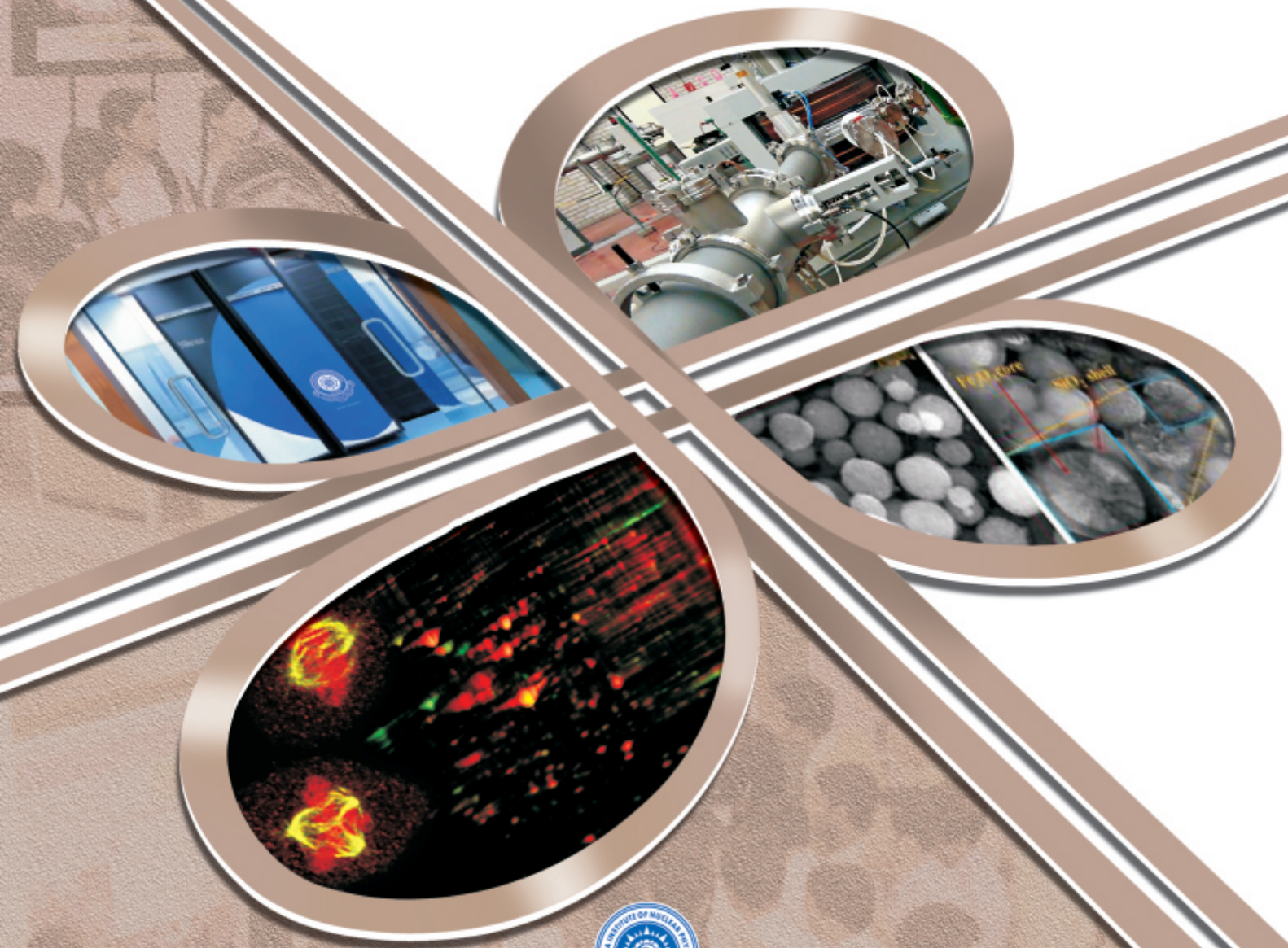
Saha Institute of Nuclear Physics

ANNUAL REPORT

2015-16



SINP

KOLKATA

Saha Institute of Nuclear Physics

Annual Report

2015–2016

Saha Institute of Nuclear Physics
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India

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January 11, 2017

Foreword

As I write this foreword for the Annual Report of this prestigious research institute, the first and foremost thought that came to my mind is that we are living in a very interesting time where scientific integrity is in high demand. At the same time, we are facing the challenge of changes conflicting with our traditional approaches, be it in science or in the society. It is a challenging time when the opposing attributes characterize dualism of various disciplines of science and also various strata of the society at large – challenges versus opportunities, risks versus benefits, interests versus conflicts, establishment versus individuals, and so on. Good thing about an establishment as prestigious as this institute is that it can withstand the challenge of changing time and move forward.

I have just completed my first year in this institute. As demanded by the changing time, lot of administrative hurdles need to be ironed out to stride forward. At the same time, the goals set for scientific research in various disciplines must be achieved. I am grateful to all my colleagues, starting from senior members of the faculty down to the junior most and staff members from administration, in helping me out. In spite of facing obstacles regarding research funding, it is good to observe number of smart publications, particularly from young faculty members holding the key in the future success of the institute. I am proud of them. Altogether 415 research publications have been credited during the period and an all time record number of 55 theses awarded for PhD degree. In this context, I congratulate all research students for contributing enormously to the academic growth of the institute. 90 publications have appeared in high impact journals like Nature group of journals, Physics Lettters B, Journal of High Energy Physics, Astrophysical Journal & Carcinogenesis to name a few. SINP is continuing International Collaborations with CERN in ALICE and CMS experiments, with SNOLab in PICASSO experiment and with Deutsches Elektronen-Synchrotron (DESY), Hamburg and Photon Factory (KEK) at Tsukuba in research utilizing synchrotron beamlines.

Yet there are many hurdles and challenges to be overcome. The long pending installation work of BL-13 beam line at RRCAT is in progress which was stopped in the year 2013 due to lack of funding. The construction work of the FRENA (Facility for Research in Experimental Nuclear Astrophysics) building has been going on in full swing with the hall for the FRENA machine expected to be ready by the end of the year 2016. A Dark Matter (DM) search experiment is planned to be located at an underground site at the UCIL, Jaduguda mine. The proposed experiment will use suitable scintillation crystals as active mass for the detector and is being pursued with active collaboration amongst several DAE organizations including SINP, BARC, NISER, INO and UCIL.

I am confident that, despite many hurdles to be overcome, the Institute will rise to the challenges of changing time and carry forward the legacy of scientific research for the benefit of the society and mankind, as dreamt by Professor Meghnad Saha, the Founder of the Institute.

October 2016

Ajit Kumar Mohanty
Director

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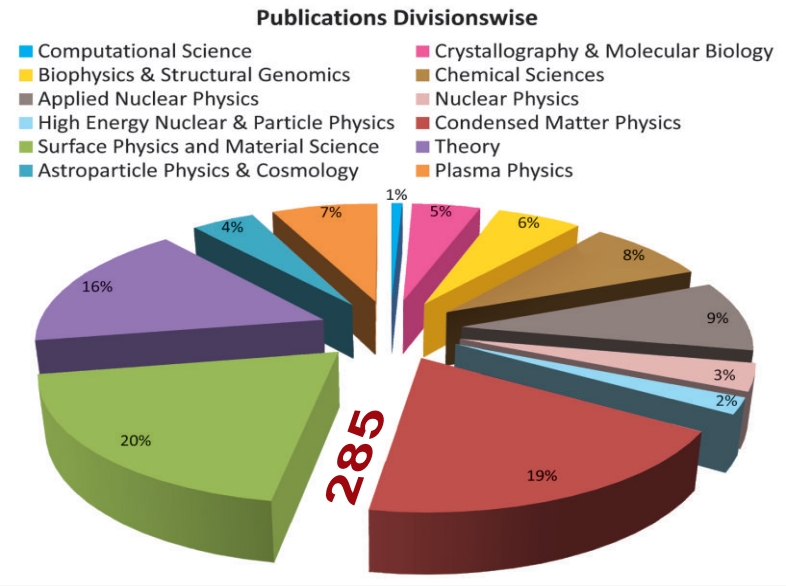
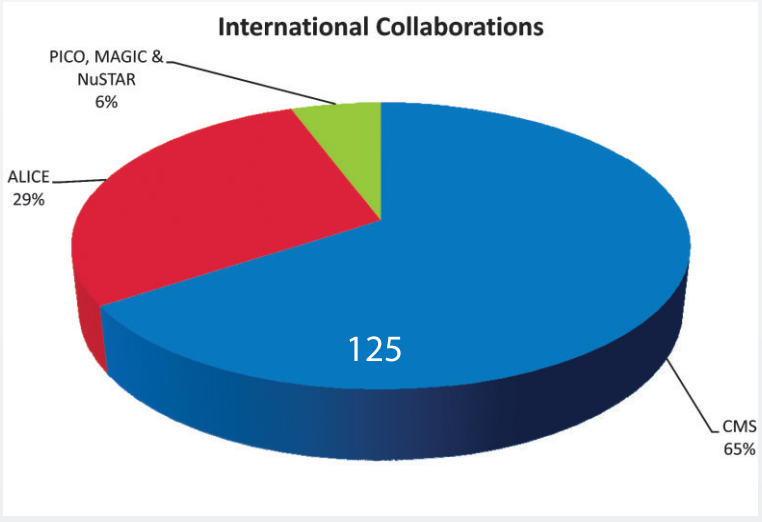
Highlights (April 2015-March 2016)

