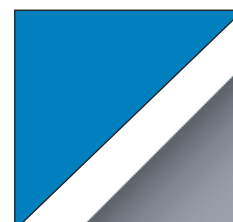
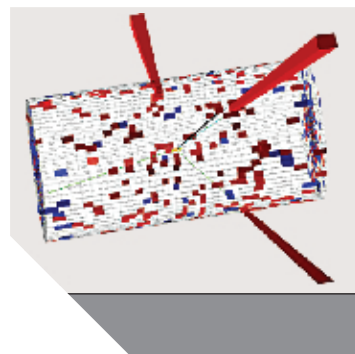
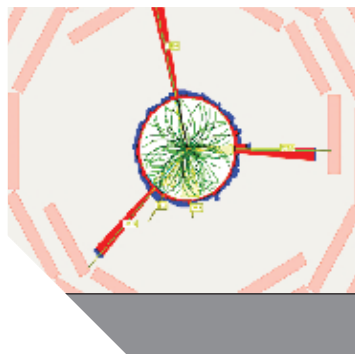
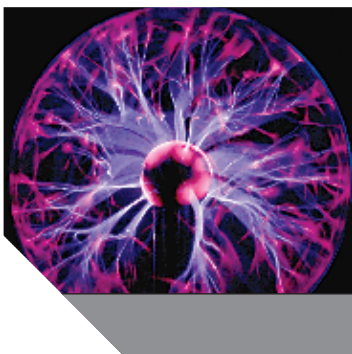
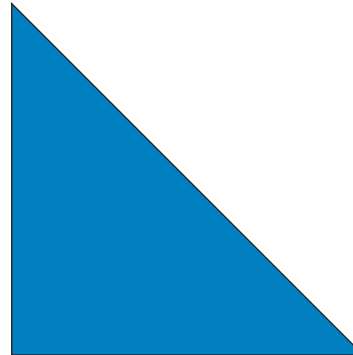
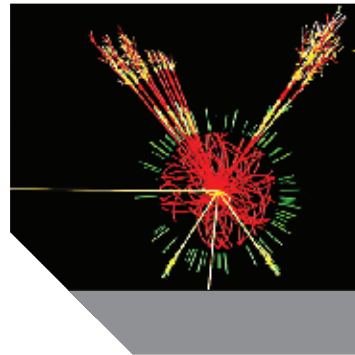
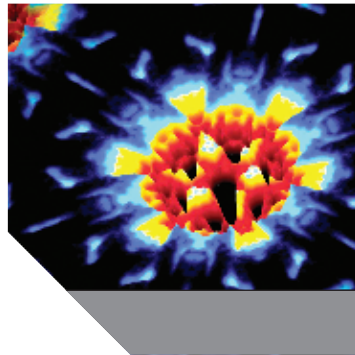
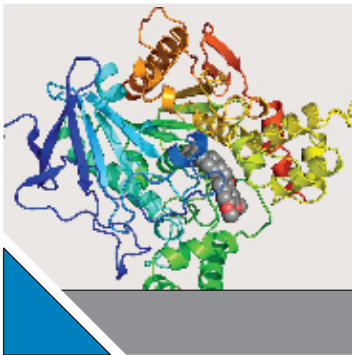


Saha Institute of Nuclear Physics



annual report | 2014-15



SINP
KOLKATA

Saha Institute of Nuclear Physics

Annual Report

2014–2015



Saha Institute of Nuclear Physics

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India

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January 11, 2016

Foreword



I am very happy to write this foreword for this Annual Report (2014-2015) of our Institute. Notwithstanding some financial constraints this year, our faculty members and students, together with the other members of the Institute, could strive towards quality researches and developments. Our members published this year more than four hundred and fifty papers in international journals, including more than seventy in journals with impact factor more than six, and authored/ co-authored more than four books published by distinguished international publishers. This bears the testimony of our commitment towards excellence. We also participated in several major international collaborations within this period.

One of our colleagues, Prof. Sushanta Lahiri got selected for for the George Hevesy Medal award of excellence in radio-analytical and nuclear chemistry. This is for the first time this international award came to India (actual award ceremony was held in April this year in Hawaii, USA). Two of our colleagues, Prof. Gautam Bhattacharyya and Prof. Anjan Kundu were elected Fellows of the Indian Academy of Sciences, Bangalore.

I am sure, members of our Institute will contribute even more successfully in the coming days.

January 11, 2016

Bikas K Chakrabarti
Director

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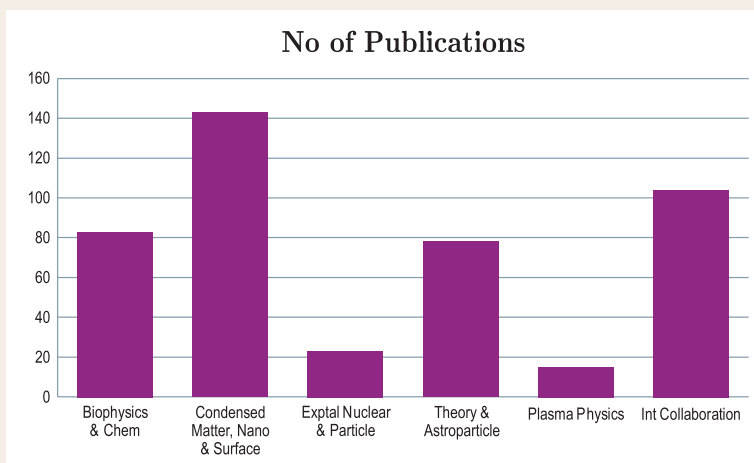
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Brief Summary



Saha Institute of Nuclear Physics (SINP) is engaged in basic scientific research on five broad subject areas (a) Experimental Nuclear and Particle Physics, (b) Condensed Matter Physics including Surface Physics and Nanoscience, (c) Biophysical science including chemistry, (d) Theoretical & Astroparticle Physics (e) Plasma Physics. 16 Post M.Sc students have been inducted into the research & teaching program during the year

2014-15. About 10 undergraduate associates and 30 students in the summer program are being trained in the Institute coming from different parts of the country.

Altogether 446 research publications have been credited during the period and 30 theses awarded for PhD degree. More than 70 publications are in high impact journals with impact factor > 6.0. Outreach programs conducted from the Centre for Advanced Research & Education (CARE) both in and outside SINP, going to remote places of Sundarban to district school in Hoogly, Birbhum and North 24 parganas, have been successful with overwhelming response from students of high school and undergraduate college.

Biophysical Sciences including Chemistry : Under this area there are about 22 faculty members and about 60 research students and associates, distributed in four Divisions, Biophysics & Structural Genomics, Computational Sciences, Crystallography and Molecular Biology and Chemical Sciences, actively engaged in different disciplines of experimental and computational biology.

Condensed Matter Physics including Surface Physics and NanoScience : Under this area there are about 27 faculty members and about 65 research students and associates, distributed in two Divisions, Condensed Matter Physics (CMP) and Surface Physics & Material Science (SPMS) actively engaged in different disciplines of both theoretical and experimental condensed matter and material physics.

Experimental Nuclear & Particle Physics : Under this area there are about 23 faculty members and 30 research students and associates, distributed in three Divisions of Nuclear Physics, Applied Nuclear Physics and High Energy Nuclear & Particle Physics, actively engaged in different disciplines of both theoretical and experimental nuclear and high energy physics.

Theoretical Physics including Mathematics : There are 22 faculty members and about 35 research students and associates, distributed in the two Divisions, Theory and Astroparticle & Cosmology engaged in research on theoretical and astroparticle physics.

Plasma Physics : There are 2 faculty members and about 10 research students and associates, in Plasma Physics Division actively engaged in research and developmental work on theoretical and experimental plasma physics.

SINP has been involved in the International Collaborations:

- (a) Beamline is functional in Photon Factory, Japan;
- (b) with CERN in ALICE and CMS experiments and
- (c) with SNOLab in PICASSO experiment for Dark Matter Search.

Important Achievements

Altogether 446 research publications have been credited during the period with 30 thesis awarded for PhD degree.

About 70 publications in high impact journals with impact factor more than 6 in Journals like Physical Review Letters, Reviews in Modern Physics, Journal of High Energy Physics, Journal of Cosmology & Astroparticles Physics, Cell Death & Disease and RNA Biology to name a few.

The successful operation of the Indian Beam Line at Photon Factory (KEK) at Tsukuba has been recognized as a flagship cooperative activity by the honorable Prime Minister of India on December 2014.

International Collaboration with CERN in ALICE and CMS experiments

International Collaboration with SNOLab in PICASSO experiment

Outreach programs conducted from the Centre for Advanced Research & Education (CARE) with overwhelming response of high school students on science and related area of contemporary interest.

Hevesy Award

HEVESY MEDAL AWARD-2015 First time from INDIA

The George Hevesy Medal Award is the premier international award of excellence in radioanalytical and nuclear chemistry. The George Hevesy Medal is awarded to an individual in recognition of excellence through outstanding, sustained career achievements in the fields of pure as well as applied nuclear and radiochemistry. The Hevesy Medal Award -2015 is given to two candidates (names in alphabetical order) (i) Professor K. V. KATTI from University of Missouri-Columbia, U.S.A., and Professor Susanta LAHIRI from Saha Institute of Nuclear Physics, Kolkata, India. For the first time Hevesy Medal Award has been bestowed to someone from India since its inception in 1968.



Professor LAHIRI will receive his award for his outstanding contributions on heavy ion induced radioisotope production, tracer packet technique, converter targets, and green chemistry. It is noteworthy to mention that except converter targets (which have been carried out in CERN-ISOLDE) all other works have been carried out in India using the Indian accelerator facilities like BARC-TIFR Pelletron and Variable Energy Cyclotron Centre.

In heavy ion activation, Professor Lahiri for the first time produced clinically important alternative radioisotopes by heavy ion activation using heavier projectiles like ${}^7\text{Li}$, ${}^{11}\text{B}$, ${}^{12}\text{C}$, ${}^{16}\text{O}$, etc. The introduction of heavy ion beam made easy access to the neutron deficient short-lived radioisotopes and expanded the horizon of clinically important radionuclides. The idea of tracer packet, conceived and coined by Professor Lahiri, is resurrection in the field of radiotracer technique and is complementary to the multitracer technique. Under his leadership for the first time radiotracer technique was punched in Green Chemistry experiments. His group reported the first radioactive gold nanoparticles using green synthesis route. Professor Lahiri and his colleagues for the first time unveiled total radioisotope inventory when a converter target like Lead-Bismuth Eutectic (LBE) are bombarded with high energy 1.4 GeV proton beam. They pointed out that these converter targets may act as huge source of clinical radionuclides including exotic therapeutic radionuclides like ${}^{149}\text{Tb}$.

Honours & Distinctions



Prof Anjan Kundu, selected as Fellow of Indian Academy of Sciences (IASc), Bangalore, (Jan 1, 2015)



Prof Gautam Bhattacharyya, selected as Fellow of Indian Academy of Sciences (IASc), Bangalore (2015)



Prof Munshi Golam Mustafa was awarded Bangabhushan by Govt of West Bengal on May 20, 2014

Faculty Members Joined the Institute



Prof Kalpataru Pradhan

Transition metal oxides (TMOs) show a wide range of electrical and magnetic properties and bear promises of technological importance for the design of new functional materials. The physics is even much more richer at the interface of two TMOs. The central theme of our research is to find a correlation between the electronic and the magnetic properties at the interface. We use model Hamiltonian approach combined with material specific first-principles density functional theory calculations for a deep understanding and further improvement of functionalities of TMOs and their interfaces. We also study magnetic properties of atomic clusters using density functional theory to design new ferromagnetic molecular-magnets.



Prof H Raghuraman

Ion channels and transporters are membrane proteins that play a crucial role in many important cellular processes. Unlike K^+ and Na^+ channels, very little is known about the gating and transport mechanisms of Mg^{2+} channels. Broadly, our research will focus on three important research areas namely the (i) Gating related structural dynamics of Mg^{2+} channels to understand the mechanism of Mg^{2+} transport at the molecular level; (ii) Structural Dynamics of voltage sensor movement; and (iii) Understanding structural and mechanistic details of sodium calcium exchanger proteins. My aim is to establish a laboratory equipped with membrane protein biochemistry, electrophysiology, and continuous-wave (CW) and pulsed electron paramagnetic resonance (EPR) spectroscopy together with steady-state and time-resolved fluorescence spectroscopy to generate functionally-compatible low-resolution models of novel membrane proteins in different functional states that are not amenable to crystallographic approaches.



Prof Soumen Kanti Manna

Systems-level characterization of the effect of gene-environment interaction on biochemical networks is essential for holistic understanding of pathogenesis and inter-individual variations in the outcome. We are currently using mass spectrometry-based metabolomics to investigate the reorganization of biochemical landscape associated with liver diseases, diabetes, and cancer. The ultimate goal is to identify biomarkers for early diagnosis and target pathways for personalized interventions. We are also working on mass spectrometry-based direct biochemical finger-printing of microbes for high-throughput species identification and functional characterization required for applications in functional metagenomics, public health and critical care set-ups.



Prof Sangram Bagh

The molecular connectivity between genes and proteins inside a cell shows a good degree of resemblance with complex electrical circuits. This inspires the possibility of engineering a cell similar to an engineering device. By adapting engineering principle in the molecular biology regime, we design, construct, and implement synthetic gene circuits to 're-program' living cells to perform various human designed tasks. We are particularly interested in 1) developing cellular robotics platform for cancer gene therapy, 2) developing synthetic biology solutions for in-situ resource utilization in human space missions.

Special Events



On the occasion of celebration of the Diamond Jubilee year of Department of Atomic Energy, members of Biophysical Sciences in organized a National Symposium on Frontiers of Biology : The DAE Spectra, during the December 23rd and 24th, 2014 with eminent scientists and research scholars from the DAE fraternity BARC, ACTREC, TIFR, NISER and RRCAT along with our own. The Symposium covered subjects under the DAE mandate such as Cancer, Radiation Biology, Structural Biology, Genomics & Proteomics, Stem Cell & Gene Therapy, Chemical Biology and Biospectroscopy. We had received patronage from DAE for organizing the meeting giving excellent opportunity for students and young faculty members to get exposure and interact with scientists of the same family having international repute working in the exiting frontiers of biology.



The 14th International Spin Chemistry Meeting 2015 (SCM-2015) on Spin and Magnetic Field Effects in Chemistry and Related Phenomena was organized first time in India at Saha Institute of Nuclear Physics, Kolkata during March 15-20, 2015 under the convenership of Samita Basu, one of the International Spin Chemistry Committee Members, partially funded by BARD project, SINP, Department of Atomic Energy, India. It was a huge and successful gathering of several eminent scientists along with their groups from Germany, UK, Canada, Japan, USA, Austria, Portugal, Croatia, Russia and India working on theoretical and experimental aspects of spin chemistry, physics as well and biology.



Saha Theory Workshop: Cosmology at the Interface, was hosted by the Theory Division Jan 28-30, 2015. The program included both plenary and parallel sessions. Nearly eighty people participated in the programme that included talks by notable speakers in the field. The workshop was funded by Theory Division, CARE and Ramanujan Fellowship



Garlanding programme during the 65th Year of Foundation Day
Celebration on 11.1.2015



Director Prof. Bikas Chakrabarti felicitating Prof. Robert G. Roeder 51st
Saha Memorial Lecture on 13.1.2015



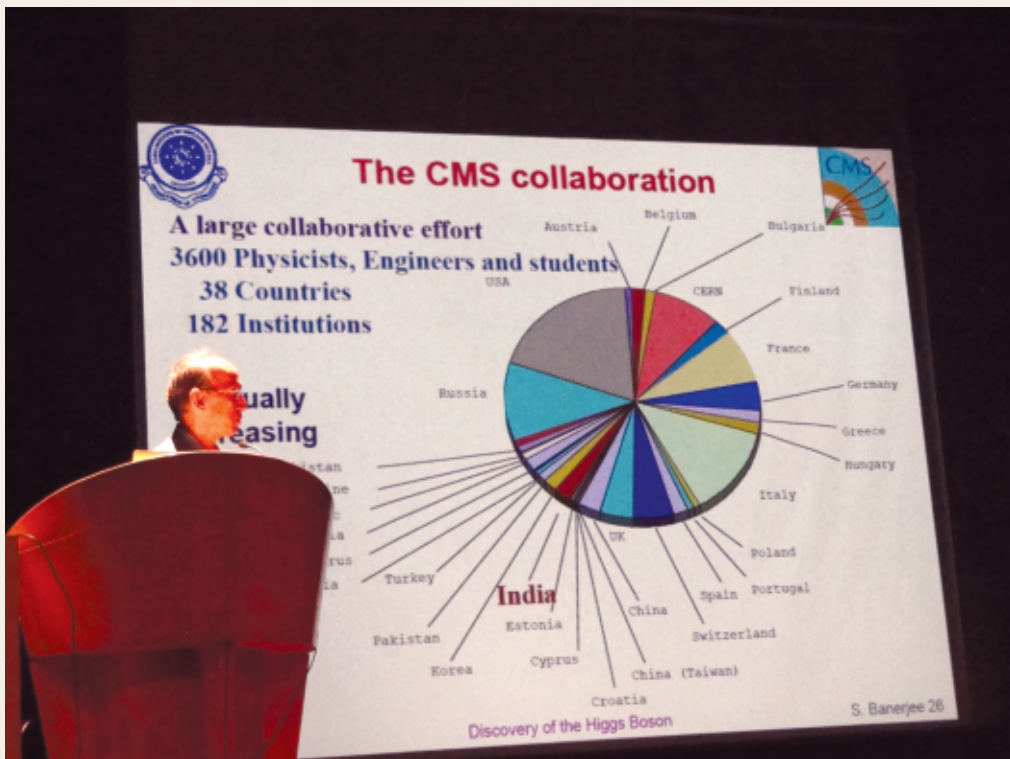
9th J C Bose Memorial Lecture delivered by Prof. Robert Rosner on 3rd Feb., 2015



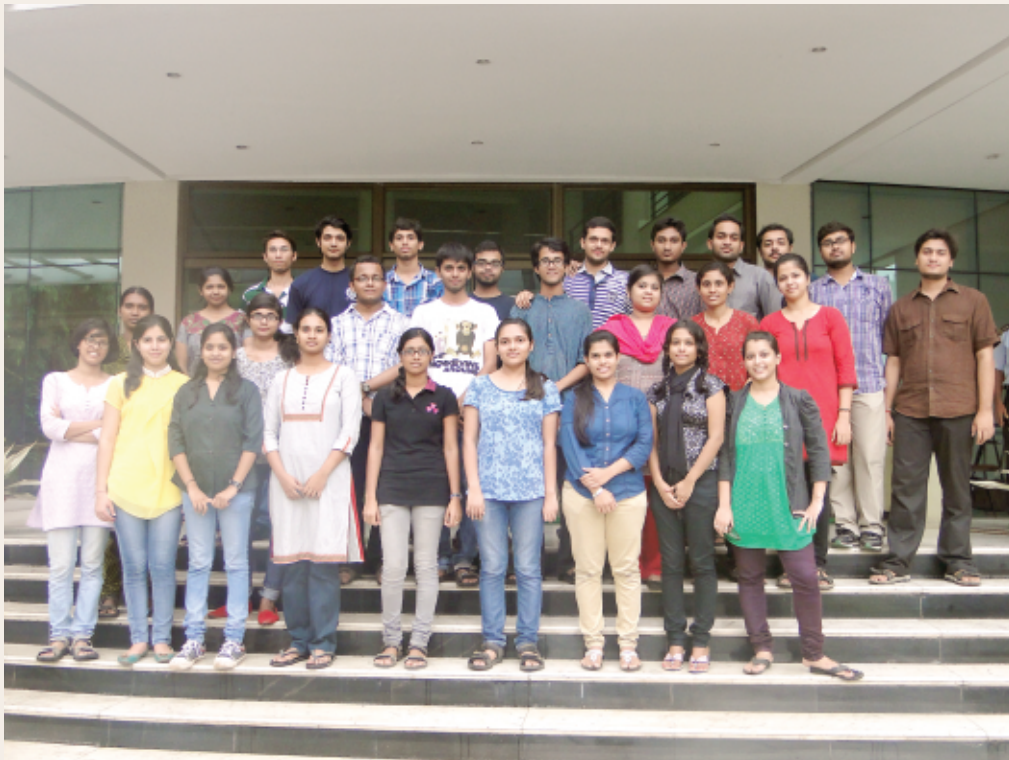
Institute Colloquium Lecture delivered by Prof. Mriganka Sur of MIT on 12.1.2015 at SINP Auditorium



SINP Outreach Programme-2015 in occasion of Science Day Celebration on 28.3.2015



Prof. Sunanda Banerjee delivering Colloquium lecture, March 2015



Students of SINP Summer Training Programme – 2014



Foreign students visit at our Science pavilion at Bignan -O-Projukti Mela at Hedua, Kolkata.



Prof. Bikas Chakrabarti, Director, SINP awarding prize to students of Barasat Kalikrishna Girls' High School during SINP Outreach Programme -2015 on 28.3.2015.



National Exhibition at Amarabati, Sodepur from 3.7.14 - 9.7.14



OUTREACH PROGRAMME OF SINP

28th March, 2015

Organized by
CARE

(CENTRE FOR ADVANCED RESEARCH & EDUCATION)
SAHA INSTITUTE OF NUCLEAR PHYSICS

Chapter 1

Biophysical Sciences including Chemistry

1.1 Biophysics and Structural Genomics

1.1.1 Summary of Research Activities

Experimental approaches to understand the biomolecular recognition process in different intracellular phenomena have been the major activities in Biophysics. The biomolecular recognition studies include mode of actions of flavones and flavonoids, chemical biology of the aureolic acid group of antibiotics, modulation of chromatin structure by small DNA binding molecules and self association of wild type and mutant lamins involved in laminopathy. In addition we have also studied the biophysical properties of lamins to understand their roles as intermediary filaments. Recognition of multiple stranded DNA (Quadruplex) and putative anticancer agents from plant source have shown that one such agent, ellipticine binds to DNA with 3:2 stoichiometry, with respect to ellipticine: DNA, also inhibiting telomerase activity. The widely prevalent disease of Eastern India, HbE-thalassemia, along with sickle cell anemia, hereditary spherocytosis and leukemia are being studied as model for hematological disorders while Alzheimers, Huntingtons, and the Prion diseases are being studied for the neurodegenerative diseases. Differential proteomics studies are being done in these diseases using clinical samples of cerebrospinal fluid, plasma, urine, red cells, cell extracts and platelets. Hundreds of proteins from these different tissue types are annotated and 10-15 proteins are identified to be differentially expressed in diseases. Classes of redox regulators and chaperone proteins have been found to be up-regulated in hemoglobinopathy. Studies in cell proliferation and differentiation have implicated the roles of self renewal pathways and cross talk between signaling pathways in chronic to blast transformation of CD34+ CML stem cells isolated from patients. Moreover, we have established that cytoplasmic sequestration of the cell cycle inhibitor, p27 led to its interaction with polycomb group of genes (Bmi1, EZH2) and activation of the Rho/Rac GTPase pathway resulting in actin depolymerization which, in turn, caused cellular egression/mobilization from the bone marrow. Currently this pathway is also being investigated to understand the process of metastasis in epithelial cancer. Among the various diseases that affect the nervous system, some of the most debilitating neurodegenerative disorders are Alzheimers, Huntingtons and Prion Diseases. These late onset but eventually fatal diseases are all caused by altered metabolism of individual proteins that interfere with normal cellular homeostasis. Several micro RNAs (miRNA), the negative regulator of protein coding gene expression, have been shown to target the Huntingtin (HTT) gene, whose mutation causes Huntingtons disease (HD). The expression of these miRNAs has been shown to decrease in cell and animal models of HD. Besides, it has been shown that

miR-150 target TP53 gene, explaining the over expression of TP53 in HD. HIPPI, a molecular partner of HTT interacting protein HIP1, has been shown to regulate many genes involved in HD pathogenesis. The normal life cycle of a protein, characterized by its biogenesis, trafficking and degradation, are compromised in these disorders resulting in misfolding, misprocessing or mislocalization of the proteins. Most likely, the aberrant protein can then engage in atypical interactions and ultimately lead to a series of unknown events culminating in cell death. The major focus of our research in Alzheimers disease (AD) is to study the downstream pathogenesis of the disease, mediated through AICD and its adaptor network. AICD possesses conserved motifs that are now known to interact with cytosolic adaptor proteins and these interactions in turn affect different signaling pathways. We have shown that Grb2, one such adaptor, interacted with AICD in late endosomal compartments. The excess protein, thus entrapped, could be degraded by autophagy. Currently, we are also trying to provide a comprehensive understanding of the disruption of the intracellular protein trafficking pathways in late-onset neurodegenerative disorders. With Prion disease as a model system, we plan to simultaneously pursue two broad facets: first, understanding the significance of the ESCRT machinery and the endo-lysosomal pathway in PrP-mediated (Prion protein) neurodegenerative diseases. This will aim to provide a molecular explanation for how the loss of function mutation of Mahogunin results in Prion disease like phenotype of spongiform neurodegeneration. Secondly, we also aim to explore how the various essential molecular components that are regulated during endoplasmic reticular stress (ER stress) and aging, both of which manifest in late onset neurodegenerative diseases. Studies on function and dynamics of transcription factors have been initiated to interpret the epigenetic language in Eukaryotic Cells. We aim to understand the critical interactions between histone posttranslational modifications and the 'readers' which regulate important cellular pathways and their dysfunctions leading to disease. A molecular systems level understanding of the combined effects of microgravity and space ionizing radiation (high energy particles) on human cells and metabolomics-guided system level elucidation of effect of radiation exposure on living systems would be envisaged.

