999-2004 I contributed in the early phase of building the online event builder network of CMS **(arXiv:physics/0306150)**. I took a leadership role in designing and building the computing facility of the department of physics and astrophysics, Univ. of Delhi and played a key role in designing and setting up of the CMS computing cluster of SINP.

I have a long term interest in calorimetry in HEP. Students under my guidance have taken significant responsibilities for photon identification in the CMS and in calibration of the hadron calorimeter. I am investigating at present the possible applications of machine learning techniques in particle identification in calorimeters (**J.Phys,Conf. Series Vol 759, Pg. 478**).

FUTURE RESEARCH/DEVELOPMENT PLAN:

I plan to continue with new particle search including dark matter search at the LHC but also get more involved in direct dark matter detection experiment in India. In computing, further development of the existing computing center and setting up GPU based systems for machine learning applications is my interest. In detector development I plan to contribute in forward calorimeter upgrade of the CMS.

SUBIR SARKAR, Associate Professor F

DoB 10 September 1966
Phone 91 33 23375346 (ext: 3433)
E-mail subir.sarkar@saha.ac.in

EDUCATION
1997: Ph.D. in Physics, University of Bombay
1991: M.Sc. in Physics, University of North Bengal
1988: B.Sc. Physics Hons, University of North Bengal

ACADEMIC POSITIONS
2011- till date: Associate Professor F, Saha Institute of Nuclear Physics, Kolkata
1997 – 2010: Post Doctoral fellow/Research Associate at INFN and University of Rome, University of Paris 6/7, CNAF-Bologna, Scuola Normale Superiore and INFN-Pisa

PUBLICATION Journals: 700+ (for 2012-2016: 400+)

SELECTED PUBLICATION (2012-2016)

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC, CMS Collaboration, *Phys. Lett. B 716, 30 (2012)*

Measurement of the double-differential inclusive jet cross section in proton–proton collisions at $\sqrt{s}$ = 13 TeV, CMS Collaboration, Eur. Phys. J. C (2016) 76:451

Evidence for the 125 GeV Higgs boson decaying to a pair of τ leptons, CMS Collaboration, JHEP 1405 (2014) 104

Evidence for the direct decay of the 125 GeV Higgs boson to fermions, CMS Collaboration, Nature Phys. 10 (2014)

Description and performance of track and primary-vertex reconstruction with the CMS tracker, CMS Collaboration, JINST 9, no. 10, P10009 (2014)

TEACHING/ GUIDANCE
Ph.D. degree awarded: 1 [in the period 2012-2016: 1]; Thesis submitted: 2; Thesis to be submitted: 1
I regularly teach C++, Python, and ROOT to the Post M.Sc. Students at SINP

AREA(S) OF RESEARCH:

- Study of Quantum Chromodynamics and measurement of the strong coupling constant
- Study of multi-jet production at the Tevatron and LHC
- Searches for the SM Higgs Boson at the LEP and LHC
- Grid computing and core software development
- Study of properties of scintillating crystals (as a member of Crystal Clear Collaboration during 1992-95)

ESSENTIAL STRENGTH OF RESEARCH / DEVELOPMENT OUTPUT:

As a member of the e^+e^- collider experiment L3 at LEP, CERN, I measured the Strong Coupling Constant, α_s at various LEP energies (30 – 202 GeV) from a single experiment, and made significant contribution to the Standard Model Higgs Searches at the LEPII energies (1993-2000).

As a member of the pp collider experiment CDF at Tevatron, Fermilab, my contribution includes the measurement of the semi-inclusive cross-section of W/Z + n-jets processes at □s = 1.96 TeV, the Silicon Vertex Trigger (SVT) online and data quality monitoring software, building a grid-enabled CDF computing cluster at INFN-CNAF and integration of CDF computing to the Grid computing paradigm (1999-2008).

As a member of the CMS collaboration at CERN, I have contributed to building a Tier-2 computing center at INFN-Pisa, developed a variety of monitoring software in the context of Grid Computing. My contribution to physics analysis includes SM Higgs boson searches in $H \rightarrow \tau\tau$, $H \rightarrow ZZ^* \rightarrow$ 4-leptons channels, multi-jet production cross-section, trigger level study of $B_S \rightarrow \phi\phi \rightarrow 4K$ aimed for HL-LHC etc. (2007 – till date).

I have led a number of projects related to Grid computing and developed HEP applications in the field of core computing, involving real-time systems, messaging system, modern web technology etc.

FUTURE RESEARCH/DEVELOPMENT PLAN:

Following the discovery of the Higgs boson in 2012 by the ATLAS and CMS experiments, searches for new physics, in particular Super-symmetry, Dark Matter and other beyond Standard Model (BSM) physics have become the main focus of the LHC experiments. I am getting involved in several physics analyses involving flavor changing decay of exotic Higgs, rare Z decays and other multi-lepton signature. I shall continue to take active part in R&D and construction plans for the CMS tracker upgrade for LHC PhaseII and contribute to the tracker related software development. Other major activities will revolve around R&D for trigger system development for future experiments using GPU and FPGA and building a powerful computing cluster at the SINP.

SUCHANDRA DUTTA, Associate Professor F

DoB 24 October 1965
Phone 91 33 23375346 (ext: 3433)
E-mail suchandra.Dutta@cern.ch

EDUCATION
1997: Ph.D. in Physics, University of Bombay (TIFR)
1991: M.Sc. in Physics, University of North Bengal
1988: B.Sc. in Physics Hons, University of North Bengal

ACADEMIC POSITIONS
2011- : Associate Professor F, Saha Institute of Nuclear Physics
1997 – 2010 : Post Doctorate and Research Associate Positions at INFN Pisa, Scuola Normale Superiore, Pisa, University of Pisa, Italy; University of Wisconsin, USA; National Central University, Taipei, CERN, Geneva

PUBLICATION Journals: total 670+ (425+ during 2012-2016)

SELECTED PUBLICATION (2012-2016)

"Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC", CMS Collaboration ***Phys. Lett. B 716, 30 (2012)***

Evidence for the direct decay of the 125 GeV Higgs boson to fermions. *CMS Collaboration*, ***Nature Phys. 10 (2014)***

Evidence for the 125 GeV Higgs boson decaying to a pair of □ leptons, CMS Collaboration, **JHEP 1405 (2014) 104**

Description and performance of track and primary-vertex reconstruction with the CMS tracker, CMS Collaboration, **JINST 9, no. 10, P10009 (2014)**

Technical Proposal for the Phase 2 Upgrade of the CMS Detector, CMS Collaboration, **CERN-LHCC-2015-010**

CMS Phase II Upgrade Scope Document, CMS Collaboration, **CERN-LHCC-2015-019**

TEACHING/ GUIDANCE
Ph.D. degree awarded: 1 [in the period 2012-2016]; Thesis submitted 1 and to be submitted: 1

AREA(S) OF RESEARCH:

- measurement of the cross section of $e^+e^- \rightarrow Z \rightarrow$ □□□□ at LEP
- Precision measurement of electroweak parameters at LEP
- Search for the Higgs boson at the LHC
- Silicon microstrip detector at the collider experiment

ESSENTIAL STRENGTH OF RESEARCH / DEVELOPMENT OUTPUT:

Member of the CMS experiment at CERN since 1997. Key contributions are :

- **Hardware:** Development of high precision and radiation hard silicon micro-strip detectors for the CMS experiment starting from R&D phase up to installation and commissioning. Expertise on charge collection efficiency, S/N etc. in the laboratory as well as in beam test

- **Physics Analysis:** Search for the SM Higgs boson produced in association with a W boson and decaying to a pair of □□leptons; Analysis of Bs → □□□□□□□□ to design the Level 1 trigger for the CMS experiment using Level 1 tracks; Experimental measurement of $e^{+}e^{-} \rightarrow Z \rightarrow$ □$^{□}$□$^{□}$cross-section and forward-backward asymmetry around the Z pole and determination of Electro-Weak Parameters at LEP.

- **Software:** Expertise on Data Quality Monitoring software; small scale DAQ software used in laboratory to test silicon detectors; Digitization software to simulate physics processes taking place during passage of particles through matter and behavior of readout electronics to make event simulation as realistic and comparable to actual data as possible. Bad Channel calibration of CMS Tracker using data collected during collision and cosmic runs.

FUTURE RESEARCH/DEVELOPMENT PLAN:

Started and like to continue working on various aspects of the PhaseII CMS Tracker, namely,

- **Hardware:** build and qualify 2000 detector modules for the barrel part of the outer tracker in collaboration with a number of India-CMS institutions. The R&D on various aspects of this project has started and we are planning to build a test set up in the common (ALICE & CMS) clean room facility to qualify detector modules at SINP. Explore possibility of application of the silicon detectors in other physics fields as well as medical application.

- **Physics Analysis:** Started working on exotic search channels. It is important to work in collaboration with the Indian phenomenologists to probe some of their predictions. Rare B-decay is another area I would like to explore. Estimation of level 1 trigger performance using newly proposed Track Trigger of CMS.

- **Software:** Monitoring and calibration of the new detector. Finalization of the digitizer optimizing it's parameters using beam test data taken with prototype and final detector modules. Define calibration procedure of these detectors and contribute there as well.

Tinku **Sinha,** Scientist F

DOB: 27th June, 1966
Phone: +91 33 2337 5345-49 (Ext. 3407/4604)
e-mail: tinku.sinha@saha.ac.in

EDUCATION
1996: PhD, S.I.N.P (Jadavpur University), Kolkata.
1990: M.Sc., Physics (Visva Bharati University), West Bengal.
1988: B.Sc., Physics (Bethune College, Calcutta University), Kolkata.

Academic PROFILE
Scientist F 2013-onwards.
Scientist E 2007-2012.
Scientist D 2005-2007.
Senior Research Associate at SINP, 2002-2004.
CNRS Post-Doc at IPN Orsay, France 2001-2002.
CSIR Research Associate at SINP, 1997-2000.
DAE fellowship for Post-MSc and PhD at SINP, 1990-1996.

Assistant Professor, Homi Bhabha National Institute (HBNI) : 2013-onwards.

SELECTED PRESENTATIONS

1. ***QM12 held at Washinton DC, USA*: "**Study of single-muon and J/Ψ production in pp collisions at √s = 2.76 TeV as a function of multiplicity with ALIC**E** (16.8.2012).
2. ***DAE-DST Special Task Force Meeting at BARC, Mumbai***: "Looking forward towards next decade for ALICE Muons" (3.9.2016).

TEACHING/GUIDANCE Project students guided: 6.

ESSENTIAL STRENGTH OF RESEARCH/DEVELOPMENT OUTPUT

1. Developmental work on high energy and low energy nuclear physics.
2. Testing of chip with pixel sensor (pALPIDE) for solid-state Si-tracker detector at SINP for ALICE upgrade Muon Forward Tracker (MFT) collaboration.
3. Supervision on the construction of 'Advanced Laboratory of Detector and Chip testing' of class 10,000 in HENPP division, SINP.
4. Performed leading role for fabricating and testing the Ist iteration of prototype of water-cooling system for Si-tracker detector at SINP; Presented in ALICE-MUON collaboration meeting in May, 2017 at Tuscany, Pisa.
5. **Supervision of PhD student who is analyzing Physics problem on the 'Study of quarkonia as a function of charged particle multiplicity' in ALICE collaboration.
6. Teaching pre-doctoral students to give knowledge about the techniques of high energy physics performing experiments at laboratory in HENPP division.
7. Simulation and real experimental Data analysis for Physics problem in ALICE collaboration.

8. Conducting ALICE experiment as a Shift Leader for all central shifts and also Shift Leader in the Matter of safety.

9. Experimental High energy Physics.

10. Experimental Nuclear Physics: nuclear reactions.

*** *ANA4104: J/ψ and ψ (2S) production as a function of charged particle multiplicity in pp collisions at √s = 2.76 TeV and √s = 5.02 TeV.**
Anisa Khatun,, **Tinku Sarkar-Sinha**,, Indranil Das, Sukalyan Chattopadhyay, Shakeel Ahmad.
Ref.: https://aliceinfo.cern.ch/Notes/node/658.

FUTURE RESEARCH/DEVELOPMENT PLAN

1. Taking leadership on the developmental work on challenging water-cooling system at SINP, Kolkata in ALICE upgrade MFT collaboration as ***Responsible for India-MFT collaboration***.

2. To set up 'Test Bench' and testing of Common R/O Unit (CRU) for ALICE-MUON and MFT collaboration at laboratory in HENPP division.

3. Continuation on supervision on the construction of 'Advanced Laboratory of Detector and Chip testing' of class 10,000 in HENPP division, SINP.

4. Supervision of PhD student who is analyzing Physics problem on the 'Heavy Flavour Muon Physics at LHC using ALICE MUON Spectrometer ' in ALICE collaboration.; The student had done Post-MSc review Project-I during January- March, 2017 and continuing Project-II to be submitted in July, 2017.

5. Continuation on the supervision of PhD student for the physics problem on 'Study of quarkonia as a function of charged particle multiplicity' in ALICE collaboration.

6. Developmental work on new generation micro pattern gas detectors Thick Gas Electron Multiplier (THGEM).

LIST OF IMPORTANT PUBLICATIONS

There are around 100 published papers in ALICE during 2012-June, 2017 where myself is one of the co-authors. I have put five ALICE papers which I obtained from SINP News-Letter and which were performed by SAHA-ALICE group. The 6th paper is on low-energy nuclear Physics with NPD, BARC group.

1. Suppression of Υ(1S) at forward rapidity in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV.
   Phys. Lett. B 738 (2014) 361-372.
2. Production of Υ(1S) and Υ(2S) in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV.
   Phys. Lett. B 740 (2015) 105-117.
3. Measurement of quarkonium production at forward rapidity in pp collisions at √s = 7 TeV.
   Eur. Phys. J. C 74, 2974 (2014).
4. Suppression of Ψ(2S) production in p-Pb collisions at s_{NN} = 5.02 TeV.
   JHEP 12, 073 (2014).
5. Precision measurement of the mass difference between light nuclei and anti-nuclei.
   Nature Physics (2015) doi:10.1038/nphys3432.
6. Understanding the two neutron transfer reaction mechanism in $^{206}Pb(^{18}O, ^{16}O)\ ^{208}Pb$.
   NPA 940 (2015) 167-180.

Debasish Das Associate Professor E
DoB 10th May 1977
Phone 91 33 23375346 (ext: 3407)
Email debasish.das@saha.ac.in

EDUCATION Doctoral Student (till 2007) in Variable Energy Cyclotron Centre, Kolkata, India. Thesis from Jadavpur University, Kolkata, India.
2000 : M.Sc (Physics), Visva-Bharati University, First Class
1998 : B.Sc (Physics), Visva-Bharati University, First Class (Rank 1st)

ACADEMIC POSITIONS
2011 - .... : Associate Professor E, Saha Institute of Nuclear Physics
2009 – 2011 : Research Associate with the High Energy Nuclear and Particle Physics Division, Saha Institute of Nuclear Physics, Kolkata in ALICE - Indian Collaboration to Muon Spectrometer, Large Hadron Collider, CERN.
2007 – 2009 : Post-Doctoral position with the Nuclear Physics Group, University of California, Davis, CA working in STAR Collaboration, Brookhaven National Laboratory, USA.

AWARDS/ HONOURS/ MEMBERSHIPS

Plot from my paper "Upsilon production in STAR" picked as the graphic for the front page of The European Physical Journal C Vol. 62 No.1 (July 2009) [Hot Quarks (HQ2008), 2008].

Third BEST presenter at the Young Physicists' Colloquium-2006 organized by The Indian Physical Society at SINP, Kolkata for the paper titled "Pion and Photon Interferometry in STAR experiment at RHIC" in Physics Teacher Vol-48, Page 68 (2006).

BEST POSTER [first award] at Bhabha Atomic Research Centre (BARC, India) for the paper titled "Testing of Photon Multiplicity Detector for STAR Experiment" [DAE Nuclear Physics Symposium, 2003] .

The Indian Physical Society (LIFE MEMBERSHIP)
The Indian Science Congress Association (LIFE MEMBERSHIP)
American Physical Society (MEMBERSHIP from 2008-2009)

PUBLICATIONS SELECTED
(2012 onwards)
(Full publication citations/list here : https://inspirehep.net/author/profile/Debasish.Das.1

1) Psi(2S) and Upsilon(3S) Suppression in p-Pb 8 TeV Collisions and Mixed Heavy Quark Hybrid Mesons - Leonard S. Kisslinger and **Debasish Das**.
Int.J.Theor.Phys. 55 (2016) no.12, 5152-5156.

2) Psi and Upsilon Production in p-p Collisions at E=5, 14 TeV; and Comparison With Experiment at E= 7 TeV - Leonard S. Kisslinger and **Debasish Das**.
Int.J.Theor.Phys. 55 (2016) no.10, 4362-4370.

3) **Review** of QCD, quark–gluon plasma, heavy quark hybrids, and heavy quark state production in p-p and A–A collisions - Leonard S. Kisslinger and **Debasish Das**.
Int.J.Mod.Phys. A31 (2016) no.07, 1630010. *[45 pages]*

4) Psi and Upsilon Production in proton–proton collisions at E = 13 TeV
Leonard S. Kisslinger and **Debasish Das**.
Int.J.Mod.Phys. E24 (2015) no.05, 1550038.

5) J/psi, Psi(2S) Production in pp Collisions at E=510 GeV
Leonard S. Kisslinger and **Debasish Das**.
Int.J.Theor.Phys. 54 (2015) no.8, 2737-2739.

6) Suppression of Upsilon (1S) at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV,
ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Lett. B738 (2014) 361-372.
7) Psi and Upsilon Production In pp Collisions at 8.0 TeV
Leonard S. Kisslinger and **Debasish Das**.
Mod.Phys.Lett. A29 (2014) 1450082.
8) Production of inclusive Upsilon(1S) and Upsilon(2S) in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV ,
ALICE Collaboration (Betty Bezverkhny Abelev et al.).
Phys.Lett. B740 (2015) 105-117.
9) Ψ and Υ Production In pp Collisions at 7.0 TeV
Leonard S. Kisslinger and **Debasish Das**.
Mod.Phys.Lett. A28 (2013) 1350120.
10) Upsilon Production In pp Collisions For Forward Rapidities At LHC
Leonard S. Kisslinger and **Debasish Das**.
Mod.Phys.Lett. A28 (2013) 1350067.

TEACHING/GUIDANCE/TALKS/REVIEWING (selected)

- Taught courses on “Error propagation and Monte Carlo techniques” (in 2014, 2015, 2016) , on “Basic detector concepts and Gas detector functionalities” (in 2015, 2016, 2017) and on “Paper, Thesis writing and Ethics” (in 2015) for SINP Post-M.Sc (pre-PhD) programme.
- Students (from IISc Bangalore and from Universities like Jadavpur, Calicut, Andhra, Delhi, Berhampur) in the Under Graduate Associateship and Summer Students' Programme have worked with me towards the understanding of particle physics and different aspects of QGP physics at SINP.
- Talks delivered at various national workshops and conferences (like DAE-NP '12, WHEPP-XIII, HF-Meet'13 etc) and presentations in ALICE forums (like ALICE-Week, ALICE-India and annual ALICE-Muon meetings).
- Reviewer (on invitation) for International and National (DAE, Nuclear Physics) conference proceedings.

AREAS of RESEARCH / ACADEMIC Expertise (RESEARCH and DEVELOPMENT)

- Member of ALICE Collaboration and working in ALICE-Indian collaboration to Muon Spectrometer (at forward rapidity) towards the understanding of Quark-Gluon Plasma (QGP) properties using heavy-quark resonances from ALICE data-sets.
- Interpretations of quarkonia production at forward rapidity at Large Hadron Collider (LHC) energies towards the understanding of production mechanisms of bottomonia in p-p and p-Pb collisions and the suppression pattern in relativistic heavy-ion (Pb-Pb) collision (ALICE) data-sets.
- Responsibilities in ALICE :
(i) As a Upsilon Physics Analysis Group(PAG) Coordinator towards the ALICE Physics analysis effort on Upsilon into dimuons topic from year 2012 till 2016 (June).
(ii) Member of “future physics task force” of ALICE-India (onwards from 2017).

FUTURE GOALS

Involvement in ALICE upgrade project of Muon Forward Tracker (MFT) studies, where MFT will enable to look into the quarkonia states and their production ratios with more precision. Further broaden the interpretations with varied Monte-Carlo Models to understand critically the production mechanisms of quarkonia, heavy - quarks and correlations. The comparative studies in quarkonia and Heavy-Flavour (HF) Electro-weak production in forward rapidity regions of LHC for probing the matter that filled the early universe and experimentally produced in ALICE.