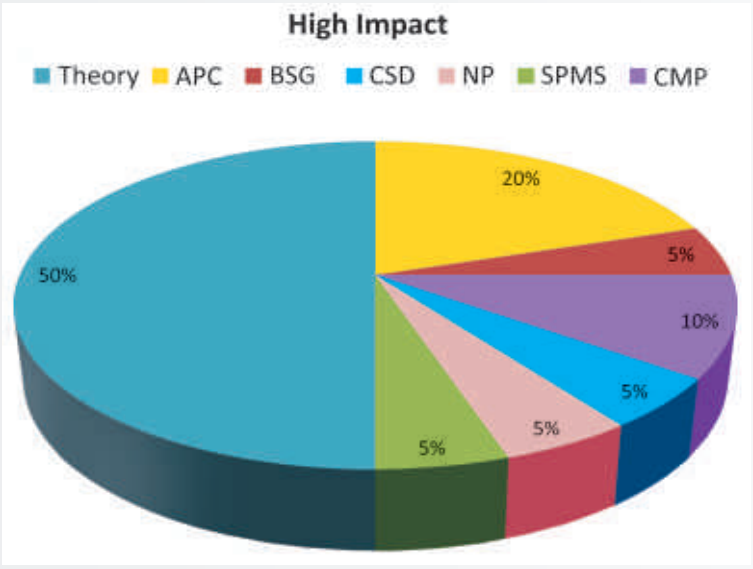
Saha Institute of Nuclear Physics (SINP) is engaged in basic scientific research on five broad subject areas (a) Experimental Nuclear and Particle Physics, (b) Condensed Matter Physics including Surface Physics and Nanoscience, (c) Biophysical science including chemistry, (d) Theoretical & Astroparticle Physics (e) Plasma Physics.



Under the area Biophysical Sciences including Chemistry, there are 23 faculty members and 32 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. There are 27 faculty members and 62 research students and associates, under Condensed Matter Physics including Surface Physics and NanoScience, distributed in two Divisions, Condensed Matter Physics and Surface Physics & Material Science actively engaged in different disciplines of both theoretical and experimental condensed matter and material physics. Under the area of Experimental Nuclear & Particle Physics, there are 22 faculty members and 24 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. There are 24 faculty members and 35 research students and associates, distributed in the three Divisions, Theory, Astroparticle & Cosmology and Plasma Physics engaged in research on theoretical, plasma and astroparticle physics.



35 Post M.Sc students have been inducted into the research & teaching program during the year



2015-16. About 10 undergraduate associates and 30 students in the summer program have been trained in the Institute coming from different parts of the country. Altogether **415** research publications have been credited during the period and about **55** theses awarded for PhD degree. **90** publications are in high impact (IF>6.0) journals like Physics Lettters B, Journal of High Energy Physics, Astrophysical Journal, Carcinogenesis and Scientific Reports to name a few.

International Collaboration with CERN in ALICE and CMS experiments, with SNOLab in PICASSO experiment and the Indo - German collaboration in Deutsches Elektronen-Synchrotron (DESY), Hamburg continued. Successful operation of the Indian Beam Line at Photon Factory (KEK), Tsukuba has been recognized as a flagship cooperative activity by the honorable Prime Minister of India.

Outreach programs conducted from the Centre for Advanced Research & Education (CARE) both in and outside SINP, going to remote places of Sundarban to district schools of West Bengal, have been successful with overwhelming response from the participant students.

The Unveiling of the exihibits of medals obtained by Meghnad Saha on the 66th Foundation Day.

Honours & Distinctions

Prof Milan K Sanyal

Prof. Milan K Sanyal has been elected Fellow of the The World Academy of Science (TWAS) in November 2015.

Prof Sukalyan Chattopadhyay

Prof. Sukalyan Chattopadhyay has been selected Fellow of National Academy of Science, India (NASI), Allahabad, August 2015.

The Members of the Saha Family with other dignitaries on the 66th Foundation Day, January 11, 2016

The Third International Conference on Advances in Astroparticle Physics and Cosmology (AAPCOS)

October 12-17, 2015

The first one and half days of the Confernce were devoted to pedagogical lecture series on dark matter for students and young researchers. This was followed by an outreach programme on "Different Aspects of Astroparticle Physics and Cosmology" which showcased India's first space borne observatory ASTROSAT, Dark Matter Search Experiments around the world and Square Kilometre Array, the next generation radio telescope to school students. The main conference focused on recent excitements in Astroparticle Physics and Cosmology, and brought together experts in theory and experiment from India and abroad. Furthermore, a fest colloquium was organized in honor of Professor Pijushpani Bhattacharjee under AAPCOS2015. Over 100 scientists and students participated in this conference. (Convener : Prof. Debashis Majumdar)

Special Events

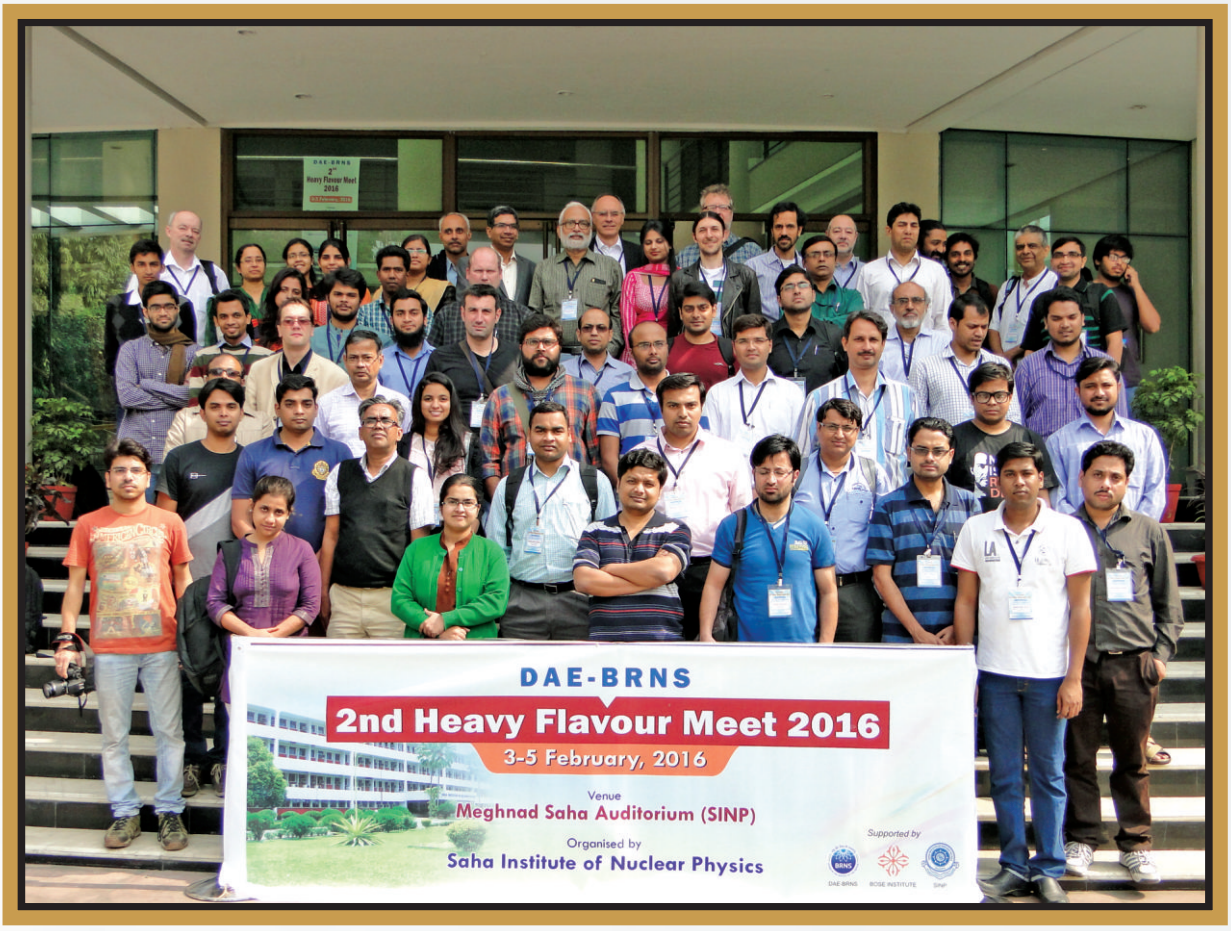
30th National Symposium of Plasma Science and Technology