1.1.2 Publications

1.1.2.1 Publications in Journal

Tarun K Dua†; Saikat Dewanjee†; Moumita Gangopadhyay; et al, Ameliorative effect of water spinach, *Ipomea aquatica* (Convolvulaceae), against experimentally induced arsenic toxicity, JOURNAL OF TRANSLATIONAL MEDICINE **13** (2015) Art No: 81

Saptarni Ghosh; Dipak Dasgupta, Quadruplex forming promoter region of c-myc oncogene as a potential target for a telomerase inhibitory plant alkaloid, chelerythrine, BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS **459** (2015) 75

Nandini Pal Basak; Subrata Banerjee, Mitochondrial dependency in progression of acute myeloid leukemia, MITOCHONDRION **21** (2015) 41

Anita Roy; Subrata Banerjee, p27 and Leukemia: Cell Cycle and Beyond, JOURNAL OF CELLULAR PHYSIOLOGY **230** (2015) 504

Biswa Pathik Pahari; Sudip Chaudhuri†; Sandipan Chakraborty†; et al, Ground and Excited State Proton Transfer of the Bioactive Plant Flavonol Robinetin in a Protein Environment: Spectroscopic and Molecular Modeling Studies, JOURNAL OF PHYSICAL CHEMISTRY **B119** (2015) 2533

Saptaparni Ghosh; Jagannath Jana†; Rajiv K Kar†; Dipak Dasgupta, Plant Alkaloid Chelerythrine Induced Aggregation of Human Telomere Sequence-A Unique Mode of Association between a Small Molecule and a Quadruplex, *BIOCHEMISTRY* **54** (2015) 974

Nagaraaja Theeya; Atri Ta; Sayan DasOishee Chakrabarti; et al, An Inducible and Secreted Eukaryote-Like Serine/Threonine Kinase of Salmonella enterica Serovar Typhi Promotes Intracellular Survival and Pathogenesis, *INFECTION AND IMMUNITY* **83** (2015) 522

Shreyasi Dutta; Shibojyoti Lahiri ; Amrita Banerjee; S Saha; D Dasgupta, Association of antitumor antibiotic Mithramycin with Mn^{2+} and the potential cellular targets of Mithramycin after association with Mn^{2+} , *JOURNAL OF BIOMOLECULAR STRUCTURE & DYNAMICS* **33** (2015) 434

Ritu Khanra; Saikat Dewanjee; Tarun K Dua M Gangopadhyay; et al, Abroma augusta L. (Malvaceae) leaf extract attenuates diabetes induced nephropathy and cardiomyopathy via inhibition of oxidative stress and inflammatory response, *Journal of Translational Medicine* **13** (2015) Art No: 6

Shibojyoti Lahiri; Amrita Panja; Dipak Dasgupta, Association of a Zn^{2+} containing metallo β -lactamase with the anticancer antibiotic mithramycin, *JOURNAL OF INORGANIC BIOCHEMISTRY* **142** (2015) 75

Manindra Bera; Hema Chandra Kotamarthi; Subarna Dutta; et al, Characterization of Unfolding Mechanism of Human Lamin A Ig Fold by Single-Molecule Force Spectroscopy-Implications in EDMD, *BIOCHEMISTRY* **53** (2014) 7247

Saikat Dewanjee; Moumita Gangopadhyay; Urmil Das; et al, Signal transducer and oxidative stress mediated modulation of phenylpropanoid pathway to enhance rosmarinic acid biosynthesis in fungi elicited whole plant culture of Solenostemon scutellarioides, *ENZYME AND MICROBIAL TECHNOLOGY* **66** (2014) 1

Shounak Baksi; Sreetama Basu; Debashis Mukhopadhyay, Mutant huntingtin replaces Gab1 and interacts with C-terminal SH3 domain of growth factor receptor binding protein 2 (Grb2), *NEUROSCIENCE RESEARCH* **87** (2014) 77

Srijan Haldar; Anita Roy; Subrata Banerjee, Differential regulation of MCM7 and its intronic miRNA cluster miR-106b-25 during megakaryopoiesis induced polyploidy, *RNA BIOLOGY* **11** (2014) 1137

Abhijit Poddar†; Rinchen T Lepcha†; Debasish Mukherjee; D Bhattacharyya; et al, Comparative analysis of 16S rRNA signature sequences of the genus *Idiomarina* and *Idiomarina woesei* sp. nov., a novel marine bacterium isolated from the Andaman Sea, *RESEARCH IN MICROBIOLOGY* **165** (2014) 501

Bidisha Sengupta†; Donald Davis†; Kisa Harris†; Biswapathik Pahari; et al, Flavonoids as duplex and quadruplex DNA ligands: Biophysical studies, *ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY* **248** (2014) Meeting Abstract: 402-PHYS

Arunabha Chakrabarti; Atri Chatterjee; Mohor B Sengupta; et al, Altered Levels of Amyloid Precursor Protein Intracellular Domain-interacting Proteins in Alzheimer Disease, *ALZHEIMER DISEASE & ASSOCIATED DISORDERS* **28** (2014) 283

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Anindita Deb Pal; Nandini Pal Basak; Aditi Sengupta Banerjee; S Banerjee, Epstein-Barr virus latent membrane protein-2A alters mitochondrial dynamics promoting cellular migration mediated by Notch signaling pathway, *CARCINOGENESIS* **35** (2014) 1592

Kasturi Roy; Oishee Chakrabarti Debashis Mukhopadhyay, Interaction of Grb2 SH3 domain with UVRAG in an Alzheimer's disease-like scenario, *BIOCHEMISTRY AND CELL BIOLOGY-BIOCHIMIE ET BIOLOGIE CELLULAIRE* **92** (2014) 219

KK Kulkarni†; KG Bankar†; RN Shukla†; C Das; Amrita Banerjee; D Dasgupta, et al, Global gene expression profiling data analysis reveals key gene families and biological processes inhibited by Mithramycin in sarcoma cell lines, *GENOMICS DATA*, 2015, 3:8-14

A Banerjee, S Sanyal, KK Kulkarni†...C Das, D Dasgupta, Anticancer drug mithramycin interacts with core histones: an additional mode of action of the DNA groove binder, *FEEBS OPEN BIO* 2014, 4:987-995

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C Das†, S Roy, S Namjoshi, et al, Binding of the histone chaperone ASF1 to the CBP bromodomain promotes histone acetylation, *PROC NATL ACAD SCI USA*, 2014 Mar 25; 111 (12):E1072-81

1.1.3 Ph D Awarded

Anita Roy [Subrata Banerjee], Cross talk of Self renewal pathways and hematopoiesis, University of Calcutta, April 2014

Sapataparni Ghosh [Dipak Dasgupta], Effect of The Plant Alkaloids on Structure and Function of G-Quadruplex DNA, University of Calcutta, Oct 2014

Shreyasi Dutta [Dipak Dasgupta], Mode of Action of Two Aureolic Acid Antibiotics and Chelerythrine - a Chemical Biology Approach, HBNI, March 2015

Kasturi Roy [Debasish Mukhopadhyay], AICD Mediated Cell Fate in Alzheimer's Disease: Juxtacelluar Signaling and Downstream Pathways, University of Calcutta, Sept 2014

Sounak Bakshi [Debasish Mukhopadhyay], Alterations in Growth Factor Receptor Protein Bind-

ing Protein 2 (Grb2) Related Signaling in Huntington's Disease Cell Model, University of Calcutta, Feb 2015

1.1.4 Seminars/Lectures given in Conference/Symposium/Schools

Chandrima Das

- i. Decoding the epigenomic landscape by histone reader ZMYND8, 5th meeting of the Asian Forum for Chromatin and Chromosome Biology, 2015, JNCASR, Bangalore, Jan 15-18, 2015
- ii .Prolyl isomerization as a novel mode to regulate chromatin functioni, 4th conclave for the Ramalingaswami Fellowship recipients at Institute of Life Sciences, Nalco Square, Bhubaneswar, Jan 30- Feb 1, 2015

Kaushik Sengupta

- i. Role of LMNA mutations in higher order protein assembly: A possible mechanism in the pathogenesis of Dilated Cardiomyopathy (DCM), Indian Biophysical society meeting at Jamia Millia Islamia, New Delhi, Feb 14-17, 2015
- ii. Novel Insights into Assembly, isfolding and Viscoelastic Behavior of Lamin A Proteins: Implications in Diseases, Interdisciplinary Approach to Biological Sciences (IABS), Indian Association for the Cultivation of Science, Feb 2-3, 2015

Sangram Bag

Engineering Biology: One way or another, Indo-US Conference and Workshop in Synthetic and Systems Biology, Delhi, Nov 9-12, 2014

1.1.5 Teaching elsewhere

Pulak Ray

1. Electron Microscopy and Atomic Force Microscopy: MSc course on Biomedical Instrumentation, 3rd semester, University of Calcutta, September 2014-January 2015 (10 lectures)
2. Electron Microscopy and Atomic Force Microscopy: MTech course on Biomedical Instrumentation, 2nd semester, University of Calcutta, March-June 2015 (12 lectures)

1.2 Crystallography and Molecular Biology

1.2.1 Summary of Research Activities

In Crystallography and Molecular Biology Division multifaceted approaches are used to study the structure and conformation of proteins which are involved in various regulatory processes in biology under normal and diseased conditions. Therefore, one of the major focuses of the Division is to study the structure and dynamics of proteins and determination of the 3D structures to gain functional insights. Post-translational modification of proteins is an important mechanism to regulate their structures and functions. In this context, the mechanism of phosphorylation and the

structural elements that direct the phosphorylation to occur with high fidelity in case of fructokinase and ribokinase have been figured out with high resolution structures. The structures of Psu and the cage structure of an Acylphosphatase drew much attention in recent past. Structure of Psu, solved by Hg-SAD method, revealed a novel fold with a unique knotted dimerisation. The 12-meric nano-cage (8 nm) structure of acylphosphatase from *Vibrio cholerae*O395 (Vc-AcP), coupled with studies in solutions illuminates the basis for the formation of the cage, while a single (Cys20→Arg) mutation (Vc-AcP-C20R) transforms Vc-AcP to a potent enzyme, but disrupts the assembly into a trimer. Since it is interesting and also useful to engineer protein to obtain useful mechanistic information and modify functional specificity, one of the major focuses of divisional research is Structure-based protein engineering to alter activity, stability and specificity of proteolytic enzymes. The spacio-temporal regulation of proteolytic activity of cysteine proteases by their cognate pro-domain and through specific inhibitors of serpin family are being studied at structural and molecular level. Moreover, the important questions regarding protein folding are also addressed through theoretical and experimental approaches with cyclophilin as a model system. Differential gene expression is regulated at transcriptional level as well as through various posttranscriptional mechanisms regulating RNA turnover and translation. It has been shown that in case of disease causing *Leishmania* parasites an octamer motif in the untranslated regions (UTRs) of mRNAs is responsible S-phase specific periodic stability of the messages and a large multidomain riboendonuclease cleaves the mRNAs differentially in a monoubiquitination dependent manner. Interestingly, octamer motifs have been found in 5 UTRs of several cell cycle regulated genes also in human and their importance in differential stability of the messages and regulation of translation is being investigated. Effect of posttranslational modifications like phosphorylation of some replication factor on initiation step of DNA replication is also being investigated. Cell cycle dependent genome-wide interaction of some initiation proteins with replication origins in human cells will be studied using high throughput ChIP-Seq approach in our newly installed Next Generation Sequencing platform. The parasitic diseases leishmaniasis and growing resistance of the causative parasites to the existing regime of drugs are serious health concern in several countries including India. Works are also focused on bioinformatics related to the leishmanial genome and crystallography of the proteins from the same group of parasites that could be potential drug targets. The basis of development of drug resistance in some of the strains of *Leishmania* parasites are also being studied using high throughput sequencing approach. One of the key components of cell is the plasma membrane which along with many embedded and associated proteins and its dynamic interaction with cytoskeleton such as spectrin is responsible for maintaining the shape of cell, selective transfer of materials and communication with outside. Recombinant fragments of different structural domains of erythroid and non-erythroid spectrin are being designed, cloned and expressed for further studies using spectroscopic, biochemical and biophysical approaches in the context of lipid-protein interactions and chaperone activities. A laboratory for the study of structure and dynamics of membrane proteins equipped with single-channel electrophysiology and electron magnetic resonance (EPR) spectroscopy together with fluorescence techniques are being established to generate functionally compatible models of novel membrane proteins under physiological conditions that are not amenable to crystallographic approaches. It has been found that chaperone-like protein HYPK interacts with the first 17 amino acid region of the protein Huntingtin (HTT) and modulates mutant HTT-mediated toxicity. Altered microRNA expression has already been implicated in HD pathogenesis. We have demonstrated the transcriptional regulation of multiple miRNAs (miR-100, miR-146a, miR-150) in human and mouse cells and also identified miR-432 as the first miRNA known to be regulated by Heat Shock Factor 1. Investigation is underway on the post-transcriptional regulation of Mitofusin 2 (MFN2) via miR-214 and transcriptional regulation by a transcription factor E2F1.

1.2.2 Publications

1.2.2.1 Publications in Journal

Abhijit Chakrabarti; Malay Patra, Differential interactions of two local anesthetics with phospholipid membrane and nonerythroid spectrin: Localization in presence of cholesterol and ganglioside, GM(1), *BIOCHIMICA ET BIOPHYSICA ACTA-BIOMEMBRANES* **1848** (2015) 821

Sumana Bhattacharjya; Kumar Singha Roy; Abira Ganguly; Nitai P Bhattacharyya; et al, Inhibition of nucleoporin member Nup214 expression by miR-133b perturbs mitotic timing and leads to cell death, *MOLECULAR CANCER* **14** (2015) Art No: 42

Mahan Ray†; Neha Rai†; Kuladip Jana; et al, Beta catenin is degraded by both caspase-3 and proteasomal activity during resveratrol-induced apoptosis in He. La cells in a GSK3 beta-independent manner, *INDIAN JOURNAL OF BIOCHEMISTRY & BIOPHYSICS* **52** (2015) 7

Malay Patra; Chaitali Mukhopadhyay; Abhijit Chakrabarti, Probing Conformational Stability and Dynamics of Erythroid and Nonerythroid Spectrin: Effects of Urea and Guanidine Hydrochloride, *PLOS ONE* **10** (2015) Art No: e0116991

Kamalika Roy Choudhury; Nitai P Bhattacharyya†, Chaperone protein HYPK interacts with the first 17 amino acid region of Huntingtin and modulates mutant HTT-mediated aggregation and cytotoxicity, *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS* **456** (2015) 66

Anindita Das; Abhijit Chakrabarti; Puspendu K Das, Suppression of protein aggregation by gold nanoparticles: a new way to store and transport proteins, *RSC ADVANCES* **5** (2015) 38558

Avik Basu; Abhijit Chakrabarti, Defects in Erythrocyte Membrane Skeletal Architecture, Edited Chakrabarti, A; Surolia, A in *BIOCHEMICAL ROLES OF EUKARYOTIC CELL SURFACE MACROMOLECULES* Book Series: Advances in Experimental Medicine and Biology **842** (2015) 41

Rakhi Paul; Madhumita Dandopath Patra; Udayaditya Sen, Crystal Structure of Apo and Ligand Bound Vibrio cholerae Ribokinase (Vc-RK): Role of Monovalent Cation Induced Activation and Structural Flexibility in Sugar Phosphorylation, Edited Chakrabarti, A; Surolia, A in *BIOCHEMICAL ROLES OF EUKARYOTIC CELL SURFACE MACROMOLECULES* Book Series: Advances in Experimental Medicine and Biology **842** (2015) 293

Shilpita Karmakar; Sutapa Saha; Debasis Banerjee†, Abhijit Chakrabarti, Differential proteomics study of platelets in asymptomatic constitutional macrothrombocytopenia: altered levels of cytoskeletal proteins, *EUROPEAN JOURNAL OF HAEMATOLOGY* **94** (2015) 43

Sudip Majumder; Susmita Khamrui; Ramanuj Banerjee; P Bhowmik; U Sen, A conserved tryptophan (W91) at the barrel-lid junction modulates the packing and stability of Kunitz (STI) family of inhibitors, *BIOCHIMICA ET BIOPHYSICA ACTA-PROTEINS AND PROTEOMICS* **1854** (2015) 55

Kasturi Guha; Sneha Das; Partha Saha, Lys-413 of S-phase mRNA cycling sequence binding protein from *Leishmania donovani* (LdCSBP) is modified through monoubiquitination that is responsible for inhibition of its riboendonuclease activity, *INDIAN JOURNAL OF BIOCHEMISTRY & BIOPHYSICS* **51** (2014) 559

Sangita Maiti Dutta†; Soumyajit Banerjee Mustafi; Sanghamitra Raha; et al, Assessment of thermal stress adaptation by monitoring Hsp70 and MnSOD in the freshwater gastropod, *Bellamya bengalensis* (Lamarck 1882), *ENVIRONMENTAL MONITORING AND ASSESSMENT* **186** (2014) 8961

Srijit Das; Nitai Pada Bhattacharyya, Heat shock factor 1 regulates hsa-miR-432 expression in human cervical cancer cell line, *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS* **453** (2014) 461

Piyali Mitra; Prabal Kumar Chakraborty; Partha SahaSamita Basu, Antibacterial efficacy of acridine derivatives conjugated with gold nanoparticles, *INTERNATIONAL JOURNAL OF PHARMACEUTICS* **473** (2014) 636

Arup Kumar Bag†; Sutapa Saha; Shyam Sundar† Abhijit Chakrabarti; et al, Comparative proteomics and glycoproteomics of plasma proteins in Indian visceral leishmaniasis, *PROTEOME SCIENCE* **12** (2014) Art No: 48

Swasti Raychaudhuri; Rachana Banerjee; Subhasish Mukhopadhyay; et al, Conserved C-terminal nascent peptide binding domain of HYPK facilitates its chaperone-like activity, *JOURNAL OF BIOSCIENCES* **39** (2014) 659

Rakhi Paul; Madhumita Dandopath Patra; Ramanuj Banerjee; U Sen, Crystallization and preliminary X-ray analysis of a ribokinase from *Vibrio cholerae* O395, *ACTA CRYSTALLOGRAPHICA SECTION F-STRUCTURAL BIOLOGY COMMUNICATIONS* **70** (2014) 1098

Kasturi Guha; Dipankar Bhandari; Titash Sen†; Partha Saha, Ubiquitination-mediated interaction among domains is responsible for inhibition of RNA endonuclease activity of mRNA cycling sequence binding protein from *L. donovani* (LdCSBP), *PARASITOLOGY RESEARCH* **113** (2014) 2941

Soma Banerjee†; Siddhi Chaudhuri†; Anup Kumar Maity; Partha Saha; et al, Role of caffeine in DNA recognition of a potential food-carcinogen benzo[a]pyrene and UVA induced DNA damage, *JOURNAL OF MOLECULAR RECOGNITION* **27** (2014) 510

Seema Nath; Ramanuj Banerjee; Udayaditya Sen, Atomic resolution crystal structure of VcLMWPTP-1 from *Vibrio cholerae* O395: Insights into a novel mode of dimerization in the low molecular weight protein tyrosine phosphatase family, *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS* **450** (2014) 390

Malay Patra; Madhurima Mitra; Abhijit Chakrabarti; et al, Binding of polarity-sensitive hydrophobic ligands to erythroid and nonerythroid spectrin: fluorescence and molecular modeling studies, *JOURNAL OF BIOMOLECULAR STRUCTURE & DYNAMICS* **32** (2014) 852

Sankar Basu; Dhananjay Bhattacharyya; Rahul Banerjee, Applications of complementarity plot in error detection and structure validation of proteins, INDIAN JOURNAL OF BIOCHEMISTRY & BIOPHYSICS **51** (2014) 188

Eashita Das; Nitai Pada Bhattacharyya, MicroRNA-432 contributes to dopamine cocktail and retinoic acid induced differentiation of human neuroblastoma cells by targeting NESTIN and RCOR1 genes, FEBS LETTERS **588** (2014) 1706

1.2.3 Ph D Awarded

Kamalika Roychaudhuri [Prof. Nitaipada Bhattacharyya], Protein Interacting Partners of HYPK, a Huntingtin-Interacting Protein, University of Calcutta, 2014

Joyeeta Ghose [Prof. Nitaipada Bhattacharyya], Regulation of microRNAs by p53 and NFkB in Cell Models of Huntington's Disease, University of Calcutta, October 2014

Sankar Basu [Prof. Rahul Banerjee], Self Complementarity: its Application in Probing Protein Internal Architecture, Fold Recognition and Structure Validation, University of Calcutta, June 2014

1.3 Chemical Science

1.3.1 Summary of Research Activities

Research in the Chemical Sciences Division is wide-ranging and interdisciplinary, and addresses fundamental aspects of science. Overarching goals of the research projects include understanding the excited state dynamics of complex phenomena using ultra fast spectroscopy and single molecule imaging, finding new functions for old drugs: Non Steroidal Anti-inflammatory Drugs (NSAIDs), different areas in Nuclear Chemistry, Radiochemistry and Green Chemistry, developing nanotechnology and novel advanced materials for a myriad of applications, unraveling problems associated with devising new, alternative sources of energy, neutron interaction, nano particle dosimetry and radiation safety. The excited state dynamics involving photo induced electron transfer between riboflavin and aliphatic amine was explored which helps to decipher different mechanisms of electron transfer operating from femtosecond to microsecond time domain. Moreover, photoinduced electron transfer and excited-state proton transfer reactions involving 9-aminoacridine hydrochloride hydrate and methyl viologen as well as simple organic amines were studied using laser flash photolysis corroborated with magnetic field effect. A spectroscopic inquest under surfactant and β -CD confinement involves photophysics of solvent sensitive keto-tetrahydrocarbazole based fluorophores and their interactions with amines. The amine moiety of acridine derivatives binds strongly to the gold nanoparticles which are very important as drug delivery vehicles for clinical applications. The antibacterial efficacy of these drugs coated with gold nanoparticles was studied against various strains of Gram positive and Gram negative bacteria. A control on hydrophobic and hydrophilic interactions was highlighted while studying the structural effects of different copper(II) and nickel(II)

Schiff base complexes on hen egg white lysozyme using steady state and time resolved absorption and fluorescence, and circular dichroism spectroscopy.

Copper complexes of Oxycam NSAIDs have been synthesized to study their biological applications. They form a new class of membrane anchors that require neither molecular recognition nor strength of interaction between interacting molecular partners, but still can effectively increase membrane fusogenic efficacy over the bare drugs. This new class of membrane anchors is therefore a step ahead of traditional anchors that are based on two interacting molecular partners. DNA-binding with high base sequence specificity and apoptosis inducing properties have also been found for these complexes.

Au-Polyaniline based conducting nano-composite has been utilized for bio-sensing of glucose, DNA and protein, using different electrochemical techniques and also for detecting the positional effect of single base mismatch in oligonucleotides. PEDOT-MnO₂ and graphene based materials have been used to fabricate supercapacitors of high specific capacitance.

A single molecule and ensemble spectroscopic study of protein folding, misfolding, aggregation and DNA-protein interaction have been carried on. Quantum chemical calculations have also been carried out to address some of the fundamental problems based on experimental findings.

The Nanophotonics group is actively engaged in the field of sustainable nano-architecture addressing both their development and applications. Recently the group has developed different architecture of nanomaterials which include tunable gold nano-flowers, silver nano-wires, selenium nano-spheres, intercalated nano-prism, branched gold nano-crystals, and porous silver nano-materials. Nanophotonics group also successfully used these materials in effective drug delivery, Raman sensing of environmental heavy metals, catalysis, therapeutic prevention of viral infection, and in nanoplasmon biochip for bioanalytical detection. Recently the nuclear chemistry group along with the international collaboration working at GSI, Germany independently confirmed new element 117 and discovered new isotope ²⁶⁶Lr.

Carbonic acid (H₂CO₃) molecule is an unstable and elusive species as it decomposes rapidly into CO₂ and H₂O molecules. However, in the vast literature of carbonic acid, it was not known how carbonic acid decomposes into its constituents CO₂ and H₂O molecules. This article describes that the primary mechanism for the decomposition of carbonic acid is autocatalytic, especially at its source, where the vapor phase concentration of H₂CO₃ molecules reaches its highest levels. In other words, H₂CO₃ molecule decomposes in presence of another H₂CO₃ molecule. The results of this study specifically and strongly suggest that double hydrogen transfer within the eight-membered cyclic doubly hydrogen-bonded (H-bonded) ring interface of the H₂CO₃ homodimer is ultimately the starting mechanism for the isomerization of the carbonic acid, especially, during the sublimation of the H₂CO₃ polymorphs at cold temperature (210-260K). Computational studies for a new mechanism for the diol formation catalyzed by formic acid have been completed. More generally, the results of this study have important mechanistic ramifications for how the gas phase hydrolysis of carbonyl compounds, which is the forbidden process in presence of single water molecule in our atmosphere, can be catalyzed by organic acids in the atmosphere. How glyoxal-diol and glyoxal-tetrol might be formed under atmospheric conditions associated with water-restricted environments have also been studied. In addition, present work also strongly suggest that the formation of these precursors for secondary organic aerosol growth is not likely restricted solely to the bulk aqueous phase as is currently assumed.

Dose distribution profile for photon and charged particle therapy have been studied in the framework of particle interaction and transport code FLUKA. Synthesis and influence of silver nano-particles in dose enhancement for gamma irradiation is being studied. Effect of nuclear mean field in neutron emission from heavy ion reaction has been studied in the energy range of 10 MeV/amu to 30

MeV/amu. For $^{20}\text{Ne}+^{165}\text{Ho}$ system it has been observed to remove the over prediction at back angles.

1.3.2 Publications

1.3.2.1 Publications in Journal

Ankan Dutta Chowdhury; Nidhi Agnihotri; Amitabha De, Hydrolysis of sodium borohydride using Ru-Co-PEDOT nanocomposites as catalyst, *CHEMICAL ENGINEERING JOURNAL* **264** (2015) 531

Moumita Maiti; Kaustab Ghosh; Susanta Lahiri, Green methods for the radiochemical separations of no-carrier-added ^{61}Cu , ^{62}Zn from ^7Li irradiated cobalt target, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **303** (2015) 2033

Agnihotri, Nidhi; Ankan Dutta Chowdhury; Amitabha De, Non-enzymatic electrochemical detection of cholesterol using beta-cyclodextrin functionalized graphene, *BIOSENSORS & BIOELECTRONICS* **63** (2015) 212

Nidhi Agnihotri; Kuntal Chakrabarti; Amitabha De, Highly efficient electromagnetic interference shielding using graphite nanoplatelet/poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) composites with enhanced thermal conductivity, *RSC ADVANCES* **5** (2015) 43765

Sourav Ghoshal; Montu K Harzra, $\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ decomposition in the presence of H_2O , HCOOH , CH_3COOH , H_2SO_4 and HO_2 radical: instability of the gas-phase H_2CO_3 molecule in the troposphere and lower stratosphere, *RSC ADVANCES* **5** (2015) 17623

Chaitrali Sengupta; Manas Kumar Sarangi; Abhishek Sau Samita Basu, A case study of photo induced electron transfer between riboflavin and aliphatic amine: Deciphering different mechanisms of ET operating from femtosecond to microsecond time domain, *JOURNAL OF PHOTOCHEMISTRY AND PHOTOBIOLOGY* **A296** (2015) 25

Amrit Krishna Mitra; Sujay Ghosh; Manas Kumar Sarangi; Abhishek Sau Samita Basu, Influence of microheterogeneity on the solution phase photophysics of a newly synthesised, environment sensitive fluorophore 2-((7,8-dimethyl-1-oxo-2,3,4,9-tetrahydro-1H-carbazol-6-yl)oxy) acetic acid and its tagged derivative, *JOURNAL OF PHOTOCHEMISTRY AND PHOTOBIOLOGY* **A296** (2015) 66

Moumita Maiti; Susanta Lahiri, Measurement of yield of residues produced in C-12+Y-nat reaction and subsequent separation of Ru-97 from Y target using cation exchange resin, *RADIOCHIMICA ACTA* **103** (2015) 7

Moupriya Nag; Kallol Bera; Soumen Basak, Intermolecular disulfide bond formation promotes immunoglobulin aggregation: Investigation by fluorescence correlation spectroscopy, *PROTEIN-STRUCTURE FUNCTION AND BIOINFORMATICS* **83** (2015) 169

Satya N Guin†; Velaga Srihari; Kanishka Biswas†, Promising thermoelectric performance in n-type AgBiSe_2 : effect of aliovalent anion doping, *JOURNAL OF MATERIALS CHEMISTRY* **A3**

(2015) 648

Tahsina Shireen†; Arnab Basu; Munna Sarkar; et al, Lipid composition is an important determinant of antimicrobial activity of alpha-melanocyte stimulating hormone, *BIOPHYSICAL CHEMISTRY* **196** (2015) 33

Anupa Majumdar; Sreeja Chakraborty; Munna Sarkar, Modulation of Non Steroidal Anti-Inflammatory Drug Induced Membrane Fusion by Copper Coordination of These Drugs: Anchoring Effect, *JOURNAL OF PHYSICAL CHEMISTRY* **B118** (2014) 13785

Moumita Maiti; Susanta Lahiri, ARCEBS-2014: a platform for nuclear and accelerator scientists, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **302** (2014) 755

Kaustab Ghosh; Moumita Maiti†; Susanta Lahiri; et al, Ionic liquid-salt based aqueous biphasic system for separation of ^{109}Cd from silver target, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **302** (2014) 925

Arpita Datta; Moumita Maiti; Susanta Lahiri, Separation of ^{97}Ru from niobium target using PEG based aqueous biphasic systems, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **302** (2014) 931

Moumita Maiti†; Kaustab Ghosh; Tania M Mendonca†; Susanta Lahiri, Comparison on the production of radionuclides in 1.4 GeV proton irradiated LBE targets of different thickness, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **302** (2014) 1003

Alok Srivastava†; Susanta Lahiri; Moumita Maiti†; et al, Study of naturally occurring radioactive material (NORM) in top soil of Punjab State from the North Western part of India, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **302** (2014) 1049

Ankan Dutta Chowdhury; Nidhi Agnihotri; Amitabha De; Munna Sarkar, Detection of positional mismatch in oligonucleotide by electrochemical method, *SENSORS AND ACTUATORS* **B202** (2014) 917

Amrit Krishna Mitra†; Sujay Ghosh; Manas Kumar Sarangi; Samita Basu, Photophysics of a solvent sensitive keto-tetrahydrocarbazole based fluorophore and its interaction with triethylamine: A spectroscopic inquest under surfactant and beta-CD confinement, *JOURNAL OF MOLECULAR STRUCTURE* **1074** (2014) 617

Sujay Ghosh; Amrit Krishna Mitra†; Samita Basu; et al, 5,6,7,9-Tetrahydro-[1,3]dioxolo[4,5-h]carbazol-8-one: A solvatochromic PET-acceptor fluorescent probe, *JOURNAL OF LUMINESCENCE* **153** (2014) 296

Mitra, Piyali; Brotati Chakraborty; Samita Basu, Exploring photoinduced electron transfer and excited-state proton transfer reactions involving 9-aminoacridine hydrochloride hydrate and methyl viologen using laser flash photolysis, *CHEMICAL PHYSICS LETTERS* **610** (2014) 108