National Level Academic Review

NUCLEAR PHYSICS DIVISION (NPD)

A Report for the period 2012-2017

Permanent members of the division:

<table>
<tr><th colspan="3">Faculty members</th><th colspan="3">Scientific Officers</th></tr>
<tr><td>Subinit Roy</td><td colspan="2">Senior Prof. H</td><td>Sujib Chatterjee</td><td colspan="2" rowspan="4">Scientific Officer - D</td></tr>
<tr><td>Maitreyee Saha Sarkar</td><td colspan="2">Senior Prof. H, Head</td><td>Ajoy Kumar Mitra</td></tr>
<tr><td>Asimananda Goswami</td><td colspan="2">Senior Prof. H</td><td>Jonaki Panja</td></tr>
<tr><td>Ushasi Datta</td><td colspan="2">Prof G</td><td>Kaushik Chatterjee</td></tr>
<tr><td>Anjali Mukherjee</td><td colspan="2">Prof. G</td><td colspan="3">Technicians</td></tr>
<tr><td rowspan="2">Chinmay Basu</td><td colspan="2" rowspan="2">Prof. F</td><td>Pradip Barua</td><td colspan="2" rowspan="2">Technician D</td></tr>
<tr><td>Sankar Prasad Singh</td></tr>
<tr><td colspan="3">CSIR Emeritus Scientist</td><td colspan="3">Administrative Staff</td></tr>
<tr><td>Polash Banerjee</td><td colspan="2"></td><td>Tultul Dutta</td><td colspan="2">Superintendent</td></tr>
<tr><td colspan="3">Ramanujan Fellow</td><td colspan="3">Auxilliary Staff</td></tr>
<tr><td>Haridas Pai</td><td colspan="2"></td><td>Siladitya Chakraborty</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3">Superannuated Faculty Members</td><td colspan="3">Superannuated Members</td></tr>
<tr><td>Polash Banerjee</td><td>Senior Prof. H</td><td>April 2013</td><td>Nitish Sarkar</td><td>Office-In-Charge</td><td>Feb 2012</td></tr>
<tr><td>Padmanava Basu</td><td>Prof G</td><td>Dec 2015</td><td>Rita Ghosh</td><td>Scientific Assistant-F</td><td>Dec 2016</td></tr>
<tr><td></td><td></td><td></td><td>Dilip Sil</td><td>Scientific Assistant-F</td><td>Mar 2016</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Ph. D. Students (2011 onwards):

No	Candidate	Supervisor	Thesis details	Present status
1.	Mandira Sinha	Harashit Majumdar and Rupayan Bhattacharya (Gurudas College)	Experimental Nuclear Physics, PhD (2011) : University of Calcutta,	Post doc fellow, Bose Institute, Kolkata
2.	Dhrubajyoti Gupta	Subinit Roy and Manoranjan Sarkar	Environmental Science, August 2011, West Bengal University of Technology	Research Scientist at Inha Univ, South Korea

3.	Mukesh Kumar Pradhan	Anjali Mukherjee	Experimental Nuclear Physics, June 2012, CU	Assistant Professor, Belda College, Paschim Medinipur	
4.	Abhijit Bisoi	Maitreyee Saha Sarkar	Experimental Nuclear Physics, May 2015, CU	Assistant Professor, Indian Institute of Engineering Science and Technology, Shibpur, Howrah-711103	
5.	Md. Moin Shaikh	Subinit Roy	Experimental Nuclear Physics, Calcutta University PhD (2016)	Post Doc Fellow, IUAC, New Delhi (to join shortly)	
6.	Subhendu Rajbanshi	Asimananda Goswami	Experimental Nuclear Physics, Calcutta University PhD (2016)	Assistant Professor, Dumdum Motijhil College	
7.	Santosh Chakraborty	Ushasi Dutta	Experimental Nuclear Physics,Calcutta University, Thesis Submitted 2016	Waiting for the degree	
8.	Anisur Rahaman	Ushasi Dutta	Experimental Nuclear Physics, Calcutta University, 5000 words Synopsis Submitted	Assistant Professor of Physics at Jalpaiguri Government Engineering College	
9.	Moumita Roy	Maitreyee Saha Sarkar	Theoretical Nuclear Physics, CU, 5000 words Synopsis Submitted	Calcutta University	Part Time
10.	Suprita Chakraborty	Subinit Roy	Jadavpur University, Submitted April 2017	Aswini Dutta Vidyapith for Girls, Howrah.	
11.	Jayati Ray	Ushasi Dutta	Calcutta University, Registration - 2013	Left the Institute for a job	
12.	Sangeeta Das	Maitreyee Saha Sarkar	HBNI, Registration 2017	Joined Division in March 2016	
13.	Sajad Ali	Asimananda Goswami	HBNI, Registration 2017	Joined Division in August 2016	
14.	Ashok Mondal	Chinmay Basu	HBNI, Enrolled 2017	Joined Division in March 2017	
15.	Piyasi Biswas	Anjali Mukherjee	HBNI, Enrolled 2017	Joined Division in March 2017	
16.	Sathi Sharma	Maitreyee Saha Sarkar	HBNI, Enrolled 2017	To join Division in August 2017	
17.	Rajkumar Santra	Subinit Roy	HBNI, Enrolled 2017	To join Division in August 2017	
18.	Prithwijita Ray	Asimananda Goswami	HBNI, Enrolled 2017	To join Division in August 2017	

Post Docs and visiting scientists (2012 onwards):

Dr. Sucheta Adhikari, DST-WOS (A) project - 2012-2014
Dr. Sudatta Ray, -2013
Dr. Mandira Sinha, -2013
Dr. Mukesh Pradhan, -2014
Dr. Vishal Vilas Desai, October 2016-April 2017

Equipment and resources in the division:

1. CLOVER detectors with BGO anti-Compton shields –
   - 4 were contributed to the Indian National Gamma Array (INGA) for use at the different Accelerator Centers
   - One of them has been procured during ninth plan. Other two are procured recently. One of them is just installed – the other is about to be delivered. Purchase procedure of another Clover and shields are continuing.

2. Four Clovers with BGO shields and four segmented Planar HPGe (LEPS) detectors have been assembled to setup a detector array for offline studies. The detectors were procured during 11th Plan. The stand and the accessories are procured in 12th Plan. The array is supported by digital data acquisition system.

3. Large NaI(Tl) Sum Spectrometer

4. Target Laboratory with a facility for preparing thin targets by evaporation technique using electron gun;rolling machine for rolling thin foils. This facility is about to be upgraded.

5. Different Vacuum Systems for detector testing annealing of detectors (Dry Turbo pumping system, rotary + Diffusion system, Dry Turbo molecular pump andassociated gadgets for HPGe annealing, etc.), Mass Analyzer for gas-flow system.

6. Liquid Nitrogen cooled HPGes, electrically cooled HPGes, thin-window Si(Li)s, Surface barriers, NaI(Tl), CsI(Tl), BGO and other scintillators, Strip detectors(Single-sided and double-sided Silicon)

7. NIM electronics, PC-based MCAs and digital data acquisition systems.

8. Workstations for theoretical calculations

9. Polarized EDXRF Spectrometer (EPSILON 5): A Polarized Energy Dispersive XRF Spectrometer with 600W X-Ray Tube , Capable of operating in both vacuum and helium environment

10. The ELAN2 Liquid Nitrogen Generator Autotransfer Station .

11. Alpha Absorption Set-up for target thickness measurement.

12. Hand-held x-ray generator and a Si-PIN detector with digital data acquisition system have been assembled and suitable mechanical arrangement developed in our Workshop for target thickness measurement.

13. CAMAC and VME based digital data acquisition systems

Accomplishments

- Division has played an active role to host 61st DAE-BRNS Symposium on Nuclear Physics in December 2016.
- FRENA -Facility for research in Nuclear Astrophysics has been Planned and Designed by the Nuclear Physics Group at SINP in consultation with scientists from India and abroad : efforts taken since 2004. Four (4) Schools on Low Energy Nuclear Astrophysics (SLENA) conducted from 2006 -2012 to plan the facility fruitfully.
- Faculty members are regularly performing PAC approved experiments at National facilities like VECC(Kolkata), IUAC(New Delhi), TIFR (Mumbai),and IOP (Bhubaneswar). Faculty members are working as members of PAC of National Accelerator Centres.
- One of the members has worked as Principal Investigator in several experiments at GSI (Darmstadt), NSCL(Lansing), GANIL (CAEN), INFN (Legnaro), ISOLDE(Geneva), and approximately, one third of the other experiments have been performed with her major responsibility.
- Members are actively involved in Indian National Gamma Array (INGA) collaboration from its inception. Nuclear Physics group of SINP had contributed 4 (four Clover detectors+shields) to the array at its initiation. Recently we are procuring some more Clovers, which may be used in INGA as and when necessary.
- Members work as referees of National and International Journals.
- They work as experts for thesis evaluation, question setter and examiners in University exams.
- Experts in academic selection committees and faculty recruitment board in University
- Members of Board of Research Studies of Universities
- Members are considered as experts in Theoretical Nuclear Structure and Reaction model calculations. Collaborators from National and International groups seek their advice for theoretical interpretation of data.
- One of NPD Faculty was a member of ISOLDE (CERN) Collaboration Committee (ISCC), 2012 – 2015. She worked as Deputy of NeuLAND' R3B, FAIR (Germany) working group (2005-2012).
- Collaborators from other Institutes and University are using our facilities for different scientific investigations.

Research Highlights of Nuclear Physics Division

Nuclear Physics

The main thrust of the research activities in Nuclear Physics Division involves the experimental study of low & intermediate energy nuclear physics using different accelerator centres in India and a few abroad. In addition, members of the division are also actively involved in the setting up of the FRENA facility for nuclear astrophysics research. The other major activities are: theoretical research and developmental activities. Several faculty members of the division actively participated in the summer student's programme of the Institute and also undertook teaching courses both in SINP and other neighbouring universities.

Nuclear Structure

Experimental research work in nuclear structure has been primarily pursued utilising campaigns of Indian National Gamma Array (INGA) facility at different accelerator centres in India as well as using radioactive ion beams at international centres.

- ***Utilisation of INGA***

- *Study of the mechanisms to generate angular momentum in weakly deformed nuclei*

The primary focus is to study the mechanism of generation of angular momentum in weakly deformed systems with special emphasis in mass ~140, 120 and 100 regions where different possible mechanisms like Magnetic and Anti magnetic rotation, chiral symmetry breaking, triaxial bands, octupole correlation etc. and try to understand them from theoretical model calculations.
Antimagnetic rotation in ^{143}Eu has been conclusively established from the experimental data. The abrupt increase in the B(E2) values after the band crossing in the quadrupole band, a novel feature observed in the experiment, may possibly indicate the crossing of different shears configurations resulting in the re-opening of a shears structure. The results are reproduced well by numerical calculations within the framework of a semi-classical geometric model. A chiral partner band and magnetic rotation band in ^{141}Sm have been observed. Comparison between the experimental characteristics and the semi-classical shears mechanism with the principal axis cranking (SPAC) model calculations were utilised to interpret the data for the magnetic band. The low spin excited states of a few nuclei in mass A ~ 140 region have been studied from the EC and/or $\beta^{\pm}$ decay of the residual nuclei populated in fusion evaporation reaction of ^{31}P with ^{116}Cd. Level lifetimes of the several isomeric states in ^{139}Pr, ^{141}Pm and ^{142}Sm nuclei have been measured from the present study of the time stamped decay data. The quadrupole bands observed in the level structure in ^{142}Eu have been connected to the lower spin part of the level scheme from the coincidence and intensity measurements. The data analysis for assigning the spin parity of the levels in the quadrupole bands are in progress. Evidence for octupole correlation and chiral symmetry breaking has been observed in ^{124}Cs. The enhanced B(E1) rates for the linking transitions between the bands with the above configurations suggest existence of octupole correlations in ^{124}Cs. The observed electromagnetic properties for the positive-parity bands in ^{124}Cs agree well with the characteristics pattern required for chiral symmetry breaking.

- *Collectivity, alpha cluster structure in A~40 region:*

Several nuclei in A~40 have been studied to investigate their properties and evolution of structural features of these light nuclei with increasing neutron / proton numbers and angular momentum. Study of spectroscopic properties of upper sd shell nuclei, ^{35}Cl, ^{34}Cl and ^{33}Sprovided us important information about different distinctive features of nuclear structure like single-particle and collective modesofexcitations, theirinterplay, α clusterstructure and its correlation with the super-deformed states. The low spin spectra of these nuclei show a single-particle mode of excitation, which evolves in collectivity (in ^{34}Cl) manifested through super-deformation (^{35}Cland ^{33}S) at higher spins. Thus, these nuclei give us a unique opportunity to study the competition and combination of these two modes of excitation both experimentally and theoretically. A superdeformed (SD) band has been identified in a non - alpha - conjugate nucleus ^{35}Cl. Enhanced B(E2), B(E1) values as well as energetics provide evidences for superdeformation and existence of parity doublet cluster structure in an odd-A nucleus for the first time in A~40 region. A sequence of three levels connected by strong E2 transitions have been identified in ^{33}Sas a super-deformed band based on well-known criteria of these bands in this mass region.

Theoretically, these single particle as well as collective states are well explained within the purview of mixed large-scale shell model calculations in *sd-pf* basis performed by our group. Comparison of energy spectra as well as level lifetimes with experiment helped us to understand the underlying structure of different states.Large scale shell model calculations indicate that excitation of nucleons in *pf* shell is responsible for generation of collective features in these nuclei. Calculated spectroscopic factors correlate the SD states in ^{35}Cl to those in ^{36}Ar.

- *Shape evolution in A~150 region:*

The neutron-deficient rare-earth isotopes near the magic nucleus ^{146}Gd have shown a multitude of structural features as functions of neutron number as well as spin. For isotones with N =86, excitation spectra show single-particle nature associated with non-collective modes.This mass region has been investigated extensively, particularly for even-even nuclei. For odd-Z nuclei, such as holmium (Ho), although individual studies of different isotopes exist; systematic analysis of the structural evolution of this element with variations in neutron number is scarce. Ho (Z =67) is the nearest odd-Z neighbor of most extensively studied Dy (Z =66). A systematic study of the isotopes of element Ho ($^{151-154}$Ho) has been initiated to understandhownuclearstructurediffersduetotheadditionof a single unpaired proton compared to isotopes of Dy (Z=66). From the comparison of experimental and theoretical results, it is found that there are definite indications of shape coexistence in the high-spin states of ^{153}Ho. The RF-gamma time difference spectra have been useful to confirm the half-lives of isomers in this nucleus. The experimental and calculated lifetimes of these isomers have been compared to follow the coexistence and evolution of shape with increasing spin.

Experimental data on ^{152}Ho have been analysed to connect the three groups of transitions across two isomers with lifetimes, ~47 ns and ~8.4 μs and confirm the possibility of a fourth isomer in the excitation spectrum.

Total Routhian Surface calculations indicate a deformed character for ^{154}Ho along with a secondary minimum for an oblate structure. We have obtained some evidences from experimental data in favour of these predictions. The strongest evidence for stable octupole deformation is the existence of quasimolecular bands consisting of positive and negative parity levels connected by very fast E1 transitions. In our study, it has been possible to correlate the two opposite parity bands with new gammas. This seems to an indication of stable octupole deformation. Our study therefore eventually will be important to study shape coexistence predicted in this region as well as in this nucleus.

- ***Preparation, characterisation and utilisation of implanted targets for Nuclear Astrophysics experiments***

Implantation technique has been found to be one of the most effective methods to produce targets necessary for low energy nuclear astrophysics experiments. In last few years we have prepared a few implanted targets and characterized them

^{14}Nand ^{22}Ne implanted target are prepared at TIFR and characterised by relevant resonance reactions and other techniques in India and abroad.

- *Lifetime of the 6792 keV state in ^{15}O*

A preliminary estimate of the lifetime of 6792 keV state of ^{15}O has been obtained using Doppler shift attenuation method (DSAM) from proton capture reaction of a Ta backed implanted Nitrogen target. The dose and composition stoichoimetry of the target determined from Rutherford Backscattering Spectroscopy (RBS) has strong relevance for estimating the stopping power of the recoiling ^{15}O ions. We have tested the sensitivity of our results with respect to the uncertainties in various input quantities. We hope our present endeavour will be helpful to design a better experiment to extract more precise lifetime for this important state.

- ***Nuclear Structure and Reaction studies utilizing Radioactive Ion Beams (RIB) from International Facilities***

Quantum many body systems (i.e. atomic nuclei) interacting via strong and weak interactions are studied in experiments at International RIB facilities. Particularly, the focus is on structure and reaction dynamics of the exotic nuclei, nuclear astrophysics, neutrino physics and cosmology. Our group is deeply involved in studying disappearance of magic shell gaps in the neutron-rich nuclei, modification of shell structure near drip-line, the ground state configuration of neutron-rich nuclei, exotic shapes, exotic decay near proton-drip line, the resonance states, cluster structure, quantum phase transition, fusion process near drip line, capture cross-section relevant to explosive burning scenario, neutron-skin, cosmic age of meteorites etc. Study of the structure, reaction dynamics of the nuclei near and beyond the drip line using both stable and radioactive ion beams with wide range of advanced technology detector systems at different international accelerator based laboratories is being pursued. A number of experiments have been performed using RIB facilities at GSI, Darmstadt, ISOLDE, CERN and NSCL, MSU to explore the shell evolution near the drip lineand experimental signature of reduced or vanishing shell gap at traditional magic numberhave been observed.

- *Coulomb breakup of neutron-rich isotopes near the island of inversion*

First results are reported on the ground state configurations of the neutron-rich ^{29,30,31}Na, ^{33}Mg, ^{35}Al isotopes, obtained via Coulomb dissociation (CD) measurements. The invariant mass spectra of these nuclei have been obtained through measurement of the four-momenta of all decay products after Coulomb excitation of those nuclei on a ^{208}Pb target at energies of 400–430 MeV/nucleon using the FRS-ALADIN-LAND setup at GSI, Darmstadt. A comparison with the direct breakup model, suggests the predominant occupation of the valence neutron in the ground state of ^{29}Na and ^{30}Na is the d-orbital with a small contribution from the s-orbital, which are coupled with the ground state of the core. Thespectroscopic factors for the valence neutron occupying the s and d orbitals for these nuclei in the ground state have been extracted and reported for the first time. A comparison of the experimental findings with shell model calculation using the MCSM suggests a lower limit ofaround 4.3 MeV of the sd–pf shell gap in ^{30}Na.

- *Direct experimental evidence for a multiparticle-hole ground state configuration of deformed ^{33}Mg*

The first direct experimental evidence of a multiparticle-hole ground state configuration of the neutron-rich ^{33}Mg isotope has been obtained via intermediate energy (400 A MeV) Coulomb dissociation measurement. The major part ;(70±13)% of the cross section is observed to populate the excited states of ^{32}Mg after the Coulomb breakup of ^{33}Mg. The shapes of the differential Coulomb dissociation cross sections in coincidence with different core excited states favor that the valence neutron occupies both the $s_{1/2}$ and $p_{3/2}$ orbitals. These experimental findings suggest a significant reduction and merging of sd and pf shell gaps at N=20 and 28. The experimentally obtained quantitative spectroscopic information for the valence neutron occupation of the s and p orbitals, coupled with different core states, is in agreement with Monte Carlo shell model (MCSM) calculation using 3 MeV as the shell gap at N=20.

- *Ground-state configuration of neutron-rich Aluminum isotopes through Coulomb Breakup*

Neutron-rich ^{34,35}Al isotopes have been studied through Coulomb excitation using LAND-FRS setup at GSI, Darmstadt. The method of invariant mass analysis has been used to reconstruct the excitation energy of the nucleus prior to decay. Comparison of experimental CD cross-section with direct breakup model calculation with neutron in $p_{3/2}$ orbital favours ^{34}Al(g.s)$\otimes\nu$ $p_{3/2}$ as ground state configuration of ^{35} Al. But ground state configuration of ^{34}Al is complicated as evident from γ-ray spectra of ^{33}Al after Coulomb breakup of ^{34}Al.

- *Exotic decay of hot rotating nuclei near proton drip line*

Hot and rotating exotic ^{124}Ce nucleus near proton drip line has been populated through fusion evaporation reaction of ^{32}S and ^{92}Mo. This exotic nucleus was de-excited by evaporating p, n, α and/or light nuclei etc and several exotic nuclei have been populated. The experimentally obtained relative population of those exotic nuclei have been compared with the statistical model calculation. Agreement between experimental and statistical model calculation have been observed for most of the evaporation channels. Huge enhancement in comparison to statistical model calculation have been observed for a few channels related to multiple proton evaporation which could not be explained by using default and modified input parameters in statistical calculation.

- *Structure of ^{16}C: Testing shell model and ab initio approaches*

Excited states in ^{16}C were populated via the ^{9}Be(^{17}N,^{16}C)X one-proton knockout reaction at NSCL, Michigan. The lifetime of the 2+ state in ^{16}C was measured using the recoil distance method. The extracted lifetime of 2^{+} =11.4 ps yields a deduce B(E2)= 4.2(0.28) e^2fm^4 value in good agreement with a previous measurement. The one-protonknockout cross section is used to extract the proton amplitude of the ^{16}C(2^{+}) state, which confirms the neutron dominant character of this state. The results are compared with pf;sd shell model and no-core shell model (with NN and NN+NNN) calculations. The inclusion of three-body forces are essential in order for the no-core shell model calculations to reproduce the experimental findings .

- *^{12}C+p resonant elastic scattering in the Maya active target*

In a proof-of-principle measurement, the Maya active target detector was employed for a ^{12}C(p, p) resonant elastic scattering experiment in inverse kinematics at ISOLDE, CERN. The excitation energy region from 0 to 3MeV above the proton breakup threshold in ^{13}N was investigated in a single measurement. By using the capability of the detector to localize the reaction vertex and record the tracks of the recoiling protons, data covering a large solid angle could be utilized, at the same time keeping an energy resolution comparable with that of direct-kinematics measurements. The excitation spectrum in ^{13}N was fitted using the R-matrix formalism. The level parameters extracted are in good agreement with previous studies. The active target proved its potential for the study of resonant elastic scattering in inverse kinematics with radioactive beams, when detection efficiency is of primary importance.

Nuclear Structure :Theory

- *Study of Neutron-rich nuclei around ^{132}Sn isotopes and the effect of three body forces*

To understand the region away from stability, nuclei close to doubly closed ^{132}Sn are being studied within large basis shell model. These nuclei have important implications to understand the synthesis of very neutron-rich nuclei in the Universe. It has been shown that the experimentalresultsfor neutron rich Sn isotopes have good agreement with theory in which three-body forces have been includedin a realistic interaction. The theoretical results on transition probabilities are discussed toidentify the experimental quantities which will distinguish between different views.New experimental data on 2^+ energies of ^{136,138}Sn confirms the trend of lower 2^+ excitation energies of even-even tin isotopes with N > 82 compared to those with N< 82. However, none of the theoretical predictions using both realistic and empirical interactions can reproduce experimental data on excitation energies as well as the transition probabilities (B(E2; 6+ → 4+)) of these nuclei, simultaneously, apart from one whose matrix elements have been changed empirically to produce mixed seniority states by weakening pairing. We have shown that the experimental result also shows good agreement with the theory in which three body forces have been included in a realistic interaction. The new theoretical results on transition probabilities have been discussed to identify the experimental quantities which will clearly distinguish between different views. Systematic studies of Sn, Te and Sb isotopes with neutron numbers ranging from N=50-82 have been initiated and utilized to interpret data from other groups.

Nuclear Reactions

- *Investigation of near-barrier heavy-ion reaction mechanisms, especially with weakly bound nuclei.*

So far, we have been engaged in measuring the complete and incomplete fusion excitation functions and hence understanding the fusion mechanism of weakly bound systems. Proper theoretical calculations still do not exist that can predict the complete and incomplete fusion cross sections. Our measurements have been important contributions in this field, at least to a certain extent, and this is well evidenced by several citations by other workers and invited talks, both national and international. Quasielastic scattering excitation functions for weakly bound systems have been measured; the barrier distributions extractedand are compared with the fusion barrier distributions. This investigation is very important in light of the present difficulties involved in measuring precise fusion excitation functions and hence extracting meaningful barrier distributions for reactions with radioactive beams of nuclei. Our measurements are carried out using the 14 UD BARC-TIFR Pelletron accelerator at Mumbai.

- *Investigations of fusion and quasi-elastic excitation functions of ^{6,7}Li+^{64}Ni around the barrier energies*

In order to understand the interplay of the reaction mechanisms in near the Coulomb barrier energies, the fusion excitation functions of ^{6}Li+^{64}Ni and ^{7}Li+^{64}Ni have been measured and compared. While the weak binding of ^{6}Li compared to ^{7}Li dominates the fusion at above barrier energies, in the below barrier region transfer reactions have greater influence on producing enhanced fusion for ^{7}Li than for the fusion of ^{6}Li. Also, to describe the fusion barrier distribution of ^{6}Li+^{64}Ni, coupling to inelastic excitations are found to be sufficient. The reproduction of quasi-elastic barrier distribution function of ^{6}Li+^{64}Ni is observed to be shifted to lower energies relative to the fusion barrier distribution. Coupling to one-nucleon transfer channels reproduces the features of the quasi-elastic barrier distribution including the observed shift from the fusion barrier distribution.