December 01-04, 2015

The symposium was organised jointly with Plasma Science Society of India (PSSI). The purpose of this conference was to provide a focal point and forum for the exchange of both educational and research ideas among scientists in this diverse field. Research in plasma physics is extraordinarily broad which covers basic physics of plasmas, fusion sciences, space and astrophysics, beam and accelerator physics, laser-matter interactions, and industrial processing. Approximately, four hundred (400) delegates, both from India and abroad, attended and shared their knowledge in the frontier areas of plasma physics in this Symposium via intense oral discussions and poster presentations. We sincerely believe that the exchange of ideas between different disciplines helped and improved the knowledge in frontline direction of plasma research. (Convener : Prof. Nikhil Chakrabarti).

2nd heavy Flavour Meet

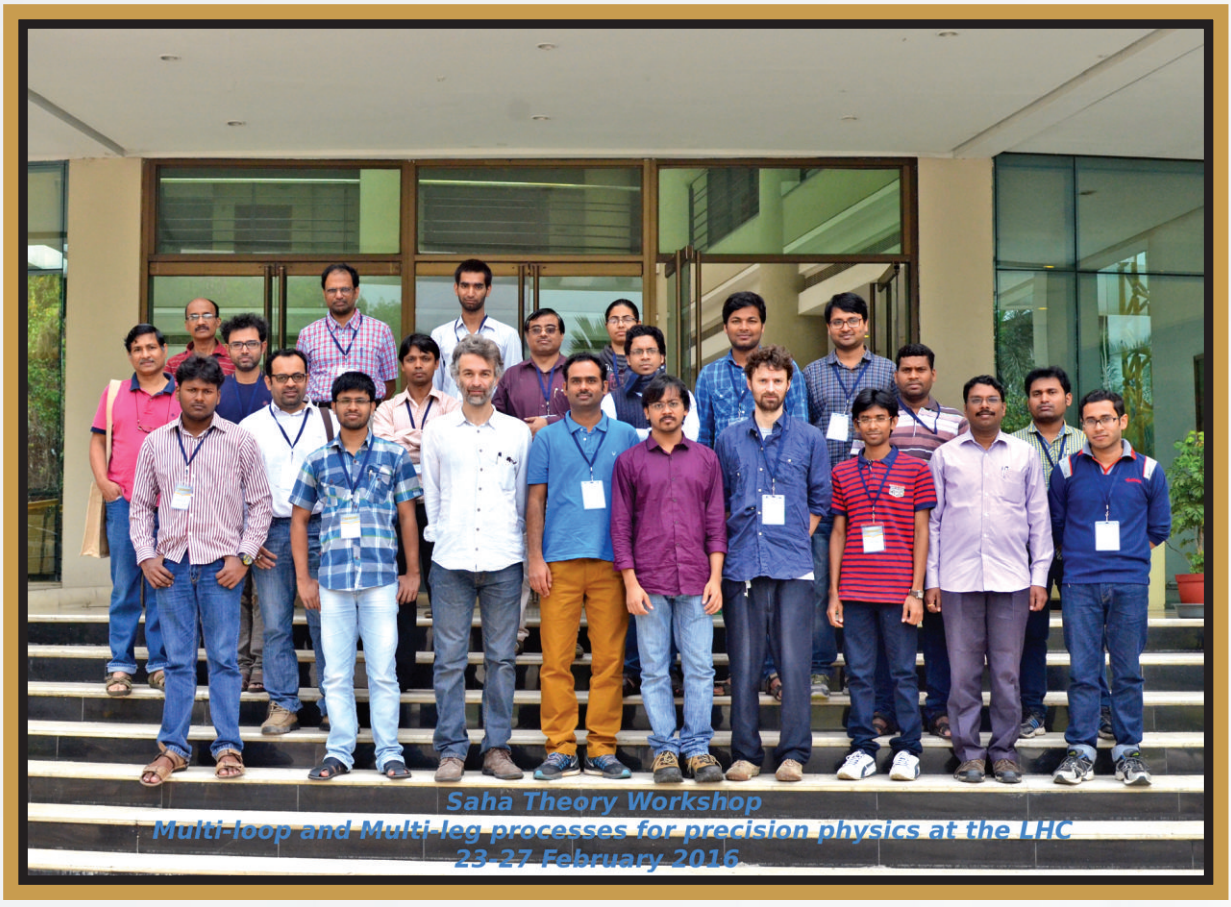
February 3-5, 2016



On going high energy collider experiments at LHC CERN involving pp, pA and AA collisions reveal wealth of information about the medium with heavy flavours as probes. Fixed target high luminosity experiments CBM at FAIR GSI are upcoming. Heavy quarks by virtue of their large masses (Mc~1.5 GeV, Mb~5 GeV) are produced in high virtuality processes at the initial stage of the high energy heavy-ion collisions with short formation time (Δt > 1/2M ~ 0.1 fm) which is much much less than the Quark Gluon Plasma (QGP) life time (5-10 fm). Their production in the QGP are subdominant and interactions with QGP don't change flavour identity. The uniqueness of heavy quarks is that they cannot be “destroyed/created” in the medium but transported through the full system evolution. They are good probes of the medium as well provide a good test to pQCD. The purpose of this “Heavy Flavour Meet” series is to bring together the leading experts comprising experimentalist and theoretician in this field across the globe to benefit the young researchers working in this field (Convener : Prof. Munshi Golam Mustafa).