Upal Das Ghosh†; Chinmay Saha†; Moumita Maiti†; Susanta Lahiri; et al, Root associated iron oxidizing bacteria increase phosphate nutrition and influence root to shoot partitioning of iron in

tolerant plant *Typha angustifolia*, *PLANT AND SOIL* **381** (2014) 279

Sourav Ghoshal; Montu K Hazra, Autocatalytic Isomerizations of the Two Most Stable Conformers of Carbonic Acid in Vapor Phase: Double Hydrogen Transfer in Carbonic Acid Homodimers, *JOURNAL OF PHYSICAL CHEMISTRY* **A118** (2014) 4620

Shyamaprosad Goswami†; Avijit Kumar Das†; Abhishek Manna† Partha Saha; et al, Nanomolar Detection of Hypochlorite by a Rhodamine-Based Chiral Hydrazone in Absolute Aqueous Media: Application in Tap Water Analysis with Live-Cell Imaging, *ANALYTICAL CHEMISTRY* **86** (2014) 6315

Swadesh Mandal; Ajoy Mandal, A simple and sensitive separation technique of ^{99}Mo and ^{99m}Tc from their equilibrium mixture, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **301** (2014) 297

Susanta Lahiri, Letter to the Editor: A simple and sensitive separation technique of ^{99}Mo and ^{99m}Tc from their equilibrium mixture (DOI: 10.1007/s10967-013-2770-x), *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **301** (2014) 301

Swadesh Mandal, Letter to the Editor: A simple and sensitive separation technique of ^{99}Mo and ^{99m}Tc from their equilibrium mixture (DOI: 10.1007/s10967-013-2770-x) Reply, *JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY* **301** (2014) 303

Montu K Hazra; Joseph S Francisco†; Amitabha Sinha†, Hydrolysis of Glyoxal in Water-Restricted Environments: Formation of Organic Aerosol Precursors through Formic Acid Catalysis, *JOURNAL OF PHYSICAL CHEMISTRY* **A118** (2014) 4095

J Khuyagbaatar†; A Yakushev†; Ch E Duellmann† S Lahiri; et al, $^{48}\text{Ca} + ^{249}\text{Bk}$ Fusion Reaction Leading to Element $Z=117$: Long-Lived α -Decaying ^{270}Db and Discovery of ^{266}Lr , *PHYSICAL REVIEW LETTERS* **112** (2014) Art No: 172501

Piyali Mitra; Brotati Chakraborty; Samita Basu, A spectroscopic investigation of the photophysical behaviour of 9-aminoacridine hydrochloride hydrate in presence of organic amines in homogeneous and heterogeneous media, *JOURNAL OF LUMINESCENCE* **149** (2014) 221

Hari Shankar Biswas; Jagannath Datta; Pintu Sen†; et al, Raman spectra of electrochemically hydrogenated diamond like carbon surface, *CHEMICAL PHYSICS LETTERS* **600** (2014) 10

Sourav Ghoshal; Montu K Hazra, New Mechanism for Autocatalytic Decomposition of H_2CO_3 in the Vapor Phase, *JOURNAL OF PHYSICAL CHEMISTRY* **A118** (2014) 2385

Piyali Mitra; Prabal Kumar Chakraborty; Partha Saha; P Ray, S Basu, Antibacterial efficacy of acridine derivatives conjugated with gold nanoparticles, *INTERNATIONAL JOURNAL OF PHARMACEUTICS* **473** (2014) 636

Banabithi Koley Seth; Aurkie Ray; Sampa Biswas; Samita Basu, NiII Schiff base complex as an enzyme inhibitor of hen egg white lysozyme: a crystallographic and spectroscopic study, *METALLOMICS* **6** (2014) 1737

BHV Pai; M Nandy; A Krishnamoorthy; et al, Comparative study of Self-Compacting Concrete mixes containing Fly Ash and Rice Husk Ash, AMERICAN JOURNAL OF ENGINEERING RESEARCH **03** (2014) 150

BHV Pai†; M Nandy; A Krishnamoorthy†; et al, Experimental study on Self-Compacting Concrete containing industrial by-products, EUROPEAN SCIENTIFIC JOURNAL **10** (2014) 292

BHV Pai†; M Nandy; A Krishnamoorthy†; et al, Development of Self-Compacting Concrete with Various Mineral Admixtures, AMERICAN JOURNAL OF CIVIL ENGINEERING **2** (2014) 96

Arjunan Manikandan†; Biplab Sarkar†; Maitreyee Nandy, et al, Detector system dose verification comparisons for arc therapy: couch vs gantry mount, JOUR APPL CLINIC MED PHYS **15** (2014) 41

Mala Das, Debasish Das; Anjali Mukherjee, Maitreyee Nandy, Exploring radiation in many splendors, CURRENT SCIENCE **107** (2014) 15

1.3.3 Ph D Awarded

Binita Dutta[Prof Sushanta Lahiri], Studies on Detection, Complexation and Dynamics of Technetium, Rhenium and Osmium using Analytical and Nuclear Techniques, University of Calcutta, Kolkata, July 10, 2014

Sreeja Chakraborty[Prof Munna Sarkar], Metal complexes of NSAIDs and their bio application, Jadavpur University, Kolkata, December 2014

1.3.4 Seminars/Lectures given in Conference/Symposium/Schools

Samita Basu

- i. Protein small molecule interactions using spectroscopy and crystallography, Biennial Conference on Frontiers in Chemical Sciences (FICS-2014), Indian Institute of Technology, Guwahati, Dec 4-6, 2014
- ii. Deciphering charge transfer reaction of red-ox active riboflavine with amines at different time scales and its application in cell imaging assembled with Au nanoparticles, Advances in Spectroscopy and Ultrafast Dynamics (ASUD-2014), Indian Association for the Cultivation of Science, Kolkata, Dec 12-14, 2014
- iii. Electronic Spectroscopy: a tool for elucidation of photophysical and photochemical pathways of chemical and biological reactions, World Science Congress, 4th International Conference on Science for Sustainable Development, Jadavpur University, Kolkata, Dec 16-18, 2014
- iv. A spectroscopic study on interactions between hen egg white lysozyme protein and copper and nickel schiff base complexes, National Symposium 2015, Department of Chemistry, Burdwan University, Feb 19-21, 2015
- v. Importance of structure of reactant and medium in photoinduced reactions probed by steady-

state and time-resolved electronic spectroscopic techniques and magnetic field effect, Barasat University, West Bengal, Feb 19, 2015

vi. Spectroscopy: an interaction of light with matter, DST-JBNSTS INSPIRE Science Camp, JBNSTS, Kolkata, Mar 25, 2015

vii. Electronic Configuration and Valency, DST-JBNSTS INSPIRE Science Camp, JBNSTS, Kolkata, July 23, 2014

Maitreyee Nandy

i. Nuclear reaction - Probing the nucleus before equilibration, Workshop on Physics of Particles & Nuclei and related Instrumentation, Physics Department, Benaras Hindu University, Jan 27-31, 2015

ii. Heavy ion reaction at low energies and the HION model, Workshop on Physics of Particles & Nuclei and related Instrumentation, Physics Department, Benaras Hindu University, Jan 27-31, 2015

1.3.5 Teaching elsewhere

Samita Basu

M Sc (Inorganic Chemistry special), Calcutta University on Spectroscopy, January-March, 2015

M Sc (Physical Chemistry special), Midnapore College, Vidyasagar University, West Bengal, on Photochemistry, April, 2014

M Sc (General and Physical Chemistry special), Bidhannagar College, West Bengal State University, West Bengal on Photochemistry, August-September, 2014

Maitreyee Nandy

M Sc (Radioactivity), Biophysics & Molecular Biology, University of Calcutta, III semester, 2014-2015

M Sc (Bioinformatics), University of Calcutta, III semester, Oct-Dec, 2014

1.4 Computational Science

1.4.1 Summary of Research Activities

Computational Science Division installs and maintains the following infrastructure in the SINP campus. All the central facilities are open to all the users of the Institute.

High Speed Local Area Network Wired and Wireless Infrastructure: SINP boasts to have a fully structured network environment in place for more than a decade now. The network is divided into security zones called MZ (Military zone) and DMZ (de-Military Zone); and connected to Internet via a Firewall/Router. All inward access is either via VPN or dual-hop inward secured shell access. All the internet facing servers are placed in the DMZ.

Presently there are 2 core switches and 12 distribution switches. All the distribution switches are fibre-connected to both of the core switches forming seamless HA (high available) infrastructure. The main backbone (Core-Distribution) is 1Gbps and Distribution to Edge switches, about 32 in

number, are either connected through 100Mbps or in some cases through 1 Gbps via copper.

There are about 42 Access Points connecting to Wireless LAN Controller via the wired network to provide wireless access cloud throughout the campus. Various SSIDs are broadcast to facilitate different categories of users. Users are authenticated with Radius servers in the backend which are running in virtual and physical infrastructures on High Availability mode. Segregation between guests and local users are ensured based on local user accounts and hardware addresses to ensure wireless security.

Layer 3 IP Virtual LANs are configured and various access control lists (ACL) are employed to sanitize traffic and ensure better utilization of the network resources. The ACLs also help to mitigate any malware propagation.

High Available (HA) Cluster running Internet Services: HA Cluster is running all the major Internet facing services namely Web, Proxy, Ftp, Mail, IMAP/POP, DNS, LDAP, secured dual hop inward access etc. All the services are authenticated from central LDAP services and user uses same credential to access all or most of the services. The Division has installed a Disaster Recovery setup. So that in case of declared disaster, such as fire in the main center (Room no. 235 and 237) that hamper the activities, the setup would provide continued service from a secondary site. To accommodate the data centre needs of Disaster Recovery (DR) site a modular data centre is procured and currently operational in Room no. 3401. The enhanced setup will ensure all round better availability, security and performance. Presently the services run in a mix of Virtual and Physical instances, having high availability achieved between both the instances.

Modular Data Centre and Data Centre: New initiative was taken up for the project of implementation of a full-fledged Data Centre at the server room to house namely High performance Computing Facilities, CMS Grid Infrastructure, HA Cluster etc. To house the Disaster Recovery (DR) infrastructure, a Modular Data Centre (MDC) was procured and installed. The Modular Data Centre or MDC, i.e. a Data Centre in a box with all the functionality of a formal Data Centre (DC), e.g. Precision Air Conditioning, HA UPS, Proper design of rack for air-flow etc. MDC architecture is also chosen for its movability. In future if the Institute opens up another campus, we would shift the MDC to that campus to achieve better disaster recovery and meet the guidelines of a proper DR setup. Both the projects assume availability of appropriate backup power like DG sets.

New Website for the Institute: The division along with members of New-Website committee worked hand in hand to address the need of a structured CMS (Content Management System) based website for our Institute incorporating modern technology, standards, and UAT and security guidelines. Using the system departmental, personal, different application part of the website can be updated by the appropriate authorised persons in a de-centralized manner. Apart from that the scope included implementation of some applications like Conferences, Colloquia/Seminar, Newsletter, Tender Management, Telephone Directory, Video and Image Gallery, Document Store. The implementation includes a unique Class of User concept for authentication for various services/applications. The new website was inaugurated on the foundation day i.e. 11th Jan, 2014 by the Director.

Perimeter and End Point Security and other Security Measures: The Project of hardware Firewall/Unified Threat Management (UTM) system for perimeter and end points, the system was placed in the network replacing its software counterpart. Other than basic Firewalling/Intrusion Prevention System, the UTM also works as a gateway agent for malware and spam control. Some of the benefits of the Unified Threat Management (UTM) system are the following: Hardware Gateway for high-speed Access (>1Gbps)

Authenticated Access and hardware proxy

Anti-malware Gateway

Hardware Firewall

High Availability of Firewall and Internet access

Network Access Control and endpoint security

The division also takes care of the various IT security needs of the above installations and that of the Institute at large. The recommendations and guidelines of the CISAG (Computer & Information Security Advisory Group), DAE are followed and periodic exercises and assessments are carried out. As instructed by the CISAG (Chief Information Security Audit Group, DAE), initiatives were taken to form a group of technical members to help CISO in the domain of work.

1.4.2 Publications

1.4.2.1 Publications in Journal

Gautam Garai; Biswanath Chowdhury†, A cascaded pairwise biomolecular sequence alignment technique using evolutionary algorithm, *INFORMATION SCIENCES* **297** (2015) 118

Manas Mondal; Devapriya Choudhury†; Jaydeb Chakrabarti†; Dhananjay Bhattacharyya, Role of indirect readout mechanism in TATA box binding protein-DNA interaction, *JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN* **29** (2015) 283

Sanchita Mukherjee; Senthilkumar Kailasam†; Manju Bansal†; Dhananjay Bhattacharyya, Stacking Interactions in RNA and DNA: Roll-Slide Energy Hyperspace for Ten Unique Dinucleotide Steps, *BIOPOLYMERS* **103** (2015) 134

Manas Mondal; Sanchita Mukherjee; Dhananjay Bhattacharyya, Contribution of phenylalanine side chain intercalation to the TATA-box binding protein-DNA interaction: molecular dynamics and dispersion-corrected density functional theory studies, *JOURNAL OF MOLECULAR MODELING* **20** (2014) Art No: 2499

Antarip Halder†; Sukanya Halder; Dhananjay Bhattacharyya; et al, Feasibility of occurrence of different types of protonated base pairs in RNA: a quantum chemical study, *PHYSICAL CHEMISTRY CHEMICAL PHYSICS* **16** (2014) 18383

Sanchita Mukherjee; Sangeeta Kundu; Dhananjay Bhattacharyya, Temperature effect on poly(dA).poly(dT): molecular dynamics simulation studies of polymeric and oligomeric constructs, *JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN* **28** (2014) 735

Antarip Halder†; Ayan Datta†; Dhananjay Bhattacharyya; et al, Why Does Substitution of Thymine by 6-Ethynylpyridone Increase the Thermostability of DNA Double Helices?, *JOURNAL OF PHYSICAL CHEMISTRY* **B118** (2014) 6586

Pavan Kumar Pingali; Sukanya Halder; Debasish Mukherjee; Sankar Basu; Rahul Banerjee; Dhananjay Bhattacharyya, Analysis of stacking overlap in nucleic acid structures: algorithm and application, *JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN* **28** (2014) 851

1.4.3 Ph D Awarded

Sukanya Halder[Prof Dhananjoy Bhattacharya], Structural Study of Ribonucleic Acids Using Theoretical Approaches, University of Calcutta, February 2014

Sanchita Mukherjee[Prof Dhananjoy Bhattacharya], Analysis of Nucleic Acids Through Computational Approaches University of Calcutta, January 2015

Chapter 2

Condensed Matter Physics including Surface Physics and NanoScience

2.1 Condensed Matter Physics

2.1.1 Summary of Research Activities

Colossal piezoresistance effect in $\text{Sm}_{0.55}(\text{Sr}_{0.5}\text{Ca}_{0.5})_{0.45}\text{MnO}_3$ single crystal has been observed. A huge piezoresistance $\sim 10^7$ at a small pressure (0.09 GPa) and a remarkable increase (at the rate of ~ 80 K/GPa) of metal-insulator transition temperature have been observed when uniaxial pressure was applied along the c-axis.

A new mechanism has been presented where doping a correlated band insulator leads to a half-metallic ferrimagnet. This mechanism is quite distinct from the mechanisms in well-known materials that exhibit this phenomenon like the manganites, double perovskites or Heusler alloys. This study can motivate a search for materials having the predicted properties and open up new opportunities in the area of spintronics

It has been shown that a charge qubit, comprising of an electron tunneling between two dots in an oxide-based double quantum dot (DQD), has very small decoherence at low temperatures and the size of the system can be only a few nanometers. This is in contrast to the usual charge qubit based on a semiconductor DQD. It has also been shown that stronger the electron couples to the environment lesser is the qubit decoherence.

Enhanced dielectric response has been observed for $\text{Gd}_2\text{Ti}_2\text{O}_7\text{-SiO}_2$ nano-composite with smaller $\text{Gd}_2\text{Ti}_2\text{O}_7$ particles. There is a peak broadening of ϵ' (real part of dielectric constant) versus temperature curves on increasing frequency which suggests diffuse phase transition. This work is expected to raise interest in similar materials as potential candidates for device application such as in gate dielectrics.

Why gamma-like distributions arise in different contexts irrespective of different dynamical rules is

addressed. A broad class of mass transport models are studied and it is shown that the variance of the subsystem mass in these models is proportional to the square of its mean. This form of the variance constrains the subsystem mass distribution to be a gamma distribution.

A bundle of fibers has been considered as a model for composite materials where breaking of the fibers occur due to a combined influence of applied load and external noise. They show that there exists a robust phase boundary between continuous (no waiting time) and intermittent fracturing regimes. They propose a prediction scheme that can tell when the system is expected to reach the continuous fracturing point from the intermittent phase.

A hydrodynamic description of the spherically symmetric outward flow of nuclear matter, using a nuclear model that introduces a weakly dispersive effect in the flow, has been considered. It is shown that even arbitrarily small values of dispersion makes the horizon fully opaque to any acoustic disturbance propagating against the bulk flow.

A giant enhancement of magnetoresistance (MR) by the formation of $\text{La}_{0.67}\text{Sr}_{0.33}\text{MnO}_3$ (LSMO) $\text{Pr}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ (PCMO) core-shell nanostructure has been achieved. The observed giant enhancement is the result of significantly weakened charge ordered state in the created ferromagnetic-charge ordered core-shell nanostructure. This study could be important for magnetic field sensor technology.

2.1.2 Developmental Work

2.1.2.1 Microstrip Ferromagnetic Resonance (MS-FMR)

We have developed Microstrip Ferromagnetic Resonance as a powerful probe for the spintronics materials. This technique is used to record electromagnetic wave absorbed by a system where its spin magnetic moments coupled by exchange interaction which is influenced under DC magnetic field. The precession frequency of ferromagnetics lies at the regime of microwave (-wave) ranged from 0.1 to about 100 GHz. This technique is employed to study the both static magnetic properties, for instances anisotropies, saturation magnetization, exchange coupling, etc. and as well as the dynamic magnetic properties such as spin wave study, magnon modes, g-factor, spin relaxation, etc. Our experimental set up is a very rare facility in India.

Biswanath Samantaray, Prabhat Mandal

2.1.3 Publications

2.1.3.1 Publications in Journal

M Majumder; S Kanungo†; A Ghoshray†; K Ghoshray, Magnetism of the spin-trimer compound $\text{CaNi}_3(\text{P}_2\text{O}_7)_2$: Microscopic insight from combined ^3P NMR and first-principles studies, PHYSICAL REVIEW **B91** (2015) Art No: 104422

Analabha Roy; Arnab Das, Fate of dynamical many-body localization in the presence of disorder, PHYSICAL REVIEW **B91** (2015) Art No: 121106

Chandan Upadhyay†; Pappu Kumar Harijan†; Anatoliy Senyshyn†...R Ranganathan; et al, Extraordinary enhancement of Neel transition temperature in nanoparticles of multiferroic tetragonal

compositions of $(1-x)\text{BiFeO}_3-x\text{PbTiO}_3$ solid solutions, APPLIED PHYSICS LETTERS **106** (2015) Art No: 093103

Hossein Ahmadvand†; Sayed Reza Safdari†; Ahmad Nozad Golikand†; Papri Dasgupta; Asok Poddar; et al, Exchange bias in $\text{Co}/\text{CoO}/\text{Co}_3\text{O}_4$ nanostructures, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **377** (2015) 19

Debarshee Bagchi, Thermally driven classical Heisenberg chain with a spatially varying magnetic field: thermal rectification and negative differential thermal resistance, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2015) Art No: P02015

S Mukherjee; BK Chakrabarti, Multivariable optimization: Quantum annealing and computation, EUROPEAN PHYSICAL JOURNAL-SPECIAL TOPICS **224** (2015) 17

Anirban Chakraborti†; Damien Challet†; Arnab Chatterjee; Bikas K Chakrabarti, Statistical mechanics of competitive resource allocation using agent-based models, PHYSICS REPORTS-REVIEW SECTION OF PHYSICS LETTERS **552** (2015) 1

S Dhara; R Roy Chowdhury ; S Lahiri ; et al, Synthesis, characterization and magnetic properties of $\text{Co}_x\text{Cu}_{1-x}$ ($x \sim 0.01-0.3$) granular alloys, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **374** (2015) 647

Kalipada Das; Tapas Paramanik; I Das, Large magnetocaloric effect in $\text{Ln}_{0.5}\text{Ca}_{0.5}\text{MnO}_3$ ($\text{Ln}=\text{Gd}, \text{DY}$) compounds: Consequence of magnetic precursor effect of rare earth ions, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **374** (2015) 707

SK Giri†; Papri Dasgupta; A Poddar; et al, Strain modulated large magnetocaloric effect in $\text{Sm}_{0.55}\text{Sr}_{0.45}\text{MnO}_3$ epitaxial films, APPLIED PHYSICS LETTERS **106** (2015) Art No: 023507

Tirthankar Banerjee; Abhik Basu, Thermal fluctuations and stiffening of symmetric heterogeneous fluid membranes, PHYSICAL REVIEW **E91** (2015) Art No: 012119

AI Jaman; Shamik Chakraborty†; Rangana Chakraborty, Millimeterwave rotational spectrum and theoretical calculations of cis-propionic acid, JOURNAL OF MOLECULAR STRUCTURE **1079** (2015) 402

G Kalai Selvan; D Bhoi; S Arumugam†; A Midya P Mandal, Effect of pressure on the magnetic and superconducting transitions of $\text{GdFe}_{1-x}\text{Co}_x\text{AsO}$ ($x=0, 0.1, 1$) compounds, SUPERCONDUCTOR SCIENCE & TECHNOLOGY **28** (2015) Art No: 015009

Tirthankar Banerjee; Niladri Sarkar; Abhik Basu, Generic nonequilibrium steady states in an exclusion process on an inhomogeneous ring, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2015) Art No: P01024

Rakesh Chatterjee; Anjan Kumar Chandra; Abhik Basu, Asymmetric exclusion processes on a closed network with bottlenecks, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2015) Art No: P01012

MQ Lone; A Dey; S Yarlagadda, Study of two-spin entanglement in singlet states, SOLID STATE COMMUNICATIONS **202** (2015) 73

A Midya; P Mandal, Giant magnetocaloric effect in ferromagnetic superconductor RuSr₂GdCu₂O₈, JOURNAL OF APPLIED PHYSICS **116** (2014) Art No: 223905

Urna Basu; PK Mohanty, Self-organised criticality in stochastic sandpiles: Connection to directed percolation, EPL **108** (2014) (2014) Art No: 60002

Debarshee Bagchi; PK Mohanty, A microscopic model of ballistic-diffusive crossover, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2014) Art No: P11025

Arafa Hassen†; Alexander Krimmel†; Prabhat Mandal, Comparative Study of the Layered Perovskites Pr_{1-x}A_{1+x}CoO₄, (A = Sr, Ca), JOURNAL OF THE AMERICAN CERAMIC SOCIETY **97** (2014) 36090

Santanu K Maiti†; Moumita Dey; SN Karmakar, Persistent charge and spin currents in a quantum ring using Green's function technique: Interplay between magnetic flux and spin-orbit interactions, PHYSICA E-LOW-DIMENSIONAL SYSTEMS & NANOSTRUCTURES **64** (2014) 169

Asim Ghosh; Arnab Chatterjee ; Anindya S Chakrabarti†; Bikas K Chakrabarti, Zipf's law in city size from a resource utilization model, PHYSICAL REVIEW **E90** (2014) Art No: 042815

Debaleen Biswas; Sk Faruque; Abdul Kader Md; Anil Kumar SinhaSupratic Chakraborty, Effect of thermal annealing and oxygen partial pressure on the swelling of HfO₂/SiO₂/Si metal-oxide-semiconductor structure grown by rf sputtering: A synchrotron x-ray reflectivity study, APPLIED PHYSICS LETTERS **105** (2014) Art No: 113511

Asim Ghosh; Nachiketa Chattopadhyay†; Bikas K Chakrabarti, Inequality in societies, academic institutions and science journals: Gini and k-indices, PHYSICA **A410** (2014) 30

RN Bhowmik; G Vijayasri; R Ranganathan, Structural characterization and ferromagnetic properties in Ga³⁺ doped α -Fe₂O₃ system prepared by coprecipitation route and vacuum annealing, JOURNAL OF APPLIED PHYSICS **116** (2014) Art No: 123905

A Rajak; BK Chakrabarti, Quantum annealing search of Ising spin glass ground state(s) with tunable transverse and longitudinal fields, INDIAN JOURNAL OF PHYSICS **88** (2014) 951

Paramita Dutta; Santanu K Maiti†; SN Karmakar, Electric field induced localization phenomena in a ladder network with superlattice configuration: Effect of backbone environment, AIP ADVANCES **4** (2014) Art No: 097126

L Gastaldo†; K Blaum†; A Doerr†S Lahiri...et al, The Electron Capture ¹⁶³Ho Experiment ECHO, JOURNAL OF LOW TEMPERATURE PHYSICS **176** (2014) 876

A Midya; N Khan; D Bhoi; P Mandal, Giant magnetocaloric effect in antiferromagnetic DyVO₄ compound, PHYSICA **B448** (2014) 43

S Dey†; SK Dey†; S Majumder†; A Poddar; P Dasgupta; S Banerjee, Superparamagnetic behavior of nanosized $\text{Co}_{0.2}\text{Zn}_{0.8}\text{Fe}_2\text{O}_4$ synthesized by a flow rate controlled chemical coprecipitation method, *PHYSICA* **B448** (2014) 247

D Mohan Radheep†; P Sarkar†; S Arumugam†P Mandal, Critical end point of the first-order ferromagnetic transition in a $\text{Sm}_{0.55}(\text{Sr}_{0.5}\text{Ca}_{0.5})_{(0.45)}\text{MnO}_3$ single crystal, *JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS* **365** (2014) 51

S Dey†; SK Dey†; K BaganiS Banerjee; et al, Overcoming inherent magnetic instability, preventing spin canting and magnetic coding in an assembly of ferrimagnetic nanoparticles, *APPLIED PHYSICS LETTERS* **105** (2014) Art No: 063110

Niladri Sarkar; Basu Abhik, Nonequilibrium steady states in asymmetric exclusion processes on a ring with bottlenecks, *PHYSICAL REVIEW* **E90** (2014) Art No: 022109

Niladri Sarkar; Abhik Basu, Active to absorbing state phase transition in the presence of a fluctuating environment: feedback and universality, *JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT* (2014) Art No: P08016

A Ghosh; S Yarlagadda, Analysis of the t(2)-V model, *PHYSICAL REVIEW* **B90** (2014) Art No: 045140

N Khan; P Mandal; D Prabhakaran†, Memory effects and magnetic relaxation in single-crystalline $\text{La}_{0.9}\text{Sr}_{0.1}\text{CoO}_3$, *PHYSICAL REVIEW* **B90** (2014) Art No: 024421

RN Bhowmik†; N Naresh†; B Ghosh; S Banerjee, Study of low temperature ferromagnetism, surface paramagnetism and exchange bias effect in $\alpha\text{-Fe}_{1.4}\text{Ga}_{0.6}\text{O}_3$ oxide, *CURRENT APPLIED PHYSICS* **14** (2014) 970

Anand Kumar Tripathi†; Mohan Chandra Mathpal†; Promod Kumar†Sheo Kumar Mishra; et al, Synthesis based structural and optical behavior of anatase TiO_2 nanoparticles, *MATERIALS SCIENCE IN SEMICONDUCTOR PROCESSING* **23** (2014) 136

KK Bardhan†; D Talukdar; UN Nandi†; CD Mukherjee, Universal scaling in disordered systems and nonuniversal exponents, *PHYSICAL REVIEW* **B89** (2014) Art No: 184201

A Midya; N Khan; D Bhoi; P Mandal, 3d-4f spin interaction and field-induced metamagnetism in RCrO_4 ($R=\text{Ho, Gd, Lu}$) compounds, *JOURNAL OF APPLIED PHYSICS* **115** (2014) Art No: 17E114

R Ramakumar†; AN Das; S Sil†, Lattice bosons in a quasi-disordered environment: The effects of next-nearest-neighbor hopping on localization and Bose-Einstein condensation, *PHYSICA* **A401** (2014) 214

Paramita Dutta; Santanu K Maiti†; SN Karmakar, A renormalization group study of persistent current in a quasiperiodic ring, *PHYSICS LETTERS* **A378** (2014) 1388