- *Systematic R-matrix analysis of ^{13}C(p,γ) capture reaction and ^{13}C(p,p) elastic scattering at astrophysically relevant energies.*

A hybrid model analysis of ^{13}C(p,γ)^{14}N capture reaction have been completed to describe the low energy excitation function of the reaction. In the hybrid model, resonances have described by one-level Breit-Wigner formula and the non-resonant contribution is generated through the potential model approach using only folded M3Y potential. The resultant astrophysical S-factor from both the models corroborate within the error bar.

The work on the simultaneous R-matrix analysis of $^{13}C(p,\gamma)$14N capture reaction and the low energy $^{13}C(p,p)$ elastic scattering data to constrain the gamma as well as particle widths has been completed using the multi-level, multi-channel R-matrix code AZURE II. The model calculation yielded a lower astrophysical S-factor value than the adopted value in the NACRE compilation. The temperature profile of the reaction rate has also been estimated over the temperature range of interested using the estimated S-factor value.

- *Simultaneous R-matrix study of $^{13}C(\alpha,n)^{16}O$ reaction and $^{16}O(n,n)$ scattering at astrophysically relevant energies*

The work has been carried out to the study the effect of the near α-threshold resonant state in ^{17}O on S-factor of $^{13}C(\alpha,n)$16O at astrophysically interested energy region. The sharp rise in the low energy behaviour of S-factor value of $^{13}C(\alpha,n)^{16}O$ has been identified as due to the 1/2+ near threshold state but the energy location of the state is found to be not sub-threshold by -3 keV. Instead the energy location of the state is about 12 keV above the threshold. To identify the correct location of the 1/2+ state, a simultaneous analysis of $^{13}C(\alpha,n)^{16}O$ reaction and 16O(n,n) scattering have been performed. The resultant effect on the reaction rate has also been estimated.

The proton/neutron -capture reactions of a number of nuclei which are important for astrophysics scenario,were studied via Coulomb dissociation (CD) at an incident energy of about 400-500 MeV/u. The experimental results are compared to Monte Carlo simulations of the CD process using a semi-classical model.

- *Indirect method studies of reactions relevant to Nuclear Astrophysics*

Astrophysical reactions involving charged particles occur at energies well below the Coulomb barrier, making it difficult to measure directly. The $^{12}C(a,\gamma)$ reaction is one such reaction and various alternate reactions are studied to extract its cross-section at the Gamow energy (300keV). The transfer angular distributions of the $^{12}C(^{6}Li,d)$ and $^{12}C(^{7}Li,t)$ reactions have been measured to extract the Asymptotic normalization constant (ANC) that provides the Gamow energy cross-section. Breakup effect on transfer is observed at above barrier energies for the first time. At sub-Coulomb energies measurements are planned and calculations show that the population of 7.12 MeV state of ^{16}O occurs through compound nuclear process rather than direct transfer.

In- house Laboratory -based Developmental activities: Ongoing work

- *Response of Multi-strip Multi-gap Resistive Plate Chamber*.

A prototype of Multi-strip Multi-gap Resistive Plate chamber (MMRPC) with active area 40 cmx 20 cm has been developed at SINP, Kolkata. Detailed response of the developed detector was studied with the pulsed electron beam from ELBE at Helmholtz-Zentrum Dresden-Rossendorf. The obtained time resolution (σ_t)of the detector after slew correction was 91.5(3) ps. Position resolution measured along (σ_x) and across (σ_y) the strip was 2.8(0.6) cm and 0.58 cm, respectively. The measured absolute efficiency of the detector for minimum ionizing particle like electron was 95.8(1.3)%. Better timing resolution of the detector can be achieved by restricting the events to a single strip. The response of the detector was mainly in avalanche mode but a few percentage of streamer mode response was also observed. A comparison of the response of these two modes with trigger rate was studied.

- *The XRF laboratory of Nuclear Physics Division*

The XRF laboratory of Nuclear Physics Division participated in Worldwide Open Proficiency Test for XRF Laboratories (PTXRFIAEA09) conducted by IAEA Laboratories, Seibersdorf, for Determination of Major, Minor and Trace Elements in a River Clay using the Polarized EDXRF Spectrometer, EPSILON 5, installed during December, 2011. The report was published by IAEA Laboratories in December, 2012 (ftp://ftp.iaea.org/pub/PTXRFIAEA09/).
The facility for XRF analysis of liquid sample in EPSILON 5 spectrometer under He-environment has been installed, tested and operational

- *Characterisation of a Composite LEPS*

Our work on a experimental characterisation of a low energy photon spectrometer (LEPS), which is a composite planar HPGe, has been completed and published in an international Journal. It has been shown that beyond 200 keV, effect of image charges deteriorates the efficiency of the detector in its addback mode. Data has been corrected on event by- event basis resulting in improvement of the performance.

- *Gamma- neutron pulse-shape discrimination and energy and time measurements with a digital oscilloscope*

The aim of this work was to understand Digital Signal Processing by studying the working and the characteristics of a Tektronix DPO4032 (digital oscilloscope) in gamma ray spectroscopy. After obtaining an idea about the characteristics of the oscilloscope, it was used for gamma and neutron spectroscopy for measurement of energy and time differences in a Time of Flight set-up. This oscilloscope has been also utilized for pulse shape discrimination to distinguish between neutrons and gammas incident on a liquid scintillator detector from a ^{252}Cf fission source.

- *Performance of low cost photodiodes and Si-pins in nuclear spectroscopy*

The possibility of using a Si-PIN diode detector from Bharat Electronics in detection of charged particles, x-rays and gamma rays have been demonstrated. The improvement in the performance after cooling for detecting gammas beyond 100 keV is tested. Presently Photodiodes from Hamamatsu are being tested.Thermoelectric coolers are utilized to cool the detectors to improve their performance.

- *Characterization of NaI(Tl) Sum Spectrometer and its utilization*

In the present work, a sum spectrometer consisting of six large NaI(Tl) detectors procured during early 1980s has been revived, put back in the stand, tested and revived. The spectrometer has been set up with a state-of-the-art CAEN 5780 digitizer, characterized and then utilized to suppress room background. This setup will be a useful addition to our FRENA detector array.

• *Future Plan*

Physics Issues

The divisional members will continue working in Nuclear Structure and reaction studies utilising primarily National facilities and also International state -of - the art facilities if the physics question addressed needs so. Their interests in near future will be oriented more towards nuclear astrophysics studies and related developmental research related to the FRENA facility.

- Continue research on nuclear structure studies in various mass regions to look for different spontaneous symmetry breaking phenomena in finite many body quantal systems
- Study experimentally and theoretically the evolution of nuclear structure from stable nuclei to exotic ones will be the primary aim of work. However, along with utilising in-beam

studies - we are also focussing on decay studies to acquire cleaner data, and fruitfully use our in-house facilities, This measurement will train our students more in experimental techniques, state-of -the- art instruments and analysis.

- Study of resonance reaction at low energies will be pursued. The implanted targets will be useful for these studies.
- For theoretical studies - new effective interaction with empirical inputs will be generated.
- Study of the structure, reaction dynamics of the nuclei near and beyond the drip line using both stable and radioactive ion beams with wide range of advanced technology detector systems at different international accelerator based laboratories.
- To understand the effect of weak binding of 2- and 3-body cluster nuclei on the effective interaction potential and the fusion reaction, it is necessary to identify the possible reaction processes through exclusive particle-particle coincidence measurements. This again requires an efficient charged-particle detection setup for kinematically complete measurements.
- Study of breakup fragments at near-barrier energies for weakly bound systems. Fusion measurements with stable beams at deep sub-barrier energies.
- Fusion measurements with radioactive beams available from laboratories outside India
- Study of reactions of astrophysical interest, using the upcoming FRENA facility at SINP. The first reaction to be studied is $^{12}C+^{12}C$ at energies near the Gamow peak. Special preparations for carrying out this measurement are in progress.
- Study of P-nuclei through angular distribution method with FRENA: *P nuclei* refer to 32 stable neutron-deficient nuclei that, in contrast to all the other nuclei that are heavier iron, cannot be synthesized by the *s* and *r* processes. *P* nuclei lie on the proton-rich side of the stability valley between ^{74}Se and ^{196}Hg. Hence, they cannot be produced by neutron capture. They are assumed to originate from the burning of pre-existing more neutron-rich nuclei at stellar environments of high enough temperature ($T \geq 2\times10^9$), where photo-disintegrations of such nuclei can occur. My aim is to prepare a setup for study these *P* nuclei through the angular distribution method.
- Investigation of Pygmy Dipole resonance state employing the β decay techniqueusing the DESPEC SETUP@ FAIR
- Experimental proposals on the Trojan Horse method to study the $^{19}F(p,\alpha)$ reaction at IUAC, New Delhi.
- Extensive plans to investigate the sub Coulomb transfer measurements to extract ANC of several astrophysical reactions using the FRENA facility or other low energy facilities in the country.
- Study of exotic properties of nuclei using international and national RIB accelerator facilities , at USA, Japan, Europe and India to explore various aspects of N-N interaction and application to nuclear astrophysics, cosmology, medicine.

Developmental work

Keeping in mind the upcoming FRENA (Facility for Research in Experimental Nuclear Astrophysics), the members of Nuclear Physics Division has primary motivation to ensure the successful installation and operation of the low energy, high current accelerator.

- Completion of the beam-line(s) for astrophysics experiments, target-cooling system, beam-steering arrangements
- Design, Development and Fabrication of a General Purpose Scattering Chamber
- Development of Recoil Filter detector (RFD)

- Development and testing of relevant detector arrays:
    - oGamma + charged particle + neutron
    - oLow background detector setup
    - oTotal Absorption Spectrometer
- A solid state and gas detector testing facility has been made ready to use.A detailed exercise on the designing of a 1m scattering chamber for FRENA beam line is almost complete.
- First order ion optical calculations are being pursued to initiate the designing of the beam-lines of FRENA.
- The target laboratory will be upgraded soon. Preparation and characterization of implanted targets have been standardized. Alpha absorption set-up and x-ray absorption setup for target thickness measurement are being tested and validated.
- The NaI(Tl) Sum spectrometer has been rejuvenated and utilized successfully for background gamma ray suppression. Utilization of this system as a total absorption spectrometer is being planned.
- The plan is to complete a 3x3 array with Si-strip detectors + CsI(Tl)scintillators with the flexibility of arranging in a geometry that suits the physics problem. In addition the digital signal processing and acquisition facility to handle large number of parameters with improved detection limit will be designed and developed. The project is a part of the ongoing departmental programme related to the low energy nuclear reaction and structure studies. The 9-element array will be developed keeping in mind the nuclear astrophysics experiments to be carried out in the upcoming FRENA Facility. A suitable reaction chamber will also be developed to house the detector for its use in the FRENA facility.
- To provide a suitable detection facility at FRENA, a strip detector telescope array to perform low cross section measurements will be developed. This type of detector with large solid angle coverage will be essential for deep sub-barrier measurements using the light ion beams from the FRENA accelerator.
- Development of Recoil Filter detector (RFD): Development of RFD is very essential for positive identification and selection of the γ-rays from the rare wanted fusion–evaporation events. This is a useful tool to study nuclear structure of heavy and light nuclei produced in fusion evaporation reaction. RFD can be coupled to INGA facility or to FRENA to select rare events for studying exotic phenomena in Nuclear Structure and Nuclear Astrophysics.
- Exploring imaging capabilities using nuclear technology.
- Developing LaBr3, NaI(Tl) scintillator array to explore exotic properties of nuclei, such as life time measurements, exotic shapes, cluster structure, density distribution etc.

Work for outreach and societal benefit

- Almost all the faculty members are regularly attached to TEACHING in M.Sc courses in Universities in and around Kolkata and in Post M.Sc (Experiment) courses in our Institute.

- Every year 10-12 students from all over India come for project work under our supervision.

- Students from Different State, Central and Private Universities of West Bengal, Orissa, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Delhi etc pursue their fourth semester project work with us.

- Students also visit our laboratories for advanced experimental course on Nuclear Physics.

- X-ray Fluorescence Studies for toxic elemental profile of soil evolving from Municipal Solid Wastes (MSW) and vegetables grown on corresponding soil, Environmental Analysis for Heavy Metals and other toxic elements

- New Ultrafast detector development and possibility of its application in medical imaging and security

- Development of setup and testing of photodiodes as low cost, rugged nuclear radiation. Utilisingthermoelectric coolers to cool the detectors to improve their performance.

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10. Low energy cluster states in ^{34}S, Abhijit Bisoi,S Sarkar,M Saha Sarkar, Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 78
11. Investigation of nuclear structure below the ^{132}Sn core, Sangeeta Das,Abhijit Bisoi,S. Sarkar,M Saha Sarkar, Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 108
12. Mystery of ^{151}Ho isotope, S. Das Gupta,M Saha Sarkar, Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 296
13. Lifetime of the 6792 keV state in ^{15}O, Abhijit Bisoi, Indrani Ray, L.C. Tribedi, D. Misra, S. Biswas, K. V. Thulasi Ram, M. V. Rundhe, Anoop KV, V. Nanal, Sunil Ojha, P. Banerjee, S. Sarkar andM Saha Sarkar, Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60 (2015) 892
14. Silicon PIN Diode for detection of electrons, alphas, X-rays and gamma rays, Sangeeta Das,Arghya Chakraborty,Anshuman Mondal,Kushal Shaw,Ankan Sur,Satadal Das,Ranjay Laha,Arijit Das,Jonaki Panja,Chandranath Marick,Ajay Mitra,Sujib Chatterjee,M Saha Sarkar,Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 976
15. Performance of low cost photodiodes in nuclear spectroscopy, Sangeeta Das,Arghya Chakraborty,Anshuman Mondal,Arya Datta,Souryadeep Saha,Debaleen Biswas,Jonaki Panja,Chandranath Marick,Ajay Mitra,Sujib Chatterjee,M Saha Sarkar,Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 978
16. Search for isomeric state in odd-odd ^{150}Pm, A. Saha , D. Banerjee, T. Bhattacherjee, Deepak Pandit, S. S. Alam, P. Das, Soumik Bhattacharya, A. Choudhury, S. Bhattacharyya, A. Mukherjee, R. Guin, S. K. Das, and S. R. Banerjee, Proc of the DAE-BRNS Symp. on Nucl. Phys. 60, 98 (2015)

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17. Forbidden E1 transitions and isospin mixing in self-conjugate sd-shell nuclei, Abhijit Bisoi, SSarkar and M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 59 (2014) 102
18. Shell Model Calculations for ^{132}Te Abhijit Bisoi, M Saha Sarkar, SSarkar, SBiswas, and RPalit, Proc of the DAE Symp on Nucl Phys 59 (2014) 104
19. Gamma Spectroscopy with a digital oscilloscope Tuhin Malik, Krithika Raman, Rutuparna Rath, Rohan Biswas, Dibyadyuti Pramanik, Abhijit Bisoi, Shinjinee Dasgupta, M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 59 (2014) 984

20. Neutron Pulse-Shape Discrimination and Time – of – Flight Measurements with a Digital Oscilloscope, Uttiyoarnab Saha, Krithika Raman, Rutuparna Rath, Tuhin Malik, Abhijit Bisoi, M Saha Sarkar,Proc of the DAE Symp on Nucl Phys 59 (2014) 986
21. Effect of the clover geometry on the LINESHAPE analysis, SRajbanshi,Abhijit Bisoi,Somnath Nag,SSaha,JSethi,TBhattacharjee,SBhattacharyya,SChattopadhyay,GGangopadhyay,GMukherjee,RPalit,RRaut, M Saha Sarkar, AKSingh,TTrivedi, AGoswami, Proc of the DAE Symp on Nucl Phys 59 (2014) 72
22. Prompt-delayed coincidence for the investigation of high-spin states in ^{132}Te, SBiswas, RPalit, JSethi, SSaha, Purnima Singh, DChoudhury, VNanal, RGPillay, M Saha Sarkar, Abhijit Bisoi, SSarkar, LSDanu, SMukhopadhyay, DCBiswas, SKTandel, SSHota, MCarpenter, Proc of the DAE Symp on Nucl Phys 59 (2014) 128
23. Magnetic Rotational bandin ^{141}Sm nucleus, SRajbanshi, Abhijit Bisoi, Somnath Nag, SSaha, JSethi, TBhattacharjee, SBhattacharyya, SChattopadhyay, GGangopadhyay, GMukherjee, RPalit, RRaut, M Saha Sarkar, AKSingh, TTrivedi, AGoswami, Proc of the DAE Symp on Nucl Phys 59 (2014) 166
24. Evolution of collectivity in ^{160}Yb, ASaha,TBhattacharjee, SRajbanshi, ABisoi, DCurien, JDudek, PPetkov, DBanerjee, SRBanerjee, Soumik Bhattacharya,SBhattacharyya, SBiswas, AChakraborty, Gde Angelis, SKDas, SDas Gupta, BDey, GDuchene, AGoswami, DMondal, DPandit, RPalit, TRoy, M Saha Sarkar, SSaha, RPSingh, JSethi, Proc of the DAE Symp on Nucl Phys 59 (2014) 268.
25. Investigation of fusion of ^{7}Li with ^{64}Ni around the Coulomb barrier,Md. Moin Shaikh, Subinit Roy, S. Rajbanshi, A. Mukherjee, P. Basu, M. K. Pradhan, S. Pal, V. Nanal, A. Shrivastava, S. Saha, and R.G. Pillay, Proc of the DAE Symp. on Nucl. Phys. 59 (2014)
26. Spectroscopy of low lying states of N = 88 ^{150}Sm, A.Saha, D. Banerjee, T. Bhattacharjee, Soumik Bhattacharya, A. Chowdhury, P. Das, S. Bhattacharyaa, A. Mukherjee, S.K. Das, S.R. Banerjee, Proceedings of the DAE Symp. on Nucl. Phys. 59 (2014)

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27. Pairing and shell evolution in neutron rich nuclei, Maitreyee Saha Sarkar, Sukhendusekhar Sarkar, Fission and Properties of Neutron-RichNuclei, Proceedings of the Fifth International Conference: Sanibel Island, USA 4 -10 November 2012, Editors: J H Hamilton, A V Ramayya, World Scientific, (2013), Pg49.
28. High spin states in ^{33}S, Abhijit Bisoi, SRay, DPramanik, RKshetri, SNag, K Selvakumar, PSingh, AGoswami, SSaha, JSethi, TTrivedi, BSNaidu, RDonthi, VNanal, RPalit, SSarkar, and M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 58 (2013) 226
29. Confirmation of a prolate structure for ^{153}Ho,Dibyadyuti Pramanik, M Saha Sarkar, SSarkar,Proc of the DAE Symp on Nucl Phys 58 (2013) 302
30. Study of Intrinsic Photo peak Efficiency of NaI(Tl) Detectors at 662 KeV, Supriti Sen, Anirudh Chandra, Dibyadyuti Pramanik, M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 58 (2013) 934
31. Characterization of ^{22}Ne implanted target by ^{22}Ne(p,γ)^{23}Na resonance reaction, Abhijit Bisoi, M Saha Sarkar, CADesai, , LCTribedi, HSJung, KSetoodehnia, SLyons, JGörres, Ed Stech, DRobertson and MWiescher, Proceedings of the DAE Symp on Nucl Phys 58 (2013) 936
32. Bulk characterization of ^{14}N implanted target using Resonance reaction and SIMS measurements,Abhijit Bisoi, LCTribedi, DMisra, SBiswas, KVThulasi Ram, MVRundhe, Anoop KV, V Nanal and M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 58 (2013) 996

33. Neutron detection by Pulse Shape Discrimination and Time of Flight techniques,Anirudh Chandra, Dibyadyuti Pramanik, Abhijit Bisoi, Krishichayan, Chandi Charan Dey, Maitreyee Nandy, M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 58 (2013) 938
34. Measurement of Intrinsic Neutron Detection Efficiency of a Liquid Scintillator using Digital Data Acquisition System, Abhijit Bisoi, DPramanik, BDey, and M Saha Sarkar, Proc of the DAE Symp on Nucl Phys 58 (2013) 998.
35. Measurement of fusion and quasi-elastic barrier distributions of ^{6}Li+^{64}Ni, Md. Moin Shaikh, Subinit Roy, S. Rajbanshi, M. K. Pradhan, A. Mukherjee, P. Basu, S. Pal, V. Nanal, R. Pillay, R. Palit, and A. Shrivastava, Proc of the DAE Symp. on Nucl. Phys. 58 (2013)
36. Angular momentum limit to fusion for reactions of weakly bound ^{6,7}Li and ^{6}He nuclei with heavy mass targets, M.K. Pradhan, A. Mukherjee, Proc of the DAE Symp. on Nucl. Phys. 58 (2013)

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37. Abhijit Bisoi, A Nandi, M K Ray, N A Rather, S Ray, D Pramanik, and M Saha Sarkar, Accelerator and Radiation Physics, PK Sarkar, Samita Basu, Maitreyee Nandy (Eds), Narosa, chapter 34, 205 (2012)
38. Search for Shears Mechanism in ^{142}Sm S Rajbanshi, A Bisoi, S Nag, S Saha, J Sethi, T Trivedi, T Bhattacharjee, S Bhattacharyya, S Chattopadhyay, GGangopadhyay, GMukherjee, RPalit, M Saha Sarkar, AK Singh and AGoswami, Proc DAE-BRNS SympNuclPhys(India) 57 (2012) 208.
39. Competing collectivity and multiplet structure in ^{154}Ho, Dibyadyuti Pramanik, Abhijit Bisoi, Subhendu Rajbanshi, SBhattacharya, Sudatta Ray, SSGhugre, AKSinha, SSaha, JSethi, BSNaidu, RDonthi, VNanal, RPalit, M Saha Sarkar, and SSarkar,Procof the DAE Symp on NuclPhys57 (2012) 212
40. Determination of nuclear life time from time stamped decay data, SRajbanshi, ABisoi, SNag, SSaha, JSethi, TTrivedi, TBhattacharjee, SBhattacharyya, SChattopadhyay, GGangopadhyay, GMukherjee, RPalit, M Saha Sarkar, AKSinghand AGoswami, Proc of the DAE Symp onNucl Phys 57 (2012) 244
41. Deformed states in ^{35}Cl: A Shell model Description, Abhijit Bisoi, SSarkar, and M Saha Sarkar, Proc of the DAE Symp onNucl Phys 57 (2012) 302
42. Preparation and Characterization of a ^{22}Ne implanted target, Abhijit Bisoi, CADesai, LCTribedi and M Saha Sarkar, Proc of the DAE Symp onNucl Phys 57 (2012) 902
43. Characteristics of Si-PIN diode X Ray Detector with DSP electronics, Juhi Dutta, Abhijit Bisoi, Dibyadyuti Pramanik, Sudatta Ray, Archisman Saha, Srijita Tapader, and M Saha Sarkar, Proc of the DAE Symp onNucl Phys 57 (2012) 904
44. Characterization of Clover Detector for an Offline detector array, Abhijit Bisoi, Sudatta Ray, Dibyadyuti Pramanik, Suparna Hazra, Punya Chatterjee, Supriti Sen, and M Saha Sarkar, Proc of the DAE Symp onNucl Phys 57 (2012) 906.