The Saha Theory Workshop 2016 of the Theory Division,

February 23-27 , 2016

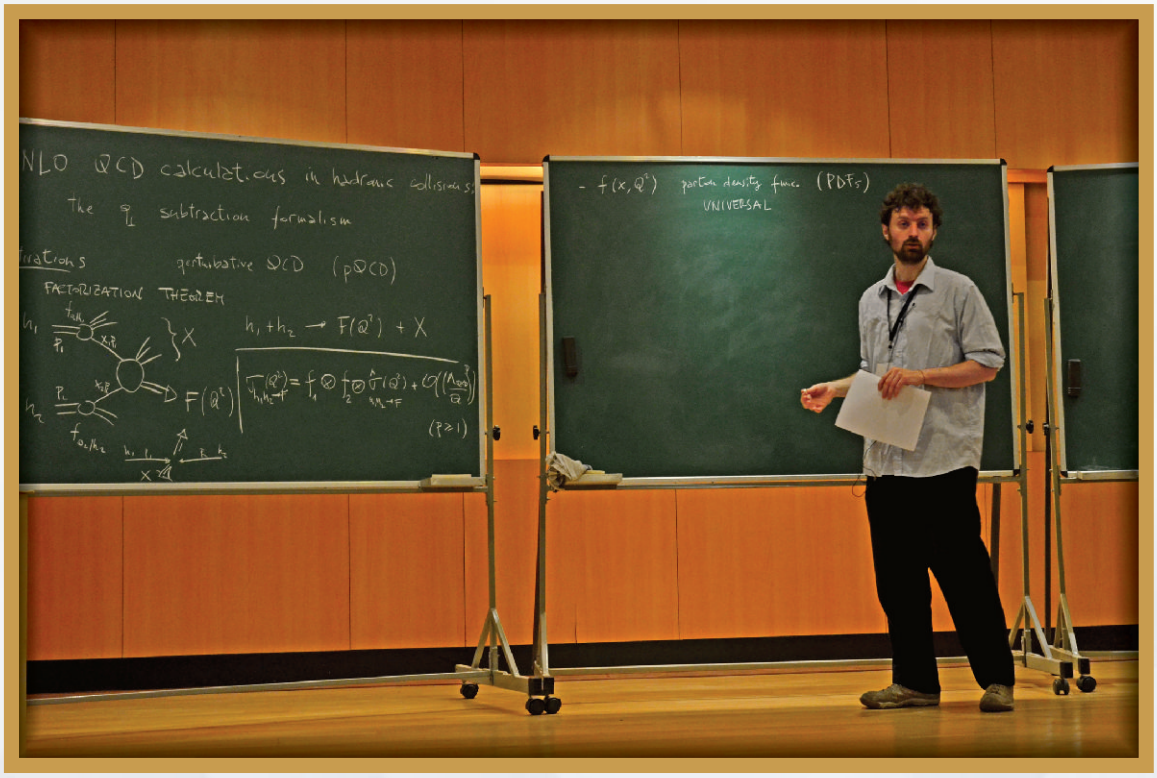


The workshop was focused on Multi-loop and Multi-leg processes for precision physics at the LHC. An instructional workshop to discuss precision QCD+EW physics at hadron colliders: primarily intended for PhD students, post doctoral fellows and young researchers in the field of Radiative Corrections. Prof. Giancarlo Ferrera and Prof. Alessandro Vicini of the University of Milano, Italy were the main experts. Participation was by invitation and was restricted to practitioner in the field of Radiative Corrections. (Convener : Prof. Prakash Mathews).

10th J.C. Bose Memorial Lecture delivered by Prof. Jogesh C Pati on January 14, 2016

Director presenting a memento to Prof.T V Ramakrishnan after delivering
52nd Saha Memorial Lecture on July 8, 2015

Post MSc Associates 2015



Prof Giancarlo Ferrera at Theory Seminar, February 25, 2016

Under graduate associates and Summer students, 2016

Participants of CARE School for Clinicians, March 28-April 1, 20016

Director & Registrar Joined in the Institute

Ajit Kumar Mohanty
Director

Dr. Ajit Kumar Mohanty is an experimental physicist and is currently the Director of Saha Institute of Nuclear Physics (SINP) at Kolkata since June 2015. Dr. Mohanty completed his B.Sc (Hons) in Physics (1979) and M.Sc (1981) in Ravenshaw College which was at that time under Utkal University. He then joined Bhaba Atomic Research Center (BARC) in the Nuclear Physics division in 1981 and completed his Ph.D in Bombay University.

Anirban Banerjee
Registrar

Anirban Banerjee, a serving Commander of the Indian Navy presently on deputation as Registrar to the Saha Institute of Nuclear Physics for a period of three years wef 01 Nov 15. An International Hydrographic Organisation Category 'A' qualified Charge Hydrographer; a Post Graduate in Hydrography with over 22 years of service in the Indian Navy. During his career he has held numerous varied assignments both operational and administrative, in various capacities. Prior to his deputation Anirban was posted at the Indian Naval headquarters at New Delhi.

A Safety Awareness Programme

November 5, 2015

The Programme was attended by members of the Institute and of Variable Energy Cyclotron Centre, Kolkata. The Safety Manual was released by Director, Prof. Ajit Kumar Mohanty. Lectures and discussion were held on electrical, industrial, cryogenic, radiation and fire safety. Handling of a small fire accident was demonstrated.

Drama: *Satty Bhuter Gappa,* staged by Staff and Students, on January 11, 2016

Prof. A K Mohanty, Director, participating in an event in Annual Sports on February 24, 2016

Breaking the earthen pot in Annual Sports on February 24, 2016

Chapter 1

Biophysical Sciences including Chemistry

1.1 Biophysics and Structural Genomics

1.1.1 Summary of Research Activities

Biophysics and Structural Genomics Division is focussed in interdisciplinary area of basic and clinical research involving Proteomics, Biomolecular spectroscopy, Chemical Biology and Synthetic & Structural Biology. The widely prevalent diseases of eastern India, HbE-thalassemia and leukemia are being studied as model for hematological disorders while Alzheimer's, Huntington's, and the Prion diseases are being investigated for gaining insights into neurodegenerative diseases. Differential proteomics studies have been performed using clinical samples of cerebrospinal fluid, blood and plasma. Classes of redox regulators and chaperone proteins have been found to be up-regulated in hemoglobinopathy and an interactome for haemoglobin has been identified in erythrocytes. Investigations in cellular signaling and its role in cell fate determination vis a vis regulation of metabolism were studied using comparative mitochondrial proteome. Our findings clearly underline that cellular signalling and differentiation, lead to the alteration of mitochondrial proteome which in turn affects the functioning of key metabolic pathways. Similar studies have also implicated deregulation in self renewal pathways in the process of metastasis in gastric and breast cancer. Biophysical studies on elasticity of nuclear membrane proteins Lamins have implicated their role not only in cardiovascular diseases but in cell differentiation as well. Currently, investigation on the role of lamins and intermediate filaments in DNA damage response, karyokinesis and carcinogenesis are underway. Epigenomics 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 such as breast cancer.
Neurodegenerative disorders like Alzheimer's, Huntington's and Prion Diseases are being pursued to study the roles of various micro RNAs in the disease process. The major focus of research in Alzheimer's has been the study of the downstream pathogenesis mediated through AICD and its adaptor network. AICD possesses conserved motifs that are known to interact with cytosolic adaptor proteins and these interactions in turn affect different signaling pathways. With Prion disease as a model system, we are trying to understand the significance of the ESCRT machinery and the endo-lysosomal pathway in Prion protein-mediated neurodegeneration. Our aim is to provide a molecular explanation for how the loss of function mutation of Mahogunin results in Prion disease like phenotype of spongiform neurodegeneration. In this regard, Ubiquitin-mediated regulation of

the E3 ligase GP78 by MGRN1 in trans have been shown to affect mitochondrial homeostasis and positioning of spindle apparatus in development and disease.
Recently, we have initiated studies on a molecular systems level understanding of the combined effects of microgravity and space ionizing radiation (high energy particles) on human cells along with a metabolomics-guided system level elucidation of the effect of radiation exposure on living systems.

1.1.2 Publications

1.1.2.1 Publications in Books/Monographs & Edited Volumes

Debashis Mukhopadhyay
Cactus & Succulents, in Ornamental Plants and Garden Design in Tropics and Subtropics, Eds TK Bose, LJ Singh, MK Sadhu & TK Maity, Astral Publishers, New Delhi, 2015

1.1.2.2 Publications in Journal

Shilpita Karmakar; Debasis Banerjee; Abhijit Chakrabarti, Platelet proteomics in thalassemia: Factors responsible for hypercoagulation, PROTEOMICS CLINICAL APPLICATIONS **10** (2016) 239

Rukmini Mukherjee; Oishee Chakrabarti, Ubiquitin-mediated regulation of the E3 ligase GP78 by MGRN1 in trans affects mitochondrial homeostasis, JOURNAL OF CELL SCIENCE **129** (2016) 757

Santanu Adhikary; Sulagna Sanyal; Moitri Basu; Isha Sengupta; Sabyasachi Sen; Chandrima Das, Selective Recognition of H3.1K36 Dimethylation/H4K16 Acetylation Facilitates the Regulation of All-trans-retinoic Acid (ATRA)-responsive Genes by Putative Chromatin Reader ZMYND8, JOURNAL OF BIOLOGICAL CHEMISTRY **291** (2016) 2664

Madhurima Mitra; Malay Patra; Abhijit Chakrabarti, Fluorescence study of the effect of cholesterol on spectrin-aminophospholipid interactions, EUROPEAN BIOPHYSICS JOURNAL WITH BIOPHYSICS LETTERS **44** (2015) 635

Pritha Bhattacharjee; Dipak Dasgupta; Kaushik Sengupta, Molecular Events in Lamin B1 Homopolymerization: A Biophysical Characterization, JOURNAL OF PHYSICAL CHEMISTRY **B119** (2015) 14014

P Majumder; O Chakrabarti, Mahogunin regulates fusion between amphisomes/MVBs and lysosomes via ubiquitination of TSG101, CELL DEATH & DISEASE **6** (2015) Art No: e1970