Atanu Rajak; Uma Divakaran†, Fidelity susceptibility and Loschmidt echo for generic paths in

a three-spin interacting transverse Ising model, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2014) Art No: P04023

Papri Dasgupta; Asok Poddar; Chandan Mazumdar, On the evaluation of specific heat from thermoelectric power, PHYSICA STATUS SOLIDI **B251** (2014) 877

Barnana Pal, Pulse-echo method cannot measure wave attenuation accurately, Ultrasonics **61** 6 (2015)

Tapas Paramanik; Kalipada Das; Tapas Samanta; I Das, Observation of large magnetocaloric effect in HoRu₂Si₂, J APPL PHYS **115** (2014) 083914

Vinay Kumar Shukla†; Soumik Mukhopadhyay; Kalipada Das; A Sarma; I Das, Direct experimental evidence of multiferroicity in a nanocrystalline Zener polaron ordered manganite, PHYSICAL REVIEW **B90** (2014) Art No: 245126

Atanu Rajak; Amit Dutta†, Survival probability of an edge Majorana in a one-dimensional p-wave superconducting chain under sudden quenching of parameters, PHYSICAL REVIEW **E89** (2014) Art No:042125

2.1.4 Ph D Awarded

Paramita Dutta [Prof SN Karmakar], Quantum Transport in Low-Divisional Systems, Sept 22, 2014

Moumita Dey [Prof SN Karmakar], Some Theoretical Aspects of spin Transport in Mesoscopic Systems, Nov 27, 2014

Niladri Sarkar [Abhik Basu], Statistical perspectives on soft matter and biologically motivated system, University Calcutta, Mar 2015

Dilip Kumar Bhoi [Prof Prabhat Mandal], Transport, Magnetic and Thermal Properties of the PrFeAsO_{1-x}Fy Superconductor, May 10, 2014

2.1.5 Seminars/Lectures given in Conference/Symposium/Schools

Barnana Pal

Acoustic resonator under pulse excitation and attenuation measurement, Conference on New Advances in Acoustics (NAA2015), Shanghai, China, Jan 31-Feb 2, 2015

Abhik Basu

Phase transitions and membrane stiffness in a class of asymmetric heterogeneous fluid membranes, Current Trends in Condensed Matter Physics - 2015", NISER, Bhubaneswar, Feb 19-22, 2015

Sudhakar Yarlagadda

Oxide devices - the next revolution, National Seminar on Recent Advances in Physics, Berhampur Univ, organized by Berhampur Univ. and IOP, Bhubaneswar, May 2014

Key-note Speaker

2.1.6 Teaching elsewhere**Abhik Basu**

Statistical Mechanics, M Sc Physics, Aug-Dec 2014, Presidency University

2.2 Surface Physics and Material Science**2.2.1 Summary of Research Activities**

Research activities of the Surface Physics & Material Science (SPMS) Division mainly encompass the growth of low-dimensional (mainly in nanometer length scale $\sim 1-100$ nm) metallic, semiconducting and organic materials via physical and chemical routes followed by their extensive characterizations with state-of-the-art techniques/tools for achieving tunable mechanical/electrical/magnetic/optical properties relevant in the forefront research areas of micro-nano science & technology. Synthesis of the condensed and soft materials in the form of ultra-thin layer and nanometer sized particles with different morphology are implemented by sophisticated growth techniques, like, molecular beam epitaxy (MBE), metal oxide vapour phase epitaxy (MOVPE), cluster ion deposition, sputtering, ion implantation, Langmuir-Blodgett (LB) techniques along with other conventional growth techniques, like, spin coating and wet chemical methods. The state-of-the-art characterization techniques, such as a 300 kV transmission electron microscope (TEM) attached with electron energy loss spectroscopy (EELS) and energy dispersive x-ray spectroscopy (EDX), high resolution scanning electron microscope (SEM) augmented with cathodoluminescence (CL) optical detection system, versatile x-ray diffraction (VXRD) system, X-ray photoelectron spectroscopy (XPS) systems along with angle resolved detection capability, ultra high vacuum based scanning tunneling microscope (STM) and ambient scanning probe microscopes (SPMs) are utilized for structural, compositional, optical, tribological and surface/interface analysis in routine manner. Epitaxially grown quantum dot structures, ion beam and cluster beam modified patterned surfaces, sputtered deposited oxide based ultrathin layer materials with high dielectric constant, ordered decorated organic thin films and chemically synthesized anisotropic metal nanoparticles render novel physical properties that have potential applications in CMOS technology, bio-sensing, plasmon based nanophotonics, optical switching devices. The ongoing activities of our division also involve strong national and international level collaborative and exchange programs. Additionally, our research activities include the materials collected from industrial areas and or used by human being to understand if they have any detrimental effect so far the social and environmental issues are concerned.

Glimpses of some important activities are given in the following.

Cathodoluminescence (CL) in a scanning electron microscope (SEM) is a powerful tool that is recently utilized for spectro-microscopy study of nanostructured semiconductors and localized sur-

face plasmon (LSP) modes from metallic nanostructures. While photon emission from semiconductor materials on interaction with an electron beam is well-understood, CL from plasmonic metal nanostructures is a relatively new field and certainly deserves more attention. Using our in-house CL-SEM facility (installed in 2010), we have investigated different LSP modes of varieties of gold (Au) nanoparticles with a high degree of spectral and spatial resolution (in the range of about 10-25 nm) which is of fundamental importance for applications such as biosensing, single molecule detection and photovoltaics. The experimental results are analysed with detail 3D finite-difference time-domain (FDTD) simulation. For a penta-twinned gold nanorod deposited on a silicon substrate, we have shown that, in the visible domain of the spectrum, the plasmon mode gets split into two distinct peaks due to substrate induced hybridization of in-plane and out-of-plane modes. We have demonstrated the first experimental realization on the selective excitation of two closely lying tips from the same spherical core of a multitipped gold nanoparticle with flower-like morphology where coupled plasmon modes are identified to be originated from the interaction between two closely spaced tips with a narrow angular separation.

Current efforts to develop novel nanostructured materials and devices are stimulating the need for implementation of suitable experimental probes to determine the structure and chemical composition of solids. Transmission electron microscopy (TEM) is one such important tool to deal with the structure of low-dimensional objects. TEM studies on various classes of materials to address a few intriguing physics issues were addressed last year. Here, following the two step reduction chemical method, we have synthesized crystalline gold coresilver shell bimetallic nanocrystals with different shapes and sizes in a single reaction environment. The HRTEM studies provide the direct experimental evidence of the silver halide model proposed by Sigmund et al. [*Lofton, C.; Sigmund, W. Adv. Funct. Mater. 2005, 15, 1197-1208*] to explain the kinetic growth mechanism behind their formation. In recent years, much attention has been paid on studies of metal dendritic nanostructures. We have adopted a simple dip-and-rinse galvanic displacement reaction to prepare dendritic silver nanostructure directly on germanium surfaces which reveal a novel growth process resulting in a new type of heteroepitaxy where large lattice mismatches (about 27.7% for the present case of the AgGe interface) can be accommodated by the formation of low-energy asymmetric tilt boundaries.

Deposition of size-selected metal nanoclusters on a substrate with very low kinetic energy helps to keep the clusters intact with respect to their shapes and sizes as compared to clusters in flight condition. Here we report formation of monodispersed films of size-selected copper nanoclusters (diameter ~ 3 nm) that are produced in a magnetron based gas aggregation type source equipped with a quadrupole mass filter (QMF) to select sizes of clusters before landing. Transmission Electron Microscopy (TEM) study shows that the size-distributions of isolated islands peaks around the predicted size of clusters which demonstrates very low diffusivity of these nano-scale islands on silicon surface.

The performances of organic semiconductor devices are crucially linked with their stability at the ambient atmosphere. The evolution of electronic structures of 20 nm thick rubrene films exposed to ambient environment with time has been studied by UV and X-ray photoemission spectroscopy (UPS and XPS), near edge X-ray absorption fine structure (NEXAFS) spectroscopy, and density functional theory (DFT). XPS, NEXAFS data, and DFT calculated values suggest the formation of rubrene-epoxide and rubrene endoperoxide through reaction of tetracene backbone with oxygen of ambient environment. Angle dependent XPS measurement indicates that the entire probed depth of the films reacts with oxygen by spending only about 120 min in ambient environment. The

HOMO peak of pristine rubrene films almost disappears by exposure of 120 min to ambient environment. The evolution of the valence band (occupied states) and NEXAFS (unoccupied states) spectra indicates that the films become more insulating with exposure as the HOMO-LUMO gap increases on oxidation. Oxygen induced chemical reaction completely destroys the delocalized nature of the electron distribution in the tetracene backbone of rubrene.

High- κ -based dielectric materials have been studied for its use as gate dielectric, an alternative to SiO_2 , to cope with the continuous miniaturization of metal-oxide-semiconductor (MOS) transistor structures for about 16 years. The control of leakage current through gate dielectric material has been still a challenge in the field of high- κ dielectric-based MOS technology and depends mainly on the crystallization of the high- κ film and formation of interfacial silicate layer. Our present studies address these issues for betterment of the high- κ -based devices. Specially, we are interested (i) to know the crystallization process of HfO_2 films; (ii) whether crystallization or Hf-Silicate formation or both are responsible for degradation of the electrical properties of the MOS device; and (iii) identification of a range of annealing temperature above which the performance of the device degrades.

A new theoretical approach for photoacoustic (PA) image simulation of an ensemble of cells with endocytosed gold nanoparticles is reported. In this model, each cell was approximated as a fluid sphere and suspended in a nonabsorbing fluid medium. It was assumed that the cellular optical absorption coefficient changed greatly because of endocytosis of nanoparticles; however, thermo-physical parameters remained unchanged because nanoparticles occupied negligible intracellular volume. The proposed model was explored to simulate PA images of numerical phantoms. It was observed that features of the phantoms are retained precisely in those simulated images. Also, speckles in PA images are significantly suppressed because of strong boundary buildup when cells are bounded to a region. Nevertheless, speckle visibility increases when cells are not bounded to a region.

The stability of Cl-terminated Si surface at ambient conditions and its evolution with time, which have immense importance for the growth of interesting nanostructures on it, were investigated using complementary methods. Structures of CTAB-silica mesostructured films on as-prepared and time-evolved Cl-Si substrates, obtained from XR and grazing incidence small-angle X-ray scattering (GISAXS) measurements, show transition from strongly attached near circular micelles to weakly attached more elliptical micelles, confirming the transition (from weak-hydrophilic toward weak hydrophobic) in microscopic level and growth of less homogeneous oxide layer.

The influence of poor solvent and thermal annealing, and their specific roles, in the crystalline ordering of poly (3-dodecylthiophene) [P3DDT] films, which are of immense importance in their performance as semiconducting materials, were investigated using complementary techniques. Edge-on oriented crystallites (Form-II like) are enhanced in the as-cast films prepared after addition of a poor solvent. However, the coil-to-rod-like conformational transition is more prevalent compared to the crystallites, suggesting that a poor solvent predominantly helps to overcome the unfavorable conformational transition. The best edge-on oriented crystallites are found for the P3DDT films prepared from a solution containing a large amount of poor solvent and subsequently annealing the film at around 130 °C.

The magnetic ground state of the $\text{Mn}_{50}\text{Ni}_{38.5}\text{Sn}_{11.5}$ alloy is investigated through dc/ac magnetization and low temperature (≥ 0.15 K) specific-heat (C_p (T)) measurements. The dc and ac

magnetization measurements indicate that the system can be identified as a cluster spin glass (CSG) phase in a ferromagnetic (FM) background, and as a conjunction of these two phases an exchange bias effect (EBE) is observed in this system. The presence of coexisting phases is further supported by our C_p (T) measurement. We attribute the existence of the CSG phase to the antiferromagnetic (AFM) interaction arising from the Mn-Mn antisite disorder which further enhances through martensite transformation. We also report the successful synthesis of both pristine Fe_3O_4 and the $\text{Fe}_3\text{O}_4@SiO_2$ core@shell structure. From SEM images we observe that each Fe_3O_4 microsphere is composed of a large number of smaller nanoballs. We have extensively studied the photoluminescence and photoconductivity properties of both pristine and SiO_2 coated Fe_3O_4 particles for the first time. An enhancement in photoluminescence emission is observed in the $\text{Fe}_3\text{O}_4@SiO_2$ core@shell samples, whereas a reduced and negative photoconductivity is observed in the same sample. SiO_2 coating reduces the concentrations of non-radiative trap levels at the interfaces of the core and shell, thereby resulting in the enhancement of photoluminescence intensity in the core-shell particles. An exponential rise and decay in photocurrent is observed upon UV irradiation in the ON and OFF state, respectively, for Fe_3O_4 , whereas for $\text{Fe}_3\text{O}_4@SiO_2$, we observe a transient rise in the photocurrent and this photocurrent is not stable. We have explained this unusual behavior of photocurrent.

Convex Arrhenius behaviour, rare in transitions between equilibrium phases of pure systems, is observed in the plot of heating rate vs. temperature for Nematic-Isotropic (N-I) transition of liquid crystalline MBBA through Differential Scanning Calorimetry (DSC). The plot is best fit by a monomolecular growth function, using which an entropy-driven activation barrier, increasing non-linearly with temperature, is obtained. Fourier Transform Infrared (FTIR) studies of MBBA around the N-I transition temperature show increase in out-of-plane benzene ring distortions and decrease in order along the C=N-C axis, consistent with DSC results of conformational entropy-driven barrier.

While monolayer area fraction versus time curves obtained from surface pressure-area isotherms for desorption-dominated (DD) processes in Langmuir monolayers of fatty acids represent continuous loss, those from Brewster Angle Microscopy (BAM) also show a 2D coalescence. For nucleation-dominated (ND) processes both techniques suggest competing processes, with BAM showing 2D coalescence alongside multilayer formation. Imaging Ellipsometry (IE) of horizontally transferred films onto Si(100) shows Stranski-Krastanov (SK) like growth for ND process in arachidic acid monolayer resulting in successive stages of monolayer, trilayer, multilayer islands, ridges from lateral island-coalescence and shallow wavelike structures from ridge-coalescence on the film surface. These studies show that lipophilic attraction between hydrocarbon chains is the driving force at all stages of long term monolayer dynamics.

We present a detailed investigation of the low-frequency dielectric and conductivity properties of conducting polymer nanowires. Our results, obtained by connecting nanowires in parallel, show that these polypyrrole nanowires behave like conventional charge-density wave (CDW) materials, in their nonlinear and dynamic response, together with scaling of relaxation time and conductivity. We find good agreement with a theory of weakly pinned CDW, screened by thermally excited carriers across the CDW gap.

The growth, morphology, and magnetic structure of ultrathin Cr films grown on a Ag(001) substrate are studied using low-energy electron diffraction (LEED), angle-resolved photoemission spectroscopy (ARPES), and ab initio density functional theory (DFT) calculations. The presence and

temperature dependence of $c(2)$ half-order spots in the LEED pattern, for low electron energies, along with the presence of characteristic Cr 3d bands in the ARPES spectra, confirm the existence of antiferromagnetic ordering for the Cr monolayer case. Our DFT calculations confirm that this is the most favored geometric and magnetic structure of the system. The Cr layer is found to retain a "two-dimensional" character with enhanced Cr 3d magnetic moments, despite being buried below a Ag monolayer, due to the absence of significant hybridization between Cr 3d and Ag 4d electronic states. The coverage dependence of the magnetic ordering indicates a maximum ordering above the expected monolayer coverage, possibly due to intermixing between Ag and Cr atoms in the overlayer.

2.2.2 Publications

2.2.2.1 Publications in Journal

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Mayukh K Ray; K Bagani; RK Singh†S Banerjee, Effect of Al doping on structural and magnetic properties of Ni₅₀Mn₃₇Al_xSb_{13-x} alloy, PHYSICA **B448** (2014) 33

Suman Mandal; Rachid Belkhou; Francesco Maccherozzi; Krishnakumar SR Menon, Magnetic skin layer of NiO(100) probed by polarization-dependent spectromicroscopy, APPLIED PHYSICS LETTERS **104** (2014) Art No: 242414

2.2.3 Ph D Awarded

Pabitra Das [Prof Tapas Kumar Chini], Optical properties of low dimensional structures using cathodoluminescence in a high resolution scanning electron microscope, University of Calcutta, September 2, 2014

Haradhan Mandal [Prof Madhusudan Roy and Prof Ashis Bhattacharya], Investigations into the Nature of some Solid Waste Pollutants through Different Physical Techniques, Viswa Bharati University, February 5, 2015

2.2.4 Seminars/Lectures given in Conference/Symposium/Schools

S Hazra

Structural ordering of semiconducting poly(3-dodecylthiophene) molecules, National Conference on Current Trends in Advanced Materials (CTMat-2014), Kolkata, Nov 19-21, 2014

Biswrup Satpati

i. Heteroepitaxy in chemically grown silver nanodendrites on germanium and mapping its surface plasmon associated photon emission, National workshop on Current Trends in Advanced Materials (CTMat-2014), VECC, Kolkata, Nov 19-21, 2014

ii. Ion Beam Induced Pattern Formation and Modification of Nanostructured Materials: Issues and Applications, CPP-IPR Workshop on Linear Tokamak Divertor Simulators for PSI Studies, CPP-IPR, Sonapur, Assam (a remote centre of Institute for Plasma Research, Gandhinagar), Nov 24-26, 2014

iii. Materials Science Research using Transmission Electron Microscopy and Associated Techniques, Workshop on CURRENT TRENDS IN RESEARCH ON ELECTRON MICROSCOPY IN MATERIALS SCIENCE, Electron Microscope Society of India East Zone, CGCRI, Kolkata, Dec 22, 2014

iv. Tilt Boundaries and Generalized Heteroepitaxy, conference on Current Trends in Condensed Matter Physics (CTCMP), National Institute of Science Education and Research (NISER), Bhubaneswar, Feb 19-22, 2015

Alokmay Datta

i. National Workshop on Physics of Low Dimensional Structures (PLDS 2015) Department of Physics & Technophysics, Vidyasagar University, Mar 25-27, 2015

ii. National Workshop on Nano Science & Technology 2015, Department of Basic Sciences, Bankura Unnayani Institute of Engineering, Sponsored by Technical Education Quality Improvement Programme (TEQIP) II, Jan 19-23, 2015

iii. MATISSE Visiting Professor at Institut des Nanosciences de Paris, Universit Pierre et Marie Curie, France, 20 April 2014

iv. DST-JSPS Special Lecture Tour in Japan:
(a) Structure and Dynamics at some Biologically Interesting Interfaces. Nagoya University, Dec 10, 2014

(b) Long term dynamics at the air-water interface, J-PARC, Tokai, Dec 12, 2014

(c) Two-dimensional Pattern Evolution, Kyoto University, Dec 14, 2014

(d) Two Aspects of A Liquid Crystal: Phase Transition and Self-Organized Growth Template, Doshisha University, Dec 15, 2014

Chapter 3

Experimental Nuclear and Particle Physics

Chapter 3

Experimental Nuclear and Particle Physics

3.1 Applied Nuclear Physics

3.1.1 Summary of Research Activities

Research work done at the Applied Nuclear Physics Division involves probing the atomic, nuclear, molecular and nanocrystalline systems using nuclear probes, lasers, X-rays, electron and ion beams. Molecules of biological importance, hydrated crystalline compounds and low-dimensional systems, such as nano-crystalline wide band-gap semiconductors are also being studied to explore their properties. Research conducted during 2014-2015 are in the subject areas of coherent control mechanisms for neutral atoms using lasers, investigation on the structure and phase transition of nanomaterials, multiferroics, crystalline hydrated and intermetallic systems, soft matter and biomaterials, development, characterization and optimization of radiation detectors, model based simulation and cognitive science research to understand the details of visual perception.

In the positron annihilation laboratory, several new classes of materials have been studied using positron annihilation spectroscopic tools. The studies of nanocrystalline wide band gap semiconductors were continued whereas multiferroic materials and hexaferrite systems were also studied this year. Recently, the effects of calcium-doping in magnesium ferrite were studied. Useful information on graphene oxide reinforcement and subsequent reduction of polymer systems has also been obtained.

Inulins, the nano-meter size semi-crystalline particles, composed of oligomeric fructose units, have been subjected to fine micro-structural analysis under temperature variations using mainly positron annihilation spectroscopy for the first time. The results show a non-monotonous temperature sensitive behaviour of the positron parameters that help to understand the molecular stacking pattern. Considerable variation of its free volume size has been observed through the ortho-positronium pick-off component annihilation results. The material shows a major thermotropic transition at $\sim 320\text{K}$ and further a structure loss due to glass transition. Differential scanning calorimetry confirms the onset of the major molecular transition around the same temperature. A four detector TDPAC spectrometer, with $\text{LaBr}_3(\text{Ce})$ and BaF_2 scintillation detectors, has been installed where

the excellent γ -ray energy resolution of LaBr₃(Ce) detector is employed for detecting the 133 keV γ -ray energy of ¹⁸¹Ta (emitted from the ¹⁸¹Hf PAC probe). This gives also a relatively better time resolution compared to a BaF₂-BaF₂ set up. Using the BaF₂-BaF₂ and LaBr₃(Ce)-BaF₂ TDPAC set up, perturbed angular correlation studies in different Nickel, Cobalt, Zirconium, Hafnium and Rubidium based chemical compounds and intermetallic compounds of have been performed. It is found that both ZrF₄·3H₂O and HfF₄·3H₂O have monoclinic and triclinic crystal structures which contradict with earlier reports that HfF₄·3H₂O has monoclinic crystal structure and ZrF₄·3H₂O belongs to the triclinic crystal structure. The electric field gradient (EFG) in ZrNi has been computed by density functional theory (DFT) and the experimental EFG (from PAC measurement) was found to be in good agreement with the calculated value. In Hf₂Co₇, no magnetic interaction has been observed from present studies although a weak ferromagnetism was reported from previous PAC measurement. Experimental and numerical investigations on Micro-Pattern Gas Detectors (MPGD) have continued in our division. Studies related to electron transmission, ion back-flow fraction are successfully completed. Numerical studies on the effects of spacers are found to be very successful in predicting experimental results. Numerical studies on distortion in Time Projection Chambers using bulk Micromegas have also met with reasonable success.

Significant progress has been made in carrying out experimental and numerical studies on the effects of geometrical artifacts (including asperities) on the performance of Resistive Plate Chambers. In addition, exploration of the possibility of finding out an environmentally friendly gas mixture has been initiated. Finally, effects of detector ageing, especially due to SF₆, are under study.

The neBEM field solver has been parallelized, resulting in substantial improvement in computational efficiency. We are regularly contributing to the INO, RD51, CMS and LCTPC collaborations. The Indo-French collaborative project is also progressing well.

In the field of cognitive science, recent physiological studies has shown that a set of V1 neurons, in the area retinotopically related to blind spot (BS area), exhibit elevated response when completion occurs. In our study at SINP, we investigated filling in process in the framework of efficient hierarchical predictive coding (HPC) of natural images. In this framework, each processing level of visual system learns statistical regularities from natural scene and accordingly, it sends prediction signal to next lower level via feedback connections, as well as receives the residual error signal as an input via feed-forward connection. We simulated the bar completion experiment on the model network of HPC and recorded the response of neurons estimating the input signal at the lower level at the BS area of model network. The recorded responses exhibited good agreement with the physiological findings. Moreover, we generated the perceptual representation of those neural responses, and it resembled the bar completion. This study suggests that filling-in process could be an emergent property of the visual system following the general computational principle of HPC of natural images.

In the laser spectroscopy and Atomic Physics laboratory, observation of Electromagnetically Induced Transparency (EIT) in a six-level Lambda-type system in atomic Rbvapor containing both ⁸⁷Rb and ⁸⁵Rb is undertaken. The experimental observation includes five velocity selective optically pumped (VSOP) absorption dips for both ⁸⁷Rb and ⁸⁵Rb. The EIT signal appears on the background of one such VSOP absorption dips. The measured EIT linewidth shows sub-natural values for both lower and higher values of pump Rabi frequencies. A density matrix based theoretical model for the system is developed and solved numerically including the Doppler broadening. The simulated spectra are in good agreement with the experimental findings.

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. The discrepancies observed were found to be sub-shell dependent and attempts to account for it is being explored.

3.1.2 Publications

3.1.2.1 Publications in Journal

Bichitra Nandi Ganguly; Madhusudan Roy; SP Moulik†, Positron annihilation study of biopolymer inulin for understanding its structural organization, *POLYMER* **60** (2015) 137

CC Dey, An unusual structural phase transition in Rb_2HfF_6 , *JOURNAL OF PHYSICS AND CHEMISTRY OF SOLIDS* **78** (2015) 12

S Ghosh†; PMG Nambissan; S Thapa; et al, Defect dynamics in Li substituted nanocrystalline ZnO: A spectroscopic analysis, *PHYSICA* **B454** (2014) 102

A Roy†; A Banerjee†; S Biswas; S Saha, Performance simulation of a MRPC-based PET imaging system, *JOURNAL OF INSTRUMENTATION* **9** (2014) Art No: C10030

CC Dey, Microcrystalline phase transformation from $\text{ZrF}_4 \cdot \text{HF} \cdot 2\text{H}_2\text{O}$ to ZrO_2 through the intermediate phases ZrE_4 center dot $3\text{H}_2\text{O}$, $\text{ZrF}_4 \cdot \text{H}_2\text{O}$, Zr_2OF_6 center dot H_2O and ZrF_4 , *CHEMICAL PHYSICS LETTERS***612** (2014) 8

Barna Roy; Nand Kishor Kumar; Padinharu Madathil Gopalakrishnan Nambissan; et al, Evolution and interaction of twins, dislocations and stacking faults in rolled alpha-brass during nanostructuring at sub-zero temperature, *AIP ADVANCES* **4** (2014) Art No: 067101

HV Rahangdale; M Guerra†; PK Das; S Saha, Determination of subshell-resolved L-shell-ionization cross sections of gold induced by 15-40-keV electrons, *PHYSICAL REVIEW* **A89** (2014) Art No: 052708

NG Kling; D Paul; A Gura...S De...et al, Thick-lens velocity-map imaging spectrometer with high resolution for high-energy charged particles, *JOURNAL OF INSTRUMENTATION* **9** (2014) Art No: P05005

P Bhattacharya; S Bhattacharya; N Majumdar; S Mukhopadhyay; S Sarkar; et al, Performance studies of bulk Micromegas of different design parameters, *JOURNAL OF INSTRUMENTATION* **9** (2014) Art No: C04037

CE Rallis†; TG Burwitz†; PR Andrews†... S De; et al, Incorporating real time velocity map image reconstruction into closed-loop coherent control, *REVIEW OF SCIENTIFIC INSTRUMENTS* **85** (2014) Art No: 113105

3.1.3 Seminars/Lectures given in Conference/Symposium/Schools

Sankar De

- i. Intra-molecular scattering within dissociative diiodoacetylene, 20th National Conference on Atomic and Molecular Physics (NCAMP-XX), Thiruvananthapuram, Dec 2014
- ii. Dynamic fieldfree orientation of polar molecules by intense twocolor femtosecond laser pulses, 8th Asian Symposium on Intense Laser Science (ASILS8), Institute of Atomic and Molecular Sciences, Academia Sinica, National Taiwan University, Taipei, Taiwan, Nov 2014

3.1.4 Honours and Distinctions

Sankar De

Received the 5th ISUILS (International Symposium of Ultrafast Intense Laser Science) Award for Young Researchers, 2014. The award was sponsored by Japan Intense Light Field Science Society (JILS) and was presented by the International Committee on Intense Laser Sciences (ICILS). The symposium was held in Jodhpur, India in October, 2014. At the symposium, JPY 100,000 was awarded in cash as financial support to attend the symposium.

3.2 High Energy Nuclear and Particle Physics

3.2.1 Summary of Research Activities

The research activities in HENPP division can be categorized in four major directions. The details of these activities are given below.