INVITED LECTURES DELIVERED

2017

1. *Gas targets for cross section measurements at energies relevant to nuclear astrophysics* – Thematic Workshop on Underground Accelerator Based Nuclear Astrophysics Facility, UGC-DAE Consortium for Scientific Research, Kolkata Centre, May 17 - 18 2017, S Roy
2. Our Adventures in Nuclear Structure and Nuclear Astrophysics with light-ions and low energy beams, Talk delivered at Institute of Physics, Bhubaneswar on 28th April 2017, M Saha Sarkar
3. *Ratio of neutron to proton matrix elements – an indicator of collectivity in nuclei* – Variable energy Cyclotron Centre, April 27, 2017, S. Roy
4. International Conference in Nuclear Physics with Energetic Heavy Ion Beams, March, 2017, Department of Physics, Panjab University, *Effect of Alignment and Core Rotation on Shears Mechanism in Mass ~140 region*, A. Goswami
5. Outreach lecture on *Nuclear Physics: a key to explore the stellar environme*nt, Dum Dum Motijheel College, Kolkata, March 2, 2017, A. Mukherjee
6. *Principles and applications of XRF* –School on Trace Analysis (STA 2017), Saha Institute of Nuclear Physics, Kolkata, March 31, 2017, S. Roy
7. "*Study of Quasi-elastic scattering at back angles for the weakly bound system $^{7}Li+^{159}Tb$ at near-barrier energies*" at the *FUSION17 conference*, held at Hobart, Australia during February 20-24,2017, A. Mukherjee
8. *Nuclear Physics: From Triviality To Eternity* : Talk delivered on National Workshop on *Nuclear and Astrophysics: Two opposite ends of Dimensions (NATD-2017) * held at Vidyasagar University, Midnapore from 17-19 January 2017, M. Saha Sarkar

2016

9. DAE- BRNS symposium on Nuclear Physics, December 2016, Saha Institute of Nuclear Physics, Kolkata,
    a. *Large back angle quasi-elastic scattering for weakly bound systems at near-barrier energies*, A. Mukherjee
    b. Plenary talk on *FRENA: An upcoming facility for Experimental Nuclear Astrophysics*, A. Goswami
    c. *Studies in Nuclear Structure relevant to Astrophysics: experimental efforts*:M. Saha Sarkar
10. *Nuclear structure near exotic doubly closed Sn isotopes* :two (2) talks in the Workshop on "Nuclear structure and inputs for possible experiments with upcoming high resolution gamma ray array at FAIR facility" ***SPIN-2016,*** University of Calicut, Calicut, from 15th-19th November, 2016, supported by Bose Institute Indo-FAIR Co-ordination Centre (BI-IFCC) , M. Saha Sarkar
11. *Why And How Study Nuclear Physics?*Talk delivered at National Conference on Nuclear and Accelerator Physics (NCNAP-2016), Centre for Applied Physics, Central University of Jharkhand, Brambe, Ranchi,October 4-6, 2016,M. Saha Sarkar
12. *Nuclear Physics: From Triviality To Eternity*: 22 September,16, Rammohan College, Kolkata,M. Saha Sarkar
13. *Study of isomers near doubly closed ^{208}Pb with $N<126$* : Workshop on isomer studies at the focal plane of HYRA on 19th September 2016,M. Saha Sarkar
14. School on Experimental techniques in gamma-ray spectroscopy, April 2016, Inter University Accelerator Centre, New Delhi
    a. *Polarization and polarization correlation in gamma spectroscopy (2 Lectures)*, A.Goswami

b. 3 lectures on *Angular distribution, correlation, and DCO ratio,* M. Saha Sarkar

15. National School cum work shop in Accelerator Physics, March 2016, Physics Department, Panjab University, Chandigarh, *FRENA: An upcoming facility for Nuclear Astrophysics: Simulating stars in the laboratory*, A. Goswami
16. Workshop on Nuclear Astrophysics, February 2016, University of Calcutta,
    a. *Challenges of Experimental Nuclear Astrophysics (4 Lectures),* A. Goswami
    b. *Modeling the Nuclear Astrophysical Reactions (3 Lectures), S Roy*
    c.
17. International workshop on Recent Trends in Nuclear Structure and it implication in Astrophysics January 2016, Tata Institute of Fundamental Research, Institute of Physics, Puri
    a. *FRENA: An upcoming facility for Nuclear Astrophysics;Capabilities and Potentials*, A. Goswami
    b. *Studies in Nuclear Structure relevant to Astrophysics: theoretical and experimental efforts*,M. Saha Sarkar

2015

18. DAE- BRNS symposium on Nuclear Physics, December 2015, Sri Sathya Sai Institute of Higher Learning, Prasanthi Nilayam
    a. Influence of proton and neutron alignment on shears mechanism: A case in mass ~140 region, A. Goswami
    b. Ultra fast timing MMRPC: a versatile detector for basic and applied science, U. Datta
19. *Study of $^{19}F(p,\alpha)$ reaction using the Trojan Horse Method*, 59th Accelerator Users Workshop, 15-19 December, 2015, IUAC, New Delhi, Chinmay Basu
20. Workshop on the use of Low Energy Ion Beams (WIB@2015), November 2015, Institute of Physics, Bhubaneswar, *Journey through an esoteric path: From IOP Ion beam laboratory to FRENA*, A. Goswami
21. Recent Trends in Nuclear Physics, IUAC, New Delhi, 14-15 September 2015,
    a. *Superdeformed bands in light nuclei*, M. Saha Sarkar.
    b. *The Trojan Horse Method*, Chinmay Basu
22. *Direct probe to the ground state configuration of 'ISLAND OF INVERSION' nuclei through Coulomb Breakup* " at Dept. of Physics and Astronomy, Ohio University, Athens, Ohio state, USA, 12th June, 2015, U. Datta
23. *Direct probe to the ground state configuration of 'ISLAND OF INVERSION' nuclei through Coulomb Breakup* at Physics Dept., Argonne National Laboratory, Argonne, Chicago, USA, 23rd June, 2015, U. Datta
24. *Nuclear physics and neutrino*, First Conference on science at Sanford underground facility, South Dakota School of Mines, Rapid City, May, 2015, U Datta
25. *Direct Evidence of melting shell-gap of the neutron-rich nuclei through novel spectroscopic tool*, International Conference on Electromagnetic Isotope Separators and related topics (EMIS 2015), Grand Rapids, Michigan, (11-15th May, 2015), U Datta
26. Frontiers in Gamma Ray Spectroscopy 2015 (FIG-15), February 2015, Variable Energy Cyclotron Centre, Kolkata
    a. Summary Talk, A. Goswami
    b. *Experimental and Theoretical Efforts- Relevance To Nuclear Astrophysics*, M Saha Sarkar
27. *Experimental activities in and around FRENA* – Two lectures delivered at CNT Winter School on Nuclear Astrophysics, Variable Energy Cyclotron Centre, Kolkata, January 19- 31, 2015, S Roy

2014

28. *Journey to Nuclear Island of Inversion using a novel spectroscopic tool*, International Workshop on Science with Rare Ion Beams (SCRIBE-2014) Nov 25-28, 2014, VECC, U Datta
29. DST-SERC school on Nuclear structure at high angular momentum and Isospin, October 2014, Tata Institute of Fundamental Research, Mumbai
    a. *3 lectures: Advance technique in gamma spectroscopy,* A. Goswami
    b. *3 lectures: Spectroscopy of nuclei near ^{132}Sn and shell model results,* M Saha Sarkar
30. *Distinguishing the reaction mechanisms around the barrier energy* – Talk delivered at Workshop on Ancillary Equipments for Nuclear Physics at IUAC, Inter University Accelerator Centre, New Delhi, July3-4, 2013, S Roy
31. *Coulomb Breakup as a novel spectroscopic tool to probe quantum numbers of valence nucleon of loosely bound nuclei*, Texas A & M, USA, 23th June., 2014, U Datta
32. 75-years of Nuclear Fission: Present status and future perspectives" held during May 8-10, 2014 at BARC, Mumbai,*^{136}Sn and three body forces*, M Saha Sarkar
33. *Study of exotic properties of nuclei using various RIB facilities,* At Physics Dept., Stanford University, May, 2014, U Datta
34. *Fusion at Near Barrier Energies* – Invited talk delivered at Summer School on Nuclear Fission and Related Phenomena**,** Variable Energy Cyclotron Centre, Kolkata**,** May 13-23, 2014, S Roy
35. A school on Nuclear structure at IUAC, New Delhi during 21 to 26th April 2014, six (6) lectures on *Shell evolution and collectivity in sd-shell nuclei - an experimentalist's view*, M Saha Sarkar
36. 6th Asian nuclear physics association symposium ANPhAS-2014, February 2014, Variable Energy Cyclotron Center, Kolkata, *Nuclear structure research and Status of FRENA project at SINP,* A Goswami
37. Two-day Satellite School on Nuclear Reactions around the barrier, IUAC, New Delhi, Feb 21-22, 2014. *Fusion with Loosely Bound Nuclei and Influence of Breakup Mechanism*, A. Mukherjee.
38. *Coulomb Breakup as a novel spectroscopic tool to probe quantum numbers of valence nucleon of loosely bound nuclei and new results on Na, Mg and Al neutron-rich nuclei*, at RUTGERS University, USA, 6th Feb., 2014, U Datta

2013

39. *Systematic R-matrix analysis of $^{13}C(p,\gamma)^{14}N$ capture reaction* - at International Symposium on Nuclear Physics, DAE Symposium on Nuclear Physics, BARC, Mumbai, 02-06 December, 2013, S Roy .
40. *Coulomb Breakup as a Novel spectroscopic tool to probe quantum numbers of loosely bound nucleon(s) of exotic nuclei*, The 10th Latin American Symposium on Nuclear Physics and Applications, December 1-6, 2013 in Montevideo, Uruguay, U Datta
41. *The effect of breakup on transfer*, Secondary RIB using HYRA, IUAC, New Delhi November14-15, 2013, Chinmay Basu
42. National workshop on exploring radiation in many splendors, November 2013, Saha Institute of Nuclear Physics, Kolkata,
    a. *Radiation: A Stethoscope of a Nuclear Physicists,* A. Goswami
    b. *Solid state detectors*, Chinmay Basu
43. 9th International Conference in Subatomic Physics and Applications (CIPSA 2013), Constantine 1 University, Constantine, Algeria, October 2013, M. Saha Sarkar
    a. *Superdeformation and alpha-cluster structure in sd-shell nuclei* (Plenary talk)
    b. *Shell evolution in neutron rich nuclei* (Invited seminar).

44. *Measurement of mass of neutrino from unique technique beta-decay measurement at SINP laboratory*" at International School of Nuclear Physics, 35th Course, Neutrino Physics: Present and Future, Erice-Sicily, September 16-24, 2013, U. Datta
45. Coupled channel calculations with ECIS – Two lectures delivered at DST - SERC school on "*Theory of Nuclear Structure and Reactions*", IIT – Roorkee , September 23 – October 4, 2013.
46. Ion Beam induced material modification & Neutron generation using 3 MV particle accelerators: application in physical, chemical and life sciences, August 2013, Guru GhasidasVishwavidya, Bilaspur, *Investigation of Stellar processes in the laboratory: An upcoming facility to study Nuclear Astrophysics*, A. Goswami
47. *Direct probe to the ground state configuration of Island of Inversion neutron-rich nuclei through Coulomb Breakup*, International Nuclear Physics Conference, Firenze, and 3rd June, 2013, Ushasi Datta
48. *Nuclear Energy and research with Radioactive ion beam facility*, at, International workshop on 'At the Crossroads Of Africa, Asia and Europe: Challenges and Perspective', Humboldt-Kolleg, Venice International University , Venezia, 30th May to 1st June, 2013, U. Datta
49. *Importance of n-stripping process in the $^{6}Li+^{159}Tb$ reaction at near barrier energies* at the HIAS2013, Department of Nuclear Physics, Australian National University, Canberra, April 8-12, 2013, A. Mukherjee
50. *Nuclear Astrophysics Research Program at SINP*, Conference on Particle Accelerators - Technology and Applications at IUAC, New Delhi during April 4-5, 2013, P. Banerjee
51. National Conference on Nuclear Dynamics and Nuclear Astrophysics, organized by the Department of Physics, University of Calcutta, held during Feb 5-6, 2013,
    a. Invited Talk, A. Mukherjee
    b. *Breakup transfer in $^{12}C(^{6}Li,d)$ reaction*, Chinmay Basu
52. *Studies in Nuclear Astrophysics: experimental and theoretical efforts*, DAE-BRNS theme meeting on the physics aspects of accelerator radiation protection, February 20-22, 2013 at BARC, M.Saha Sarkar

2012

53. *Sub-Coulomb transfer reactions*, School-cum-Workshop on Low Energy Astrophysics (SLENA 12), November 26-29, 2012, SINP, Kolkata, Chinmay Basu
54. Research Awareness program using accelerated nuclear beam,at Jharkhand Central University, Ranchi, Bihar, 16th Nov, 2012, U. Datta
55. Exploring Nuclear Structure and Reaction dynamics using Radioactive Ion Beam, International Workshop on Science with Rare Ion Beams SCRIBE-2012, (07-09) Nov, U Datta
56. *Pairing and shell evolution in neutron rich nuclei*, Physics and Astronomy at Rutgers, The State University of New Jersey, November 14-16, 2012, M Saha Sarkar
57. *Study of neutron - rich nuclei near doubly magic ^{132}Sn and its implication in other neutron – rich domains*, Department of Physics and Astronomy, University of Tennessee, Knoxville, TN, USA , 12 – 14 November, 2012, M Saha Sarkar
58. 5th International Conference on Fission and Properties of Neutron-Rich Nuclei, November 4-10, 2012 at Sanibel Island, Florida, USA. *Pairing and shell evolution in neutron rich nuclei*, M Saha Sarkar
59. *Understanding Nuclei in the upper sd shell*, John D. Fox Superconducting Accelerator Laboratory, Physics Department, The Florida State University, Tallahassee, Florida, USA, Oct. 30 to Nov. 4, 2012, M Saha Sarkar
60. *Study of neutron - rich nuclei near doubly magic ^{132}Sn and its implication in other neutron – rich domains*, Physics Department, Argonne National Laboratory, Argonne, USA, 28-31 October 2012, M Saha Sarkar

61. NUSTAR WEEK 2012 meeting, Variable Energy Cyclotron Centre (VECC), Kolkata, INDIA, during October 8-12, 2012,
    a. *High energy Neutron detector: NeuLAND development and final design, for R3B, FAIR facility*, U Datta
    b. *Shell structure and evolution of collectivity in nuclei above the ^{132}Sn core*, M Saha Sarkar.
62. *Study of proton capture cross-sections on Cd isotopes*, at the National Workshop on Experimental Proposals and Possibilities for the Nuclear Studies with INGA at VECC, May 22-23, 2012, P. Banerjee
63. *Future plan of Indian scientists at ISOLDE, CERN*, Isolde Scientific Collaboration Committee, ISOLDE, CERN, Geneva, 3rd, July, 2012, U. Datta
64. *Alpha clustering in ^{212}Po*, Nuclear Structure & Dynamics Conference July 9-13 2012, Opatija, Croatia, Chinmay Basu
65. Energy Dispersive X-ray Fluorescence– Invited Talk delivered at BRNS-AEACI Summer School on Analytical Chemistry (SAC-4), Variable Energy Cyclotron Centre, Kolkata, July 22-29, 2012, S Roy
66. Frontiers In Gamma spectroscopy (FIG 12), March 2012, Inter University Accelerator Centre, New Delhi
    a. *Mechanism for the generation of angular momentum in weakly deformed nuclei in mass 140-150 region,* A Goswami
    b. *Understanding Nuclei in the upper sd shell*, M Saha Sarkar.
67. *Glimpses of new excitements in Nuclear Physics*, Department of Physics, University of Calcutta, two day meeting for M.Sc students on 'Recent trends in Physics', 7th and 8th February, 2012, M Saha Sarkar
68. *Exotic decay of neutron deficient Ba isotopes at ISOLDE*, CERN, Feb, 2012, through Video conference, Ushasi Datta

Subinit Roy, Sr. Professor H

DOB December 11, 1960

Phone +91 33 2337 5345-49 (Ext. 1204)

E-mail subinit.roy@saha.ac.in

EDUCATION M.Sc. Ph.D

ACADEMIC POSITIONS	1993-1994	Research Associate, SINP, Kolkata
	1994 (March-September)	Visiting Fellow, TIFR, Mumbai
	1994-1997	Lecturer C SINP, Kolkata
	1997-2001	Reader D SINP, Kolkata
	2001-2005	Associate Professor E, SINP, Kolkata
	2005-2008	Professor F SINP, Kolkata
	2008-2016	Professor G, SINP, Kolkata
	2016-	Professor H, SINP, Kolkata

TEACHING/ GUIDANCE

Teaching regularly at Department of Physics, University of Calcutta, Kolkata

Teaching at Post M.Sc. Course, SINP, Kolkata

Guided the thesis work of four (4) students. Degree awarded three (3). Thesis submitted one (1).

Guided the M.Sc. Project work/ Summer project of 10 students (2011-2017)

AREAS OF RESEARCH

Experimental Low Energy Nuclear Physics

Energy Dispersive X Ray Fluorescence (EDXRF) studies of Environmental Samples.

ESSENTIAL STRENGTH OF RESEARCH/DEVELOPMENT OUTPUT

Fusion and Quasi-elastic Barrier distribution study of ^{6,7}Li induced reactions at near barrier energies on medium mass nucleus, ^{64}Ni. Investigated the influence of breakup of weakly bound projectiles on fusion and quasi-elastic scattering and subsequently explored the relative importance of other direct reaction process on the fusion and quasi-elastic barrier distributions with decreasing bombarding energy. Related experiments were carried out at the TIFR/BARC Pelletron Facility in Mumbai to measure the fusion as well as quasi-elastic excitation functions. Subsequently, the barrier distribution was constructed from the measured excitation functions to further delineate the effect of coupling.

A systematic R-matrix analysis of proton and alpha capture reactions, (p,γ) and (α,n), on ^{13}C nucleus using the code **AZURE II**, have been performed during this period. Existing capture reaction data along with the low energy proton,alpha and neutron elastic scattering data were used simultaneously in the fitting programme to constrain the partial widths of the resonance states. The required spectroscopic amplitudes or the Asymptotic Normalization Constants (ANC) for estimation of direct capture cross sections to low-lying states of the composite nuclei ^{14}N (p-capture) and ^{17}O (α-capture) were extracted from relevant transfer reaction data. The simultaneous analysis highlights the requirement of new measurements to identify the correct locations of the resonances and the their effect on low energy extrapolation of astrophysical S-factor of the capture reactions to astrophysically relevant region.

Investigations of Municipal Solid Waste contaminated surface and depth soil samples from the East Calcutta Dumping site (Dhapa) and apparently non-contaminated country-side soil samples, from about 50 kms away from the city of Kolkata, were carried out during this period using the EDXRF technique with Polarized EDXRF Spectrometer (EPSILON 5) in the XRF laboratory of the division. Systematic analysis reveals that elevated levels of most elements, especially Cu, Zn, and Pb, in dumping site samples suggesting that the top-soil, which has been evolving mainly from MSW, is highly contaminated with heavy metals, far exceeding the ecological screening limits for soil. On the other hand, the depth variations of concentrations of most of the elements remain constant but some of the toxic elements show a systematic pattern of variation along depth.

The XRF laboratory of Nuclear Physics Division participated in **Worldwide Open Proficiency Test for XRF Laboratories (PTXRFIAEA09)** conducted by IAEA Laboratories, Seibersdorf, for Determination of **Major, Minor and Trace Elements in a River Clay** using the Polarized EDXRF Spectrometer, EPSILON 5, installed during December, 2011**.** The report was published by IAEA Laboratories in December, 2012 (ftp://ftp.iaea.org/pub/PTXRFIAEA09/).

FUTURE RESEARCH/DEVELOPMENT PLAN

Keeping in mind the upcoming FRENA (Facility for Research in Experimental Nuclear Astrophysics), as a member of Nuclear Physics Division the primary motivation of my future plan will be to ensure the successful installation and operation of the low energy, high current accelerator. To provide a suitable detection facility at FRENA, a strip detector telescope array to perform low cross section measurements will be developed. This type of detector with large solid angle coverage will be essential for deep sub-barrier measurements using the light ion beams from the FRENA accelerator.

NO. OF PUBLICATIONS (2011-2017)   Journals – 14; Conference Proceedings – 10

SOME SELECTED PUBLICATIONS (during 2011-2017)

1. The effect of breakup of ^{6}Li on elastic scattering and fusion with ^{28}Si at near barrier energies
Mandira Sinha, Subinit Roy, Padmanava Basu and Harashit Majumdar, **Int. J. of Modern Physics E, Vol. 25, No. 1 (2016) 1650003**

2. Probing the fusion of ^{7}Li with ^{64}Ni at near-barrier energies
Md.M.Shaikh, Subinit Roy, S.Rajbanshi, A.Mukherjee, M.K.Pradhan, P.Basu, V.Nanal, S.Pal, A. Shrivastava, S.Saha, R.G.Pillay **Phys. Rev. C 93, 044616 (2016)**

3. **Barrier distribution function for the system ^{6}Li+^{64}Ni and the effect of channel coupling.**
Md. Moin Shaikh, Subinit Roy, Subhendu Rajbanshi, M.K. Pradhan, A. Mukherjee, P. Basu, S. Pal, V. Nanal, R.G. Pillay, A. Shrivastava, **Phys. Rev. C91, 034615 (2015)**

4. Systematic R-matrix analysis of the ^{13}C(p,γ)14N capture reaction
Suprita Chakraborty, Richard deBoer, Avijit Mukherjee, Subinit Roy, **Phys. Rev. C. 91, 045801 (2015)**

5. Investigation of ^{6}Li+ ^{64}Ni fusion at near barrier energies
Md. Moin Shaikh, Subinit Roy, Subhendu Rajbanshi, M.K. Pradhan, A. Mukherjee, P. Basu, S. Pal, V. Nanal, R.G. Pillay, A. Shrivastava, **Phys. Rev. C90, 024615 (2014)**

6. Chemical composition of soil evolving from municipal solid waste using energy dispersive Xray fluorescence, D.Gupta, Subinit Roy, Rita Ghosh, A.K.Mitra, **X-Ray Spectrometry 39, 364 (2012).**

Name: Asimananda Goswami

Present position: Professor `H’

Division: Nuclear Physics Division

Academic qualification: Ph.D.