Avik Basu; Sandra Harper†; Esther N Pesciotta†; A Chakrabarti; et al, Proteome analysis of the triton-insoluble erythrocyte membrane skeleton, JOURNAL OF PROTEOMICS **128** (2015) 298

Avik Basu; Abhijit Chakrabarti, Hemoglobin interacting proteins and implications of spectrin hemoglobin interaction, JOURNAL OF PROTEOMICS **128** (2015) 469

Anindita Deb Pal; Subrata Banerjee, Epstein-Barr virus latent membrane protein 2A mediated activation of Sonic Hedgehog pathway induces HLA class Ia downregulation in gastric cancer cells, VIROLOGY **484** (2015) 22

Suchismita Halder; Ranjan Kumar Dey; Anadi Roy Chowdhury; et al, Differential regulation of urine proteins in urothelial neoplasm, JOURNAL OF PROTEOMICS **127** (2015) 185

Rajarshi Chakrabarti†; Sulagna Sanyal; Amit Ghosh; C Das; et al, Phosphatidylinositol-4-phosphate 5-Kinase 1 α Modulates Ribosomal RNA Gene Silencing through Its Interaction with Histone H3 Lysine 9 Trimethylation and Heterochromatin Protein HP1-α, JOURNAL OF BIOLOGICAL CHEMISTRY **290** (2015) 20893

Devika Srivastava; Oishee Chakrabarti, Ubiquitin in regulation of spindle apparatus and its positioning: implications in development and disease, BIOCHEMISTRY AND CELL BIOLOGY-BIOCHIMIE ET BIOLOGIE CELLULAIRE **93** (2015) 273

Amrita Banerjee; Sulagna Sanyal; Parijat Majumder; et al, Recognition of chromatin by the plant alkaloid, ellipticine as a dual binder, BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS **462** (2015) 352

Joydeep Roy†; Sahana Mitra†; Kaushik Sengupta; et al, Hsp70 clears misfolded kinases that partitioned into distinct quality-control compartments, MOLECULAR BIOLOGY OF THE CELL **26** (2015) 1583

Madhurima Mitra; Arunima Chaudhuri; Malay Patra; Abhijit Chakrabarti, Organization and Dynamics of Tryptophan Residues in Brain Spectrin: Novel Insight into Conformational Flexibility, JOURNAL OF FLUORESCENCE **25** (2015) 707

Debashree Das; Malay Patra; Abhijit Chakrabarti, Binding of hemin, hematoporphyrin, and protoporphyrin with erythroid spectrin: fluorescence and molecular docking studies, EUROPEAN BIOPHYSICS JOURNAL WITH BIOPHYSICS LETTERS **44**(2015) 171

1.1.3 Ph D Awarded

Anindita Deb Pal [Subrata Banerjee], Cell proliferation, differentiation and mitochondrial dynamics, CU, March 2015

Amrita Banerjee [Dipak Dasgupta], Effect of small molecules on chromatin assembly, CU, May 2015

Nandini Pal Basak [Subrata Banerjee], Mitocondrial proteome in the progression of Leukemia, JU, June 2015

Avik Basu [Abhijit Chakrabarti], Proteomic studies of erythrocytes in sickle cell disease, erythrocyte membrane skeleton and post translational modifications, CU, July 2015

Shilpita Karmakar [Abhijit Chakrabarti], Differential proteomic studies of platelets in hematological disorders, CU, July 2015

Suchismita Halder [Abhijit Chakrabarti], Differential Proteomics in Hematological Disorders, HBNI, July 2015

Mohor Biplab Sengupta [Debashis Mukhopadhyay], Comparative and Quantitative Proteomics Study of Cerebrospinal Fluid from Spinal-Injured Subjects, CU, February 2016

1.1.4 Seminars/Lectures given in Conference/Symposium/Schools

Sangram Bagh
i. Immunity and disease related cellular and metabolic signatures in human cells and bacteria in microgravity, Annual Meeting of National Network for Mathematical and Computational Biology, IISER Pune, December 27-30, 2015
ii. Can we program a cell like an engineer programs a device?
(a)DBT sponsored workshop on Physics on Biology, St Xaviers College, Kolkata, January 19, 2016
(b)Recent trends in Physics and Biology Colloquium, Rahara Ramkrisha Mission College, Rahara, January 28, 2016
(c)Biological Sciences Colloquium Series, Presidency University, Kolkata, March 2, 2016
iii. Can Synthetic Biology program a cell like an engineer programs a device?, Jagadish Chandra Bose Lecture Series, Department of Electronics and Telecommunication Engineering, IIEST, Shibpur, March 16, 2016

Debashis Mukhopadhyay
i. Neuro De-/Re-generation Proteomics!, seminar on Frontiers in Proteomics Research, Proteomics Day Celebration, Dept of Biochemistry, University of Delhi South Campus, March 18, 2016
ii. Comparative and Quantitative Proteomics Studies of Cerebrospinal Fluid from Spinal-Injured Subjects, Two Day National Symposium on Exploring Biological System: Cell to Organism (EBS2016), orgainsed by Dept of Biophysics, Molecular Biology & Bioinformatics, University of Calcutta, Kolkata, March 1-2, 2016
iii. HDL a good cholesterol? - It Surely Is!, Int Conf on Biotechnological Advances in Environmental Health and Biodiversity Conservatiom (EHBC), organized by State Biotech Hub, Govt of Manipur in collaboration with Environmental Mutagen Society of India, Manipur University, May 21-23, 2015

1.2 Crystallography and Molecular Biology

1.2.1 Summary of Research Activities

Main focus of Crystallography and Molecular Biology Division is study of the structure and conformation of proteins involved in various cellular regulatory processes. Studies relating the structure and dynamics of biological macromolecules to function are essential part of modern biophysics in or-

der to unravel the mechanism of action of proteins at the molecular level. Our research is strongly focused on understanding the mechanistic insights of various classes of proteins such as membrane skeletal proteins; cell-cycle regulatory proteins; signaling and heat shock proteins; cysteine proteases and inhibitors; proteins involved in unique sugar metabolism; and integral membrane proteins. Using well-established expertise of recombinant DNA technology, X-ray crystallography and structure-guided protein engineering, we attempt to understand the mechanism of proteolytic activity of cysteine proteases, alter the function of cysteine proteases (like imparting hemoglobinase activity), design and generate specific protein inhibitors from serpin family against falcipain2 from *Plasmodium falciparum*, a drug target for the malaria parasite. Structural and functional aspects of *Vibrio cholera* proteins involved in many processes such as c-di-GMP mediated biofilm formation, transcription termination and activation (Rho-specific), small heat shock proteins (HSP31, HSP15, DnaK etc.) mediated protein folding and protein phosphorylation / dephosphorylation involved in metabolic activity and signal transduction will be studied in great detail.
Several unique sugar metabolizing proteins have been identified in *Leishmania donavani*, a protozoan parasite that causes Leishmaniases, which are potential drug targets. Structural characterizations have been initiated with the proteins UDP-Glc 4 '-epimerase, UDP-galactopyranose mutase and Galactose Mutarotase. Works are in progress to elucidate the functional interaction of DNA repair protein (Ku) with the cell cycle modifier polo-like kinase 1 (Plk1). Further, structural and thermodynamic insights related to the interaction of cyclophilin, a peptidyl-prolyl cis-trans isomerase, with a transmembrane protein CD147 would be examined since this interaction has been implicated in inflammation, cancer and cardiac disorders. We would use the newly installed Next Generation Sequencer (NGS) to ellucidate any differential relationship of involvement of Ku with the origin-uses in a specio-temporal manner
Erythroid spectrin is a major constituent of Red Blood Cells (RBC) and plays a vital role in maintaining the cytoskeletal structure and flexibility of the erythrocyte. Cloning, expression and purifications of spectrin domains such as the ankyrin binding domain, self-associating domain, SH3 domains etc have been initiated to explore their protein-protein interactions, chaperone activity and membrane binding potential. We are starting a new research area on characterizing the structural dynamics of membrane proteins. Importantly, ∼30% of human genome codes for membrane proteins and ∼60% of available drugs target membrane proteins. Structural dynamics of potassium and magnesium ion channels have been just initiated to decipher lipid-dependent voltage gating mechanisms.