ALICE Collaboration activities

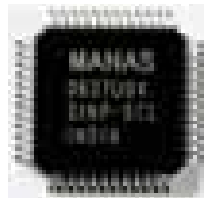
The current theory of strong interaction, Quantum Chromo Dynamics (QCD), predicts that at very high temperatures and energy densities, quarks and gluons are no longer confined inside the hadrons and they would exist in the form of free quarks and gluons, a state called Quark Gluon Plasma (QGP). Within the first few microseconds of the birth of the Universe, the temperature and energy density was extremely high and the primordial state of matter was a system of QGP. Thus, to understand the evolution of our Universe during its infancy, we need to create and study the formation of QGP in the laboratory. This can be done by colliding two heavy nuclei at very high energies. In the LHC heavy-ion programme, Lead beams collide at energies up to 30 times higher than in previous laboratory experiments. In these heavy-ion collisions, matter is heated to more than 100,000 times the temperature at the centre of the Sun over a tiny volume of the size of a nucleus and for an infinitesimally short instant. We then observe this QGP state as it reverts to hadronic matter through a complex set of particle and gamma detectors. A Large Ion Collider Experiment (ALICE) is the only dedicated heavy-ion experiment of LHC study this extreme, high-temperature phase of matter and provide novel access to the question of how most of the mass of visible matter in the Universe was generated in the first microseconds after the Big Bang. During the first three years of LHC operation, ALICE has collected data for p-p collisions ($\sqrt{s} = 0.9, 2.76, 7$ and 8 TeV), p-Pb collisions ($\sqrt{s} = 5.02$ TeV) and Pb-Pb collisions ($\sqrt{s} = 2.76$ TeV/nucleon).

Hardware and Software Deliverables

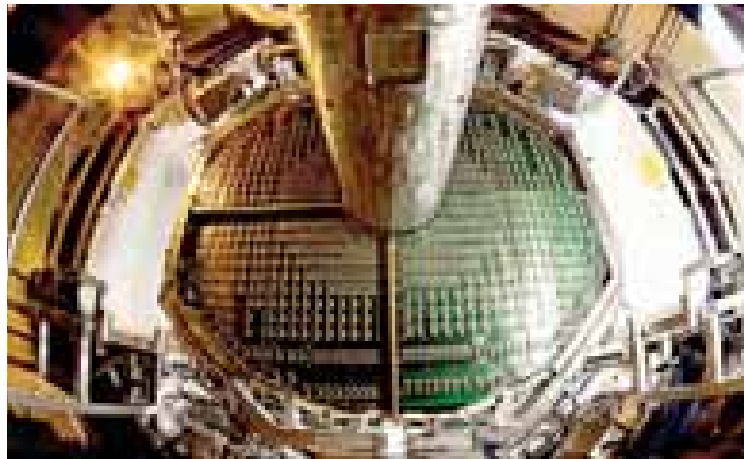
The Saha-ALICE group joined the ALICE Collaboration in 1997 and has been one of the founder laboratories who developed the Muon Spectrometer. Incidentally this has been the largest spectrometer ever built and Saha Institute has contributed substantially in its development and functionality. These contributions are:

1. MANAS Chip: This chip was designed and built in India and is being used by scientists from India, France, Italy, Russia and South Africa. A total of 1.1 Million tracking channels are read out by this chip and for this purpose a total of 1,10,000 MANAS chips were fabricated, tested and validated for quality assurance indigenously. The chips were fabricated at Semiconductor Complex Laboratory at Chandigarh under ISRO. During the first period of operation of LHC (2010-13) the performance of the chip was exceptionally stable and **eighteen (18) research papers** have been published in reputed journals using the data collected solely with MANAS chip.

2. The Muon Tracking Chambers: Saha Institute has fabricated ten (10) Cathode Pad chambers of 1.2 meters in diameter for tracking the muons emitted in the forward direction in ALICE.

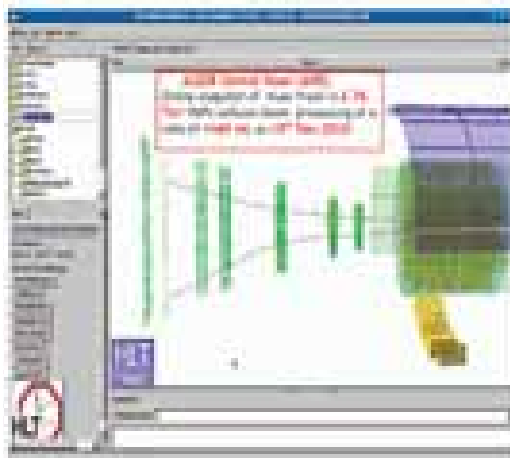


All the components of these chambers are made in India and the full assembly was carried out at Saha Institute. These are the largest detectors of its kind ever built. The detectors operation was stable and the data could be collected for the entire period of the LHC operation.



3. The Muon HLT: On the software front, the Saha-ALICE group developed the High Level Trigger (HLT) for the Muon Spectrometer right from the beginning. The entire program was

developed for real-time operation as there is no data buffer. **For this reason, specific hit reconstruction and track reconstruction algorithms were developed at Saha Institute.** This framework runs on a computer cluster at the ALICE experimental site and is capable of constructing online muon tracks from the digitized data.



Participation in Experiment and Data Analysis

Saha Institute is closely associated with the data collection, analysis and physics of heavy quarks (charm and beauty) which are formed at early stages of collision and are the unique probe for the QGP. The major milestones have been:

1. SINP group was responsible for the run-coordination of Muon Spectrometer in 2010 which was the first year of operation.
2. All the data were analyzed at SINP using the GRID facility.
3. The first measurements of suppression of Upsilon production at extreme forward angles (2^0 to 9^0) for the first time in nucleus-nucleus and proton-nucleus collisions and led to four publications of the ALICE Collaboration [Phys. Lett. B738, 361 (2014), Phys. Lett. B740, 105 (2014)].
4. SINP group was first to study Psi(2S) resonance in ALICE using the Muon Spectrometer [Eur. Phys. J. C74, 2974 (2014)]. The recent study on the production cross-section of Psi(2S) in proton-nucleus collisions has shown an anomalous behavior which cannot be described by existing models [Journal of High Energy Physics 12, 073 (2014)].
5. All the four publications are in journals with Impact Factor greater than five.
6. The first measurement of the double differential cross-sections of Jpsi at forward angles at LHC energies.
7. We reported the experimental results on suppression of Upsilon production for the first time in an International Conference which was Hard Probes 2013.

QGP Phenomenology

This activity is being pursued for last 15 years with emphasis on the study of anisotropic quark-gluon plasma (AQGP), intensity correlations and heavy quarks in ultra-relativistic heavy ion collisions. The highlights of these studies in recent times are:

1. We have worked on the characterisation of collective modes induced by relativistic jets in a collision-less anisotropic quark-gluon plasma (AQGP) assuming a colorless Tsunami-like momentum distribution of the jet partons. Within the framework of the transport equation, we derive and discuss the dispersion relations for both the stable and unstable modes of the composite system in the Vlasov approximation. We consider the case when the wave vector is parallel to the anisotropy direction as the growth rate of the unstable mode is maximum in this scenario [Phys.Rev. D89

(2014) 7, 074016].

2. We have also studied the intensity correlation for the photons dileptons at most central collision at RHIC energy having fixed transverse momentum of one of the photons ($k_{1T} = 2$ GeV) to have an idea about the emission zone in presence of initial momentum space anisotropy [Phys.Rev. C89 (2014) 5, 054915].

3. We have studies quarkonium production in p-p collisions at LHC energies using the formalism of non-relativistic QCD and showed that the existing data from the four Collaborations namely, ALICE, ATLAS, CMS and LHCb, can well be reproduced within our model. [accepted in Jour. Phys. G.]

4. In another study we have shown that due to the consideration of thermalized charm quark, the energy loss of heavy quark increases if the QCD coupling is taken as running [arXiv:1408.6705]

CMS Collaboration activities

After a very successful period of data taking during Run I and the much awaited discovery of the Standard Model Higgs boson, the Large Hadron Collider (LHC) went offline from early 2013 for energy and luminosity upgrade. The CMS detector also underwent a number of upgrade to get ready for the Run II data taking which is scheduled to start in mid-2015. The CMS group from SINP has ongoing responsibilities for the Run II data taking, in detector performance and calibration studies of the hadron calorimeter, tracker validation, bad channel calibration, and tracking performance studies. The group is also involved in the LHC Phase II tracker development studies.

Run I Physics Studies and Computing:

A major effort was made in analyzing proton-proton data collected by the CMS experiment during the period 2009-2013 (termed as Run 1). We have contributed to the study of a number of key physics questions with long term involvement, namely: (1) SM Higgs boson studies in the 4-lepton decay mode, e.g $11\tau\tau$, in associated production with W where the higgs decays into $\tau\tau$; (2) search for dark matter and extra-dimension; (3) search for compositeness for leptons; (4) inclusive jet production at different energies and event shape studies. We have also been involved in (1) SM Higgs boson studies in the $\gamma\gamma$ decay mode (differential distributions), and in the 4-lepton decay mode ($4e$, 4μ , $2e2\mu$). The Asian CMS Data Analysis (CMSDAS) school was held in SINP in November 2013. All the data analysis exercises of the school with more than 50 participants was locally supported by our local computing cluster, set up in 2013. The same cluster also served significantly for the PhaseII Tracker related simulation studies.

Run II Preparation:

We have made substantial contribution to the calibration of the hadron calorimeter. Different approaches to do relative and absolute calibration of the calorimeter have been studied. In addition, strategies to trigger on isolated particles are pursued. Our group shares a major responsibility for the validation of the present tracker detector, tracker bad channel calibration and tracking performance studies.

Hadron Calorimeter Upgrade:

Several operational limitations and long-term concerns warrant the replacement of all existing photo-detectors that instrument the current HCAL detectors. It has been decided to replace HPDs with Silicon PMs (SiPM) and the single anode PMTs with multi-anode PMTs. There will be substantial increase in the number of channels in barrel (HB), endcap (HE) and forward (HF) detectors. This will demand higher speed communication. Also finer trigger primitives are required to handle

high pile-up. So the back-end electronics will be rebuilt by replacing VMEs with μ TCA crates and equipping them with μ HTR cards which are built in India as a joint venture of India-USA.



First set of cards is required for HF. A total of 54 μ HTR cards is required in total within LS1. All the required cards have been built in the industries in Bangalore and tested at SINP before being shipped to CERN. These cards required some power mezzanine cards and they have been tested at SINP. The three crates are now ready to be installed at CERN.

Phase II Upgrade:

The CMS tracker detector will be replaced entirely with a new design in order to operate at the high luminosity LHC. The proposed tracker will provide trigger at Level 1 in order to reduce and keep event rate at an acceptable limit. We've contributed towards the Associative Memory (AM) based L1 track trigger simulation studies. We have also made major contribution to the study of performance of the proposed L1 track trigger by looking at the improvement in electron rate. This study will be a part of the PhaseII tracker Technical Proposal. We are also responsible for the development of the digitizer software for the new tracker. Both ECAL and HCAL endcap calorimeters need replacement and there are two possible designs that have been proposed. The first of these uses a Shashlik type detector while the second option will utilize highly granular silicon pads for both ECAL and the front part of the HCAL. We have made major contribution to the simulation of both these options. The work will be a part of the Technical Proposal and eventually to the Technical Design Report (TDR).

Angular momentum generation mechanisms in $A \sim 100$ region

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.



The Indian National Gamma Array at TIFR

Research work in the field of "Nuclear structure studies at high spins" using the techniques of measuring ultrashort lifetimes of discrete nuclear states has been done. These lifetimes are in the picosecond or sub-picosecond range and are measured by using Doppler shift techniques. These techniques have been extensively used for the last 15 years. The highlights of their recent work in this field are the first experimental evidence of interplay between anti-magnetic and collective rotation [Physics Letters B 694 , 322 (2011)]
 development of a model to explore this interplay [Physical Review. C. 83, 024305 (2011)]
 the first systematic study to establish the transition from magnetic to collective rotation as a function of neutron number [Physics Letters B 710, 587 (2012)]
 the first experimental evidence of anti-magnetic rotation in a nucleus other than Cadmium [Phys. Rev. C89, 061303 (R) (2014)]
 the first measurement of level lifetimes in Doublet Bands of A 100 region [Phys. Rev. Lett 112, 202503 (2014)].

3.2.2 Publications

3.2.2.1 Publications in Journal

J Sethi†; R Palit†; JJ Carroll† S Chattopadhyay; et al, Spectroscopy of the low-lying states near the high spin isomer in $^{108}\text{Ag}^*$, ACTA PHYSICA POLONICA **B46** (2015) 703

Satyaki Bhattacharya; Mariana Frank†; Katri Huitu†; et al, Probing the light radion through diphotons at the Large Hadron Collider, PHYSICAL REVIEW **D91** (2015) Art No: 016008

AG Agocs; F Barile; GG BarnafoeldiS Chattopadhyay; D Das; K Das; L Das-Bose; et al, R&D on high momentum particle identification with a pressurized Cherenkov radiator, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION **A766** (2014) 92

Payal Mohanty; Mahatsab Mandal; Pradip K Roy, Two-photon correlation in anisotropic quark-gluon plasma, PHYSICAL REVIEW **C89** (2014) Art No: 054915

Leonard S Kisslinger†; Debasish Das, Psi and Upsilon production in pp collisions at 8.0 TeV,

MODERN PHYSICS LETTERS **A29** (2014) Art No: 1450082

N Rather; P Datta†; S Chattopadhyay; S Rajbanshi; A Goswami; et al, Exploring the Origin of Nearly Degenerate Doublet Bands in Ag-106, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 202503

Mahatsab Mandal; Pradip Roy, Jet-induced collective modes in an anisotropic quark-gluon plasma, PHYSICAL REVIEW **D89** (2014) Art No: 074016

TV Acconcia†; AG Agocs†; F Barile†S Chattopadhyay; D Das; K Das; L Das-Bose et al, A very high momentum particle identification detector, EUROPEAN PHYSICAL JOURNAL PLUS **129** (2014) Art No: 91

3.2.2.2 ALICE Collaboration

ALICE Collaboration, Two-pion femtoscopy in p -Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, PHYSICAL REVIEW **C91** (2015) Art No: 034906

ALICE Collaboration, Multiplicity dependence $K^*(892)^0$ and $\phi(1020)$ production in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICAL REVIEW **C91** (2015) Art No: 024609

ALICE Collaboration, Multiplicity dependence of jet-like two-particle correlation structures in p -Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV, PHYSICS LETTERS **B741** (2015) 38

ALICE Collaboration, Production of $\Sigma(1385)^\pm$ and $\Xi(1530)^0$ in proton-proton collisions at $\sqrt{s}=7$ TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 1

ALICE Collaboration, Measurement of electrons from semileptonic heavy-flavor hadron decays in pp collisions at $\sqrt{s}=2.76$ TeV, PHYSICAL REVIEW **D91** (2015) Art No: 012001

ALICE Collaboration, Production of inclusive $\gamma(1S)$ and $\gamma(2S)$ in p -Pb collisions at $\sqrt{S_{-NN}}=5.02$ TeV, PHYSICS LETTERS **B740** (2015) 105

ALICE Collaboration, Freeze-out radii extracted from three-pion cumulants in pp, p -Pb and Pb-Pb collisions at the LHC, PHYSICS LETTERS **B739** (2014) 139

ALICE Collaboration, Exclusive J/ψ Photoproduction off Protons in Ultraperipheral p -Pb Collisions at $\sqrt{s_{NN}}=5.02$ TeV, PHYSICAL REVIEW LETTERS **113** (2014) Art No: 232504

ALICE Collaboration, Measurement of Prompt D-Meson Production in p -Pb Collisions at $\sqrt{s_{NN}}=5.02$ TeV, PHYSICAL REVIEW LETTERS **113** (2014) Art No: 232301

ALICE Collaboration, Beauty production in pp collisions at $\sqrt{s}=2.76$ TeV measured via semi-electronic decays, PHYSICS LETTERS **B738** (2014) 97

ALICE Collaboration, Suppression of $\Upsilon(1S)$ at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$

TeV, PHYSICS LETTERS **B738** (2014) 361

ALICE Collaboration, Multiparticle azimuthal correlations in p-Pb and Pb-Pb collisions at the CERN Large Hadron Collider, PHYSICAL REVIEW **C90** (2014) Art No: UNSP 054901

ALICE Collaboration, Measurement of visible cross sections in proton-lead collisions at $\sqrt{s_{NN}}=5.02$ TeV in van der Meer scans with the ALICE detector, JOURNAL OF INSTRUMENTATION **9** (2014) Art No: P11003

ALICE Collaboration, Neutral pion production at midrapidity in pp and Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3108

ALICE Collaboration, Event-by-event mean $p(T)$ fluctuations in pp and Pb-Pb collisions at the LHC, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3077

ALICE Collaboration, Transverse momentum dependence of inclusive primary charged-particle production in p-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3054

ALICE Collaboration, Azimuthal anisotropy of D-meson production in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICAL REVIEW **C90** (2014)

ALICE Collaboration, Production of charged pions, kaons and protons at large transverse momenta in pp and Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICS LETTERS **B736** (2014) 196

ALICE Collaboration, Performance of the ALICE experiment at the CERN LHC, INTERNATIONAL JOURNAL OF MODERN PHYSICS **A29** (2014) Art No: 1430044

ALICE Collaboration, Measurement of quarkonium production at forward rapidity in collisions at TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2974

ALICE Collaboration, Upgrade of the ALICE Experiment Letter Of Intent, JOURNAL OF PHYSICS **G41** (2014) Art No: 087001

ALICE Collaboration, Technical Design Report for the Upgrade of the ALICE Inner Tracking System, JOURNAL OF PHYSICS **G41** (2014) Art No: 087002

ALICE Collaboration, Centrality, rapidity and transverse momentum dependence of J/Ψ suppression in Pb-Pb collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICS LETTERS **B734** (2014) 314

3.2.2.3 CMS Collaboration

CMS Collaboration, Search for supersymmetry using razor variables in events with b-tagged jets in pp collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW **D91** (2015) Art No: 052018

CMS Collaboration, Search for resonances and quantum black holes using dijet mass spectra in

proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW **D91** (2015) Art No: 052009

CMS Collaboration, Measurements of jet multiplicity and differential production cross sections of Z plus jets events in proton-proton collisions at $\sqrt{s}=7$ TeV, PHYSICAL REVIEW **D91** (2015) Art No: 052008

CMS Collaboration, Search for Monotop Signatures in Proton-Proton Collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW LETTERS **114** (2015) Art No: UNSP 101801

CMS Collaboration, Long-range two-particle correlations of strange hadrons with charged particles in pPb and PbPb collisions at LHC energies, PHYSICS LETTERS **B742** (2015) 200

CMS Collaboration, Study of Z production in PbPb and pp collisions at $\sqrt{s(NN)}=2.76$ TeV in the dimuon and dielectron decay channels, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 3** (2015) Art No: 022

CMS Collaboration, Search for Displaced Supersymmetry in Events with an Electron and a Muon with Large Impact Parameters, PHYSICAL REVIEW LETTERS **114** (2015) Art No: 061801

CMS Collaboration, Measurement of electroweak production of two jets in association with a Z boson in proton-proton collisions at $\sqrt{s}=8$ TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 66

CMS Collaboration, Differential cross section measurements for the production of a W boson in association with jets in proton-proton collisions at $\sqrt{s}=7$ TeV, PHYSICS LETTERS **B741** (2015) 12

CMS Collaboration, Study of Vector Boson Scattering and Search for New Physics in Events with Two Same-Sign Leptons and Two Jets, PHYSICAL REVIEW LETTERS **114** (2015) Art No: UNSP 051801

CMS Collaboration, Performance of the CMS missing transverse momentum reconstruction in pp data at $\sqrt{s}=8$ TeV, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: UNSP P02006

CMS Collaboration, Search for long-lived neutral particles decaying to quark-antiquark pairs in proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW **D91** (2015) Issue: 1

CMS Collaboration, Search for disappearing tracks in proton-proton collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2015) Art No: 096

CMS Collaboration, Measurement of the W boson helicity in events with a single reconstructed top quark in p p collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2015) Art No: 053

CMS Collaboration, Search for new physics in events with same-sign dileptons and jets in pp collisions at $\sqrt{s}=8$ TeV (vol 01, pg 163, 2014), JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2015) Art No: UNSP 014

CMS Collaboration, Search for new resonances decaying via WZ to leptons in proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICS LETTERS **B740** (2015) 83

CMS Collaboration, Measurement of the $pp \rightarrow ZZ$ production cross section and constraints on anomalous triple gauge couplings in four-lepton final states at $\sqrt{s}=8$ TeV, PHYSICS LETTERS **B740** (2015) 250

CMS Collaboration, Measurement of Prompt $\psi(2S)$ to J/ψ . Yield Ratios in Pb-Pb and p-p Collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICAL REVIEW LETTERS **113** (2014) Art No: 262301

CMS Collaboration, Searches for heavy Higgs bosons in two-Higgs-doublet models and for $t \rightarrow ch$ decay using multilepton and diphoton final states in pp collisions at 8 TeV, PHYSICAL REVIEW **D90** (2014) Art No: 112013

CMS Collaboration, Measurement of the $t\bar{t}$ production cross section in pp collisions at $\sqrt{s}=8$ TeV in dilepton final states containing one tau lepton, PHYSICS LETTERS **B739** (2014) 23

CMS Collaboration, Search for pair production of third-generation scalar leptoquarks and top squarks in proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICS LETTERS **B739** (2014) 229

CMS Collaboration, Identification techniques for highly boosted W bosons that decay into hadrons, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 12** (2014) Art No: 017

CMS Collaboration, Search for supersymmetry with razor variables in pp collisions at $\sqrt{s}=7$ TeV, PHYSICAL REVIEW **D90** (2014) Art No: 112001

CMS Collaboration, Search for standard model production of four top quarks in the lepton plus jets channel in pp collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 11** (2014) Art No: 154

CMS Collaboration, Search for heavy neutrinos and W bosons with right-handed couplings in proton-proton collisions at $\sqrt{s}=8$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3149

CMS Collaboration, Searches for electroweak neutralino and chargino production in channels with Higgs, Z, and W bosons in pp collisions at 8 TeV, PHYSICAL REVIEW **D90** (2014) Art No: 092007

CMS Collaboration, Measurement of differential cross sections for the production of a pair of isolated photons in pp collisions at $\sqrt{s}=7$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3129

CMS Collaboration, Search for excited quarks in the gamma plus jet final state in proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICS LETTERS **B738** (2014) 274

CMS Collaboration; TOTEM Collaboration, Measurement of pseudorapidity distributions of charged particles in proton-proton collisions at $\sqrt{s}=8$ TeV by the CMS and TOTEM experiments, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3053

CMS Collaboration, Search for neutral MSSM Higgs bosons decaying to a pair of tau leptons in pp collisions, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 10** (2014) Art No: 160

CMS Collaboration, Search for the associated production of the Higgs boson with a top-quark pair (vol 9, 087, 2014), JOURNAL OF HIGH ENERGY PHYSICS, **Issue 10** (2014) Art No: 106

CMS Collaboration, Measurement of the ratio of inclusive jet cross sections using the anti- k_T algorithm with radius parameters $R=0.5$ and 0.7 in pp collisions at $\sqrt{s}=7$ TeV, PHYSICAL REVIEW D **90** (2014) Art No: 072006

CMS Collaboration, Observation of the diphoton decay of the Higgs boson and measurement of its properties, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3076

CMS Collaboration, Study of hadronic event-shape variables in multijet final states in pp collisions at $\sqrt{s}=7$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue 10** (2014) Art No: 087

CMS Collaboration, Upgrade of the CMS muon system with triple-GEM detectors, JOURNAL OF INSTRUMENTATION **9** (2014) Art No: C10036

CMS Collaboration, Description and performance of track and primary-vertex reconstruction with the CMS tracker, JOURNAL OF INSTRUMENTATION **9** (2014) Art No: P10009

CMS Collaboration, Evidence of b-Jet Quenching in PbPb Collisions at root S-NN=2.76 TeV, PHYSICAL REVIEW LETTERS **113** (2014) Art No: 132301

CMS Collaboration, Measurement of top quark-antiquark pair production in association with a W or Z boson in pp collisions at $\sqrt{s}=8$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3060

CMS Collaboration, Measurement of prompt J/psi pair production in pp collisions at $\sqrt{s} = 7$ TeV, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 9** (2014) Art No: 094

CMS Collaboration, Search for the associated production of the Higgs boson with a top-quark pair, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2014) Art No: 087

CMS Collaboration, Measurement of the ratio $B(t \rightarrow j Wb)/B(t \rightarrow j Wq)$ in pp collisions at root s=8 TeV, PHYSICS LETTERS **B736** (2014) 33

CMS Collaboration, Constraints on the Higgs boson width from off-shell production and decay to Z-boson pairs, PHYSICS LETTERS **B736** (2014) 64

CMS Collaboration, Search for top-squark pairs decaying into Higgs or Z bosons in pp collisions at $\sqrt{s}=8$ TeV, PHYSICS LETTERS **B736** (2014) 371

CMS Collaboration, Search for massive resonances in dijet systems containing jets tagged as W or Z boson decays in pp collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 8** (2014) Art No: UNSP 173

CMS Collaboration, Search for massive resonances decaying into pairs of boosted bosons in semi-leptonic final states at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 8** (2014) Art No: UNSP 174

CMS Collaboration, Search for WW gamma and WZ gamma production and constraints on anomalous quartic gauge couplings in pp collisions at root s=8 TeV, PHYSICAL REVIEW **D90** (2014) Art No: 032008

CMS Collaboration, Measurement of jet multiplicity distributions in $t(\bar{t})$ production in pp collisions at $\sqrt{s}=7$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3014

CMS Collaboration, Search for jet extinction in the inclusive jet-p(T) spectrum from proton-proton collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW **D90** (2014) Art No: 032005

CMS Collaboration, Measurement of jet fragmentation in PbPb and pp collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICAL REVIEW **C90** (2014) Art No: 024908

CMS Collaboration, Measurement of the muon charge asymmetry in inclusive pp $\rightarrow W$ plus X production at $\sqrt{s}=7$ TeV and an improved determination of light parton distribution functions, PHYSICAL REVIEW **D90** (2014) Art No: 032004

CMS Collaboration, Search for invisible decays of Higgs bosons in the vector boson fusion and associated ZH production modes, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2980

CMS Collaboration, Measurement of WZ and ZZ production in pp collisions at in final states with b-tagged jets, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2973

CMS Collaboration, Measurement of the production cross section for a W boson and two b jets in pp collisions at $\sqrt{s}=7$ TeV, PHYSICS LETTERS **B735** (2014) 204

CMS Collaboration, Studies of dijet transverse momentum balance and pseudorapidity distributions in pPb collisions at $\sqrt{s_{NN}}=5.02$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2951

CMS Collaboration, Observation of a peaking structure in the $J/\psi\phi$ mass spectrum from $B^\pm \rightarrow J/\psi\phi K^\pm$ decays, PHYSICS LETTERS **B734** (2014) 261

CMS Collaboration, Search for pair production of excited top quarks in the lepton plus jets final state, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: 125

CMS Collaboration, Measurement of the production cross sections for a Z boson and one or more b jets in pp collisions at $\sqrt{s}=7$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: 120

CMS Collaboration, Measurement of the t -channel single-top-quark production cross section and of the V_{tb} CKM matrix element in pp collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: 090

CMS Collaboration, Probing color coherence effects in pp collisions at $\sqrt{s}=7$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2901

CMS Collaboration, Search for new physics in the multijet and missing transverse momentum final state in proton-proton collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: 055

CMS Collaboration, Observation of the Associated Production of a Single Top Quark - and a W Boson in pp Collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 231802

CMS Collaboration, Measurement of the triple-differential cross section for photon plus jets production in proton-proton collisions at $\sqrt{s}=7$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: 009

CMS Collaboration, Study of the production of charged pions, kaons, and protons in pPb collisions at $\sqrt{SN\bar{N}}=5.02$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 2847

CMS Collaboration, Search for supersymmetry in pp collisions at $\sqrt{s}=8$ TeV in events with a single lepton, large jet multiplicity, and multiple b jets, PHYSICS LETTERS **B733** (2014) 328

CMS Collaboration, Alignment of the CMS tracker with LHC and cosmic ray data, JOURNAL OF INSTRUMENTATION **9** (2014) Art No: P06009

CMS Collaboration, Measurement of four-jet production in proton-proton collisions at $\sqrt{s}=7$ TeV, PHYSICAL REVIEW **D89** (2014) Art No: 092010

CMS Collaboration, Search for $W' \rightarrow tb$ decays in the lepton plus jets final state in pp collisions at $\sqrt{s}=8$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 5** (2014) Art No: 108

CMS Collaboration, Evidence for the 125 GeV Higgs boson decaying to a pair of tau leptons, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 5** (2014) Art No: 104

CMS Collaboration, Measurement of the properties of a Higgs boson in the four-lepton final state, PHYSICAL REVIEW **D89** (2014) Art No: 092007

CMS Collaboration, Measurement of Inclusive W and Z Boson Production Cross Sections in pp Collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 191802

CMS Collaboration, Measurement of the W gamma and Z gamma inclusive cross sections in pp collisions at $\sqrt{s}=7$ TeV and limits on anomalous triple gauge boson couplings, PHYSICAL REVIEW **D89** (2014) Art No: 092005

CMS Collaboration, Measurements of $t\bar{t}$ Spin Correlations and Top-Quark Polarization Using Dilepton Final States in pp Collisions at $\sqrt{s}=7$ TeV, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 182001

CMS Collaboration, Search for Flavor-Changing Neutral Currents in Top-Quark Decays $t \rightarrow Zq$ in pp Collisions at $\sqrt{s}=8$ TeV, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 171802

CMS Collaboration, Search for Top-Quark Partners with Charge 5/3 in the Same-Sign Dilepton Final State, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 171801

CMS Collaboration, Measurements of the $t(\bar{t})$ charge asymmetry using the dilepton decay channel in pp collisions at $\sqrt{s}=7$ TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2014) Art No: 191

CMS Collaboration, Search for Top Squark and Higgsino Production Using Diphoton Higgs Boson Decays, PHYSICAL REVIEW LETTERS **112** (2014) Art No: 161802

CMS Collaboration, Event activity dependence of (nS) production in $\sqrt{s}=5.02$ TeV pPb and $\sqrt{s}=2.76$ TeV pp collisions, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2014) Art No: 103

CMS Collaboration, Measurement of higher-order harmonic azimuthal anisotropy in PbPb collisions at $\sqrt{s_{NN}}=2.76$ TeV, PHYSICAL REVIEW **C89** (2014) Art No: 044906

CMS Collaboration, Measurement of the top-quark mass in all-jets $t(\bar{t})$ events in pp collisions at $\sqrt{s}=7$ TeV, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: UNSP 2758

CMS Collaboration, Search for baryon number violation in top-quark decays, PHYSICS LETTERS **B731** (2014) 173

3.2.3 Seminars/Lectures given in Conference/Symposium/Schools

Sukalyan Chattopadhyay

- i. Fractional double differential cross-section of Jpsi in p-p and Pb-Pb collisions, ALICE Muon Workshop on 16.07.2014, Anton, France
- ii. Study of angular momentum generation mechanisms in atomic nucleus using INGA, the international conference on Frontiers of gamma spectroscopy 2015 (FIG15), VECC, Kolkata, Feb 18, 2015
- iii. Shapes and symmetries of Atomic Nucleus, NSF Colloquium of TIFR, Jan 14, 2015

3.3 Nuclear Physics

3.3.1 Summary of Research Activities

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 students programme of the Institute and also undertook teaching courses both in SINP and other neighbouring universities.