Essential strength of research/development output:

Research output:

The main interest of my research during the last five years centered on the study of high spin states using the technique of in-beam gamma-ray spectroscopy in different mass region using the fusion-evaporation reaction with stable beams obtained from different accelerator centers of our country. The detector system used was Indian National Gamma Array (INGA) consists of Compton suppressed clover detectors. The primary focus is to study the mechanism of generation of angular momentum in weakly deformed systems with special emphasis in mass ~140, 120 and 100 regions where different possible mechanisms like Magnetic and Anti magnetic rotation, chiral symmetry breaking, triaxial bands, octupole correlation etc. and try to understand them from theoretical model calculations.

In addition I am involved several other collaborative works some of which are listed below:

i) Onset of deformation at $N = 112$ in Bi nuclei

ii) High spin band structures in doubly odd ^{194}Tl

iii) Superdeformed band in ^{35}Cl

iv) High spin spectroscopy in ^{34}Cl

v) Structural change of the unique-parity $\pi h_{11/2} \otimes \nu h_{11/2}$ configuration in ^{134}Cs

v) Experimental investigation of shell-model excitations of ^{89}Zr up to high spin

vi) Fusion of ^{6}Li with ^{159}Tb at near-barrier energies

Development output:

- Development of the Facility for Research in Experimental Nuclear Astrophysics (FRENA)
- Indian National Gamma Array (INGA)

Future research/development plan:

Development plan:

The primary aim is to establish a national centre for research in experimental nuclear astrophysics in our country at SINP campus. The first phase in this endeavor is to install the low energy high current accelerator and associated facilities for FRENA.

Research plan:

Continue research on nuclear structure studies in various mass regions to look for different spontaneous symmetry breaking phenomena in finite many body quantal systems.

List of important publication starting with the recent publication (2012-2017):

1. Novel evolution of the positive parity shears band in ^{106}Ag

B. Das, N. Rather, P. Datta, S. Chattopadhyay, S. Rajbanshi, A. Goswami, S. Roy, S. Pal, R. Palit, S. Saha, J. Sethi, S. Biswas, P. Singh, and H. C. Jain

Phys. Rev. C 95, 051301(R) (2017)

2. Shears mechanism and development of collectivity in ^{141}Sm

S. Rajbanshi, Sajad Ali, Abhijit Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Bhattacharjee, S. Bhattacharyya, S. Chattopadhyay, G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, T. Trivedi, A. Goswami

Phys. Rev. C 94, 044318 (2016)

3. Three proton hole structure in ^{106}Ag

B. Das, N. Rather, S. Chattopadhyay, S. Rajbanshi, A. Goswami, P. Datta, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, H. C. Jain

Phys. Rev. C 93, 064322 (2016)

4. Evidence for octupole correlation and chiral symmetry breaking in ^{124}Cs

K. Selvakumar, A. K. Singh, Chandan Ghosh, Purnima Singh, A. Gowsami, R. Raut, A. Mukherjee, U. Datta, P. Dutta, S. Roy, G. Gangopadhyay, S. Bhowal, S. Muralithar, R. Kumar, R. P. Singh, M. Kumar Raju.

Phys. Rev. C 92, 064307 (2015)

5. Antimagnetic rotation and sudden change of electric quadrupole transition strength in ^{143}Eu.

S. Rajbanshi, S. Roy, Somnath Nag, Abhijit Bisoi, S. Saha, J. Sethi, T. Bhattacharjee, S. Bhattacharyya, S.Chattopadhyay, G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, T. Trivedi, A. Goswami.

Phys. Lett. B 478, 387 (2015)

6. Multiple magnetic rotational bands based on proton alignment in ^{143}Eu

S. Rajbanshi, Abhijit Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Bhattacharjee, S.Bhattacharyya, S. Chattopadhyay,G. Gangopadhyay, G. Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, T. Trivedi, A. Goswami.

Phys. Rev. C90, 024318 (2014)

8. Exploring the Origin of Nearly Degenerate Doublet Bands in Ag^{106}

N. Rather, P. Datta, S. Chattopadhyay, S. Rajbanshi, A. Goswami, G. H. Bhat, J. A. Sheikh, S. Roy, R. Palit, S. Pal, S. Saha, J. Sethi, S. Biswas, P. Singh, H. C. Jain

Phys. Rev. Lett. 112, 202503 (2014)

9. Shape coexistence in near spherical ^{142}Sm nucleus

S. Rajbanshi, Abhijt Bisoi, Somnath Nag, S. Saha, J. Sethi, T. Trivedi, T. Bhattacharjee, S. Bhattacharyya, S. Chattopadhyay, G. Gangopadhyay, G.Mukherjee, R. Palit, R. Raut, M. Saha Sarkar, A. K. Singh, A. Goswami

Phys. Rev. C89, 014315 (2014)

MAITREYEE SAHA SARKAR, Sr Professor H,
DoB : 14 September 1960
E-mail: maitrayee.sahasarkar@saha.ac.in

Citation indices	All	Since 2012
Citations	1029	504
h-index	17	11
i10-index	32	15

EDUCATION
1993: Ph.D. in Physics, University of Calcutta
1984: M.Sc. in Physics, University of Calcutta; 1stclass, 2nd in rank
1982: B.Sc. Physics Hons, University of Calcutta; 1st class, 6th
1977: Secondary Exam, 7th in rank

ACADEMICPOSITIONS
2016- ...... : Senior Professor H, Saha Institute of Nuclear Physics
2008-2016: Professor G, Saha Institute of Nuclear Physics
2005-2008: Professor F, Saha Institute of Nuclear Physics
2001-2005: Associate Professor E, Saha Institute of Nuclear Physics
1998-2001: Reader ‘SD’ Saha Institute of Nuclear Physics
19 April 1996-1998: Lecturer ‘SC’, Saha Institute of Nuclear Physics

Essential strength of research/development output

- I always aim to get a comprehensive understanding of nuclear structure from experimental and theoretical studies.
- Characterization of Composite LEPS and Clover detectors has been useful to the national and international community. Our in-house detector array is being utilized for offline-measurements and will be an important setup for FRENA utilization. Rejuvenation of large NaI(Tl) Sum spectrometer is an achievement.
- Our group has demonstrated the possibility of using Si-PIN diodes made by BEL for detection of electrons, alphas and X-rays. We are continuing this study further and testing other photodiodes for these measurements.
- Working with digital data acquisitions is another strong point of our group. Apart from working with standard digitizers, we have also utilized digital oscilloscopes for useful measurements.
- Preparation, characterization and utilization of implanted targets for use in experiments of Nuclear Astrophysics in the Low energy accelerator facilities has been demonstrated.
- Our experimental studies of nuclei in A~40 have generated some impact in the understanding of the cluster structure, super-deformation and the role of intruders and th*e sd-fp* shell gap. Experimental identification of super deformation and parity doublet bands in ^{35}Cl and its theoretical interpretation using Large scale Shell model is an important achievement.
- Development of an improved empirical shell model Hamiltonian, having excellent predictive power for very neutron rich nuclei above ^{132}Sn is an achievement for our group. We are collaborating with experimentalists for interpretation of their data.
- Collaborators from other Institutes and University are using our laboratory for testing scintillator crystals grown by them, utilize nuclear techniques for follow erosion of land by river and study the Radon content in river water etc.

Future research/development plan

- The implanted targets will be utilized at different accelerator centers and the upcoming Facility for Research in experimental Nuclear Astrophysics (FRENA) facility for understanding problems of Nuclear structure and Astrophysics.
- The photodiodes will be utilized to develop a setup for internal conversion electron detection for off-line studies.
- Large NaI(Tl) Sum spectrometer will be utilized as total gamma absorption spectrometer.

- Extension of shell model studies to nuclei below ^{132}Sn core and study nuclei in this region close to stability and away from that within the same interaction.

Teaching, Research Guidance, Administrative responsibilities

- A regular teacher in our Post M. Sc course and a member of Academic Standing Committee.
- My students Dr. Ritesh Kshetri (2009) and Dr. Abhijit Bisoi (2015) are presently working as Assistant Professors at Burdwan University and Indian Institute of Engineering Science and Technology, Shibpur, respectively. Ms. Sangeeta Das has started working in 2016. Ms. Moumita Basu Roy is working under my supervision since September 2004 on Part time basis. Ms, Sathi Sharma is now completing her Post M.Sc course work and working her project with me.
- Have supervised project work of quite a few undergraduate and Postgraduate students in the last few years(http://www.saha.ac.in/web/npd-personal-page?mid=66&tab=tab5).
- Have worked as referee for several International and National Journals. I have reviewed an evaluation of Nuclear Data Table for A=35.
- Have worked as a member of the School Board of Physical Sciences (SBPS) and Board of Post Graduate Studies (BPGS) in Physics Department of North Eastern Hill University, Shillong, Meghalaya, during 2013-2015.
- Worked as examiner for several PhD theses of students from IIT and Central Universities
- Have been working for DAE-BRNS Symposium on Nuclear Physics as
  - member of the Organizing Committee since 2010.
  - referee for evaluation of the papers submitted in the Nuclear Structure category.
  - Chairperson of the jury for the C.V.K. Baba best thesis award 2013 at BARC
  - Chairperson of Local Organising Committee of 2016 Symposium at SINP, Kolkata.
- Have been working as Departmental Head, Nuclear Physics Division since January 2016.
- Have been working actively for Implementation of FRENA since its inception. I am a member of FRENA project implementation committee.

Publications

Total (Journal): 79 (Since 2012: 13); Conference: 121 (Since 2012: 39)

Most recent important ones:

1. Shape coexistence in ^{153}Ho, Dibyadyuti Pramanik, S. Sarkar, **M. SAHA SARKAR**, Abhijit Bisoi, et al., Phys. Rev. C94, 024311 (2016).
2. Characterisation of a Composite LEPS, Moumita Roy Basu, Sudatta Ray, Abhijit Bisoi, **M. SAHA SARKAR**, JINST 10, T07002 (2015).
3. ^{136}Sn and three body forces, **M. SAHA SARKAR**, S. Sarkar,Pramana, 85, 403 (2015).
4. Superdeformation and α-cluster structure in ^{35}Cl, Abhijit Bisoi, **M. SAHA SARKAR**, S. Sarkar, S. Ray, M. Roy Basu, Debasmita Kanjilal, Somnath Nag, K. Selvakumar, A. Goswami, N. Madhavan, S. Muralithar, and R.K. Bhowmik, Phys. Rev.C88, 034303 (2013)

- Characterization of NaI(Tl) Sum Spectrometer and its utilization, **M SAHA SARKAR** et al,Proc. DAE-BRNS Symp. Nucl. Phys. (India) 61(2016) 1022
- Silicon PIN Diode for detection of electrons, alphas, X-rays and gamma rays, Sangeeta Das, Arghya Chakraborty,Anshuman Mondal, Kushal Shaw, Ankan Sur, Satadal Das, Ranjay Laha, Arijit Das, Jonaki Panja, Chandranath Marick, Ajay Mitra, Sujib Chatterjee, **M. SAHA SARKAR,** Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60(2015) 976 (Best Poster award)
- Preparation and Characterization of a ^{22}Ne implanted target, Abhijit Bisoi, C.A. Desai, L.C. Tribedi and **M. SAHA SARKAR**, Proc. of the DAE Symp. on Nucl. Phys. 57 (2012) 902 (Best Poster award).
- Lifetime of the 6792 keV state in ^{15}O, Abhijit Bisoi, Indrani Ray, L.C. Tribedi, D. Misra, S. Biswas, K. V. Thulasi Ram, M. V. Rundhe, Anoop KV, V. Nanal, Sunil Ojha, P. Banerjee, S. Sarkar and **M. SAHA SARKAR**, Proc. DAE-BRNS Symp. Nucl. Phys. (India) 60 (2015) 892.
- Gamma-ray responses of organic single crystal grown by unidirectional Sankaranarayanan-Ramasamy technique, N Durairaj, S Kalinathan, **M SAHA SARKAR**, C. C. Dey,Proc. DAE-BRNS Symp. Nucl. Phys. (India) 61(2016) 976.

Prof. Ushasi Datta or Ushasi DattaPramanik, PhD
ushasi.dattapramanik@saha.ac.in,
Telephone (Office): +91-33-23370379 (ext 1339,)
http://www.saha.ac.in/web/scientific/personal-page?mid=ushasi.dattapramanik&tab=tab2

PROFESSIONAL POSITIONS:

- **Professor-'G', SINP, Kolkata** (July, 2013-onwards)
- **Professor-'F', SINP, Kolkata** (Feb., 2008- June,2013)
- **Visiting scientist, GSI, Darmstadt (Jan.-April.,2009, Aug., -Oct, 2010)**
- **Assoc. Professor-'E', SINP, Kolkata** (Aug,2005-Feb, 2008)
- Visiting scientist, INFN, Legnaro (April-May, 2007)
- **Visiting scientist , GSI, Darmstadt, Germany (July, 2004- Feb.2005, July-Dec. 2006)**
- Visiting scientist, CSNSM, Orsay, France (May-Aug., 2003)
- **Reader-'D', SINP, Kolkat**a (June,2002-Aug,2005)
- **Post Doctoral Fellow, GSI, Darmstadt, Germany (June,1999-June,2002)**
- Visiting research Fellow, INFN, Italy (Nov-Dec, 1998, April-May,1999)
- **Junior/Senior research Fellow, DAE, SINP (1991-1998)**

PROFESSIONAL AWARDS / FELLOWSHIPS:

- Foundation day award for research Achievement, Saha Institute Of Nuclear Physics, 2010
- Alexander Von Humboldt Fellowship, Germany, 2004-2006, 2008-2009, 2010
- CNRS Fellowship, Orsay, France, May-August, 2003
- INFN/FAI, Italy Grants (1998, 1999, 2007)
- DFG-BMBF, Fellowship, Germany (June,1999-June,2002)
- International INFN fellowship, Catania, Legnaro, Italy (1999-2001) (decline)
- DAE(govt. of India) Fellowship (1991-1998),
- National Scholarship (1983), National Merit certificate (1981**)**

MEMBERSHIP/SPECIAL ACHIEVEMENT:

- Member of ISOLDE (CERN) Collaboration Committee (ISCC), 2012-2015
- Member of PROJECT-X (USA)-Indian working group (2011)
- Life time member of Indian Physical society (IPA), (IPS)
- Member of council of Nustar collaboration of FAIR, Darmstadt (2006-2009)
- Member of R3B, FAIR (Germany) collaboration technical board (2005-2010)
- Member of R3B, FAIR (Germany) collaboration/steering committee (2005-2010)
- Deputy of NeuLAND' R3B (Germany) working group (2005-2012)
- Registered Ph. d supervisor of University of Kolkata, India
- Adjunct faculty and affiliated research guide of Homi Bhaba National Institute , India
- Reviewer of International and national journals and projects
- Chair Of the session in R3B collaboration meeting, University of Milano, 2006
- Member of organizing committee, FRENA2008, 2010
- Convener of the international workshop on "future plan for radioactive ion beam (FPRIB 2012)", Kolkata,
  April, 2012:http://www.saha.ac.in/cs/fprib.2012/Index.htm
- Invited as a lead guest editor (2014) (could not accept the offer because of work load)
- Member of organizing comm. of 60th DAE-BRNS symposium on Nucl. Phys., India, 2015
- Chair of the session in EMIS 2015, Grand Rapids, Michigan
- Member of Int. advisory comm. of Int. conference on proton emitting nuclei, 2015, China
- Chair of the session, 61th National Nuclear Physics Symp. (DAE-BRNS), Kolkata, Dec. 2016

RESEARCH ACTIVITIES AND EXPERIENCE: I have been deeply involved in understanding properties of the exotic nuclei, nuclear astrophysics in explosive burning scenario, cosmology, detector development for imaging by performing many experiments with leadership as well as an active collaborator using table -top setup at my developed laboratory and national, international accelerator facilities along with large scale experimental setup across the world. My global interest is to understand quantum many body systems via strong and weak interactions. Presently, my research topics are focused on disappearance of magic shell gap in the neutron-rich nuclei, modification of shell structure near drip-line, ground state configuration of neutron-rich nuclei, exotic shapes, exotic decay near proton-drip line, resonance states, cluster structure, quantum phase transition, fusion process near drip line, neutron-skin etc. Recently, I have started to explore the properties of active and sterile neutrino. I took major responsibility to established new techniques/methods using Coulomb breakup to explore disappearance of magic shell gap, indirect measurement of capture cross-section etc. We have reported for the first time observation of merging and disappearance of the magic shell gap at N=20, 28 in ^{33}Mg with a unique view of exotic structure which solves many contradictory previous results. Being an active collaboration, I am also involved in measurement of the neutron skin from low-lying dipole strength. All these papers citations are more than hundred, two hundreds etc. I have been successful in securing funds for these research from national funding agencies (DAE) as well as international level (AvH, Germany). I have successfully formed a strong and active research group (mainly with young PhD students and undergraduate students) to extend and expand these activities. I have been involved as a sub-leader in some major large scale collaboration in the international scenario. I was also involved actively in developing and planning FRENA. An advance laboratory in the institute was developed to building technologically challenging modern detectors with timing resolution 100 ps using local facilities. These state of the art facilities are not only useful in exploring nuclear science and imaging applications but young generation get an opportunity to work with advanced technical systems at par with international standard while sitting at India. Thus I could attach myself in the forefront of nuclear physics research activity while staying at India. I have been deeply involved in performing almost thirty-five PAC approved experiments, at VECC (Kolkata), IUAC (New Delhi), TIFR (Mumbai), GSI (Darmstadt), NSCL (Lansing), INFN (Legnaro), ISOLDE(Geneva), and approximately, one third of the experiments have been performed with my major responsibility.

- **TEACHING EXPERIENCE:**
- I serve as a teacher and examiner of pre-doctoral courses at SINP, since 2005. I teach advance courses on nuclear physics to the students of Post M.Sc. diploma course at our institute. This combines lectures on basic and advance course of nuclear physics and laboratory work, ranging from basic and advanced signal processing, implementations, and operations of semiconductor and scintillators, gas detectors to radiation imaging etc. I also teach the graduate and undergraduate level courses via summer project program, on advanced concepts in Radiation Detection and technology, basic concept of nuclear physics theory and related calculations etc.. Eighteen students did project work under my supervision with duration two to six months at various levels of university degree courses from various universities at India.

PhD STUDENTS PERFORMED RESEARCH WORK FOR PhD THESIS UNDER MY SUPERVISION:

- **Mr. Santosh Chakraborty**

Title of thesis**: Study of Neutron-rich Al isotopes through Coulomb breakup**
Thesis submitted on Sept, 2016, waiting for degree. At present working as a guest lecturer WBUT, Kolkata.

- **Md. Anisur Rahaman**

Title of thesis: **Study of exotic features of the nuclei in and around ISLAND of inversion using Radioactive beam.** Expected thesis submission date is Aug., 2017.
At present working as a Assistant Professor in North Bengal Govt. Engg. College, Jalpaiguri, India

- **Ms. Jayati Ray (Joined in September, 2011) ;** Registered for PhD at University of Kolkata, 2012**;**

Title of thesis: **Study of exotic properties of nuclei near proton drip line through in-beam gamma-ray spectroscopy,** At present working as a Assistant Professor in West Bengal. Govt. College, India

UNDERGRADUATE STUDENTS PERFORMED RESEARCH PROJECT FOR FULLFILMENT OF DEGREe (2-6 months) UNDER MY SUPERSION**:**

- **M. Roy , P. M.Sc, SINP, Kolkata, March-August'2012**
- **Hirok Bandopadhyay , IISER , Kolkata, May-Aug, 2013, June, 2014,**
- **R.Gnansundari, M.Sc. final year ANDHRA UNIVERSITY, 2016**
- **B.Mani Subhash, M.Sc. final year ANDHRA UNIVERSITY, 2016**
- **Sourav Sarkar**, **IISER, (INSPIRE Fellow) Kolkata** , **Ist year of integrated M.Sc. in Physics, May-June, 2016**
- **Visal Kumar P.M.Sc review work , Dec.16-March,17**
- Ram Sewak , **P.M.Sc review work , Dec.16-March,17**

List of publications international journals (recognized by ISI web of science):

H-index-21 (ISI web of science) , total citations: 1951, publications: 94, Communicated: 2, under preparation: 3List of No. of peer reviewed publications in the international journals (2012-2017): 28
No. of Invited talks in the international conference, international laboratories, international institutes: 16

1. Name: Prof. Anjali Mukherjee **2. Educational background:** M.Sc , Ph.D. **3. Ph.D.(Year & Name of University):** Thesis submitted: 19.11.97 Degree awarded: 1.08.98 University of Calcutta	

4. **Academic awards:**

i) Amongst the top 9 candidates in the CSIR-UGC NET (National Eligibility Test) examination for junior research fellowship, 1990

ii) Among the best three presentations in the Young Physicist's Colloquium of the Indian Physical Society, 1998

iii) Best thesis presentation award of The Indian Physics Association, 1998

5. **Membership of professional bodies**: Life Member of

i) Indian Physics Association

ii) Indian Physical Society (**presently Council Member of the Society**)

6. **Academic assignments (Post Doctoral / Teaching etc.) prior to joining SINP in a permanent position**

Sl. #	Position held	Univ./Inst.	Period	
			From	To
1.	Research Associate	SINP, Kolkata	Aug. 1998	Nov. 1999
2.	Postdoctoral Fellow	Australian National University, Australia	Nov. 1999	Sep. 2002
3.	Postdoctoral Fellow	VECC, Kolkata	Sep. 2002	Feb. 2004

7. **Date of joining SINP (in a permanent position): 23.02.04**

8. **Present position held: Prof. 'G'**

9. **Promotions obtained in chronological order:**

Sl. #	Designation change		Year of Promotion
	From	To	
1.	Reader 'D'	Asso. Prof. 'E'	Feb. 2007
2.	Asso. Prof. 'E'	Prof. 'F'	August 2009
3.	Prof. 'F'	Prof. 'G'	July 2014

10. **Students:**

Ph.D. Students

i) Dr. Mukesh Kumar Pradhan completed his Ph.D. degree in 2012. Thesis tile: ***"Influence of projectile breakup on fusion with ^{159}Tb target".*** Then he worked as a Research Associate with me till 2014. Presently he has a permanent position of lecturer in a college.

ii) Mrs. Piyasi Biswas has joined me this year for her Ph.D. work. She will be working on Quasielastic scattering at near barrier energies.