1.2.2 Publications

1.2.2.1 Publications in Journal

Barnali Waugh; Udayaditya Sen; Rahul Banerjee, Crystal structure of phosphoglucomutase from Leishmania major at 3.5 angstrom resolution, BIOCHIMIE **121** (2016) 102

Kamalika Roy Choudhury; Srijit Das; Nitai P Bhattacharyya, Differential proteomic and genomic profiling of mouse striatal cell model of Huntington's disease and control; probable implications to the disease biology, JOURNAL OF PROTEOMICS **132** (2016) 155

Siddhi Chaudhuri; Samim Sardar; Damayanti Bagchi; Sushanta Debnath; Partha Saha; et al, Photoinduced Dynamics and Toxicity of a Cancer Drug in Proximity of Inorganic Nanoparticles under Visible Light, CHEMPHYSCHEM **17** (2016) 270

Srabanti Ghosh†; Prabal Chakraborty; Adrita Chakrabarti†; Partha Saha; et al, Biological activity of dendrimer-methylglyoxal complexes for improved therapeutic efficacy against malignant cells, RSC ADVANCES **6** (2016) 6631

Sourav Roy; Sankar Basu; Dipak Dasgupta; et al, The Unfolding MD Simulations of Cyclophilin: Analyzed by Surface Contact Networks and Their Associated Metrics, PLOS ONE **10** (2015) Art No: e0142173

Sudha Bucha; Debashis Mukhopadhyay; Nitai Pada Bhattacharyya, Regulation of mitochondrial morphology and cell cycle by microRNA-214 targeting Mitofusin2, BIOCHEMICAL AND BIOPHYSICAL RESEARCH, COMMUNICATIONS **465** (2015) 797

Sumanta Kumar Ghatak†; Dipanwita Majumdar†; Achintya Singha†; D Das; A Chakrabarti; et al, Peanut protein sensitivity towards trace iron: A novel mode to ebb allergic response, FOOD CHEMISTRY **176** (2015) 308

Supratim Ghatak; Sanghamitra Raha, Micro RNA-214 contributes to proteasome independent downregulation of beta catenin in Huntington's disease knock-in striatal cell model STHdhQ111/Q111, BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS **459** (2015) 509

Sanjay Dey†; Maitree Biswas†; Udayaditya Sen; et al, Unique ATPase Site Architecture Triggers *cis*-Mediated Synchronized ATP Binding in Heptameric AAA^{+}-ATPase Domain of Flagellar Regulatory Protein $FlrC^{*}$, JOURNAL OF BIOLOGICAL CHEMISTRY **290** (2015) 8734

Jayeeta Ghose; NP Bhattacharyya, Transcriptional regulation of microRNA-100,-146a, and-150 genes by p53 and NF kappa B p65/RelA in mouse striatal STHdh(Q7)/Hdh(Q7) cells and human cervical carcinoma HeLa cells, RNA BIOLOGY **12** (2015) 457

Atanu Ghorai†; Asitikantha Sarma†; Nitai P Bhattacharyya; et al, Carbon ion beam triggers both caspase-dependent and caspase-independent pathway of apoptosis in HeLa and status of PARP-1 controls intensity of apoptosis, APOPTOSIS **20** (2015) 562

M Patra†; C Mukhopadhyay†; A Chakrabarti, Malachite green interacts with the membrane skeletal protein spectrin, RSC ADVANCES **5** (2015) 91166

N Rai; M Sarkar; S Raha†, Piroxicam, a traditional non-steroidal anti-inflammatory drug (NSAID) causes apoptosis by ROS mediated Akt activation. PHARMACOL REP **67** (2015) 1215

1.2.3 Ph D Awarded

Ramanuj Banerjee [Udayaditya Sen], Structural and functional aspects of Rho dependent transcription termination in Vibrio cholerae O395, CU, May 2015

Seema Nath [Udayaditya Sen], Structure function relationship of phosphatases from Vibrio Cholerae

O395, HBNI, May 2015

Kasturi Guha [Partha Saha], Studies on post-transcriptional control of gene expression in eukaryotes, CU, June 2015

Eashita Das [Nitai Pada Bhattacharyya], Regulation of cell cycle, autophagy and neuronal differentiation by microRNAs, CU, June 2015

Sourav Roy [Rahul Banerjee], Protein Folding and Conformational Stability Studies on Cyclophilin and its Mutants, HBNI, July 2015

Barnali Waugh [Rahul Banerjee], Crystal structure solution of Phosphoglucomutase from L major at 3.5 resolution and pharmacophore based data-mining to identify prospective anti-Leishmanials, HBNI, October 2015

Srijit Das [Nitai Pada Bhattacharyya], Transcription regulation of coding and non-coding genes by Heat Shock Factor 1: Possible role in Huntington's Disease, CU, November 2015

1.2.4 Seminars/Lectures given in Conference/Symposium/Schools

H Raghuraman
Water as a Structural Component in Potassium Channel Gating, Workshop on Biophysics, organized by St Xavier's College, Kolkata, January 19, 2016

Abhijit Chakrabarti
i. Protein aggregation, Disease and Gold Nanoparticles, International Conference on Electron Microscopy and XXXVI Annual Meeting of the Electron Microscope Society of India (EMSI), Bhabha atomic Research Center, Mumbai, July 6-10, 2015
ii. Red cell, Disease, Proteomics & Chemical Biology, BioScience Group, Molecular Biology Division, Bhabha Atomic Research Centre, Mumbai, July 8, 2015
iii. Clinical Proteomics: a Decade in a non-Clinical Set-up, Department of Biological Sciences, Presidency University, Kolkata, February 17, 2016
iv. One protein versus Many proteins (EkTi protein bawnam Onekguli protein), Lead Lecture in 23rd West Bengal Science & Technology Congress 2016, Presidency University, February 28, 2016, Kolkata
v. Clinical Proteomics in Hematological Disorders, International Conference on Scenario of Biotechnology in 21st Century, School of Biotechnology, Devi Ahilya University, INDORE, March 11, 2016
vi. Clinical proteomics in haematological diseases, National Symposium & Workshop on Advances in Proteomics, Institute of Life Sciences (ILS), Bhubaneswar, March 15, 2016

Partha Saha
Phosphorylation of Ku70 subunit by cell cycle kinases modulates the replication related function of Ku heterodimer, Current Trend in Modern Biology Research in Health & Diseases, Department of Biochemistry and Biophysics, University of Kalyani, February 29, 2016

1.2.5 Teaching elsewhere

Abhijit Chakrabarti
i. Refresher course in Integrative Life Sciences: The Destiny, Academic Staff College, University of Calcutta, during March 27-April 20, 2015 on Proteomics : Its future in the Clinics to the College and University Teachers, April 10, 2015
ii. Refresher course in Aspects of Aprisals in Life Sciences, Academic Staff College, University of Calcutta, Department of Botany, Center of Advanced Study, December 8-31, 2015 on Proteins & Proteomics to the College and University Teachers, December 9, 2015

1.2.6 Miscellany

Abhijit Chakrabarti
i. Discussion in Hindi on Ethical, Legal & Social Implications of New Genetic Knowledge by Abhijit Chakrabarti and Debashis Mukhopadhyay of BSG Division, All India Radio, Kolkata, April 22, 2015
ii. Discussion in Hindi on The Energy Resource, Management and Environment, All India Radio, Kolkata, December 10, 2015
iii. Resource person, National Science (Vijoshi-2015) Camp-2015, organized by KVPY, IISER Kolkata & Department of Science & Technology, EZCC, Kolkata, December 16-18, 2015

1.3 Chemical Sciences

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 spectrometry and interaction, nano particle dosimetry and radiation safety.

Time-resolved spectroscopy within femtosecond to nanosecond time regime is being used extensively to study excited state dynamics on photoinduced electron transfer, proton transfer, etc with small organic molecules as well as to decipher the mode of intercalation of some common acridine derivatives with calf Thymus DNA. Similarly the results from laser flash photolysis experiments corroborated with magnetic field highlight the inter-radical separation distance between acridine derivatives and serum albumin proteins undergoing photoinduced electron transfer during binding. Moreover, steady-state and time-resolved spectroscopic studies supported by theoretical docking analyses on structure dependent hydrophobic and hydrophilic interactions of Schiff base complexes, comprising of different metal ions and ligands, with serum albumins as well as hen egg white lysozyme proteins emphasize the potentiality of less explored nickel complexes in drugprotein interactions.