Nuclear Structure

Research work in nuclear structure can be broadly classified into two mass regions viz., $A \sim 140$ and $A \sim 40$ regions.

$A \sim 140$ region

Nuclear structure studies in the $A = 140$ region have been extended for the following isotopes: ^{142}Sm & ^{143}Eu . Excited states of ^{142}Sm (excitation energy ~ 12.5 MeV and spin 28^+) have been investigated using the INGA set up at TIFR. A new dipole band and three new quadrupole bands has been observed in ^{142}Sm . The life-times for the negative parity excited levels of these newly observed bands have been determined by means of DSAM analysis. The experimental $B(M1)$ values of the dipole band are well reproduced in the framework of the SPAC (Shears with Principal Axis Cranking) model calculation and were interpreted as magnetic rotational band.

The parity of the two observed dipole bands in ^{143}Eu has been firmly established from linear polarization measurements. Level lifetimes of these bands have been measured using DSAM. The drop in $B(M1)$ values, with spin, exhibits a clear signature of magnetic rotational character of these two bands. Configurations were assigned to the bands in the framework of shears mechanism with SPAC model calculation. Alignment of an additional proton in the $h_{11/2}$ orbital give rise to the unique observation of large increase in the $B(M1)$ values for the higher lying band. Further, life times of the states in the quadrupole structure have been measured using DSAM. The deduced $B(E2)$ values shows the characteristic decrease with spin which conclusively proves that these states have originated from anti magnetic rotation. This is the first evidence of anti magnetic rotation in a region other than $A \sim 100$.

$A \sim 40$ region

High spin states of ^{34}Cl and ^{33}S , populated through $^{27}\text{Al}(^{12}\text{C},\alpha n)$ and $^{27}\text{Al}(^{12}\text{C},\text{apn})$ reactions respectively, at $E(^{12}\text{C})=40\text{MeV}$, have been studied using the INGA facility. The level schemes of both these nuclei have been extended, utilizing the results of intensity, directional correlation and linear polarization measurements. Lifetimes of a few excited states have also been estimated for the first time using the DSAM. Large-basis shell-model (LBSM) calculations within the sd-pf space have been done to understand the microscopic origin of the excited states. For ^{34}Cl , the involvement of pf orbitals has been found to be essential to reproduce the negative-parity as well as high spin positive-parity states. Onset of collectivity, manifested through short half-lives and large $B(E2)$ values, have been reproduced well in the calculations. For ^{33}S , three levels of the negative parity yrast sequence were found to be connected by strong $E2$ transitions. The lifetimes of these states were determined by DSAM and have been utilized to study the evolution of collectivity with spin. These results provide the first experimental evidence of cluster structure and super deformation in odd- A nuclei of upper-sd shell. Theoretical interpretation of these states within LBSM is also unique.

Nuclear Reactions:

Quasi-elastic scattering excitation functions for the systems $^6,7\text{Li}+^{159}\text{Tb}$ have been measured from near-barrier to deep sub-barrier energies. Presently the data are being analyzed. From the quasi-elastic events the fusion barrier distribution will be extracted. The deep sub-barrier cross sections will be used to determine the surface diffuseness parameters for the two systems. The work on the simultaneous R-matrix analysis of $^{13}\text{C}(p,\gamma)^{14}\text{N}^*$ capture reaction and the low energy $^{13}\text{C}(p,p)$

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 been estimated using the estimated S-factor value.

In order to understand the effect of coupling of direct reaction channels on fusion and also the back angle quasi-elastic barrier distribution functions, the systems ${}^6,7\text{Li} + {}^{64}\text{Ni}$ was experimentally studied at near barrier energies. The results on the investigation of fusion of ${}^6\text{Li}$ with ${}^{64}\text{Ni}$ have been published. Subsequently, the detailed probing of the barrier distribution function in terms of the channel coupling effects have been completed and submitted for publication. The analysis of the experimental measurement of fusion excitation function and quasi-elastic barrier distribution function of ${}^7\text{Li} + {}^{64}\text{Ni}$ has recently been completed.

Study of the astrophysically important ${}^{12}\text{C}(\alpha, \gamma)$ reaction have been carried out using the indirect method. Two transfer reactions viz. ${}^{12}\text{C}({}^6\text{Li}, d)$ and ${}^{12}\text{C}({}^7\text{Li}, t)$ reactions, at 20 MeV, have been measured and studied. The alpha spectroscopic factor of the bound state of ${}^{16}\text{O}$ and especially of the ground state has been concluded to be strongly influenced by breakup. This has a scaling effect on the astrophysical E2 S-factor of the alpha capture reaction.

Developmental activities:

A low energy photon spectrometer (LEPS), which is a composite planar HPGe, has been characterized experimentally. 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.

3.3.2 Developmental Work

3.3.2.1 The development of the gas scintillation counter is being continued

The development of the gas scintillation counter is being continued. The detector has been tested with ${}^{55}\text{Fe}$ (5.5 keV X ray) source using Xenon gas and without any grid to produce secondary scintillation. A ET VUV Photomultiplier with peak spectral sensitivity at 130-180 nm was used to detect scintillation. However, no primary scintillation could be observed. The grids are now being fabricated to operate the detector in the secondary scintillation mode.

Chinmay Basu

3.3.2.2 Detection of alpha, gamma and Internal conversion electrons using Si-PIN diodes

The Si-PIN diode detectors and the preamplifiers, which are specially designed for X-ray and gamma ray detection, are costly and only available from international vendors. We are working to utilize cheap commercially available Si-PIN diodes to detect alpha, gamma and electrons. We are testing the diodes to select the most suitable one. Later, we are comparing their responses using commercial and locally fabricated preamplifiers for detection of radiation. To decrease the dark current at reverse bias condition, we have designed ways to cool the detector by liquid Nitrogen. Efforts are on to utilise thermoelectric coolers for the same.

Sangeeta Das; Arghya Chakraborty†; Arya Datta†; Sujib Chatterjee; Chandranath Marick; Jonaki Panja, M Saha Sarkar

3.3.3 Publications

3.3.3.1 Publications in Journal

S Sambhi; R Raabe; MJG Borge U Datta, $^{12}\text{C}+\text{p}$ resonant elastic scattering in the Maya active target, EUROPEAN PHYSICAL JOURNAL **A51** (2015) Art No: 25

D Banerjee; A Saha; T Bhattacharjee A Mukherjee; et al, Role of p-induced population of medium-mass ($A \sim 150$) neutron-rich nuclei, PHYSICAL REVIEW **C91** (2015) Art No: 024617

JT Matta; U Garg; W Li; et al, Transverse Wobbling in ^{135}Pr , PHYSICAL REVIEW LETTERS **114** (2015) Art No: 082501

Md Moin Shaikh; Subinit Roy; S Rajbanshi; MK Pradhan; A Mukherjee; P Basu; et al, Barrier distribution functions for the system $^6\text{Li}+^{64}\text{Ni}$ and the effect of channel coupling, PHYSICAL REVIEW **C91** (2015) Art No: 034615

Abhijit Bisoi; M Saha Sarkar; S Sarkar† S Ray R Kshetri A Goswami; et al, Collective excitations in S-33, PHYSICAL REVIEW **C90** (2014) Art No: 024328

S Rajbanshi; Abhijit Bisoi; Somnath Nag†; S Chattopadhyay; M Saha Sarkar A Goswami, Multiple magnetic rotational bands based on proton alignment in ^{143}Eu , PHYSICAL REVIEW **C90** (2014) Art No: 024318

Md Moin Shaikh; Subinit Roy; S Rajbanshi; MK Pradhan; A Mukherjee; P Basu; et al, Investigation of $^6\text{Li}+^{64}\text{Ni}$ fusion at near-barrier energies, PHYSICAL REVIEW **C90** (2014) Art No: 024615

S Adhikari; C Basu; IJ Thompson† AK Mitra, Observation of a breakup-induced α -transfer process for some bound states of O-16 populated by the C-12(Li-6,d)O-16* reaction, PHYSICAL REVIEW **C89** (2014) Art No: 044618

3.3.4 Seminars/Lectures given in Conference/Symposium/Schools

Ushasi Datta Pramanik

- i. Coulomb breakup as a novel spectroscopic tool and New results on 'ISLAND of inversion nuclei' i.e. Neutron-rich Na, Al, Mg, Department of Physics and Astronomy, Rutgers University, Rutgers, USA, Feb 6, 2014
- ii. Study of exotic nuclei using RIB facility, Stanford University, Physics Dept, USA, May 15, 2014
- iii. Coulomb breakup as a novel spectroscopic tool to probe directly the quantum numbers of the valence nucleon, Cyclotron Colloquium, Cyclotron Institute, Texas A & M, USA, Jun 24, 2014

Asimananda Goswami

- i. Advance techniques on gamma ray spectroscopy, DST-SERC School on Nuclear Structure at High Angular Momentum and Isospin, Oct 5-25, 2014, Tata Institute of Fundamental Research, India
- ii. Lifetime Measurements using Doppler Shift Attenuation Method
- iii. Gamma ray spectrometer

with high efficiency and energy resolution: Basics of gamma-ray tracking. iv. Summary talk, Frontiers in Gamma-Ray Spectroscopy (FIG15), Variable Energy Cyclotron Centre, Kolkata, India, Feb 18-20, 2015

Subinit Roy

Fusion Near Barrier(Two Talk), Summer School on Nuclear Fission and Related Phenomena, Variable Energy Cyclotron Centre, Kolkata, May 13-23, 2014

Experimental activities in and around FRENA (Two Talk), Winter School on Nuclear Astrophysics, Variable Energy Cyclotron Centre, Kolkata, Jan 19-31, 2015

M Saha Sarkar

^{136}Sn and three body forces, 75-years of Nuclear Fission: Present status and future perspectives, May 8-10, 2014, BARC, Mumbai

Experimental and theoretical efforts- relevance to Nuclear Astrophysics, Conference on Frontiers in Gamma-Ray Spectroscopy 2015 (FIG15), Variable Energy Cyclotron Centre, Kolkata, India, Feb 18-20, 2015

3.3.5 Teaching elsewhere

Chinmay Basu

Nuclear Reactions & Nuclear Astrophysics, Jan-Mar 2015, Department of Physics, University of Kolkata

Subinit Roy

Nuclear Astrophysics (21 Lectures) in Nuclear Reactions (Advance II), Advance Courses, M Sc (Physics), University of Calcutta, Kolkata, Jan-Mar, 2015

Asimananda Goswami

γ decay & Nuclear Instrumentation in Nuclear Reactions, Department of Physics, University of Calcutta , Jan-Mar, 2015

M Saha Sarkar

i. Shell evolution and collectivity in sd-shell nuclei - an experimentalist's view, school on Nuclear structure, IUAC, New Delhi, Apr 21-26th, 2014 (6 lectures)

II. Spectroscopy of nuclei near ^{132}Sn and shell model results, SERC-school for graduate students on "Nuclear structure at high angular momentum and isospin, Mumbai, Oct 5-25, 2014 (3 lectures)

Chapter 4

Plasma Physics

Chapter 4

Plasma Physics

4.1 Plasma Physics

4.1.1 Summary of Research Activities

Research activities in the plasma physics division encompass a variety of theoretical and experimental studies in the field of linear and nonlinear wave propagation. 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 environments and laboratory experiments. Using Lagrange fluid approach, collapse type processes associated with magnetosonic waves 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. Investigations on Bursian diodes in presence of transverse magnetic fields reveal interesting results that can help in designing fast electron switches with current interruption. Studies are also being pursued to understand the formation of different types of nonlinear structures in classical as well as quantum plasmas.

In the field of strongly coupled dusty plasmas, effects of velocity shear have been extensively studied to show new types of instabilities in dust acoustic and shear waves. In non-Newtonian plasmas, shear flow-rate dependent viscosity in the shear thickening and thinning regimes is shown to modify the growth rates of Kelvin-Helmholtz as well as Rayleigh-Taylor instabilities. The stability of large scale vortex in a strongly coupled dusty plasma is being studied with short scale perturbations. 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. Such process can transfer energy from long scale vortex to the short scale secondary wave and ultimately contribute to turbulence.

Experimental activities are being carried out in the MaPLE (Magnetized Plasma Linear Experiment), Double Layer Experiment (DLX), glow discharge plasma and the tokamak devices. In MAPLE device, nitrogen plasma produced by ECR discharge is used to study the parametric decay of waves in the ion cyclotron range of frequencies into linear modes. Along with a mode whose frequency lies in the range of density gradient driven drift wave, sidebands of incident wave are

also observed when the amplitude of the exciter signal goes above a threshold value. Sideband of the second harmonic is also observed. Preliminary analysis shows the possibility of ion Bernstein waves in the device. Wave dispersion studies to confirm the identity of the excited waves are in progress.

In DLX, 2D measurements in a plasma diffusing in a diverging magnetic field have been carried out showing 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. Study of self-excited drift waves due to strong density gradient that varies from peaked to hollow in presence of axially varying magnetic fields is also being carried out.

Nonlinear dynamic experiments are being carried out in the DC glow discharge plasma device revealing a variety of nonlinear phenomena such as homoclinic and inverse homoclinic bifurcation, intermittent chaos, mixed mode oscillations, spiking-bursting and coherent resonance. 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 autonomous differential equations known as jerk and spasm equations explain a number of interesting phenomena based on bifurcation diagrams.

4.1.2 Publications

4.1.2.1 Publications in Journal

S Garai; D Banerjee; MS Janaki; N Chakrabarti, Stabilization of Rayleigh-Taylor instability in a non-Newtonian incompressible complex plasma, *PHYSICS OF PLASMAS* **22** (2015) Art No: 033702

Neeraj Chaubey†; S Mukherjee; AN Sekar Iyengar†; et al, Synchronization between two coupled direct current glow discharge plasma sources, *PHYSICS OF PLASMAS* **22** (2015) Art No: 022312

Debajyoti Saha; Pankaj Kumar Shaw; Sabuj Ghosh; MS Janaki; AN Sekar Iyengar, Investigation and quantification of nonlinearity using surrogate data in a glow discharge plasma, *PHYSICS OF PLASMAS* **22** (2015) Art No: 022307

Manjistha Dutta†, Manoranjan Khan†; Nikhil Chakrabarti, Nonlinear interaction of electron acoustic waves with Langmuir waves in presence of magnetic field in plasmas, *JOURNAL OF PLASMA PHYSICS* **81** (2015) Art No: 905810106

Samiran Ghosh†; Nikhil Chakrabarti, Nonlinear wave collapse, shock, and breather formation in an electron magnetohydrodynamic plasma, *PHYSICAL REVIEW* **E90** (2014) Art No: 063111

Vramori Mitra†; Arun Sarma†; MS Janaki ; AN Sekar Iyengar Pankaj Kumar Shaw; Debajyoti Saha; Sabuj Ghosh, Order to chaos transition studies in a DC glow discharge plasma by using recurrence quantification analysis, *CHAOS SOLITONS & FRACTALS* **69** (2014) 285

Anirban Bose†; Mylavaram S Janaki, A simple method to obtain the equilibrium solution of Wigner-Boltzmann equation with all higher order quantum corrections, *EUROPEAN PHYSICAL JOURNAL* **B87** (2014) Art No: 259

Ashish Adak†; Samiran Ghosh†; Nikhil Chakrabarti, Rayleigh-Taylor instability in an equal mass plasma, *PHYSICS OF PLASMAS* **21** (2014) Art No: 092120

SS Ghosh†; AN Sekar Iyengar, Effect of cooler electrons on a compressive ion acoustic solitary wave in a warm ion plasma-Forbidden regions, double layers, and supersolitons, *PHYSICS OF PLASMAS* **21** (2014) Art No: 082104

Chandan Maity, Phase-mixing of Langmuir oscillations in cold electron-positron-ion plasmas, *PHYSICS OF PLASMAS* **21** (2014) Art No: 072317

Abhik Mukherjee; Anirban Bose†; MS Janaki, Quantum corrections to nonlinear ion acoustic wave with Landau damping , *PHYSICS OF PLASMAS* **21** (2014) Art No: 072303

Abhik Mukherjee; MS Janaki, Phase-modulated solitary waves controlled by a boundary condition at the bottom, *PHYSICAL REVIEW* **E89** (2014) Art No: 062903

Arun Sarma†; Supin Gopi†; Debajyoti Saha, Reformation of hydrocarbons using non-thermal plasma at atmospheric pressure: discharge characteristics and associated nonlinear dynamics, *PHYSICA SCRIPTA* **T161** (2014) Art No: 014064

SK Saha; S Chowdhury; MS Janaki; A Ghosh; AK Hui; S Raychaudhuri, Plasma density accumulation on a conical surface for diffusion along a diverging magnetic field, *PHYSICS OF PLASMAS* **21** (2014) Art No: 043502

4.1.3 Ph D Awarded

Chandan Maity [Nikhil Chakrabarti], Lagrangian Fluid Technique to study Nonlinear plasma Dynamics, Jadavpur university, Dec, 2014

Manjistha Dutta [Nikhil Chakrabarti & M Khan], Study of Nonlinear electron acoustic waves and their stability in plasmas, Jadavpur University, Dec, 2014

4.1.4 Seminars/Lectures given in Conference/Symposium/Schools

Nikhil Chakrabarti

Linear and weakly nonlinear waves in a strongly coupled plasma in presence of density dependent viscosity, the Second National symposium on Nonlinear and Complex Phenomena, organized by IASST, CPP-IPR (Assam) in association with ACNCP (Kolkata), Mar 26-28, 2015
Chaired a session

M S Janaki

i. Plasma density pile up on a conical surface during expansion along a divergent magnetic field, 29th National Symposium On Plasma Science & Technology, MG university, Kottayam, Kerala, Dec 8, 2014

ii. Plasma confinement in magnetic fields, Physics and Applied Mathematics Researchers' Meet -

2015, Indian Statistical Institute, Kolkata, Mar 18-20, 2015

iii. Nonlinear jerk equation describing chaotic electrostatic ion-cyclotron oscillations, National Seminar on Recent Trends in Applied Mathematics and its Computational Aspects, Dept of Applied Mathematics, Univ. Kolkata, Kolkata, Mar 25 -27, 2015

Chapter 5

Theoretical Physics & Astroparticle Physics

5.1 Astroparticle Physics and Cosmology

5.1.1 Summary of Research Activities

The Astroparticle Physics & Cosmology (APC) Division carries out research in the interface of High Energy Astrophysics, Cosmology and Particle & Nuclear physics. During the year 2014-2015 members of the Division have carried out research in a variety of observational, experimental and theoretical topics in Astroparticle Physics. Some highlights are given below: (i) Dark matter search with PICO-2L and bubble nucleation in superheated droplets: The PICO-2L dark matter search experiment with 2L-C3F8 bubble chamber is currently underway at the SNOLab underground facility in Sudbury, Canada, since November 2013. In this context, SINP group has performed research pertaining to (a) new study of bubble nucleation with tiny superheated droplets at low frequency. This study is useful in rejecting backgrounds both in neutron detection and dark matter search. (b) the detection of bubble nucleation event in superheated drop detector by pressure sensor and the associated circuits for the measurement of pressure.

(ii) High Energy Gamma Ray Astronomy: (a) Members of the Division are involved in analysis of middle-aged mixed-morphology (MM) supernova remnants (SNRs) interacting with molecular clouds using Fermi, X-rays and TeV gamma-ray data. This analysis has revealed radiative recombination structures of silicon and sulfur from supernova remnant 3C-391 using Suzaku data. The possible origin of this type of radiative plasma and hadronic gamma rays has been discussed. (b) The scientists of the Division are taking a leading role in various softwares and hardwares in connection to the calibration of telescopes as part of the future Cerenkov Telescope Array project.

(iii) Physics of Supernovae and Neutron Stars: (a) Exotic matter and its influences on neutron star structures have been investigated. A new hyperon equation of state (EoS) has been constructed for supernova simulations and neutron star mergers. This EoS is compatible with recently observed 2M solar neutron star. (b) The influence of isospin dependent entrainment has been stud-

ied in slowly rotating superfluid neutron stars. The Kepler frequency is modified due to the isospin dependent entrainment.

(iv) Theoretical research on Dark Matter: The particle nature of dark matter has been investigated within the framework of non-SUSY beyond standard models and these models were confronted with different observed phenomena such as observed gamma-ray excess from galactic center, 3.55 keV X-ray lines from Andromeda and other galaxies and galaxy clusters as well as several direct detection observational results. In this context we investigate the two-component Dark Matter scenario. The non-thermal dark matter such as out-of-equilibrium decay has been investigated. The astrophysical observation of excess gamma-rays as a possible signature of annihilating dark matter and thus, a possible indirect dark matter detection is elaborately and extensively studied in case of gamma-rays from galactic center, dwarf galaxies, Fermi bubbles as well as extra galactic sources.

While the particle nature of dark matter is probed from particle physics, the process of generation of dark matter as well as the astrophysical aspect of dark matter have also been studied in great details. The direct and indirect detection of dark matter have also been addressed with equal importance.

Furthermore, the rotation curve (RC) of the Galaxy has been constructed from a galactocentric distance of ~ 0.2 kpc to ~ 200 kpc by using kinematical data on a variety of both disk and non-disk objects that trace the gravitational potential of the Galaxy without assuming any theoretical models of the visible and dark matter components of the Galaxy. The resulting RC in the disk region is found to depend significantly on the choice of the Galactic Constants (GCs) while the dominant uncertainty in the RC at large distances beyond the stellar disk comes from uncertainties in the value of the velocity anisotropy parameter of the halo tracer objects.

(v) Neutrino mass models and baryogenesis: In continuation towards understanding a model of neutrino masses and mixing through the implementation of symmetries/ansatz, the following studies have been done: (a) Texture zero neutrino mass matrices with scaling ansatz property within the framework of inverse and linear seesaw mechanisms, (b) Maximal zero textures of the neutrino mass matrices in inverse seesaw mechanism with broken $\mu\tau$ reflection symmetry, (c) In addition, baryogenesis through leptogenesis (flavored, unflavored and τ -flavored) mechanism in a Cyclic symmetric model.

(vi) Gravitation: (a) The exact frame-dragging rate inside rotating neutron stars has been derived. The exact frame-dragging rate depends on both distance and angle. The application of this formalism leads to the appearance of local maximum and minimum along the equatorial distance. (b) The radius of the innermost stable circular orbit (ISCO) has been computed exactly for extremal KTN, Taub-NUT and massless Taub-NUT spacetimes. It is noted that the radius of the ISCO is independent of the NUT charge in the KTN spacetime.

5.1.2 Developmental Work

Single module detector system using superheated liquid

The R & D on the single module detector system using superheated liquid with condensation chamber for the next generation detector for dark matter search has been carried out. After studying several variations of the module, it has been observed that the bulk superheated liquid in a glass vessel, where possible nucleation sites are reduced using a surfactant, is the most stable one. The up-gradation of this chamber to larger volume and the maintaining of differential temperature along the condensation chamber tube are under way.