Project Students

i) Miss. Merin Joseph, National Institute of Technology, Karnataka, Project title: "***Detection and identification of background gamma radiation in a gamma-charged particle laboratory at SINP"***

ii) Mr. Amitava Ray, West Bengal State University, Barasat, W.B. Project title: "***Kinematics of ^{6}Li+^{89}Y nuclear reaction"***

iii) Mr. Rajarshi Mondal, West Bengal State University, Barasat, W.B. Project title: "***Relative efficiency of FALCON 5000 liquid nitrogen free gamma ray detector "***

iv) Miss Snigdhashree Mallick, Fakir Mohan University, Balasore. Project Title: "***Importance of ^{12}C+^{13}C & ^{13}C+^{13}C fusion reactions in astrophysical scenario"*** *v)* Mr. Arnab Kanti Ghosh, West Bengal State University, Barasat, W.B. Project title: "***Studying the characteristics of the digitizer DT5720"***

vi) Mr. Arindam Kr. Chatterjee, West Bengal State University, Barasat, W.B. Project title: "***Current Status of*** ^{12}***C+***^{12}***C Fusion Reaction***s

11. Teaching / Lectures delivered

a) Taught Quantum Mechanics as a part of the Basic Course to Post M.Sc. students of the year 2015

b) Presented an invited lecture at the Two-day Satellite School on Nuclear Reactions around the barrier, held at IUAC, New Delhi during Feb 21-22, 2014**.** Presented an ***invited lecture*** on the topic ***"Fusion with Loosely Bound Nuclei and Influence of Breakup Mechanism"***, at the Two-day Satellite School on Nuclear Reactions around the barrier, held at IUAC, New Delhi during Feb 21-22, 2014.

c) Taught M.Sc. students as a Guest Lecturer at the West Bengal State University, Barasat, since 2016.

12. Invited talks delivered in Conference/Workshop/schools:

i) National: **3**

ii) International: **2**

13. Essential strength of research/development output:

My current field of research interest is primarily investigation of near-barrier heavy-ion reaction mechanisms, especially with weakly bound nuclei. So far, we have been engaged in measuring the complete and incomplete fusion excitation functions and hence understanding the fusion mechanism of weakly bound systems. Proper theoretical calculations still do not exist that can predict the complete and incomplete fusion cross sections. We feel our measurements have been important contributions in this field, at least to a certain extent, and this is well evidenced by several citations by other workers and invited talks, both national and international. During the last three years we have also started to measure the quasielastic scattering excitation functions for weakly bound systems and hence extract the barrier distributions and compare them with the fusion barrier distributions. This investigation is very important in the light of the present difficulties involved in measuring precise fusion excitation functions and hence extracting meaningful barrier distributions for reactions with radioactive beams of nuclei. Our measurements are carried out using the 14 UD BARC-TIFR Pelletron accelerator at Mumbai.

Besides, I am an active member in the development of the upcoming FRENA facility at our Institute. As is well known to all of us, once the facility starts operating, it will be an unique facility in our country and will also open up a different avenue of research, especially low energy nuclear astrophysics, in India. This will be a facility strongly competing with other such facilities around the world.

14. Future research/development plan:

i) Study of breakup fragments at near-barrier energies for weakly bound systems.

ii) Fusion measurements with stable beams at deep sub-barrier energies.

iii) Fusion measurements with radioactive beams available from laboratories outside India

iv) Study of reactions of astrophysical interest, using the upcoming FRENA facility at SINP. One of the reactions that I would like to study within the first series of experiments is ^{12}C+^{12}C at energies near the Gamow peak. Special preparations for carrying out this measurement are in progress.

15. Publications:

Cumulative: Total Publications (Journal): 56, h-index:15.

During 2012-2017: Total publications (Journal): 11

17. Other professional recognition:

a) ***i) National organizing Committee Member***: International conference: ***FUSION14***, New Delhi
ii) International Advisory Committee Member: ***FUSION17***, Hobart, Australia

b) ***Acted as a referee for both International (PLB) and National (Pramana) research journals***.

c) ***Invited as subject expert in different academic selection committees outside SINP. This includes the invitation as an external expert for a faculty recruitment at Thapar University, Patiala***

16. Outreach:

Was ***invited*** to give an ***outreach lecture*** on "***Nuclear Physics: a key to explore the stellar environment***" to the students of Dum Dum Motijheel College, Kolkata on March 2, 2017

Chinmay Basu, Professor F
DOB 14.09.1967
Phone +91 2337 5345 to 49 (Extn 1206, 1606)
Email:chinmay.basu@saha.ac.in

Education B.Sc-Physics (H), University of Calutta, 1989
M.Sc (Pure Physics), University of Calcutta, 1991
P. MSc (Physics), SINP, 1992-93
NET, Qualified Joint CSIR-UGC Fellowship, Dec 1992
Ph.D (Theoretical Nuclear Physics) University of Calcutta/
Saha Institute of Nuclear Physics, 1999

Academic Profile Senior Research Fellow -I (SINP), 1.10.1992 to 30.09.1995
Senior Research Fellow-II (SINP), 1.10.1995 to 31.10.2000
Research Associate (SINP), 1.11.2001 to 11.4.2002
Associate Professor E 1.2.2006 to 31.7.2008
Professor F 1.8.2008 till date
Faculty HBNI

Essential strength of research/development output:

(a) Study of cluster structure in nuclei using resonance breakup reactions and elastic scattering The direct evidence of alpha cluster structure and cluster states can be obtained from resonance breakup reactions. Our group for the first time here attempted to study the alpha+^{14}C structure of ^{18}O using the resonance breakup technique. Experiments were carried out at the TIFR-BARC Pelletron facility. A study of cluster states of ^{212}Po was done by alpha elastic scattering on ^{208}Pb. The experiments were done at the VECC Cyclotron.

(b) Indirect methods in Nuclear Astrophysics The determination of Asymptotic Normalization Constant (ANC) helps to determine low energy capture cross-section of astrophysical reactions. These reactions are very difficult to measure directly. The indirect method experiments involve measurement of transfer angular distributions and analysis with a direct reaction model. The $^{12}C(\alpha,\gamma)$ reaction was studied through alpha transfer reactions $^{12}C(^{6/7}Li,d/t)$ and experiments were performed at IUAC, New Delhi Pelletron facility. The effect of breakup on transfer was studied for the first time in these reactions. The ANC technique is particularly useful when determined at sub-Coulomb energies.. The sub Coulomb measurements are planned in FRENA.

(c) Developmental work has also been carried out regularly on gas detectors in our laboratory.

In summary our group has developed expertise on the Indirect method studies of Astrophysical reactions. It has also extensive experience in developing various kinds of gas detectors.

Teaching Experience

Basic Course: Nuclear Physics Post M Sc 2012 (25 lectures)
MSc (Pure Physics) Special paper: Nuclear reactions and Astrophysics (Rajabazar Science College, University of Calcutta) January-March 2013 (25 Lectures)
MSc (Pure Physics) Special paper: Nuclear reactions and Astrophysics (Rajabazar Science College, University of Calcutta) January-March 2014 (25 Lectures)
MSc (Pure Physics) Special paper: Nuclear reactions and Astrophysics (Rajabazar Science College, University of Calcutta) January-March 2015 (25 Lectures)
PMSc 2015 batch (experimental stream)-Nuclear Physics-July-September -15 lectures
MSc (Advanced Course in Nuclear Reactions & Nuclear Astrophysics), Rajabazar Science College, University of Kolkata, January-March 2016 (25 Lectures)
MSc (Advanced Course in Nuclear Reactions & Nuclear Astrophysics), Rajabazar Science College, University of Kolkata, January-March 2017 (25 Lectures)

PMSc 2016-17 batch (experimental stream)-Nuclear Reactions-January to March 2017 (20 lectures)

Students Ph.D student- A. Mondal

RA & DST WOS-A- S. Adhikari (2008-2014)

Project students- A. De (2014 IITKGP), S. Chakraborty and S. Bhattacharya (2014, St Xaviers College, Kolkata), A. Chatterjee (2015 RK Mission Narendrapur), S. Jayaraman (2016, NIIT Calicut), A. Dey & S. Saha (2016-17 CU, Kolkata), I. Kanungo (2017 Central University, Haryana), A.Chatterjee (2016-17 Presidency University, Kolkata)

Future research/development plan:

My interests in near future will be oriented to nuclear astrophysics studies and related developmental research related to the FRENA facility. I have approved experimental proposals on the Trojan Horse method to study the $^{19}F(p,\alpha)$ reaction at IUAC, New Delhi. I have extensive plans to investigate the sub Coulomb transfer measurements to extract ANC of several astrophysical reactions using the FRENA facility or other low energy facilities in the country.

I am also developing a 1m scattering chamber for one of the FRENA beamline.

List of important publications:

1. Effect of Compound nuclear reaction mechanism in $^{12}C(^{6}Li,d)$ reaction at sub-Coulomb energy
Ashok Mondal, S. Adhikari, **C. Basu**
Phys. Lett. B 772 (2017) 216

2. Breakup effects on alpha transfer in $^{12}C(^{7}Li,t)16O$
S. Adhikari, **C. Basu**, P. Sugathan, A. Jhinghan, B.R. Behera, N. Saneesh, G. Kaur, M. Thakur, R. Mahajan, R. Dubey and A.K. Mitra
Journal of Physics G 44, 015102 (2016)

3. The study of $^{12}C(\alpha,\gamma)$ astrophysical reaction using $^{12}C(^{6}Li,d)$ and $^{12}C(^{7}Li,t)$ reaction at 20 MeV and in the framework of the potential model.
S. Adhikari, **C. Basu**, P. Sugathan, A. Jhinghan, B.R. Behera, N. Saneesh, G. Kaur, M. Thakur, R. Mahajan, R. Dubey and A.K. Mitra EPJ Web of Conferences, 86 , 00001 (2015)

4. Observation of breakup induced alpha transfer process for some bound states of ^{16}O populated from $^{12}C(^{6}Li,d)^{16}O^{*}$ reaction
S. Adhikari, **C. Basu**, I. J. Thompson, P. Sugathan, A. Jhinghan, K. S. Golda, A. Babu, D. Singh, S. Ray, and A. K. Mitra Physical Review C 89 (2014) 044618

5. Observation of breakup transfer process for the bound states of 16O populated from $^{12}C(^{6}Li,d)$ reaction at 20 MeV S. Adhikari, **C. Basu**, I. J. Thompson, P. Sugathan, A. Jhinghan, K. S. Golda, A. Babu, D. Singh, S. Ray, and A. K. Mitra AIP Conf. Proc. 1491, 359 (2012): doi 10.1063/1.4764276 (ISBN: 978-0-7354-1103-6)

6. Properties of alpha cluster states of ^{212}Po from elastic scattering of alpha particles from 208Pb
C. Basu, S. Adhikari, S. Bhattacharya, C. Bhattacharya, T. K. Ghosh, K. Banerjee, T.K. Rana, S. Ray, R. Pandey, G. Prajapati, A. Dey, A.K. Mitra, J.K. Meena AIP Conf. Proc. 1491, 321 (2012): doi 10.1063/1.4764267

7. The ANC of ^{16}O subthreshold states from $^{12}C(^{6}Li, d)$ reaction at energies near the barrier
Sucheta Adhikari and **Chinmay Basu** Phys.Lett. B 704, 308 (2011)

Haridas Pai, Ramanujan Fellow

DOB May 21, 1984

Phone +91 33 2337 5345-49 (Ext. 1614)

E-mail h.pai@saha.ac.in

EDUCATION M.Sc. Ph.D

ACADEMIC POSITIONS

Aug 2012- Sept 2012: APS-IUSSTF Physics Student Visitation Program, at Argonne National Laboratory, USA.

October 2012 – Dec 2012: Visiting Fellow, at IPN Orsay, France.

February 2013 – March 2016: Postdoctoral Fellow, at Technische Universität Darmstadt, Germany and also associate with GSI, Germany.

April 2016 – July 2016: Visiting scientist, at Variable Energy Cyclotron Centre, India.

September 2016 - Ramanujan Fellow, Saha Institute of Nuclear Physics, India.

TEACHING Teaching at Post M.Sc. Course, SINP, Kolkata.

AREA OF RESEARCH Experimental Low Energy Nuclear Physics

CURRENT RESEARCH ACTIVITIES

- High-spin spectroscopy data of ^{143}Sm (N = 81), populated by fusion evaporation reaction at IUAC, New Delhi, and the de-exciting gamma rays detected by the INGA array, are being analyzed. One magnetic rotational (MR) band has been observed in this nucleus. The sharp rise in the B(M1)/B(E2) rates has been observed which is rare phenomena. This is interpreted as the decreasing of the core rotation along the MR band. Manuscript under preparation.
- Beam time has been approved at IUAC, Delhi to study the structural phenomena of ^{202}***Bi*** with increasing angular momentum using the INGA. Another experimental proposal has also been approved to study the high spin structure of ^{142}**Tb** at TIFR. Preparation of experiment is in progress.
- Simulation work started to develop the Recoil Filter Detector (RFD). This will be used to study the nuclear structure phenomenon of heavy and light nuclei produced in fusion-evaporation reactions using INGA array.
- In the first phase of the project a low energy high current accelerator is going to be installed, the infrastructure of which is under development at present in our campus. Periodic supervision of the progress of work along with the commissioning of various service facilities required for running of the machine has been looked after by FRENA Working Group (FWG). Being a member of FWG, I am involved in fabrication and installation of some of the items which are necessary for the machine installation.
- I have participated experiments at TIFR, Mumbai to study the high-spin states in ^{110}Ag. I have also participated in an experiment at IUAC, Delhi to measure the evaporation residue for the system of ^{6,7}Li + ^{64}Ni above the barrier energy.
- Letter of intent and experimental proposal has been submitted to GSI to study the Pygmy Dipole Resonance (PDR) in heavy nuclei through β decay using the DESPEC SETUP@ FAIR.

FUTURE RESEARCH/DEVELOPMENT PLAN

- **Preparation of setup to study of P-nuclei through angular distribution method with FRENA:** *P nuclei* refer to 32 stable neutron-deficient nuclei that, in contrast to all the other nuclei that are heavier iron, cannot be synthesized by the *s* and *r* processes. *P* nuclei lie on the proton-rich side of the stability valley between ^{74}Se and ^{196}Hg. Hence, they cannot be produced by neutron capture. They are assumed to originate from the burning of pre-existing more neutron-rich nuclei at stellar environments of high enough temperature ($T \geq 2\times10^9$), where photo-disintegrations of such nuclei can occur. My aim is to prepare a setup for study these *P* nuclei through the angular distribution method.

- **Development of Recoil Filter detector (RFD)**: Development of RFD is very essential for positive identification and selection of the γ-rays from the rare wanted fusion–evaporation events. This is a useful tool to study nuclear structure of heavy and light nuclei produced in fusion evaporation reaction. RFD can be coupled to INGA facility or to FRENA to select rare events for studying exotic phenomena in Nuclear Structure and Nuclear Astrophysics.

- Investigation of Pygmy Dipole resonance state employing the β decay technique using the DESPEC SETUP@ FAIR.

NO. OF PUBLICATIONS (2012-2017) **Referred Journal : 36 Conference Proceedings: 40**

SOME SELECTED PUBLICATIONS (during 2012-2017)

1) **H. Pai**, G. Mukherjee, S. Bhattacharyya, M.R. Gohil, T. Bhattacharjee, C. Bhattacharya, R. Palit, S. Saha, J. Sethi, T. Trivedi, Shital Thakur, B.S. Naidu, S.K. Jadav, R. Donthi, A. Goswami and S. Chanda**:** "**High spin band structures in doubly-odd ^{194}Tl**", **Phys. Rev. C 85, 064313 (2012).**

2) **H. Pai**, G. Mukherjee, R. Raut, S.K. Basu, A. Goswami, S. Chanda, T. Bhattacharjee, S. Bhattacharyya, C. Bhattacharya, S. Bhattacharya, S.R. Banerjee, S. Kundu, K. Banerjee, A. Dey, T.K. Rana, J.K. Meena, D. Gupta, S. Mukhopadhyay, Srijit Bhattacharya, Sudeb Bhattacharya, S. Ganguly, R. Kshetri, and M.K. Pradhan: "**Onset of deformation at N = 112 in Bi nuclei", Phys. Rev. C 85, 064317 (2012).**

3) **H. Pai**, J. Beller, N. Benouaret, J. Enders, T. Hartmann, O. Karg, P. von Neumann-Cosel, N. Pietralla, V. Yu. Ponomarev, C. Romig, M. Scheck, L. Schnorrenberger, S. Volz, and M. Zweidinger: " **Low-lying dipole strength in the *N*=28 shell-closure nucleus ^{52}Cr**", **Phys. Rev. C 88, 054316 (2013).**

4) **H. Pai**, G. Mukherjee, S. Bhattacharyya, C. Bhattacharya, S. Bhattacharya, T. Bhattacharjee, S. K. Basu, S. Kundu, T. K. Ghosh, K. Banerjee, T. K. Rana, J. K. Meena, R. K. Bhowmik, R.P. Singh, S. Muralithar, S. Chanda, R. Garg, B. Maheshwari, D. Choudhury and A. K. Jain: **"Crossing of large multiquasiparticle magnetic-rotation bands in ^{198}Bi", Phys. Rev. C 90, 064314 (2014).**

5) **H. Pai**, T. Beck, J. Beller, R. Beyer, M. Bhike, V. Derya, U. Gayer, J. Isaak, Krishichayan, J. Kvasil, B. L¨oher, V. O. Nesterenko, N. Pietralla, G. Mart´ınez-Pinedo, L. Mertes, V. Yu. Ponomarev, P.-G. Reinhard, A. Repko, P. C. Ries, C. Romig, D. Savran, R. Schwengner, W. Tornow, V. Werner, J. Wilhelmy, A. Zilges, and M. Zweidinger: **"Magnetic dipole excitations of ^{50}Cr"**, **Phys. Rev. C 93, 014318 (2016).**

6) **H. Pai** in Zs. Podolyák *et al.,:* **"Role of the Δ Resonance in the Population of a Four-Nucleon State in the ^{56}Fe → ^{54}Fe Reaction at Relativistic Energies", PRL 117, 222302 (2016).**

National Level Academic Review

Plasma Physics Division (PPD)

A Report for the period 2012-2017

Present Staff

Scientific(faculties) (2)	Technical/Sc. Officers/Assistants (4)
M.S. Janaki, Prof. H	Shantanu Chowdhury, Eng. G
Nikhil Chakrabarti, Prof. G	Subhasis Basu, SO(D)
	Monobir Chattopadhyay, SO (D)
	Dipankar Das
	Administrative/Auxiliary (1)
	Asok Ram
Faculties superannuated (5)	**Technical/Adminsitrative superannuated**
Nihar Ranjan Ray (2012)	Shib Sankar Sil (Tech D)2014
Rabindranath Pal (2012)	Partha S. Bhattacharyya (SOD) 2015
Sujit K. Saha (2012)	Amalendu Bal (SA F) 2016
Santwana Raychaudhuri (2012)	Dulal Chatterjee(Adm) 2016
A.N. Sekar Iyengar (2015)	

Present Postdoctoral Fellows (PDFs)

	Name of pdf	Year of joining
1.	Sourav Pramanik	2016

Present Research Fellows (RFs)

	Name of RFs	Year of joining	Supervisor	Present status
1.	Abhijit Ghosh	2011	M.S. Janaki	
2.	Satyajit Chowdhury	2012	Nikhil Chakrabarti, R.Pal	
3.	Sayanee Jana	2012	Nikhil Chakrabarti	
4.	Pankaj Kumar Shaw	2012	M.S. Janaki, A.N.S. Iyengar	Thesis submitted
5.	Sabuj Ghosh	2012	M.S. Janaki A.N.S. Iyengar	Joined Adamas Univ./to submit in Aug 2017
6.	Debajyoti Saha	2012	M.S. Janaki A.N.S. Iyengar	Joined GSI/to submit in sep 2017
7.	Mithun Karmakar	2013	Nikhil Chakrabarti	
8.	Subha Samanta	2014	M.S. Janaki	

Ph.D. Degree Awarded (2012-todate)

	Name of RFs	**Award**	**Ph.D. supervisor**	**Present occupation**
1	Subir Biswas	2014	Rabindranath Pal	Weizmann Institute, Israel
2	Debabrata Banerjee	2014	M.S. Janaki &N.Chakravarti	Postdoc at univ. Hefei,china
3.	Chandan Maity	2014	Nikhil. Chakrabarti	Faculty at singur govt college
4.	Manjishta Dutta	2014	Nikhil Chakrabarti & M. Khan (JU)	Faculty at JIS Univ
5.	Anwesa Sarkar	2016	Nikhil Chakrabarti	Faculty at AdamasUniv
6.	Abhik Mukherjee	2016	M.S.Janaki & Anjan Kundu	Postdoc at Univ Capetown
7.	Sudip Garai	2016	M.S. Janaki & N. Chakrabarti	Faculty at WB Women's Univ
8.	Sourav Pramanik	2016	N. Chakrabarti	Postdoc at SINP

Important Equipment & facility

1. Magnetized Plasma Linear Experimental Device (MaPLE)
2. Double Layer Experiment (DLX)
3. Glow Discharge Plasma Experiment
4. Tokamak

Research Highlights (last 5 years)

Research activities in the plasma physics division encompass a variety of theoretical and experimental topics in the field of linear and nonlinear wave propagation and instabilities. Theoretical studies using nonlinear analysis in Lagrange variables for various types of electrostatic modes in unmagnetized and magnetized plasmas have been carried out to demonstrate wave breaking phenomena due to phase-mixing processes. Such studies have relevance to electron energization and plasma particle heating in astrophysical environment and laboratory experiments. Using Lagrange fluid approach, collapse type processes Using Lagrange fluid approach, collapse type processes associated with nonlinear transient structures have been identified to be a possible mechanism for generation of strongly localized magnetic fields that are important in the astrophysical context of magnetic star formation. Studies are also being pursued to understand the formation of different types of nonlinear structures in classical as well as quantum plasmas. Investigations on Bursian and Pierce diodes in presence of transverse magnetic fields reveal interesting results that can help in the design of fast electron switches with current interruption.