Copper complexes of Oxicam 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. Also, the copper complexes of traditional NSAIDs have been found to cause structural alterations upon interaction with chromatin/histone that makes them exert their effect at the epigenomic and genomic level.

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-MnO_2 and graphene based materials have been used to fabricate supercapacitors of high specific capacitance. A non-enzymatic electrochemical biosensor has been fabricated for cholesterol detection, having a distinct advantage over other conventional enzymatic processes. Chemically converted Graphene modified with β-CD, being hydrophilic, electroactive and high surface area material, provides a platform for the electrochemical detection of cholesterol using Methylene Blue as redox indicator. Graphite nanoplatelet (GNP)/conducting polymer (poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate)) (PEDOT:PSS) composites were synthesized for their application as highly efficient electromagnetic interference (EMI) shielding material (SE) in the X-band frequency region.

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.

The nuclear and radiochemistry group is engaged in various activities. For the first time non-destructive method have been designed to determine K content of ancient glass beads which eventually tells about the origin of glass bead. Contribution have made in Radio-Green Chemistry experiments. Ionic liquids and other green reagents have been used to separate no-carrier-added clinically important radionuclides like ^{61}Cu, ^{62}Zn, ^{97}Ru, ^{95,96}Tc, ^{111}In and ^{109}Cd. An effective separation of ^{163}Ho was designed from ^{163}Er which has implications in neutrino mass measurement. Another important program of nuclear and radiochemistry group is measurement of naturally occurring radioactive material in Sundarban and Punjab state in collaboration with University of Calcutta and Panjab University.

The decomposition of isolated carbonic acid (H_2CO_3) molecule into CO_2 and H_2O (H_2CO_3® CO_2 + H_2O) is prevented by a large activation barrier (>35 kcal/mol). Nevertheless, it is surprising that the detection of the H_2CO_3 molecule has not been possible yet in the Earth's atmosphere and

hunt for the free H_2CO_3 molecule has become challenging not only in the Earths atmosphere but also on Mars. In view of this fact, we first study the instability of H_2CO_3 molecule in presence of water (H_2O), formic acid (FA), acetic acid (AA) sulfuric acid (SA) and hydroperoxide radical (HOO), detected in the in the Earth's atmosphere. It is seen from this study the vapor phase of H_2CO_3 molecule is unstable in presence of H_2O, FA and AA. Moreover, we also study the energetics and kinetics of the OH radical-initiated H_2CO_3 degradation reaction (H_2CO_3 + OH → HCO_3 + H_2O) to interpret the loss of the H_2CO_3 molecule in the Earths atmosphere, as the OH radical is known as the atmospheric detergent. Importantly, it is seen from these two studies that, although the atmospheric concentration of the OH radical is substantially lower than the concentrations of the H_2O, FA, AA in the Earths atmosphere, but nevertheless, the OH radical-initiated H_2CO_3 degradation reaction has significant impact, especially, towards the loss of H_2CO_3 molecule in the Earths atmosphere. In contrary, although the catalytic efficiencies of SA, FA and AA upon the H_2CO_3 decomposition reaction are similar to each other and the concentrations of both the SA and OH radical in the Earths atmosphere are more-or-less equal to each other, but nevertheless, the SA-assisted H_2CO_3 decomposition reaction cannot compete with the OH radical-initiated H_2CO_3 degradation reaction.

Effect of nuclear mean field and multiple preequilibrium mechanism in neutron emission from heavy ion reaction has been studied in the energy range of 10 MeV/amu to 30 MeV/amu. For the available sets of double differential neutron data, e.g., ^{20}Ne and ^{12}C induced reaction on ^{165}Ho system, the model has been observed to reproduce the measured data well. Whole body dose distribution and organ absorbed dose determined using measured neutron distribution from ^{12}C + C reaction at 12 MeV/amu. Our study showed that ∼21% of the total dose is contributed by neutrons above 20 MeV and average quality factor of the neutrons from this reaction is ∼10.2. Synthesis and influence of silver nano-particles in dose enhancement for gamma irradiation is being studied.

1.3.2 Publications

1.3.2.1 Publications in Books/Monographs & Edited Volumes

B Koley Seth and Samita Basu, Magnetic Field Effect on Photo-Induced Interactions: Its Implications in Distance Dependent Photo-Induced Electron Transfer Between CT-DNA and Metal Complex, in Research Methodology in Chemical Sciences Experimental and Theoretical Approach; Eds: Tanmoy Chakraborty & Lalita Ledwani, Apple Academic Press (AAP), USA, 2015

1.3.2.2 Publications in Journal

Susanta Lahiri, Across the energy scale: from eV to GeV, JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY **307** (2016) 1571

Moumita Maiti†; Susanta Lahiri; Zoltan Szucs†, Separation of ^{163}Er from dysprosium target: a step toward neutrino mass measurement through electron capture of ^{163}Ho, JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY **307** (2016) 1667

Banabithi Koley Seth; Aurkie Ray; Mousumi Banerjee; Teerna Bhattacharyya; Dhananjay Bhattacharyya; Samita Basu, Structure dependent hydrophobic and hydrophilic interactions between

nickel(II) Schiff base complexes and serum albumins: Spectroscopic and docking studies, JOURNAL OF LUMINESCENCE **171** (2016) 85

Sourav Ghoshal; Montu K Hazra, Impact of OH Radical-Initiated H_2CO_3 Degradation in the Earth's Atmosphere via Proton-Coupled Electron Transfer Mechanism, JOURNAL OF PHYSICAL CHEMISTRY **A120** (2016) 562

Susanta Lahiri; Moumita Maiti; Kaushik Gangopadhyay, Tracing ancient silk route by nuclear-analytical technique, JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY **307** (2016) 225

Shuvendu Singha†; Gopa Dutta (Pal)†; Partha P Bose†; Munmun Bardhan; et al, Use of Spectroscopic Techniques to Reveal the Nature of the Interactions of Two Sialic Acid Specific Lectins with Gold Nanoparticles , JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY **16** (2016) 515

BHV Pai†; AA Shanbhag†; Ravi K Prabhath†; Maitreyee Nandy; et al, Estimation of trace element concentration and neutron induced radioactivity in rock samples of different geological compositions for neutron shielding, INDIAN JOURNAL OF PURE & APPLIED PHYSICS **54** (2016) 7

J Khuyagbaatar†; A Yakushev†; Ch E Duellmann†; M Maiti; et al, New Short-Lived Isotope ^{221}U and the Mass Surface Near N=126, PHYSICAL REVIEW LETTERS **115** (2015) Art No: 242502

Amrit Krishna Mitra; Abhishek Sau; Subhas Chandra Bera; et al, Monitoring the Competence of a New Keto-tetrahydrocarbazole Based Fluorosensor Under Homogeneous, Micro-Heterogeneous and Serum Albumin Environments, JOURNAL OF FLUORESCENCE **25** (2015) 1931

Susanta Lahiri; Moumita Maiti; Kaustab Ghosh, Separation of no-carrier-added ^{111}In and ^{109}Cd from α-particle induced Ag target using glass wool surface, JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY **306** (2015) 469

Amrit Krishna Mitra; Sujay Ghosh; Abhishek Sau; et al, Solution phase photophysics of 5,7-dimethoxy-2,3,4,9-tetrahydro-1H-carbazol-1-one: Analysing the lineaments of a new fluorosensor to probe different micro-environments, JOURNAL OF LUMINESCENCE **167** (2015) 233

Debranjan Mandal; Subrata Mondal; Dulal Senapati; et al, Charge Density Modulated Shape-Dependent Electrocatalytic Activity of Gold Nanoparticles for the Oxidation of Ascorbic Acid, JOURNAL OF PHYSICAL CHEMISTRY **C119** (2015) 23103

Gopa Dutta (Pal)†; Abhijit Paul†; Somnath Yadav†; Munmun Bardhan; et al, Time Resolved Spectroscopic Studies on a Novel Synthesized Photo-Switchable Organic Dyad and Its Nanocomposite Form in Order to Develop Light Energy Conversion Devices, JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY **15** (2015) 5775

Anupa Majumdar; Debjyoti Kundu; Munna Sarkar, Differential Effect of Oxicam Non-Steroidal Anti-Inflammatory Drugs on Membranes and Their Consequence on Membrane Fusion, JOURNAL OF PHYSICAL CHEMISTRY **B119** (2015) 9627