Mala Das

5.1.3 Publications

5.1.3.1 Publications in Books/Monographs & Volumes Edited

Debasish Majumdar

Dark Matter: An Introduction, CRC Press, Taylor & Francis, 2014, ISBN 9781466572119

5.1.3.2 Publications in Journal

Kamakshya Prasad Modak, 3.5 keV X-ray line signal from decay of right-handed neutrino due to transition magnetic moment, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 3** (2015) Art No: 064

BS Acharya; C Aramo; A Babic; et al, The Cherenkov Telescope Array potential for the study of young supernova remnants, ASTROPARTICLE PHYSICS **62** (2015) 152

Apurba Kheto; Debades Bandyopadhyay, Slowly rotating superfluid neutron stars with isospin dependent entrainment in a two-fluid model, PHYSICAL REVIEW **D91** (2015) Art No: 043006

Biswajoy Brahmachari†; Probir Roy, Testable constraint on near-tribimaximal neutrino mixing, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 2** (2015) Art No: 135

Mainak Chakraborty; H Zeen Devi†; Ambar Ghosal, Scaling ansatz with texture zeros in linear seesaw, PHYSICS LETTERS **B741** (2015) 210

Basudhara Basu; Sibaji Raha; Swapan K Saha; et al, Observation of a rare cosmic ray event at mountain altitude, ASTROPARTICLE PHYSICS **61** (2015) 88

Amit Dutta Banik; Debasish Majumdar, Velocity- induced neutrino oscillation and its possible implications for long baseline neutrinos, MODERN PHYSICS LETTERS **A30** (2015) Art No: 1550001

MAGIC Collaboration; VERITAS Collaboration, Multiwavelength observations of Mrk 501 in 2008, ASTRONOMY & ASTROPHYSICS **573** (2015) Art No: A50

Amit Dutta Banik; Debasish Majumdar, Inert doublet dark matter with an additional scalar singlet and 125 GeV Higgs boson, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3142

A Shukla†; VR Chitnis†; BB Singh†; P Bhattacharjee, RJ Britto; L Saha; et al, multi-frequency, multi-epoch study of mrk 501: hints for a two-component nature of the emission, *ASTROPHYSICAL JOURNAL* **798** (2015) Art No: UNSP 2

VERITAS Collaboration, Investigating broadband variability of the TeV blazar 1ES 1959+650, *ASTROPHYSICAL JOURNAL* **797** (2014) Art No: 89

Abhishek Majhi; Parthasarathi Majumdar†, 'Quantum hairs' and entropy of the quantum isolated horizon from Chern-Simons theory, *CLASSICAL AND QUANTUM GRAVITY* **31** (2014) Art No: 195003

Sarmistha Banik; Matthias Hempel; Debades Bandyopadhyay, NEW HYPERON EQUATIONS OF STATE FOR SUPERNOVAE AND NEUTRON STARS IN DENSITY-DEPENDENT HADRON FIELD THEORY, *ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES* **214** (2014) Art No: 22

Biswajit Adhikary; Mainak Chakraborty; Ambar Ghosal, Masses, mixing angles and phases of general Majorana neutrino mass matrix (vol 10, 043, 2013), *JOURNAL OF HIGH ENERGY PHYSICS*, **Issue: 9** (2014) Art No: 180

B Adhikary; A Ghosal; P Roy, Maximal zero texture of the inverse seesaw with broken mu tau symmetry, *INDIAN JOURNAL OF PHYSICS* **88** (2014) 979

Srijit Bhattacharjee; Parthasarathi Majumdar, Gravitational Coleman-Weinberg potential and its finite temperature counterpart, *NUCLEAR PHYSICS* **B885** (2014) 481

Chandrachur Chakraborty; Kamakshya Prasad Modak; Debades Bandyopadhyay, DRAGGING OF INERTIAL FRAMES INSIDE THE ROTATING NEUTRON STARS, *ASTROPHYSICAL JOURNAL* **790** (2014) Art No: 2

T Ergin; A Sezer; L Saha; et al, RECOMBINING PLASMA IN THE GAMMA-RAY-EMITTING MIXED-MORPHOLOGY SUPERNOVA REMNANT 3C 391, *ASTROPHYSICAL JOURNAL* **790** (2014) Art No: 65

Mala Das; Debasish Das; Anjali Mukherjee; et al, Exploring radiation in many splendors, *CURRENT SCIENCE* **107** (2014) 15

Prasanta Char; Sarmistha Banik, Massive neutron stars with antikaon condensates in a density-dependent hadron field theory *PHYSICAL REVIEW* **C90** (2014) Art No: 015801

S Archambault; T Arlen; T Aune; P Majumdar; et al, test of models of the cosmic infrared background with multiwavelength observations of the blazar 1ES 1218+30.4 IN 2009, *ASTROPHYSICAL JOURNAL* **788** (2014) Art No: 158

R3B Collaboration, B-13, B-14(n, gamma) via Coulomb Dissociation for Nucleosynthesis towards the r-Process, *NUCLEAR DATA SHEETS* **120** (2014) 197

Pijushpani Bhattacharjee; Soumini Chaudhury ; Susmita Kundu, ROTATION CURVE OF THE

MILKY WAY OUT TO similar to 200 kpc, *ASTROPHYSICAL JOURNAL* **785** (2014) Art No: 63

Chandrachur Chakraborty; Majumdar Parthasarathi, Strong gravity Lense-Thirring precession in Kerr and Kerr-Taub-NUT spacetimes, *CLASSICAL AND QUANTUM GRAVITY* **31** (2014) Art No: 075006

PICASSO collaboration, Searching for dark matter with PICASSO, *Physics Procedia* 61 (2015) 107

Kamakshya Prasad Modak; Debasish Majumdar; Subhendu Rakshit, A Possible Explanation of Low Energy γ -ray Excess from Galactic Centre and Fermi Bubble by a Dark Matter Model with Two Real Scalars, *JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS* **1503** (2015) 011

5.1.4 Ph D Awarded

Lab Saha [Pijushpani Bhattacharjee], Some aspects of gamma-ray astronomy, HBNI, Mumbai, September, 2014

Abhishek Majhi [Parthasarathi Majumdar], Black Holes in Loop Quantum Gravity Thermal Stability, Entropy and Energy Spectrum, HBNI, Mumbai, January, 2015

Soumini Choudhury [Pijushpani Bhattacharjee], Rotation curve of the Milky way and the phase space structure of its Dark Matter Halo: Implication for direct detection of weakly interacting massive particle candidates of dark matter, HBNI, Mumbai, January, 2015

Susnata Seth [Pijushpani Bhattacharjee], Aspects of superheated droplet detectors and their application in dark matter search, HBNI, Mumbai, February, 2015

5.1.5 Seminars/Lectures given in Conference/Symposium/Schools

Mala Das

- i. Dark matter direct search with PICASSO/PICO, Conference on Light in the dark side, Banaras Hindu University, Varanasi, Mar 17, 2015
- ii. Exploring the dark side of the Universe, DAE Symposium on Nuclear Physics (SNP-2014), Banaras Hindu University, Varanasi, Dec, 8-12, 2014
- iii. Activities related to PICO and various aspects of SDD, PICO collaboration meeting', SNOLab, Sudbury, Canada, Aug, 28-29, 2014

Debasish Majumdar

- i. "Dark Matter", Indian Institute of Technology, Indore, April 2014 (series of two lectures)
- ii. "A Possible Explanation of Low Energy gamma-ray Excess from Galactic Centre and Fermi Bubble by a Dark Matter Model with Two Real Scalars" invited talk at the meeting International Workshop on Unification and Cosmology after Higgs Discovery (UNICOS2014), Department of Physics, Panjab University, Chandigarh, May 15, 2014

- iii. A nonthermal dark matter model for explaining Fermi-LAT observed gamma-ray excess, IBS-MultiDark Joint Focus Programme meeting , Center for Theoretical Physics of the Universe in Daejeon, South Korea, Oct 15, 2014
- iv. Confronting GeV γ -ray excess from Galactic Centre and Fermi Bubble with Inert Higgs Doublet Model, Conference on Dark Side of the Universe, Center for Astrophysics Cosmology and Gravity, University of Cape Town, South Africa, Oct 21, 2014
- v. Generalising Thawing Dark Energy Models, Seminar on Exploring the Cosmos, North Bengal University, Siliguri, Jan 22, 2015
- vi. Late Time Acceleration In A Slow Moving Galileon Field, Topical Conference on Gravity and Cosmology (Eastern Region), Indian Institute of Technology, Kharagpur, Feb 28, 2015
- vii. Nonthermal Two Component Dark Matter Model for Fermi-LAT Gamma Ray Excess and 3.55 keV X-ray Line, Three Week Workshop on LHC and Dark Matter (LHCDM), Indian Association for the Cultivation of Science, Kolkata, Feb 9-28, 2015
- viii. Fermi-LAT Observation of gamma rays from galactic and extra-galactic sources and a possible explanation from dark matter annihilation, Workshop on Light from dark side of the Universe, Banaras Hindu University, Varanasi, Mar 17-20, 2015

Debades Bandyopadhyay

- i. Supernova Explosions: The role of hyperon matter, 59th DAE-BRNS Nuclear Physics Symposium, Benaras Hindu University (BHU), Varanasi, Dec 11, 2014
- ii. Thermodynamic properties of nuclear surface, workshop on Nuclear Equation of State for Supernovae and Compact Stars 2014, Frankfurt Institute for Advanced Studies (FIAS), Germany, Dec 3-5, 2014
- iii. Masses and Radii of Neutron Stars: Probing Neutron Star Interior”, Neutron Stars: A brainstorming workshop, NCRA-TIFR, Pune, November 20-21, 2014
- iv. Supernova Explosions: The role of exotic matter, Indian Institute of Science, Bangalore, Sept 2, 2014
- v. New hyperon equation of state for supernovae and neutron stars, Institute for Nuclear Physics, Orsay, France, June 11, 2014
- vi. Thermal properties of nuclear surface, Colloquium at Texas A & M University, College Station, USA, May 20, 2014

5.1.6 Teaching elsewhere

Debades Bandyopadhyay

Physics of Supernovae and Compact Stars [8 lectures], the Winter school on Nuclear Astrophysics, VECC, Kolkata, Jan 19-31, 2015

5.2 Theory

5.2.1 Summary of Research Activities

a) Particle Physics Phenomenology:

Phenomenology of Two-Higgs' Doublet models has been studied focusing on two aspects in particular, namely, appropriate suppression of flavor-changing neutral currents and the role of global

symmetries in scalar potential together with the soft breaking terms in ensuring smooth decoupling of heavy scalars.

Precision QCD studies at LHC for beyond the SM and SM processes: Next to leading order (NLO) in QCD with parton shower, all di-final state processes in the RS model, three photon production process in the SM to NLO and including parton shower effects, implemented in the aMCNLO framework. Two Loop Amplitudes: Two loop QCD corrections to amplitudes, massive spin-2 resonance $\rightarrow g + g + g$ and Higgs $\rightarrow b + \bar{b} + g$. These results constitute one of the ingredients to a full NNLO QCD process. NNLO: Next to Next to Leading Order (NNLO) QCD corrections to the graviton production in models of TeV-scale gravity working within the soft-virtual approximation. These predictions are closely comparable to exact NNLO results.

b) Nonperturbative Studies of Quantum Field Theories:

Gauge fixing in the usual Fadeev-Popov and BRST schemes cannot be pursued in case of non-perturbative compact lattice gauge fields. A new investigation has been started in the Theory Division to test an equivariant BRST scheme (eBRST) evading a no-go theorem. A U(1) compact lattice gauge theory has been studied with a standard BRST breaking gauge fixing term and a dimension-two counter term. An interesting phase diagram in this extended parameter space has been obtained which indicates a hitherto unfound continuous phase transition in the weak gauge coupling regime. In addition, there seems to exist a tricritical line in strong gauge coupling regime where quenched chiral condensates may show a nontrivial behavior. The Abelian part of the work is near completion.

The fermion measure was studied in the presence of axion fields and it was argued that such fields may not play a decisive role in the so-called strong CP problem.

Towards the goal of extracting the continuum properties, the topological charge density correlator and the inverse participation ratio for the topological charge density were studied in SU(3) Lattice Yang-Mills theory for relatively small lattice spacings including some smaller than those explored before.

c) Gravity and Cosmology:

Black hole entropy was investigated in the framework of Loop Quantum Gravity with special attention paid to the classical area, which has usually not been taken into account in entropy calculations. The dynamics of multiple scalar fields in inflationary cosmology (N-flation) has been explored in the framework of supergravity and string theory. In addition, phenomenological implications of long lived particles like moduli and gravitinos have been explored. In particular, how the existence or production of these particles affects the inflationary models have been analyzed.

Planck scale corrections to the quasinormal frequencies of black holes have been calculated in a noncommutative model of quantum gravity.

d) Strings:

A de-Sitter solution upto a conformal factor has been constructed from certain anisotropic space-like D3 brane solution of type IIB string theory. Similar constructions as well as accelerating cosmologies have been obtained from spacelike Dp-branes in two different limits. How the thermodynamic phase structure of black D6-brane changes with the inclusion of D0-brane has been demonstrated and its origin has been discussed. Finally, both a supersymmetric as well as a non-supersymmetric

version of interpolations between AdS5 space in the UV and hyperscaling violating Lifshitz space in the IR have been obtained.

The perturbative study of entanglement entropy and thermodynamic first laws of some AdS black hole spacetimes under boost was done. An attempt was made to identify the correct ground state for a strongly coupled large- N gauge theory at finite density. A family of solutions of 10 dimensional supergravity which are dual to the infrared limit of strongly coupled large- N gauge theories at finite density were constructed. The effect of a nonvanishing chemical potential on the thermalization time for a prototypical strongly coupled large- N gauge theory by studying the gravitational collapse dynamics in an asymptotically anti de-Sitter space-time was analyzed. The possibility of an effective thermodynamic description for a class of steady state systems within Gauge-Gravity duality was explored.

e) QCD at Finite Temperature and Density:

The determination of static and dynamic quantities of QCD matter are extremely important to QGP phenomenology. These are studied in both perturbative and nonperturbative approaches of QCD.

f) Nuclear Theory:

The equation of state (EoS) of nuclear matter is obtained using the empirically determined values of some of the characteristic constants associated with homogeneous nuclear matter at normal and sub-normal densities. Extrapolation of such EoS at supra-normal densities shows a striking agreement with the one extracted from the experimental data. The predicted density dependence of symmetry energy and nuclear matter incompressibility are in close consonance with those gleaned from diverse approaches.

g) Mathematical Physics:

A challenging integrable defect problem is solved with an innovative application of space-time duality, hidden in integrable systems. The oceanic rogue waves have been modeled through exact dynamical lump solitons of a novel nonlinear equation, controlled by the ocean currents. Arbitrary bending of optical solitonic beam is achieved, regulated by boundary resonant medium within the framework of integrable models.

A new class of exactly solvable spin Calogero models associated with the D_N root system has been constructed using the polarized spin reversal operators. Exact expressions of the partition functions of the related spin chains have been derived in terms of products of known partition functions of Polychronakos spin chains of type A_{N-1} . Several global properties of the D_N -type chain's spectrum such as the asymptotic level density, the distribution of consecutive spacings of the unfolded spectrum, and the average degeneracy have been analyzed at the large N limit.

The effect of topological defects on screening and transport properties of gapless graphene has been analyzed.

The von-Neumann entropy arising from scaling symmetry breaking has been calculated and its relation to the Cardy formula and the associated quantum information theory has been pointed out.

5.2.2 Publications

5.2.2.1 Publications in Books/Monographs & Volumes Edited

Partha Mitra

Partha Mitra, Symmetries and symmetry breaking in field theory, CRC Press, Taylor and Francis group, Florida, 2014

Palash Baran Pal

Palash B Pal, An Introductory Course of Particle Physics, CRC Press, 2014 (ISBN 978-1-4822-1698-1)

5.2.2.2 Publications in Journal

Dante Carcamo†; Jorge Gamboa†; Fernando Mendez†; Ashok K Das; et al, Cosmic four-fermion neutrino secret interactions, enhancement, and total cross section, PHYSICAL REVIEW **D91** (2015) Art No: 065028

Ayan Chatterjee†; Avirup Ghosh, Quasilocal conformal Killing horizons: Classical phase space and the first law, PHYSICAL REVIEW **D91** (2015) Art No: 064054

Ashok K Das; Sudhakar Panda†; JRL Santos†, A path integral approach to the Langevin equation, INTERNATIONAL JOURNAL OF MODERN PHYSICS **A30** (2015) Art No: 1550028

Ashok K Das; Pushpa Kalauni†, Supersymmetry, shape invariance and the solubility of the hypergeometric equation, MODERN PHYSICS LETTERS **A30** (2015) Issue: 6

Arnab Kundu; Sandipan Kundu†, Steady-state physics, effective temperature dynamics in holography, PHYSICAL REVIEW **D91** (2015) Art No: 046004

V Caudrelier†; A Kundu, A multisymplectic approach to defects in integrable classical field theory, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 2** (2015) Art No: 088

Koushik Dutta; Anshuman Maharana†, Inflationary constraints on modulus dominated cosmology, PHYSICAL REVIEW **D91** (2015) Art No: 043503

Kuntal Nayek; Shibaji Roy, Space-like Dp branes: accelerating cosmologies versus conformally de Sitter space-time, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 2** (2015) Art No: 021

Anton F Faedo ; Arnab Kundu; David Mateos; et al, (Super) Yang-Mills at finite heavy-quark density, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 2** (2015) Art No: 010

Aminul Islam Chowdhury; Sarbani Majumder; Najmul Haque; Munshi G Mustafa, Vector meson spectral function and dilepton production rate in a hot and dense medium within an effective QCD approach, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 2** (2015) Art No: 011

Parijat Dey; Shibaji Roy, Interpolating solution from AdS(5) to hyperscaling violating Lifshitz

spacetime, PHYSICAL REVIEW **D91** (2015) Art No: 026005

Gautam Bhattacharyya; Dipankar Das, Nondecoupling of charged scalars in Higgs decay to two photons and symmetries of the scalar potential, PHYSICAL REVIEW **D91** (2015) Art No: 015005

Amit Ghosh; Daniele Pranzetti†, CFT/gravity correspondence on the isolated horizon, NUCLEAR PHYSICS **B889** (2014) 1

Cristina Manuel†; Sreemoyee Sarkar; Laura Tolos†, Thermal conductivity due to phonons in the core of superfluid neutron stars, PHYSICAL REVIEW **C90** (2014) Art No: 055803

N Alam; BK Agrawal; JN De; SK Samaddar, Equation of state of nuclear matter from empirical constraints , PHYSICAL REVIEW **C90** (2014) Art No: 054317

Kumar Das; Koushik Dutta, N-flation in supergravity, PHYSICS LETTERS **B738** (2014) 457

Michael Strickland† ;Jens O Andersen†; Aritra Bandyopadhyay;Aritra Bandyopadhyay; Najmul Haque; Munshi G Mustafa; et al, Three loop HTL perturbation theory at finite temperature and chemical potential , NUCLEAR PHYSICS **A931** (2014) 841

A Sulaksono†; Naosad Alam; BK Agrawal, Core-crust transition properties of neutron stars within systematically varied extended relativistic mean-field model, INTERNATIONAL JOURNAL OF MODERN PHYSICS **E23** (2014) Art No: 1450072

BK Agrawal, Density content of nuclear symmetry energy from nuclear observables, PRAMANA-JOURNAL OF PHYSICS**83** (2014) 695

Goutam Das; Prakash Mathews; V Ravindran†; Satyajit Seth, RS resonance in di-final state production at the LHC to NLO plus PS accuracy, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 10** (2014) Art No: 188

Atanu Rajak; Tanay Nag; Amit Dutta†, Possibility of adiabatic transport of a Majorana edge state through an extended gapless region, PHYSICAL REVIEW**E90** (2014) Art No: 042107

MK Mandal; Prakash Mathews; V Ravindran Ravindran; Satyajit Seth, Three photon production to NLO plus PS accuracy at the LHC, EUROPEAN PHYSICAL JOURNAL **C74** (2014) Art No: 3044

Sanjay K Ghosh†; Anirban Lahiri†; Sarbani Majumder;Munshi G Mustafa; et al, Quark number susceptibility: Revisited with fluctuation-dissipation theorem in mean field theories, PHYSICAL REVIEW **D90** (2014) Art No: 054030

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Abhishek Chowdhury; A Harindranath ; Jyotirmoy Maiti†, Open boundary condition, Wilson flow and the scalar glueball mass, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2014) Art No: UNSP 067

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Abhishek Majhi, The microcanonical entropy of quantum isolated horizon, 'quantum hair' N and the Barbero-Immirzi parameter fixation, CLASSICAL AND QUANTUM GRAVITY **31** (2014) Art No: 095002

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Anjan Kundu; Tapan Naskar†, Arbitrary bending of optical solitonic beam regulated by boundary excitations in a doped resonant medium, PHYSICA **D276** (2014) 21

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Amit Ghosh; Karim Noui†; Alejandro Perez†, Statistics, holography, and black hole entropy in loop quantum gravity, PHYSICAL REVIEW **D89** (2014) Art No: 084069

BK Agrawal; D Bandyopadhyay; JN De; SK Samaddar, Thermal properties of the nuclear surface, PHYSICAL REVIEW **C89** (2014) Art No: 044320

Atanu Kumar, Covariant perturbations through a simple nonsingular bounce, PHYSICAL REVIEW **D89** (2014) Art No: 084059

Anjan Kundu; Abhik Mukherjee; Tapan Naskar, Modelling rogue waves through exact dynamical lump soliton controlled by ocean currents, PROCEEDINGS OF THE ROYAL SOCIETY **A470** (2014) Art No: 20130576

Daniel de Florian†; Maguni Mahakhud†; Prakash Mathews; et al, Next-to-next-to-leading order QCD corrections in models of TeV-scale gravity, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2014) Art No: 028

Ashok K Das; J Frenkel†, Large-time behavior in an exactly soluble out of equilibrium model, PHYSICAL REVIEW **D89** (2014) Art No: 087701

JN De; SK Samaddar; BK Agrawal, S-matrix approach to the equation of state of dilute nuclear matter, PRAMANA-JOURNAL OF PHYSICS **82** (2014) 625

B Basu-Mallick; Nilanjan Bondyopadhyaya†; Pratyay Banerjee, Partition functions of Polychronakos like spin chains associated with polarized spin reversal operators, NUCL PHYS **B883** (2014) 501

B Basu-Mallick; Tanaya Bhattacharyya†; Diptiman Sen†, Clusters of bound particles in a quantum integrable many-body system and number theory, JOURNAL OF PHYSICS: CONFERENCE SERIES **563** (2014) 012003

5.2.3 Ph D Awarded

Priti Bhajan Byakti [Palash Baran Pal], Some aspects of supersymmetry breaking, University of Calcutta, December 2014

Kalyan Brata Chatterjee [Gautam Bhattacharyya], Some Implications of R-Parity Violation in Supersymmetry, University of Calcutta, May 2014

Pratyay Banerjee [B Basu-Mallick], Aspects of some quantum integrable systems with long-ranged Interactions, University of Calcutta, March, 2015

Abhishek Chowdhury [A Harindranath], Perturbative and non perturbative aspects of Lattice Quantum Chromodynamics, Homi Bhabha National Institute, December 2014

Najmul Haque[Munshi G Mustafa], Some Applications of Hard Thermal Loop Perturbation Theory in Quark Gluon Plasma, HBNI

Satyajit Seth [Prakash Mathews], A Journey towards QCD Radiative Corrections in the SM and Beyond at the LHC, HBNI, September 2014

5.2.4 Seminars/Lectures given in Conference/Symposium/Schools

Anjan Kundu

1. Asymmetric Skyrmions in Helimagnets, International Spin Chemistry Meeting, SINP, Calcutta, Mar 15-20, 2015
2. Generation of Integrable Models from from Ancestor Lax operator and Beyond, International Workshop on Discrete Integrable Systems, Indian Institute of Science, Bangalore, Jun 9-14, 2014

Partha Mitra

1. Fermion measure and Peccei-Quinn fields, Workshop on "New Trends in Field Theories", BHU, Varanasi, November 2014
2. Black hole entropy with and without log correction, Workshop on "Field Theoretic Aspects of Gravity", IISER Mohali, December 2014

Palash Baran Pal

1. The importance of neutrinos, "StatCosmo15" conference, Indian Statistical Institute, Calcutta, Feb 13, 2015
2. What's so special about neutrinos?, Evening talk at the "CNT winter school on nuclear astrophysics" Variable Energy Cyclotron Centre, Calcutta, Jan 21, 2015
3. Unification of forces:
 - i. Talk at the National seminar on "Frontiers of research in Physical Sciences", Karimganj College, Sep 20, 2014
 - ii. Physics Department Seminar, Visva-Bharati University, Santiniketan, Mar 28, 2015
4. Discovering elementary particles:
 - i. Physics Department Seminar, Indian Institute of Science Education and Research (IISER), Calcutta, Mar 25, 2015
 - ii. Physics Department Seminar, Presidency University, Calcutta, Nov 05, 2014
5. SatyendraNath Bose and counting particles, National seminar on "Scientists who dared and made the difference", organized by the Asiatic Society, Kolkata, 03 Mar 03, 2015
6. Kyalendarer rohosyo (The mystery of calendars):

- i. Lecture at the West Bengal State Science Congress, North Bengal University, Shiliguri, 28 Feb 2015
- ii. Public lecture at Karimganj College, Sep 20, 2014
- 7. Journey to the world of fundamental particles, Outreach program to commemorate the diamond jubilee of the Department of Atomic Energy of the Government of India, Institute of Physics, Bhubaneswar, Feb 1, 2015
- 8. Understanding the Higgs boson, CMS outreach program held at the Saha Institute of Nuclear Physics, Calcutta, Jan 8, 2015
- 9. The world of neutrinos, Lecture at the Outreach Program for the Indian Neutrino Observatory held at Bardhaman University, Bardhaman, Apr 1, 2014

Gautam Bhattacharyya

- 1. “Naturally light uncolored and heavy colored superparticles”, (a) Plenary in PLANCK 2014 International Conference, Paris, May 2014 (b) Instituto Superior Tecnico, Lisbon, May 2014
- 2. “The so-called God Particle: An incredible journey of mankind” – Physics and Applied Mathematics Researchers’ Meet, Indian Statistical Institute, Kolkata, Mar 2015
- 3. “Geometrical CP violation and nonstandard Higgs decays” – Instituto Superior Tecnico, Lisbon, Portugal, Jun 2014
- 4. “2HDM scalar potential and the role of symmetries” – LHCDM-2015 Workshop, IACS, Kolkata, Feb 2015

B Basu-Mallick

- i) Clusters of bound particles in a quantum many-body system and number theory, Plenary in The XXII International Conference on Integrable Systems and Quantum symmetries (ISQS-22), Prague, Czech Republic, June 23-29, 2014
Chaired a Session
- ii) Exactly solvable many particle systems (3 talks), Workshop on Recent developments in quantum theories, Department of Physics, Banaras Hindu University, Varanasi, Feb 20-24, 2015
- iii) Bound states of a quantum many-body system, Physics and Applied Mathematics Unit, Indian Statistical Institute, Kolkata, July 22, 2014

Munshi Golam Mustafa

Rapature -II (Theory), 7th International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPAQGP), Kolkata, Feb 2-6, 2015

Koushik Dutta

- a. Light Fields In Cosmology, Centre for Theoretical Science, Indian Institute of Technology, Kharagpur, Mar 2015
- b. Constraints on Moduli Mass from Inflation, StatCosmo, ISI, Kolkata, Feb 2015
- c. Inflationary Constraints on Late Time Modulus Dominated Cosmology, LHC to DM, IACS, Kolkata, Feb 2015
- d. Inflationary Constraints on Late Time Modulus Dominated Cosmology, DESY Theory Workshop: Particle Cosmology after Planck, Sept 2014
- e. Inflation Model Building in Particle Physics, HRI, Allahabad, Aug 2014
- f. Cosmology with pNGBs, PASCOS, Warsaw Jun 2014
- g. Dark Energy and Inflation with pNGBs Aspects of Cosmology, IIA, Bengaluru, Apr, 2014
- h. Open Inflation after BICEP II, Cosmology Day, ICTS, Bengaluru, Apr, 2014

5.2.5 Honours and Distinctions

Koushik Dutta

Junior Associateship: International Centre for Theoretical Physics (ICTP), Trieste, Italy (2014-2019)

Chapter 6

Facilities

Chapter 6

Facilities

6.1 Centre for Advanced Research & Education

ONE YEAR PRE-PHD TRAINING PROGRAM:

CARE conducted a nationwide written test for selecting PhD students in SINP through four Post-M.Sc. coordinators, Profs. Munshi G Mustafa, Sayajit Saha, Prabhat Mandal and Partha Saha. It coordinated SINP's participation in JEST, another nationwide written test conducted by several DAE institutions together, through Prof. M G Mustafa, the JEST coordinator of SINP. These written tests are followed by interviews conducted in SINP. Tests and interviews are conducted in two major areas – Physics and Biophysical Sciences. In 2014-15, 35 students were selected. They are now going through the mandatory one-year pre-PhD course work. CARE coordinates the one-year course work following the HBNI guidelines through the Post-M.Sc. coordinators. It coordinates the formation of doctoral committee for each student as per HBNI guideline and reviews for each PhD students' annual progress and renewals of fellowships following the recommendation of doctoral committees through the Graduate Students' Coordinator Prof. Samita Basu. CARE office acts as HBNI, SINP, Dean's office – helping students enrolling with HBNI, arranging PhD viva voce exams and visits of the examiners.

UNDERGRADUATE ASSOCIATESHIP PROGRAM & SUMMER STUDENTS' PROGRAM:

In 2014, 12 undergraduate associates were trained in various labs of the Institute – the program is coordinated by Prof. Krishna Menon. In 2014 summer, 22 summer students were trained in various labs of the Institute – this program is coordinated by Prof Nikhil Chakrabarti.

INSTITUTE COLLOQUIUMS, DISTINGUISHED VISITORS:

CARE organized 8 Institute colloquiums through colloquium coordinators, Profs. Y Sudhakar, Pratik Majumdar and Dulal Senapati. CARE conducted a seminar on *the systems' view of life - a unifying vision* by Professor Pier Luigi Luisi, Pisa, Italy, on December 4, 2014, through Prof. Sampa Biswas. A special colloquium on *Brains, Minds and Machines* was delivered by Prof Mriganka Sur of Massachusetts Institute of Technology, USA on 12.1.2015 at SINP Auditorium. CARE took part in hosting the 51-st Saha memorial lecture at SINP on 13 January, 2015 and the 9-th sir J C Bose memorial lecture at SINP on 4 February, 2015.

ORGANIZING SCHOOLS/WORKSHOPS (after getting the required additional approval of DAE in each case):

Partial support in organizing the *Saha Theory workshop in cosmology and astrophysics* at SINP during January 28–30, 2015. Partial support in organizing the *7-th international conference of Physics and Astrophysics of Quark Gluon Plasma* at SINP, during Feb 1-6, 2015. Partial support in organizing 28-th meeting of the Indian Association for General Relativity and Gravitation in Raman Research Institute, Bangalore, during March 18-20, 2015.

OUTREACH PROGRAMS OF CARE

18-th National Science Exhibition during 3–7 September, 2014, at Amarabati Maidan, Kolkata 700110, organized by the Central Calcutta Science & Culture Organization for Youth.