In the field of strongly coupled dusty plasmas, propagation characteristics and instabilities associated with longitudinal acoustic modes, transverse shear modes, modification of the growth rates of Kelvin-Helmholtz as well as Rayleigh-Taylor instabilities in presence of non-Newtonian characteristics with shear flow-rate dependent viscosity in the shear thickening and thinning regimes are being studied. . It is shown that the free energy related to the velocity shear of the elliptical vortex flow can drive secondary instabilities of transverse shear wave when the resonance condition between vortex rotation frequency and secondary wave frequency are met. Numerical simulations have been carried out to study formation, evolution and interaction of vortices in a collisional strongly coupled dusty plasma in the framework of generalized hydrodynamic model.

Experimental activities are being carried out in the MaPLE (Magnetized Plasma Linear Experiment), Double Layer Experiment (DLX), glow discharge plasma devices. In MAPLE nitrogen plasma produced by ECR discharge is used to study various types of wave phenomena such as the parametric excitation of a high frequency drift mode, selective excitation of drift modes due to temporal modulation of density at resonant frequencies as well as excitation of electron acoustic waves. A new filament source has been designed and put into operational condition with the existing ECR plasma source to get high-density plasma by electron impact ionization.

In DLX, 2D measurements in a plasma diffusing in a diverging magnetic field have been carried out showing double-layers, U-shaped potential contours and hollow conical density structures defined by the maximum diverging magnetic field lines passing through the radial edge of the exit aperture of the source. We observe a slow increase of the peak density along a hollow conical surface under various conditions indicating that the phenomenon is generic in nature. Observations on self-excited wave phenomena reveal that these are of drift-wave type, but of higher frequency compared to the conventional drift modes in view of the low magnetic fields used in the device.

Nonlinear dynamic experiments are being carried out in the DC glow discharge plasma device to study homoclinic and inverse homoclinic bifurcation and intermittent chaos. Different statistical and spectral methods have been used to explore the complex dynamics of the system. Theoretical and numerical modeling based on plasma fluid models leading to third order autonomous differential equation known as jerk equation explain a number of interesting chaotic phenomena based on bifurcation diagrams.

Important Results

1. Experiments in Magnetized Linear Experimental Device (MaPLE): Measurement of Plasma parameters and Wave excitation

(a) Wave Excitation studies in MaPLE device:

Selective mode excitation of a low-frequency drift wave was done in the weak density gradient region by strong temporal modulation of the plasma density at a frequency resonant with the mode in this region. The parallel velocity induced due to the excited mode couples with the imposed density modulation to produce the spatiotemporal current modulation at the second harmonic frequency that also causes mode-selective excitation of drift mode in the nearby region. Under the condition of a sufficient growth rate for the lower frequency mode, the two modes cause parametric excitation of a higher frequency drift mode that is otherwise stable in the plasma. [PRL 111, 115004 (2013)]

Propagation of the electron-acoustic wave is observed directly in the very low wavenumber regime in a laboratory device having two electron species. For moderate temperature ratio of the species, the Landau damping should dominate. However, the new theoretical analysis shows if the cold component drifts above a critical velocity, the wave can be destabilized. The drift velocity has an upper limit above which the wave does not exist. The observed experimental results including the phase velocity agree very well with the analysis.

(b) Effect of fast drifting electrons on electron temperature measurement with a triple Langmuir probe:

Triple Langmuir probe provides an instantaneous measurement diagnostic of plasma parameters, especially the electron temperature. Effect of a fractional fast flowing electron component, influences the temperature measurement. So care must be taken to acquire knowledge about any flowing electron component in a plasma before interpreting the triple probe data for electron temperature. This knowledge about the fast component is experimentally determined independently and the corrected temperature agrees well with the temperature measured directly from the electron velocity distribution function.

(c) Developmental works in MaPLE device: machine’s upgradation

After successful operation for six years, some components in the machine are upgraded to improve the plasma production to get useful plasma parameters for the present wave experiment. A new filament source is designed and put into operational condition with the existing ECR plasma source to get high-density plasma by electron impact ionization. This high-temperature filament is also capable of producing a high energy electron component, which can be a source of free energy to destabilize different plasma modes.

A safety system has been designed and fabricated for overheating automatic protection of a large number of electromagnet coils in the MaPLE device. Tiny temperature sensing IC chips have been used to monitor coil temperatures and a small circuit board was fabricated and installed in the magnet power supply to take care of thermometer addressing and protective measures.

2. Double Layer Experimental Device (DLX): Studies on equilibrium characteristics and wave phenomena.

Two-dimensional density and potential measurements have been carried out for plasma diffusing through an aperture in a diverging magnetic field showing double layers near the throat of the expansion chamber and existence of secondary lobes in plasma potential. An accelerated ion beam has been detected in the downstream region, confirming the presence of the double layer. The radial density profile near the source is peaked on the axis but gradually evolves into a hollow profile away from the source. We observe a slow increase of the peak density along a hollow conical surface under various conditions indicating that the phenomenon is generic in nature.

Electrostatic modes propagating azimuthally in the direction of the electron diamagnetic drift and frequency greater than the ion cyclotron frequency are observed. In the radial direction, the mode amplitude peaks at a location where the radial density gradient is maximum. Theoretical modeling using a local dispersion relation based on the fluid equations predicts destabilization of modes exhibiting drift wave characteristics with frequency greater than the ion cyclotron frequency consistent with the present observations. To make a clear distinction with conventional low frequency drift modes, these modes were termed upper drift modes.

The previous results in argon plasma warrant a further investigation of the characteristics of such modes when the ion Larmor radius is further reduced. The present experiments have therefore been conducted in helium plasma for which the ion Larmor radius is smaller than that of argon. Self-excited two drift modes coexisting over a wide range of axial and radial locations with different mode numbers and frequencies were observed. Such excitation of two simultaneous modes is not possible in argon plasma that has a larger ion Larmor radius within the existing parameter range.

3. Investigation of nonlinear dynamic behaviour of glow discharge plasmas

Glow discharge plasmas exhibit various types of self-excited oscillations for different initial conditions like discharge voltages and filling pressures. Order-chaos-order has been observed in the relaxation oscillations of a glow discharge plasma with variation in the discharge voltage at a constant pressure. The first transition exhibits an inverse homoclinic bifurcation followed by a homoclinic bifurcation in the second transition. At another pressure value, intermittent chaos has been observed in a glow discharge plasma as the system evolved from regular type of relaxation oscillations (of larger amplitude) to an irregular type of oscillations (of smaller amplitude) as the discharge voltage was increased. All the above observation are made in the case of normal oscillatory state (to start with). However, with the change in the initial dynamical state of system from normal oscillatory to excitable case, intrinsic noise induced coherence resonance phenomena has been observed for the first time in a plasma device.

Investigations on effect of dipolar magnetic field on fluctuations dynamics in a glow discharge plasma have been carried out. Effect of dipolar magnetic field are noted under two different scenario to start with: 1) system had excitable dynamics, 2) system had normal oscillatory dynamics. Application of dipolar field using bar magnet near cathode surface leads to internal noise and also enhances the localized ionization near cathode surface. In the excitable state condition, internal noise leads to the observation of canard orbit and mixed mode oscillations (MMOs) whereas enhancement in the ionization in localized region leads to period doubling bifurcation in the case of normal oscillatory state. The experimental results of MMO and canard have also been corroborated by a numerical simulation using a FitzHugh-Nagumo like macroscopic model derived from the basic plasma equations and phenomenology. To understand the dynamical origin of period doubling bifurcation, we have carried out a numerical modelling for ion dynamics by considering trapping of ions inside the most likely potential structure formed near cathode surface in the presence of dipole field.

Nonlinear dynamics associated with anode fireball has been investigated in a magnetized glow discharge plasma in a currentless toroidal assembly. Floating potential fluctuations associated with an anode fireball are found to exhibit different kinds of oscillations like chaotic, periodic, intermittent, etc. under the action of vertical magnetic field of different strengths. Fireball dynamics is found to be closely related to the magnetic field applied. Hysteresis in the fluctuation behaviour is also observed.

4. Analytical modelling of different types of nonlinear plasma structures

Various types of coherent nonlinear structures are observed in space and laboratory plasmas.The existence and characteristics of nonlinear localized solutions such as solitons, shocks, double layers, current sheets, vortices have been investigated in different types of plasma models such as magnetohydrodynamic, electron-magnetohydrodynamic, pair-ion, quantum and kinetic plasmas.

5. Numerical simulation studies on vortex dynamics in a collisional strongly coupled dusty plasma

In a strongly coupled dusty plasma, numerical simulations have been carried out to study vortex formation, its evolution and interaction for different initial structures having Gaussian profile in the framework of the generalized hydrodynamic (GH) model modified by dust-neutral collisional drag. All the studies have been done by numerically integrating GH model after transforming into Fourier space using doubly periodic pseudo-spectral simulation code with Runge-Kutta-Gill time integrator. It is shown that the interplay between the nonlinear elastic stress and the dust-neutral collisional drag results in the generation of non-propagating monopole vortex before it starts to propagate like transverse shear wave. It is also found that the interaction between two unshielded monopole Gaussian vortices having both same rotation (co-rotating) and opposite rotation (counter rotating) produce two propagating dipole vortices of equal and unequal strength respectively when there is a sensitive balance between the nonlinear elastic stress and the dust-neutral collisional drag.

We have also carried out a stability analysis of a long scale two dimensional equilibrium vortex (with finite ellipticity at the core) to short scale perturbation in presence of dust-neutral collisional drag in strongly coupled dusty plasma. For vortices with finite ellipticity, it is seen that the free energy associated with the velocity shear of the vortex can drive secondary instabilities consisting of transverse shear waves when the collision modified secondary wave frequency matches with the mean rotation frequency of the vortex or one of its multiples.

Parametric studies have been carried out in strongly coupled dusty plasmas in Newtonian and non-Newtonian regimes in the context of Rayleigh-Taylor, Kelvin-Helmholtz and shear flow instabilities as well as shear-flow coupled acoustic and shear modes.

6. Studies on wave breaking of electrostatic plasma wave and its relevance to plasma wake field accelerator

In plasma accelerators creation of the largest possible coherent electric field is a big challenge. So studies of wave breaking phenomena have much importance in this regard. Studies on wave breaking via phase mixing process due to inhomogeneity in equilibrium plasma density or in the external magnetic field, relativistic effects have been done using Lagrange formalism for cold, warm magnetized and unmagnetized plasma systems. For relativistic upper-hybrid oscillations (UHO), exact nonstationary solutions reveal bursts in electron density in finite time as a result of relativistic mass variation (Phys. Rev. Lett. 110,215002(2013)). The wave breaking amplitude of relativistic UHO is calculated. An important finding is that with increasing strength of the magnetic field the breaking amplitude decreases for the magnetized plasma system. Moreover, constructing travelling wave solution for UHO from the exact space time dependent solution, it has been found that only with a particular choice of initial conditions such stationary wave can be excited in the plasma. Such stationary waves are shown to have much higher wave breaking limits compared to exact space time dependent solutions with different initial conditions. It is established that the wave breaking amplitude for mass-symmetric electron-positron plasma is higher than that of the electron-ion plasma and the breaking amplitude for the electron-positron-ion plasma lies in the intermediate regime.

We have also studied the effect of magnetic field on the electron beam driven plasma wake field acceleration (PWFA). Application of an external magnetic field plays a crucial role in controlling the de-phasing of the accelerated electron beam.

7. Studying Impact of magnetic fields on plasma diodes

Our effort was to carry out theoretical investigations on the impact of the transverse magnetic field on the space charge limited flow, the maximum allowable current at steady state as well as on the aperiodic instabilities found in plasma diodes. The analysis is presented with the help of both Eulerian and Lagrangian descriptions. It is observed that the value of the maximum steady state current (space charge limited current) decreases when the magnitude of the external magnetic field is increased. All the stationary states are visualized through the “emitter electric field vs diode gap” parametric diagram. The steady state solutions can be distinguished into three categories which are represented by three distinct branches of the “emitter electric field vs diode gap”-curves. These branches are named as, Normal C branch, C-overlap branch and B-branch (or virtual cathode branch). The width of the C-overlap branch decreases with the magnetic field and at a particular strength of the applied magnetic field, C-overlap branch disappears. With the increasing strength of the external magnetic field, “emitter electric field vs diode gap”-curve gets displaced. As a result, a diode which was initially at a state with high current density (corresponding to Normal C branch) in absence of magnetic field, now shifts to another state with negligible current (which belongs to B-branch) as soon as a magnetic field of finite strength is applied along the transverse direction. A stability analysis based on a perturbative approach shows that the Normal C branch and virtual cathode branch are always stable with respect to aperiodic perturbations, whereas C-overlap branch is unstable. As an important application of our results, an idea to develop a fast electronic switch is suggested, based on the state-transition phenomena observed in plasma diodes. For generalized Pierce diodes, a new family of solutions is observed and it is found to be very sensitive to the magnetic field. The results of our works are believed to be applicable to the systems like thermionic energy converters, microwave emitters, low pressure discharge and processing devices, xerographic technologies, Q-machines etc where space charge limited current flow plays a major role.

8. Nonlinear dynamics of regular and chaotic magnetic fields

The dynamics of charged particles has been studied in stationary regular and chaotic magnetic fields that are obtained as solutions of nonlinear coupled equations varying in one dimension. Energy gain of an ensemble of particles is studied in both cases in the presence of a uniform electric field. Ensemble averaged energy gain is shown to decrease with the increase in rms values of fluctuation in the chaotic case and increase with the increase in rms values of fluctuation in the case of regular field. Investigation of the transport properties of chaotic magnetic field lines perpendicular to a mean field is studied numerically. With increase in fluctuation level, more number of field lines become chaotic and when fluctuation is of the order of mean field, a regime of global stochasticity is reached with normal or Gaussian diffusion of field lines perpendicular to the mean field.

List of Publication (2012-2017)
(Total No. = 96)

2017

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2. Plasma wakefield excitation in a cold magnetized plasma for particle acceleration, M Karmakar, N Chakrabarti, S Sengupta, Physics of Plasmas, **24**, 052111 (2017).

3. Experimental observation of electron-acoustic wave propagation in laboratory plasma, S Chowdhury, S Biswas, N Chakrabarti, R Pal, Physics of Plasmas, **24**, 062111 (2017).

4. Possible management of near shore nonlinear surging waves through bottom boundary conditions, Abhik Mukherjee, M S Janaki and Anjan Kundu Phys. Scr., **92,** 035201 (2017) .

5. Investigation of multifractal nature of floating potential fluctuations obtained from a dc glow discharge magnetized plasma, PK Shaw, D Saha, S Ghosh, MS Janaki, ANS Iyengar, Physica A, **469**, 363 (2017).

6. Energization of charged particles in regular and chaotic magnetic fields, S Samanta, P Kumar Shaw, MS Janaki, B Dasgupta, Physics of Plasmas **24**, 054506 (2017).

7. Evidence of nonlinearity in presence of external forcing and magnetic field in a glow discharge plasma, D Saha, PK Shaw, S Ghosh, MS Janaki, ANS Iyengar Chaos, Solitons & Fractals, **98**, 46 (2017).

8. A localized cathode glow in the presence of a bar magnet and its associated nonlinear dynamics, Pankaj Kumar Shaw, Subha Samanta, Debajyoti Saha,

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14. Formation and evolution of vortices in a collisional strongly coupled dusty plasma, S Jana, D Banerjee, N Chakrabarti, Physics Letters A, **380**, 2531 (2016).

15. Stability characteristics of a non-Newtonian strongly coupled dusty plasma in the presence of shear flow, S Garai, S Jana, MS Janaki, N Chakrabarti, EPL (Europhysics Letters), **114**, 65003 (2016).

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M.S. Janaki, Sr. Professor H

DoB 1 June, 1962
Phone +91 33 2337 5345-49 (Ext. 1201)
E-mail ms.janaki@saha.ac.in

EDUCATION

1994: Ph.D. in Physics, University of Calcutta
1985: M.Sc. in Physics, University of Calcutta
1980: B.Sc. Physics Hons, University of Calcutta

ACADEMIC POSITIONS

2016- ...... : Senior Professor H, Saha Institute of Nuclear Physics
2009-2016: Professor G, Saha Institute of Nuclear Physics
2006-2009: Professor F, Saha Institute of Nuclear Physics
2002-2006: Associate Professor E, Saha Institute of Nuclear Physics
1998-2002: Reader D, Saha Institute of Nuclear Physics
1996-1998: Lecturer C, Saha Institute of Nuclear Physics
1994-1996: Post Doctoral Research Associate, Saha Institute of Nuclear Physics

PUBLICATION STATISTICS

Journal: 97 (for 2012-17: 42)

SELECTED PUBLICATIONS (2012-2016)

Energization of charged particles in regular and chaotic magnetic fields, S Samanta, P Kumar Shaw, MS Janaki, B Dasgupta, Physics of Plasmas **24**, 054506 (2017).

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TEACHING/ GUIDANCE Ph.D. awarded: 3 [in the period 2012-2016: 2]; Thesis to be submitted: 4
Current PhD students: 1

AREA(S) OF RESEARCH:

- Waves and instabilities in plasma
- nonlinear phenomena
- charged particle dynamics in chaotic magnetic fields

RESEARCH & DEVELOPMENT HIGHLIGHTS:

During the period 2012-16, the focus of my research has been in the following major areas (1) study of nonlinear structures in the framework of equilibrium kinetic models (2) waves and instabilities in plasmas (3) modelling of nonlinear phenomena observed in glow discharge plasmas, water waves (4) charged particle dynamics in regular and chaotic magnetic fields.

Our work on bifurcated current sheets(BCS) based on kinetic model gives insight into the nature of plasma distribution that gives rise to BCS. Also, our model gives a simple expression for BCS that comes handy for various types of analytical work.

The study of nonlinear shear waves due to non-Newtonian effects has led us to connect to the famous FPU problem of recurrence to show that an initial periodic solution recurs after passing through several patterns of periodic waves.

In a weakly inhomogeneous plasma, deriving and solving the Kadomtsev-Petviashvili equation, bending of solitary waves in a two dimensional plane has been shown to be a realizable phenomena. Near shore surging waves like tsunami, bore waves etc have hazardous nature when they propagate towards the shore. A leakage based method is proposed, which would suck water at the bottom causing the phase and amplitude of the solitary waves to change leading to decay of wave amplitude.

Experimental observations on self excited drift waves propagating azimuthally observed in DLX device have frequencies much higher than ion cyclotron frequency. I have carried out analytical calculations based on fluid models to show destabilization of such modes due to electron-ion collisions predicting high frequency drift modes contrary to conventional drift modes. The model is being extended to study nonlinear drift waves.

Recently, numerical studies on charged particle dynamics in Beltrami and other types of chaotic magnetic fields have been initiated to study energization and diffusion problems.

BIO-DATA

Personal data :

Name	:	Nikhil **CHAKRABARTI**.
Present position	:	Professor-G.
Postal address	:	Saha Institute of Nuclear Physics, Plasma Physics Division , 1/AF, Bidhannagar, Sector I, Calcutta - 700 064
E-mail	:	nikhil.chakrabarti@saha.ac.in nikhil.chakrabarti@gmail.com
Telephone No.	:	(+91) 33 23375345
Fax	:	(+91) 33 23374637
Parmanent address	:	16, Ballygunge Terrace Ground floor, Kolkata Pin-code 700 029, (W.B.), India.
Nationality	:	Indian.
Date and place of birth	:	January 02, 1963, and Kamarpukur, Hooghly (W.B.), India.

Postdoc/Visiting positions :

Position	Period	Institution
Jr. Research Fellow	August, 1990 - July, 1992.	Institute for Plasma Research, Gandhinagar.
Sr. Research Fellow	August, 1992 - July, 1995.	Institute for Plasma Research, Gandhinagar.
Postdoctoral Fellow	August, 1995 - July 1996	Institute for Plasma Research, Gandhinagar.
Visiting Scientist	August, 1996 - October 1996	Riso National Laboratory, Roskilde, Denmark.
Postdoctoral Fellow	November, 1996 - January, 1998	Institute for Theroretische Physik-I, Univ. Dusseldorf, Germany
Postdoctoral Fellow	March, 1998 - May, 1999	Weizmann Institute of science, Rehovot, Israel
JSPS Fellow	November, 2002 - December, 2003	National Institute for fusion Science, Toki, Japan
Visiting Scientist	October, 2007 - December 2007	Riso National Laboratory, Roskilde, Denmark.
Visiting Scientist	August, 2008 - October 2008	Riso National Laboratory, Roskilde, Denmark.
Visiting Scientist	November, 2009 - December 2009	Riso National Laboratory, Roskilde, Denmark.

Faculty positions :

Position	Period	Institution
Fellow (lecturer)	June, 1999 - April, 2000	Indian Institute of Geomagnetism, Mumbai, India
Reader	May, 2000 - July 2004	Saha Institute of Nuclear Physics, Kolkata, India
Associate Professor	August, 2004 -July 2007	Saha Institute of Nuclear Physics, Kolkata, India
Professor F	August, 2007 - June 2012	Saha Institute of Nuclear Physics, Kolkata, India
Professor G	Since July 2012	Saha Institute of Nuclear Physics, Kolkata, India

Academic qualifications :

Degree	Year	Class	Marks(%)	Subjects	University or Institution
M.Sc. (Phys.)	1987	I	67.3%	Physics	University of Calcutta
Ph.D. (Phys.)†	1996	-	-	Physics	Devi Ahilya Viswavidyalaya. (Worked at Institute for Plasma Research, Gandhinagar.)

†Title of Ph. D. Thesis : *Coherent Structures and their Stability in inhomogeneous magnetized plasmas.*
Thesis Supervisor : Professor Predhiman Kaw.

Special Remarks :

- I am selected in the Joint test for the research fellowship-lecturership examination conducted by UGC- CSIR.
- I have taught in a central schlool (+2) level about one and half years in IIMC Joka, Calcutta.
- I have receives JSPS postdoctoral fellowship for two years (2002-2004). Worked at National Institute for Fusion Science, Japan, for 13 months.

Publications

I. Research Papers in Journals :

1. Satyajit Chowdhury, Subir Biswas, **Nikhil Chakrabarti** and Rabindranath pal *"Experimental Observation of Electron-Acoustic Wave Propagation in Laboratory Plasma"* Physics of Plasmas **24** 062111 (2017).
2. Mithun Karmakar, **Nikhil Chakrabarti** and Sudip Sengupta *"Plasma Wakefield Excitation in a Cold Magnetized Plasma for Particle Acceleration"* Physics of Plasmas **24** 052111 (2017).
3. Victor Kuznetsov, Sourav Pramanik, Alexander Gerasimenko and **Nikhil Chakrabarti** *"Stability properties of the steady state solutions of a non-neutral plasma diode when there is a uniform magnetic field along transverse direction"* Physics of Plasmas **24** 023107 (2017).
4. Sourav Pramanik, V. I. Kuznetsov, A. B. Grasimenko and **Nikhil Chakrabarti** *"Time-independent states of a non-neutral plasma diode when emitted electrons are partially turned around by a transverse magnetic field"* Physics of Plasmas **23** 103105 (2016).
5. Sudip Garai, M. S. Janaki and **Nikhil Chakrabarti** *"Nonlinear coupling of acoustic and shear mode in a strongly coupled dusty plasma with a density dependent viscosity"* Astrophysics and Space science. **361**, 294 (2016).
6. Sourav Pramanik, V. I. Kuznetsov, L. A. Bakaleinikov and **Nikhil Chakrabarti** *"A study on the steady-state solutions of a relativistic Bursian diode in the presence of a transverse magnetic field"* Physics of Plasmas **23** 082110 (2016).
7. Sayanee Jana, Samiran Ghosh and **Nikhil Chakrabarti** *"Nonlinear Coherent structures of Alfvén wave in a Collisional Plasma"* Physics of Plasmas **23** 072304 (2016).
8. S. Garai, S. Jana, M. S. Janaki and **N. Chakrabarti** *"Stability characteristics of a non-Newtonian Strongly coupled Dusty Plasma in presence of Shear flow"* Euro Physics Letter **114** 65003 (2016).
9. Sourav Pramanik, V. I. Kuznetsov, A. B. Grasimenko and **Nikhil Chakrabarti** *"Non-neutral plasma diode in the presence of a transverse magnetic field"* Physics of Plasmas **23** 062118 (2016).

10. Mithun Karmakar, Chandan Maity and **Nikhil Chakrabarti** *"Wave-breaking amplitudes of relativistic upper-hybrid oscillations in a cold magnetized plasma"* Physics of Plasmas **23** 064503 (2016).

11. Sayanee Jana, Debabrata Banerjee and **Nikhil Chakrabarti** *"Formation and evolution of vortices in a collisonal strongly coupled dusty plasma"* Physics Lett.**A 380** 2531 (2016).

12. Mithun Karmakar, Chandan Maity and **Nikhil Chakrabarti** *"Relativistic wave-breaking limit of electrostatic waves in cold electron-positron-ion plasmas"* The European Physical J. D **70:** 144 (2016).

13. Sourav Pramanik, Chandan Maity and **Nikhil Chakrabarti** *"Phase mixing of upper hybrid wave in a magnetized pair ion plasma"* Physica Scripta **91** 065602 (2016)

14. Samiran Ghosh and **Nikhil Chakrabarti** *"Nonlinear Low-frequency Electrostatic Wave Dynamics in a Two-Dimensional Quantum Plasma"* Annals of Physics **371** 67 (2016).

15. S. Garai, D. Banerjee, M. S. Janaki and **N. Chakrabarti** *"Shear flow driven instability in an incompressible dusty plasma with a density dependent viscosity"* Indian J. Physics **90(6)** 717 (2016).

16. Sourav Pramanik, V. I. Kuznetsov and **Nikhil Chakrabarti** *"A study on the steady-state solutions of a Bursian diode in presence of transverse magnetic field, when the electrons of the injected beam are turned back partially or totally"* Physics of Plasmas **22** 0112108 (2015)

17. Ashish Adak, Samiran Ghosh and **Nikhil Chakrabarti** *"Ion acoustic shock wave in collisional equal mass plasma"* Physics of Plasmas **22** 102307 (2015).

18. Sayanee Jana, Debabrata Banerjee and **Nikhil Chakrabarti** *"Stability of an elliptical vortex in a strongly coupled dusty plasma"* Physics of Plasmas **22** 083704 (2015)

19. S. Pramanik, V. I. Kuznetsov and **N. Chakrabarti** *"Stability analysis of steady state solutions of Bursian Diode in presence of transverse magnetic field"* Physics of Plasmas **22** 082103 (2015)

20. Anwesa Sarkar, **Nikhil Chakrabarti** and Hans Schamel *"Nonlinear Alfven Wave Dynamics in Plasmas"* Physics of Plasmas **22**, 072307 (2015).

21. S. Garai, M. S. Janaki and **N. Chakrabarti** *"Coupling of dust acoustic and shear mode through velocity shear in a strongly coupled dusty plasma"* Physics of Plasmas **22** 073706 (2015)

22. S. Pramanik, C. Maity and **N. Chakrabarti** *"Phase-mixing of ion plasma modes in pair-ion plasmas "* Physics of Plasmas **22** 052303(2015)

23. S. Pramanik, A. Ya. Ender, V. I. Kuznetsov and **N. Chakrabarti** *"The transverse magnetic field effect on steady-state solutions of the Bursian diode "* Physics of Plasmas **22** 042110(2015)

24. S. Garai, D. Banerjee, M. S. Janaki and **N. Chakrabarti** *"Stabilization of Rayleigh-Taylor Instability in a non-Newtonian Incompressible Complex Plasma"* Physics of Plasmas **22** 033701 (2015)

25. **Nikhil Chakrabarti** and Samiran Ghosh *"Longitudinal dust acoustic solitary waves in a strongly coupled complex (dusty) plasma"* J. Plasma Phys.**81** 905810310 (2015).

26. Samiran Ghosh and **Nikhil Chakrabarti** *"Nonlinear wave collapse, shock and breather formation in an electron magnetohydrodynamic plasma"* Phys. Rev. E **90** 063111 (2014).

27. Subir Biswas, Satyajit Chowdhury, Abhik M. Pal, Shashwat Bhattacharya, Subhasis Basu, Monobir Chattopadhyay, **Nikhil Chakrabarti** and Rabindranath Pal *"The MaPLE device: A linear machine for laboratory studies of the magnetized plasma physics phenomena"* J. Plasma Phys. **81** 345810205 (2015).

28. Ashish Adak, Samiran Ghosh and **Nikhil Chakrabarti** *"Rayleigh-Taylor instability in an equal mass plasma"* Physics of Plasmas **21** 092120 (2014).

29. Manjistha Dutta, Manoranjan Khan and **Nikhil Chakrabarti** *"Nonlinear interaction of electron acoustic waves with Langmuir waves in presence of external magnetic field in plasmas"* J. Plasma Phys.,**81** 905810106 (2015).

30. Sourav Pramanik, Chandan Maity, and **Nikhil Chakrabarti** *" Wave breaking of nonlinear electron oscillations in a warm magnetized plasma"* Physics of Plasmas **21**, 022308 (2014).

31. S. Ghosh, **N. Chakrabarti** and F. Haas *"New nonlinear structures in a degenerate one-dimensional electron gas"* Euro Phys. Letters. **105** 30006 (2014).

32. S. Garai, D. Banerjee, M. S. Janaki and **N. Chakrabarti** *"Velocity shear effect on the longitudinal wave in a strongly coupled dusty plasma"* Astrophysics and Space science. **349**, 789 (2014).

33. Manjistha Dutta, Samiran Ghosh, Manoranjan Khan and **Nikhil Chakrabarti** *"Nonlinear electron acoustic waves in presence of shear magnetic field"* Physics of Plasmas **20** 122112 (2013).

34. Anwesa Sarkar, Chandan Maity, and **Nikhil Chakrabarti** *" Nonlinear Electron Oscillations in a Warm Plasma"* Physics of Plasmas **20**, 122303 (2013).

35. **Nikhil Chakrabarti** and Hans Schamel, *" An exact solution in a gravitating fluid with a density dependent viscosity"* J. Plasma Phys. **79**, 1075 (2013).

36. Subir Biswas, Debjyoti Basu, Rabindranath Pal and **Nikhil Chakrabarti**,*"Selective Excitation of Low Frequency Drift Waves by Density Modulation and Parametric Excitation of Higher Frequency Mode"* Phys. Rev. Letters **111**,115004 (2013).

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38. Chandan Maity, **Nikhil Chakrabarti** and Sudip Sengupta *"Phase-mixing of electrostatic modes in a cold magnetized electron-positron plasma* Physics of Plasmas **20** 082302 (2013).

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41. Anwesa Sarkar, Chandan Maity, and **Nikhil Chakrabarti** *"Phase mixing of upper hybrid oscillations in a cold inhomogeneous plasma placed in an inhomogeneous magnetic field"* Physics of Plasmas **20**, 052301 (2013).

42. Manjistha Dutta, Samiran Ghosh, Rajkumar Roychoudhury, Manoranjan Khan and **Nikhil Chakrabarti** *Nonlinear electron acoustic cyclotron waves in presence of uniform magnetic field* Physics of Plasmas **20** 042301 (2013).

43. Samiran Ghosh and **Nikhil Chakrabarti** *Shock wave structures in a dissipative quantum plasma.* Phys. Rev. E **87** 033102 (2013).

44. Samiran Ghosh, **Nikhil Chakrabarti**, Manoranjan Khan and Mithil R. Gupta *Drift Wave in pair ion plasmas* Pramana **80**, 283 (2013).

45. Samiran Ghosh and **Nikhil Chakrabarti** *Magnetic electron drift solitons in electron magnetohydrodynamic plasmas.* Plasma Phys. Controlled Fusion **55**, 035008 (2013).

46. Manjistha Dutta, Samiran Ghosh, Rajkumar Roychoudhury, Manoranjan Khan and **Nikhil Chakrabarti** *Small Amplitude Nonlinear Electron Acoustic Solitary Waves in Weakly Magnetized Plasma* Phys. Plasmas **20** 012113 (2013).

47. C. Maity and **N. Chakrabarti***"Collisional drag may lead to disappearance of wave-breaking phenomenon of lower hybrid oscillations"* Physics of Plasmas **20** 014501 (2013).

48. Manjistha Dutta, Samiran Ghosh and **Nikhil Chakrabarti** *Electron acoustic shock waves in a collisional plasma* Phys. Rev. E **86** 066408 (2012).

49. C. Maity, **N. Chakrabarti** and S. Sengupta *Wave breaking phenomenon of lower-hybrid oscillations induced by a background inhomogeneous magnetic field* Physics of Plasmas **19** 0102302 (2012).

50. **N. Chakrabarti**, P.N. Guzdar and P. K. Kaw *The electron Geodesic acoustic mode* Physics of Plasmas. **19** 092113 (2012).

51. Samiran Ghosh , **Nikhil Chakrabarti** and P. K. Shukla *Linear and nonlinear electrostatic modes in a strongly coupled quantum plasmas.* Phys. Plasmas **19**, 072123 (2012).

52. C. Maity, **N. Chakrabarti** and S. Sengupta*Breaking of Upper hybrid oscillations in presence of an inhomogeneous magnetic field.* Phys. Rev. E **86** 016408 (2012).

53. D. Banerjee, M. S. Janaki and **N. Chakrabarti** *Shear flow instability in a strongly coupled dusty plasma.* Phys. Rev. E **85** 066408 (2012).

54. D. Banerjee, M. S. Janaki ,**N. Chakrabarti** and M. Chaudhuri *Nonlinear shear wave in a non Newtonian visco-elastic medium* Physics of plasmas. **19** 062301 (2012).

55. Chandan Maity and **Nikhil Chakrabarti***Nonlinear lower hybrid oscillations in a cold viscous plasma* Phys. Plasmas **18**, 124502 (2011).

56. Manjistha Dutta, **Nikhil Chakrabarti**, Rajkumar Roychoudhury and Manoranjan Khan *Nonlinear behavior of electron acoustic waves in an un-magnetized plasma* Phys. of Plasmas **18**,102301 (2011).

57. Samiran Ghosh and **Nikhil Chakrabarti** *Nonlinear wave propagation in a gravitating quantum fluid* Phys. Rev E **84**, 046601 (2011).

58. **Nikhil Chakrabarti** and Padma K. Shukla *Nonlinear generation of sheared flows and zonal magnetic fields by electron whistlers in plasmas* Phys. Letters A **375**, 3880 (2011).

59. M. S. Janaki, D. Banerjee and **N. Chakrabarti** *Shear waves in an inhomogeneous strongly coupled dusty plasma* Physics of Plasmas. **18**, 092114 (2011).

60. **Nikhil Chakrabarti** *Secondary instability of Jeans mode in a gravitating fluid with uniform rotation* Phys. of Plasmas **18**,062903 (2011).

61. Samiran Ghosh, Mithil R. Gupta **Nikhil Chakrabarti** and Manis Chaudhuri *Nonlinear wave propagation in a strongly coupled collisional dusty plasmas* Phys. Rev E **83**, 066406 (2011).

62. Chandan Maity, **Nikhil Chakrabarti** and Sudip Sengupta *Relativistic effects on nonlinear lower hybrid oscillations in cold plasma* J. Math. Phys. **52**, 043101 (2011).

63. **Nikhil Chakrabarti**, Chandan Maity and Hans Schamel *Exact time dependent nonlinear dispersive wave solutions in compressible magnetized plasmas exhibiting collapse"* Phys. Rev. Letters **106**,145003 (2011).

64. **N. Chakrabarti**, M. S. Janaki , M. Dutta and M. Khan *Nonlinear interaction of quantum electron plasma waves with quantum electron acoustic waves in plasmas* Phys. Rev. E 016404 (2011).

65. M. S. Janaki, **N. Chakrabarti** and D. Banerjee *Jeans instability in a viscoelastic fluid* Physics of Plasmas. **18** 012901 (2011).

66. D. Banerjee, M. S. Janaki, **N. Chakrabarti** and M. Chaudhuri *Viscosity gradient-driven instability of 'shear mode' in a strongly coupled plasmas* New J. Physics . **12** 123031 (2010).

67. D. Banerjee, M. S. Janaki and **N. Chakrabarti** *Viscoelastic modes in a strongly coupled, cold, magnetized dusty plasmas* Physics of Plasmas. **17** 113708 (2010).

68. Chandan Maity, **Nikhil Chakrabarti** and Sudip Sengupta *Nonlinear Lower hybrid osciullation in cold plasmas* Physics of Plasmas. **17** 082306 (2010).

69. M. S. Janaki and **N. Chakrabarti***Shear wave vortex solution in strongly coupled dusty plasmas* Physics of Plasmas. **17** 053704 (2010).

70. **Nikhil Chakrabarti** and Sudip Sengupta *Nonlinear interaction of electron plasma waves with electron acoustic waves in plasmas* Physics of Plasmas. **16** 072311 (2009).

71. P.N. Guzdar, R.G. Kleva, **N. Chakrabarti**,V. Naulin, J. J. Rasmussen, P. K. Kaw and R.Singh *Non-local analysis of the excitation of the geodesic acoustic mode by beta drift waves* Physics of Plasmas. **16** 052514 (2009).

72. **N. Chakrabarti**, P.N. Guzdar, R.G. Kleva, V. Naulin, J. J. Rasmussen and P. K. Kaw *Geodesic acoustic modes excited by finite beta drift wave* Physics of Plasmas. **15** 112310 (2008).

73. P.N. Guzdar, **N. Chakrabarti**, R. Singh and P. K. Kaw *Excitation of geodesic acoustic modes by ion temperature gradient modes.* Plasma Physics and controlled Fusion. **50** 025006 (2008).

74. **N. Chakrabarti** , R. Singh, P. K. Kaw and P. N. Guzdar: *Nonlinear excitation of geodesic acoustic modes by drift waves.* Phys. of Plasmas **14**, 052308 (2007).

75. **Nikhil Chakrabarti** and Ritoku Horiuchi: *Electromagnetic interchange-like mode and zonal flow in electron magnetohydrodynamic plasma.* Phys. of Plasmas **13**, 102306 (2006).

76. Manis Chaudhuri, **Nikhil Chakrabarti** and Rabindranath Pal: Nonlinear hydromagnetic waves in two ion species plasmas. **12**, 112101 (2005).

77. **Nikhil Chakrabarti** , Jens Juul Rasmussen, and Poul Michelsen: Ion temperature gradient driven mode in presence of transverse velocity shear in magnetized plasmas. **12**, 0745017 (2005).

78. **Nikhil Chakrabarti** and Raghvendra Singh *"Magnetic electron drift waves in electron magnetohydrodynamic plasma"* Phys. of Plasma **11**, 5475 (2004).

79. P.N. Guzdar , R.G. Kleva and **Nikhil Chakrabarti** *"Zonal flow and field generation by finite beta drift waves: Finite ion temperature effects"* Phys. of Plasma **11**,3324 (2004).

80. **Nikhil Chakrabarti** and M.S. Janaki *"Nonstationary nonlinear dust-acoustic wave in un-magnetized plasmas"* Phys of Plasma (Letters) **10**, 3043-3048 (2003).

81. **Nikhil Chakrabarti** *"Suppression of magnetic instabilities in accelerating plasma surfaces by sheared electron flow"* Physics of Plasma, **10**, 600-604 (2003).

82. **Nikhil Chakrabarti** and G.S. Lakhina, *"Collisional Rayleigh-Taylor instability and shear-flow in equatorial spread-F plasmas"* Annales Geophysicae **21**, 1153-1157 (2003).

83. **Nikhil Chakrabarti** and M.S. Janaki *"Nonlinear evolution of ion-acoustic wave in un-magnetized plasmas"* Phys. Letters. **A 305**, 393-398 (2002).

84. **Nikhil Chakrabarti**, Amnon Fruchtman, Ron Arad and Yitzhak Maron,: *"Ion dynamics in a two-ion-species plasma".* Phys. Letters, **A 297**, 92-99 (2002).

85. **Nikhil Chakrabarti** and G.S. Lakhina,: Nonlinear saturation of Rayleigh-Taylor instability and generation of shear flow in equatorial spread-F plasma. Nonlinar Processes in Geophysics **8**, 181-190 (2001).

86. **Nikhil Chakrabarti**, : Role of transverse velocity-shear on collisional drift-wave instability in magnetized plasma. Physics of Plasmas **8**, 97-102 (2001).

87. **Nikhil Chakrabarti**,: Interaction of Rayleigh-Taylor mode with shear-flow and vortex-flow in magnetized plasmas. Physics of Plasmas (Letters) **7**, 3495-3498 (2000).

88. **Nikhil Chakrabarti** and Jens Juul Rasmussen,: Shear flow effect on ion temperature gradient vortices in plasmas with sheared magnetic field. Physics of Plasmas **6**, 3047-3056 (1999).

89. **Nikhil Chakrabarti**,*" Flow curvature effect on linear Rayleigh-Taylor instability in magnetized plasmas".* Physics of Plasmas **6**, 1667-1669 (1999).

90. **Nikhil Chakrabarti**,: *"Steady state drift vortices in plasmas with shear flow in equilibrium".* Physics of Plasmas **6**, 417-419 (1999).

91. **Nikhil Chakrabarti** and K.H. Spatschek, *"Rayleigh-Taylor modes in presence of velocity shear and vortices".* J. Plasma Phys., **59**, 737-750 (1998).

92. **Nikhil Chakrabarti** and Predhiman Kaw, *"Transient vortex structures in low frequency magnetized plasma turbulence"*. Physics Letters A, **226**, 305-309 (1997).

93. **Nikhil Chakrabarti** and Predhiman Kaw, *"Stability of vortex flows in magnetized plasmas. II Boltzmann vortices"*. Physics of plasmas,**3**,4360-4366 (1996).

94. **Nikhil Chakrabarti** and P.K. Kaw, *"Velocity shear effect on Rayleigh-Taylor vortices in nonuniform magnetized plasmas"*. Physics of Plasmas, **3**, 3599-3603 (1996).

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96. **N. Chakrabarti** and P.K. Kaw, *" Rayleigh-Taylor vortices and their stability in magnetized plasmas"*. Physics of Plasmas, **2**, 1460-1465 (1995).

97. **N. Chakrabarti**, P.K. Kaw, S.P. Deshpande, *" Quadrupole vortex structure Plasmas with sheared field and Flow"*. Plasma Physics and Controlled Fusion, **36**, 2083-2093 (1994).

II. Papers Contributed to Workshops/Symposia/Conferences :

I have contributed papers to national and international workshops, symposia and conferences in the field. However, only referred conferences papers are sited here.

1. S. Garai, D. Banerjee, M. S. Janaki and **N. Chakrabarti** : *Dynamica of the longitudinal and transverse modes in presence of Equilibrium shear flow in a strongly coupled dusty plasma.* International conference on Complex processes in Plasmas and Nonlinear dynamical system, AIP conference Proceedings, **1582**, 93 (2014).
2. **N. Chakrabarti** P.N. Guzdar, R. G. Kleva, R. Singh, P.K. Kaw ,V. Naulin, J. J. 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).
3. **Nikhil Chakrabarti**, Barnana Pal and Vinod Krishan, *Nonlinear Jeans instability with rotation in nonconducting astrophysical fluids* Astrophysics and space science proceedings,(Springer, August 27-September 7, 2007) p-281.
4. R. Arad,A. Weingarten, K. Tsigutkin, Yu. V. Ralchenko, Y. Maron A. Fruchtman, **N. Chakrabarti**, B.V. Weber and R.J. Commisso *Interaction of Rapid Magnetic Fields with Plasmas and implications to Pulsed-Power systems* Proc. of the xiv Int. Conf. on High-Power Particle Beams (Albuquerque, NM, June 23-28, 2002).
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6. P.N. Guzdar, R.G. Kleva, A. Das, P.K. Kaw and **N. Chakrabati** *Zonal Flow and zonal field Generation by finite beta drift wave and Alfven wave* Paper presented in the APS meeting, December, 2001.
7. P.K. Michelsen, J. Juul Rasmussen and **N. Chakrabati** *Ion temperature gradient vortices in shear flow* Paper presented in the meeting of European physical theory conference, Aachen, Germany 1997.
8. **N. Chakrabarti**, A. Sen, P.K. Kaw and A.K. Sundaram ,*Ballooning vortices in plasmas in sheared field and flow*, Paper presented in the meeting of Transport Chaos and plasma physics. Marseille, 1995.
9. **N. Chakrabarti** and P.K. Kaw,:Time dependent vortices in plasmas. *Proceedings of the 1994 International Conference on Plasma Physics Brazil*, vol. 2 p. 17 (1994).
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11. G.S. Bevli, **N. Chakrabarti**, A. Das, S.P. Deshpande, P.K. Kaw, A. Sen, R. Singh and A.K. Sundaram,: Some aspects of edge turbulence in tokamak. *Proceedings of the 14th International Conference on Plasma Physics and Controlled Nuclear Fusion Research, Wurzburg , International Atom Energy Agency, Vienna*, (1993) p. 235.
12. **N. Chakrabarti**, Amita Das, Sangeeta Mahajan, A. Sen and P. Kaw,: Proceedings of Transport Chaos and plasma physics. Marseille, 1993, Edited by S. Benkadda, F. Doveil and Y. Elskens (World Scientific, Singapore, 1994), p. 319
13. P. K. Kaw, R. Singh, A. Das and **N. Chakrabarti**,:Stability of elliptical vortex flow in fusion plasmas. A collection of papers Presented at the IAEA Technical Committee Meeting on*Research Using Small Tokamaks, Hefai, China, Oct.3-8, 1991.* (International Atomic Energy Agency, Vienna, Austria) p. 342