National Science, Technology, Atomic Energy & Public Awareness Exhibition cum Fair and Seminar during 20–26 September, 2014, at the Science City Ground, JBS Haldane Avenue, Kolkata 700046.

19-th Sundarban Krishti Mela O Loko Sanskriti Utsav during 20–29 December, 2014, Kultali, organized by the Milan Tirtha Society. This is an educational fair that aims at educating the local people about the National Developmental Programs.

8-th Sundarban Lokapriya Utsav during 23-30 January, 2015, Sonakhali Bazar, PS Basanti, 24 Parganas.

Acharya Satyendranath Basu Smarak Bijnan O Prajukti Mela during 28 January–1 February, 2015, organized by Paschimbanga Vigyan Mancha at Hedua Park, Kolkata. Thousands of students and people visit the fair. Outreach programs spread great enthusiasms, awareness and knowledge on recent developments and career opportunities in science among people.

Virtual visit to CMS: An online interactive session with the people involved in the CMS experiment, CERN, with about 500 students of local schools and colleges was organized jointly by the HENPP division and CARE on 8th January, 2015, in the SINP Auditorium. Two talks were delivered by Prof. Palash Baran Pal and Sunanda Banerjee, explaining the backgrounds of Higgs' Boson and its discovery at CERN, followed by an interactive Q&A session with CERN.

Science day: CARE celebrated the Science Day on March 28, 2015 (Saturday). A day-long science outreach program was organized. About 500 students from local schools attended. Two talks were delivered, one on Relativity and Cosmology by Prof. Koushik Dutta and another on recent trends in Biology by Prof. Sangram Bag. They were followed by visits to several labs of the Institute. The day ended with a Science Quiz competition conducted by the SINP research fellows. Prizes were given to the winner schools by the Director.

MEGHNAD SAHA ARCHIVE:

CARE maintains and preserves the M N Saha archive - a unique collection of numerous letters, documents, writings, personal items and memoirs of Prof Saha and his colleagues. The archive has invaluable records of a golden era of science in India.

From time to time the archive has visitors from India and abroad, especially those who are working on the histories of Indian science. With permission of our Director, CARE office hands over copies of these documents to scholars who are working on the subject.

CONSULTANCY:

CARE arranged visits of 5 scholars (who have submitted their PhD Thesis) in March, 2015, who helped us in organizing various outreach programs. They also took part in research activities of the Institute in various labs.

PUBLICATION:

Partial support in publishing a journal called Science and Culture, published by the Council of

Indian Science News Association, Kolkata. Full financial support in developing the Institute website of SINP and coordinating, preparing and publishing the annual report of SINP. CARE office also prints all posters requested by SINP students and faculties for participating in conference/workshops/symposia.

6.1.1 The Post-M Sc Associateship Course

6.1.2 Physics

The Post-M Sc Associateship Course

61st Post-M.Sc. Course, Session 2013-14

PHYSICS:

THIRD TERM : (Student, Review Title (Supervisor))

1. Amit Kumar Chatterjee, Nonequilibrium Phase Inansition (PK Mohanty)
2. Arnab Purohit, Study of Muon Efficiency & Fake rate at CMS derived from data (Subir Sarkar)
3. Arnab Singh, One dimensional charge density wave formation in organic nanowives (Milon K Sanyal)
4. Arnab Kumar Pariari, Dirc Cone: An emerging Phenomenon in Condensed Matter Physics (Probhat Mondal)
5. Biswajit Banerjee, Fermi-LAT Observations of the TeV blazar Mrk501 (Pratik Majumdar)
6. Biswarup Das, Generation of angular momentum in A-100 regin (Sukalyan Chapadhyay)
7. Dibya Chakravorty, Possible corrections to newton's law (Parthasarathi Mitra)
8. Mithun Karmakar, Waves and instabilities in a strongly coupled plasma (Nikhil Chakrabarti)
9. Mugdha Sarkar, Lattice Fermions & self energy calcutions (Asit Kumar De)
10. Rajarshi Bhattacharya, Study of Emshower in calorimeters at moderate to high energy (Sunanda Banerjee)
11. Ranajoy Banerji, Multiwavelength analysis of the TeN blasar Mrk421 (Pratik Majumdar)
12. Rohit Mishra, The brane-like solutions in string theory (Harvendra Singh)
13. Rome Samanta, Estimation of the Najorana ptoscs in solve beyond s.r. (Ambar Ghosal)
14. Roopam Sinha, Scaling ansat3 and large B13 (Ambar Ghosal)
15. Saswati Nandan, Study of Hadronic shower in Calorimeters at moderate of High Energy (Sunanda Banerjee)
16. Shamik Ghosh, ElectrIn Identification in the CMS collision data (Satyaki Bhattacharya)
17. Sourav Karar, Holographic Entanglement Entropy & Thermodynamics (Shibaji Roy)
18. Sourav Kumar Dey, Importance of tagging devices in probing nuclear structure (Satyajit Saha)
19. Souvik Mondal, Network in Biology (PK Mohanty)
20. Srimanta Banerjee, Theoretoca; stidy of disorder in high-To Superconductors (Arti Garg)
21. Sukannya Bhattacharya, Nanguoussionistics in Cosmic Microwave Radiation (Koushik Dutta)
22. Susmita Roy, Insulator-metal transition in strongly correlated d- electron system. (Probhat Mondal)

The following 19 Physics students have successfully completed the Post-M Sc (Physics) course in the session 2013-2014 :

1. Amit Kumar Chatterjee, 2. Arnab Purohit, (Completeed 01-04-2015) 3. Arnab Singh, 4.

Arnab Kumar Pariari, 5. Biswajit Banerjee, 6. Biswarup Das, (Completed 01-04-2015) 7. Mithun Karmakar, 8. Mugdha Sarkar, 9. Rajarshi Bhattacharya, 10. Rohit Mishra, 11. Rome Samanta, 12. Roopam Sinha. 13. Saswati Nandan. 14. Shamik Ghosh, 15. Sourav Karar, 16. Sourav Kumar Dey, 17. Souvik Mondal, 18. Sukannya Bhattacharya, 19. Susmita Roy

62th Post-M Sc Course, Session 2014-15

The following (Physics) students have joined on 1st August 2014 for the session 2014-15
Physics students:

1. Arghya Mukherjee, 2. Avik Banerjee, 3. Bankim Chandra Das, 4. Bipasha Paul, 5. Debraj Das, 6. Ratnadwip Singha, 7. Udit Narayan Chowdhury, 8. Gourab Bhattacharjee, 9. Anway Pradhan, 10. Subha Samanta, 11. Suman Mukherjee

First Term

Courses (Teachers)

Mathematical Methods (Prof Palash B Pal)

Quantum Mechanics (Prof Sudhakar Yarlagadda)

Basic Experimental Techniques (Profs Asimananda Goswami, Sandip Sarkar and Satyajit Saha)

Computational and Numerical Methods (Profs Debasish Das, Nayana Majumdar and Supratik Mukhopadhyay)

Physics and Astrophysics of Supernovae and Compact Star (Prof Debades Bandyopadhyay)

Second Term

Physics of Soft materials (Prof. Alokmay Datta)

Advanced course on Plasma Physics (Profs Nikhil Chakrabarti & MS Janaki)

Quantum Field Theory-II (Prof Arnab Kundu)

Finite Temperature Field Theory (Prof Munshi G Mustafa)

General Relativity (Prof Amit Ghosh)

Particle Detectors (Profs Debasish Das & Maitreyee Nandy)

6.1.3 Biophysical Sciences

Session 2013-14

Review: **Students**, Review Topic (*Supervisor*)

1. **Abhishek Sau**, Interaction of Gold Nanoparticles with Riboflavin and Modified Riboflavin: A Spectroscopic and Microscopic Approach (*Samita Basu*)

2. **Aradhita Bhattacharjee**, Lamin-nesprin interaction in cellular mechanotransduction (*Kaushik Sengupta*)

3. **Benazir Alam**, Cloning, expression and characterization of the wild type and a disease-state mutant of Squamous Cell Carcinoma Antigen 1 (*Sampa Biswas*)

4. **Debdatto Mookherjee**, Interplay between tubulin polymerization, motor proteins and cortical cues during spindle positioning and orientation (*Oishee Chakrabarti*)
5. **Maireyee Bhattacharya**, Baby feeding Technique for Overgrown Nanoparticles: A New Approach for Nanomaterial Synthesis (*Dulal Senapati*)
6. **Monalisa Kundu**, Synthesis, characterization and dosimetry for silver nano-particles (*Maitreyee Nandy*)
7. **Sayantana Ganguly**, Functional interplay between transcription factors and chromatin remodelers: interpreting the epigenetic language (*Chandrima Das*)
8. **Shramana Chatterjee**, Substrate binding and engineering of acylphosphatase (*Udayaditya Sen*)
9. **Sudeshna Das Chakraborty**, Putative Anticancer Agent-based Gold Nano-Composite for Selective Drug Delivery: A Spectroscopic and Imaging Approach to Track Effective Therapy (*Dulal Senapati*)

The following 9 (nine) students have successfully completed the Post M Sc (Biophysical Sciences) Course in 2013-14 session

1. Abhishek Sau, 2. Aradhita Bhattacharjee, 3. Benazir Alam, 4. Debdatto Mookherjee, 5. Maireyee Bhattacharya, 6. Monalisa Kundu, 7. Sayantan Ganguly, 8. Shramana Chatterjee, 9. Sudeshna Das Chakraborty.

The following student has been awarded the best student award for session 2013-14 in Biophysical Sciences Course.

1. Debdatto Mookherjee

The following students have joined on August 2014 in Post M Sc (Biophysical Sciences) course for the session 2014-15

1. Jayshree Sadhukhan, 2. Sudeshna Pal, 3. Dipayan Bose, 4. Swarnabh Bhattacharya, 5. Saran Chattopadhyaya

Basic Courses (Compulsory)

1. **Biochemistry, Chemical Biology and Genetics (BCG) (40 lectures** by Abhijit Chakrabarti, Dipak Dasgupta, Debashis Mukhopadhyay and Chandrima Das)

Basic Biochemistry Biomolecules in water, protein and carbohydrate (complex) solutions, pH, pK, shifts in pK, self assembly, protein structure & folding, conformation, binding and enzymes, purification & characterization of proteins, vitamins & co-enzymes, glycolysis, ATP cycle, TCA cycle, oxidative phosphorylation, biosynthesis / degradation of amino acids & proteins, biosynthesis of lipids and carbohydrates, hormone and growth factors.

What is Chemical Biology? Definition of life from a current perspective, Role of water in the

chemistry of life, Biomolecular Recognition and its basics - an integral component of chemical biology, Chemical equilibrium and kinetic (including enzyme kinetics) aspects, and its basic application in chemical biology, Chemical biology and its current trends.

Development of Molecular Genetics (DM): The legacy of classical genetics; the birth of microbial genetics; DNA as the genetic material; mutation; genetic fine structure. Molecular basis of heritable diseases monogenic diseases and complex traits.

Chromatin and Epigenetics (CD): Chromosome, Chromatin, Nucleosomes, Histones, Histone Variants, Histone Chaperones, Chromatin remodelers, Euchromatin vs. Heterochromatin, DNA Methylation, Histone modification, Modifying enzymes (HATs, HDACs, HMTase, Demethylase), Chip, Chip-Seq, Chromatin readers and Histone code, Epigenetics and Cancer.

2. Molecular & Cell Biology (MCB) (40 lectures by Partha Saha, Kaushik Sengupta, Oishee Chakrabarti and Subrata Banerjee):

Biological Processes: Replication, Transcription, Translation, and related topics. Technique in molecular biology: DNA detection, RNA detection, Protein detection, cloning, PCR, and related methods.

Cell as unit, identification, characterisation, function of cellular organelles, Golgi, ER, lysosome, mitochondria, cell-membrane, cell-cell communication, cell-signalling, basics of immune system.

3. Biophysical Techniques (BPT) (40 lectures by Samita Basu, Padmaja P Mishra, Montu Hazra and Dulal Senapati).

Spectroscopy: absorption, emission, excited state properties, acidity, basicity, polarization, anisotropy, solvent relaxation, quenching, energy transfer, electron transfer, Circular dichroism, Infrared spectroscopy, FTIR, Raman spectroscopy, Nanoscience.

Basic principles of imaging techniques: SEM, TEM, transmission optical microscopy, nonlinear optical processes, wide-field fluorescence microscopy, confocal scanning microscopy and fluorescence correlation spectroscopy.

4. Computer Programming & Bioinformatics (CPB) (40 lectures by Pulak Kumar Ray, Gautam Garai and Dhananjay Bhattacharyya)

Algorithm and flow-chart, FORTRAN programming.

Brief introduction to Bioinformatics, Brief introduction to Biological databases, Sequence Alignment (Pair-wise and Multiple), Database similarity searching by available tools like FASTA, BLAST etc.

Molecular modelling software, basic statistics, regression and curve-fitting, some probability and statistical methods (such as Measures of central tendency, probability, probability distributions, Binomial distribution, Normal distribution, Poisson distribution, calculation of errors etc.)

5. Macromolecular Structure & X-ray crystallography (MMX) (20 lectures by Rahul

Banerjee, Dhananjay Bhattacharyya, Udayaditya Sen and Sampa Biswas)

Nucleic acids, Watson-Crick and non-Watson Crick basepair, DNA double helical and multistranded structures, RNA structural features.

External and internal coordinate system, non-covalent interactions stabilizing biomolecules, Proteins, amino acids, peptide, secondary tertiary, quaternary structure of protein.

Basics of Crystallography : Crystals, lattice, symmetry, Braggs law, Reciprocal lattice, Ewald sphere; Structure factors: Atomic scattering factor, temperature factor, structure factor calculation; Data collection: Technique & strategy, data processing, extinctions & space group determination; Phase problem and electron density calculation: phasing techniques like MR, MIR, MAD, etc; Fiber Diffraction & Virus Crystallography and Model building & refinement.

6. Radiochemistry & Radiation Physics (RRP) (12 lectures by Susanta Lahiri & 8 lectures by Maitreyee Nandi)

Recapitulation about radioactivity- classification of the nuclides, natural decay chain; Radioactive decay modes- secular and transient equilibrium; Introduction to Nuclear Reactions- Q-values, threshold energy, cross section, excitation functions; Different types of detectors, Nuclear Activation and its applications; Clinical and other applications of radionuclide, radiotracer technique.

Interaction of electromagnetic radiation with matter Cross-sections Attenuation and mass energy absorption coefficients

Interaction of charged particles with matter Classical Theory of inelastic collisions with atomic electrons Bremsstrahlung Passage of heavy charged particles through matter Range energy relation Stopping power Bethe-Bloch formula — Interaction of neutrons with matter Capture Neutron, charged particle and photon induced nuclear reactions and their applications

Radiation quantities and units Particle & Energy flux and fluence flux and fluence Interaction of Radiation with Cells, LET Biological Effects of Radiation, Dosimetry Energy imparted Absorbed dose Kerma-Exposure Dose equivalent Charged particle equilibrium (CPE) Ambient and directional dose equivalents $[(H^*(d) \text{ and } H(d)]$

Radiation Protection Standards, Principles of Monitoring and Protection.

Advance Courses

Each course consists of 20 lecture hours. Each student has to opt for 4 courses in total.

1. Topics in Cell Biology (Kaushik Sengupta, Oishee Chakrabarti & Partha Saha)

Mechanobiology cytoskeleton and nucleoskeleton, mechanics of cell-cell adhesion and migration, gross cell mechanics, experimental set ups to study biomechanics, disease models.

Protein translocation, protein trafficking (endocytosis, exocytosis, transcytosis), de novo organelles

biogenesis, protein quality control (role of internal vesicles), lysosomal biogenesis and degradation.

Regulation of cell cycle by cyclin-Cdk, Regulation of Initiation of eukaryotic DNA replication, Replication Licensing, Cell cycle checkpoints, Protein degradation by ubiquitination during cell cycle progression.

2. Chemical Biology of Chromatin & Epigenetics (Dipak Dasgupta & Chandrima Das)

Nucleus of prokaryotes and eukaryotes, Complexity of Eukaryotic genome, Chromatin structure, Composition and assembly from macromolecular perspective, Methods to study chromatin structure, Chromatin as drug target, Epigenetics and gene regulation, Chromatin dynamics of Histone chaperones and remodellers, Protein-Protein interaction through reader domains, Chromatin dynamics in Stem cell differentiation and cancer.

3. Macromolecular Crystallography (Udayaditya Sen and Sampa Biswas)

Structure factors, Atomic scattering factor, temperature factor, structure factor calculation, Phase problem and electron density calculation. Advanced phasing techniques (like MAD/SAD). Phasing by MR, Model building and refinement. Fiber Diffraction.

High throughput crystallography; Cryo-crystallography and its application in trapping reaction intermediates; X-ray crystallography to elucidate structure-function relationship for some important biological pathways; crystallography of large macromolecular assembly. Crystallization techniques, handling protein crystals using cryo techniques, diffraction data collection, electron density map interpretation, crystallographic data analysis.

4. Modern Spectroscopic Methods and Applications (Samita Basu, Montu Hazra, Padmaja Mishra & Dulal Senapati)

Nanosecond to Femtosecond Laser Spectroscopic Techniques and their application to the various prototype and diverse bio-molecules of different sizes related to Biophysical Sciences. The spectroscopic methods we will cover are the following: (i) Time Resolved Fluorescence and Absorption (ii) Circular Dichroism (iii) Fourier Transform Infrared Spectroscopy (iv) Laser Induced Fluorescence Excitation and Dispersed Fluorescence Spectroscopy in Supersonic Jet (v) Resonant Enhanced Multi-Photon Ionization Spectroscopy (vi) Fluorescence and Time of Flight Mass Spectroscopic Detections (vii) Laser Photoacoustic Spectroscopy (viii) Cavity Ring-down Spectroscopy (ix) Raman Spectroscopy (x) Multiple Colors IR-UV double, IR-UV-UV triple and UV-UV double resonance spectroscopy (xi) One Color UV Photo-Dissociation and Multiple Colors Vibrational Mediated Photo-Dissociation Spectroscopy (xii) X-Ray Photoelectron Spectroscopy.

5. Conducting polymers, graphene & carbon nanotube based composites and nanocomposites : Preparation, characterization and applications (Amitabha De & Dulal Senapati)

i) Introduction, ii) Synthesis Techniques: Chemical and Electrochemical Polymerization, iii) Composites, Blends and Nanocomposites: Different types, iv) Characterization techniques of Polymers and Composites, v) Graphene based materials, v) Mechanism of Charge transport, vi) Potential

application areas of conducting polymers, vii) Conducting polymers in Biosensors and Electrochemical Capacitors, viii) Gold nanoparticle-Graphene oxide hybrid materials for ultra sensitive SERS probe, ix) Chemically-attached gold nanoparticle-carbon nanotube hybrid materials for analytical applications.

6. Drug Discovery: Modern Day Approach (Munna Sarkar)

Pre 20th century drug discovery. Drug discovery pipeline, drug targets and target validation. Methods of lead identification and optimization. Early prediction of ADMET (Absorption, Distribution, Metabolism Excretion and Toxicity). QSAR (Quantitative Structure Activity Relationship) predictions. Lipinski rule of 5. Polar surface area. Blood brain barrier crossing model. Predicting toxicity. Introduction to drug docking.

7. Membrane Biophysics & Cytoskeleton (Abhijit Chakrabarti)

Aminophospholipids, membrane proteins & cell surface glycoconjugates, Membrane Dynamics : Edidin & Frye experiment, heterocaryons, membrane diffusions, membrane domains, membrane asymmetry and lipid polymorphism.

Membrane skeleton, Endocytosis, Protein translocation. Erythrocyte Biophysics. Diseases of Erythrocytes.

8. Multi Scale Modeling (Dhananjay Bhattacharya)

Brief discussion on statistical mechanics of different polymers Interaction between atoms van der Waals interaction, Coulomb interaction, hydrogen bond interaction

Hartree-Fock and Density Functional Theory methods for partial charge calculation Molecular modeling of receptor-ligand interaction considering above integration forces Grid search and Monte Carlo simulation methods to optimize receptor-ligand interaction Molecular modeling of polymer freely joined chain, flexible polymer, worm like chain models

Macromolecular modeling, concept of Force-field, potential energy

Energy minimization steepest descent, Newton-Raphson and conjugate gradient methods Molecular dynamics simulation techniques Verlet, Leap-Frog, Velocity Verlet and Langevin dynamics algorithms.

Concept of parallel programming OpenMP and MPI intrinsics

Umbrella sampling methods for free energy exploration, Replica exchange molecular dynamics, Steered molecular dynamics

Estimation of difference in free-energy.

9. Chromatography and Mass Spectrometry (Soumen Kanti Manna)

Chromatography: General principles of chromatography, common types of chromatography¹, factors affecting chromatographic separation and considerations for choosing mode of chromatography, applications.

Mass Spectrometry: General principles, ion source², types of mass analyzers³, ion fragmentation and rearrangements, mass spectrometry of protein and peptides, mass spectrometry of small molecules, imaging mass spectrometry, applications.

¹normal phase, reverse phase, HILIC, ion exchange, size exclusion, affinity, GC and chiral.

²ESI, APCI, MALDI, EI, DESI, LAESI, FAB, SIMS, NIIMS.

³quadrupole, TOF, ion trap, orbitrap, ICR.

10. Advanced Microscopy and Imaging (Padmaja Mishra & Pulak Ray)

Concepts in Microscopy and imaging: Basic Principle of Optics, Family of Microscope, Optical Microscope Aberrations, Polarized light and its interaction with matter, Detection system image formation and image analysis, Point spread function, Advanced Light microscopy: FCS and FCCS

Principle of TEM, its development, architecture, vacuum system, power supply, Sample preparation techniques for TEM, Practical on TEM: Sample preparation, Study under TEM, Principle of SEM, Scanning Probe Microscope: STM, AFM, MFM

Single molecule detection (SMD) by fluorescence: Single molecule fluorescence spectroscopy/Microscopy, Technical Challenges, Methods in single molecule detection, Total Internal reflection (TIR) spectroscopy, Types (PTIR, OTIR), Data Processing, analysis and interpretation.

Principle of trapping, Design Considerations, Trapping force, Microscope, Objective, Position detection, Data Processing, analysis and interpretation, Applications

Super resolution microscopy and application

6.2 Library

SINP Library is a major information resource centre in the eastern part of India in Physical and Biophysical Sciences. In addition to 935 SINP members it has 587 users outside SINP. The annual report of the library during 2014-15 is as follows.

Collections

Library has a huge collection of books, e-books and non-book materials. Last year, we added 141 books, 2497 e-books and 43 journals.

Online facilities implemented through XI and XII plan project

SINP library has implemented the online and archival access of all major journals through the SINP and LDRM project fund during the current XII-th plan period. More than 3000 online journals as well as online archives (full-text pdf) available from our library website.

Chapter 7

Governing Council

Chairman:

Dr RK Sinha
Chairman, Atomic Energy Commission &
Secretary to the Government of India
Department of Atomic Energy
Anushakti Bhawan, CSM Marg
Mumbai-400 001

Members:

Shri PR Baviskar, IAS
Joint Secretary(R&D)
Government of India
Department of Atomic Energy
Anushakti Bhawan, CSM Marg
Mumbai-400 001

Shri RA Rajeev
Joint Secretary (Finance)
Government of India
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Prof Mustansir Barma
Director, Tata Institute of Fundamental Research
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Dean, FC for PG Studies in Technology
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Pro Vice-Chancellor (Academic)
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Shri Sukumar Ganai, IAS
Additional Secretary
Higher Education Department
Government of West Bengal
Bikash Bhaban, 5th floor
Salt Lake, Kolkata-700 091

Prof Bikas K Chakrabarti
Director
Saha Institute of Nuclear Physics
Sector-1, Block-AF, Bidhannagar
Kolkata-700 064

7.1 Audited Accounts

SAMA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2015

	Schedule	2014-15	2013-14
CAPITAL FUND & LIABILITIES			
CAPITAL FUND	1	82878622.17	58481208.48
EARMARKED FUNDS	2	7786401.00	8591329.00
CURRENT LIABILITIES AND PROVISIONS	3	241000042.78	208800001.00
TOTAL		3254127670.95	3219622484.82
ASSETS			
FIXED ASSETS			
Gross Stock	4	402982387.88	381580160.23
Less: Accumulated Depreciation	4	2116481448.13	1885000249.38
		<u>181334248.75</u>	<u>103080131.85</u>
INVESTMENT	5	2100458.00	6200004.00
CURRENT ASSETS, LOANS & ADVANCES	6	131879863.48	88178987.88
TOTAL		3254127670.98	3219622484.82
SIGNIFICANT ACCOUNTING POLICES	14		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	15		

The Schedules referred to above form part of these Accounts


(V. P. Mishra)
Accounts Officer


(N. Bandyopadhyay)
Dy. Controller of Accounts


(Ravindra Singh)
Registrar

In terms of our attached Report of even date
For K. Sharma & Co
Chartered Accountants
FIRM 302845E


(Ajit K. Mahapatra)
Director


(K. K. Bhatnagar)
Partner



Membership No. 000212
1/11, Old Post Office Street, Room No. 8, (First Floor),
Kolkata - 700 011
Dated - 10th September, 2015

SIVA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2015

	Schedule	2014-15	2013-14
INCOME :-			
Income from Sales/Services	7	1101430.00	508966.00
Grants	8	853872883.19	814300008.26
Interest Earned	9	1816347.00	10300001.00
Other Income	10	4891584.00	6000981.75
Excess of Expenditure over Income transferred to Capital Fund		-	37800084.14
		<u>867748264.19</u>	<u>130844487.15</u>
EXPENDITURE :-			
Establishment Expenses	11	242330108.10	871304885.80
Administrative Expenses	12	344388088.00	286889583.70
Interest/Bank charges	13	23104.09	8048.54
Depreciation	4	330660080.77	388001888.01
Excess of Income over Expenditure transferred to Capital Fund		144430378.23	-
		<u>867748264.19</u>	<u>130844487.15</u>

The Schedules referred to above form part of these Accounts.


(V. P. Mishra)
Accounts Officer


(N. Sanyal)
Dy. Controller of Accounts


(Ravindra Singh)
Registrar

In terms of our attached Report of even date

For K. Sharma & Co
Chartered Accountants
Firm No. 3029452


(K. C. Sharma)
Partner

Membership No. 605313
1/B, Old Post Office Street, Room No.8, (First Floor),
Kolkata - 700 001
Dated - 10th September, 2015




(Ajit K. Mohanty)
Director

BARIA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Account for the year ended 31st March, 2015

Particulars	2014-15	2013-14	2012-13
Opening Balance B/F -			81,20,00,000.00
Cash in hand	17,74,00,000.00	18,72,20,000.00	24,20,00,000.00
Current assets of business			22,10,000.00
Bank Charges			11,20,00,000.00
Cash in hand	66,50,00,000.00	18,74,00,000.00	7,21,00,000.00
Banking	14,31,11,000.00	18,74,00,000.00	11,20,00,000.00
Non-Banking			11,20,00,000.00
Cash in hand	88,72,78,719.00	18,74,00,000.00	18,74,00,000.00
Current assets of business			1,84,000.00
Bank & Other Advances	29,00,000.00	1,47,200.00	3,20,00,000.00
Participation of Foreign Money Deposit	68,27,66,000.00	6,40,71,200.00	19,00,700.00
Participation from other Deposits	88,10,000.00	17,80,200.00	11,20,000.00
Participation of other advances	82,29,00,000.00	6,22,91,000.00	11,20,000.00
Interest Receivable	1,19,40,000.00		6,22,91,000.00
Interest Payable	81,40,000.00		
Current Liabilities			64,700.00
Particulars of Fund Receipts		17,24,00,100.00	88,74,10,000.00
	<u>81,40,000.00</u>	<u>17,24,00,100.00</u>	<u>88,74,10,000.00</u>
	3,08,82,80,000.00	3,17,27,00,000.00	3,17,27,00,000.00

Atiq Khan
 (For K. Manna & Co)
 Chartered Accountants

Atiq Khan
 (For K. Manna & Co)
 Chartered Accountants

Atiq Khan
 (For K. Manna & Co)
 Chartered Accountants

In terms of our unqualified Report of audit filed
For K. Manna & Co
 Chartered Accountants



63/11
 Street, Room No. 8, (First Floor)

1999, 2015

Chapter 8

External Collaborators

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