Banabithi Koley Seth; Aurkie Ray; Samita Basu, A control on hydrophobic and hydrophilic in-

teractions between HEWL and metal Schiff-base complexes comprising of different metal ions and ligands, JOURNAL OF LUMINESCENCE **161** (2015) 54

Gobinda Prasad Sahoo; Samita Basu; Sadhan Samanta; et al, Microwave-assisted synthesis of anisotropic gold nanocrystals in polymer matrix and their catalytic activities, JOURNAL OF EXPERIMENTAL NANOSCIENCE **10** (2015) 690

Chaitrali Sengupta; Samita Basu, A spectroscopic study to decipher the mode of interaction of some common acridine derivatives with CT DNA within nanosecond and femtosecond time domains, RSC ADVANCES **5** (2015) 78160

Brotati Chakraborty; Piyali Mitra; Samita Basu, Spectroscopic exploration of drugprotein interaction: a study highlighting the dependence of the magnetic field effect on inter-radical separation distance formed during photoinduced electron transfer, RSC ADVANCES **5** (2015) 81533

B Sarkar; A Manikandan; M Nandy; et al, Influence of monte carlo variance with fluence smoothing in VMAT treatment planning with Monaco TPS, INDIAN JOURNAL OF CANCER **53** (2016) 158

M Bhattacharya; AR Mandal†; S Das Chakraborty; Arpan Maiti; Achyut Maity; P Mondal; D Senapati, Direct experimental observation of salt induced aspect ratio tunable PFPT silver-nanowire formation: SERS-based ppt level Hg^{2+} sensing from ground water, RSC Advances **6** (2016) 45279

B Dey; RK Mondal; S Mukherjee; B Satpati, A supramolecular hydrogel for generation of a benign DNA-hydrogel, RSC Advances **5** (2016) 105961

Santu Maity; Arpita Datta; Susanta Lahiri; Jhuma Ganguly, Selective Separation of ^{152}Eu from a Mixture of ^{152}Eu and ^{137}Cs Using Chitosan Based Hydrogel, RSC Adv **5** (2015) 89338

Moumita Maiti; Arpita Datta; Susanta Lahiri, Aqueous Biphasic Separation of ^{97}Ru and ^{95,96}Tc from Yttrium, RSC Adv **5** (2015) 80919

1.3.3 Ph D Awarded

BH Venkatram Pai [Maitreyee Nandy & A Krishnamoorthy], Development of appropriate mixes of self-compacting concrete (SCC) for neutron shielding, Manipal University, May 2015

Ankan Dutta Chowdhury [Amitabha De], Application of Conducting Polymer Based Nanostructured Materials in Biosensors and Supercapacitor, CU, June 2015

Koustav Ghosh [Susanta Lahiri], Application of Greener Methods for the Radiochemical Separations of Clinically Relevant Copper, Zinc, Cadmium and Indium Radioisotopes, CU, June 2015

Sujoy Ghosh [Samita Basu], Photophysical and Photochemical Studies of the Interactions Among Molecules with Chemical and Biological Significance, JU, September 2015

Moupriya Nag [Soumen Basak], Photophysical Studies of Drug-Protein Interaction, Metal-Ion Sensors & Protein Folding and Aggregation, CU, December 2015

Ajay Mandal [Susanta Lahiri], Trace and Ultratrace Scale Studies on Detection and Dynamics of Fourth Period Elements, CU, February 2016

Piyali Mitra [Samita Basu], Photoinduced interactions of some therapeutically important small molecules with organic amines, biological macromolecules and gold nanoparticles, JU, March 2016

1.3.4 Seminars/Lectures given in Conference/Symposium/Schools

Susanta Lahiri
i. Radionuclides in Medicine: from The First Clinical Use of Radium to CERN-MEDICIS, 3rd Int Conf on Radiations and Applications in various fields of research (RAD-2015), Budva, Montenegro, June 8-12, 2015
ii. Radiochemistry: Past, Present and Prospects, Int Conf on Methods and Applications of Radioanalytical Chemistry (MARC-X), Kona, Hawaii, USA, April 12-17, 2015 (Hevesy Medal Presentation talk)
iii. The Periodic Table, Recent Advances in Chemistry, scheduled P G Deptt of Chemistry, T M Bhagalpur University, Bhagalpur, February 25-26, 2016
iv. The story of triangular affair, National seminar on Design, Synthesis, Interactions, Chemical and Biochemical Activities of Different Functional Molecules, The University of Burdwan, Burdwan, Februry 4-16, 2016
v. Story of six blind men, National Seminar on Perspectives in Envirionmental and Marine Research: Retrospect and Prospect, University of Calcutta, January 22, 2016
vi. Building The Periodic Table from Marie Curie to today, 52nd Annual Convention of Chemists 2015 and International Conference on Recent Advances in Chemical Sciences, JECRC University, Jaipur, December 28-30, 2015 (Prof JC Ghosh Memorial Award Lecture)
vii. In situ radiation: a powerful tool to synthesize nanoparticles in green method, National Seminar on Research Aspirants of nano materiaks and its applications, S J C Institute of Technology, Chikballapur, July 21-22, 2015
viii. The Periodic Table, Hooghly Mohsin College, Februry 11, 2016
ix. A Ride on Time Machine, (a) Mizoram University, Aizwal, May 12, 2015; (b) RIKEN, Japan, April 09, 2015

Samita Basu
i. Reminiscences IACS Yesterday and SINP Today, One-day Meeting on Magnetic Field Effect on Chemical Reactions, IACS, Kolkata, April 30, 2015
ii. Magnetic Field Effect: An Assessor of Geminate Inter-radical Separation Distance in Photoinduced Electron Transfer Reactions, 3rd AWEST 2015: Awaji Island Conference, Awaji Yumebutai International Conference Center, Awaji Island, Hyogo, Japan, June 14 - 17, 2015
iii. Molecular Photochemistry: an overview, Quenching of Fluorescence and Magnetic Field Effect: A Tool for Identification of Initial Spin State of Electron Transfer and An Assessor of Geminate Inter-radical Separation Distance in Photoinduced Electron Transfer Reactions, Refresher Course in Advances in Chemistry, Biotechnology and Allied Disciplines at Manipur University, Imphal, June 26-27, 2015

iv. Interactions of small molecules with biological macromolecules in vitro: Importance of magnetic field effectAcademy Staff College, Calcutta University, Aug 17, 2015
v. Spectroscopy: Photosciences, DST-JBNSTS INSPIRE Science Camp, JBNSTS, Kolkata, October 5, 2015
vi. Periodic Table, DST-JBNSTS INSPIRE Science Camp, JBNSTS, Kolkata, January 19, 2015
vii. Electron transfer while small molecules interacting with DNA, National Seminar on Design, Synthesis, Interactions, Chemical and Biochemical Activities of Different Functional Molecules, Department of Chemistry, Burdwan University, West Bengal, Februry 4-6, 2016
viii. Using spectroscopy to study interactions between therapeutically important molecules and DNA/protein, Department of Chemistry, IIT Kharagpur, Feb 25, 2016
ix. An analysis of drug-protein/DNA interactions using different spectroscopic techniques, National Conference on Recent Developments on Photochemistry and Photobiology (RDPAP-2016), School of Chemistry, Sambalpur University, Jyoti Vihar, Odisha, March 6, 2016
x. DNA/Protein - small molecule interactions: a spectroscopic perspective, OWLS-2016, TIFR, Mumbai, March 16, 2016

Maitreyee Nandy
i. Neutrons: Journey from Source through Shield, 20th National Symposium on Radiation Physics (NSRP-20), Mangalore University, Mangalore, Karnataka, October 28-30, 2016
ii. Radiation Dosimetry for Medical and Industrial Application: Recent Developments, International Conference on Materials Science and Ionizing Radiation Safety and Awareness (ICMSIRSA-2016), Shivaji University, Kolhapur, Maharashtra, January 28-30, 2016
iii. Nuclear Reaction: Evolution towards Equilibration, Physics Department, National Institute of Technology Karnataka, Surathkal, Mangalore, March 28, 2016

1.3.5 Teaching elsewhere

Samita Basu
i. M Sc (Inorganic Chemistry special), Calcutta University on Spectroscopy, January-March, 2016
ii. M Sc (General and Physical Chemistry special), Bidhannagar College, West Bengal State University, West Bengal on Photochemistry, August-September, 2015

Maitreyee Nandy
Radioisotopes and Nuclear Medicine (course MTBMI 35); Two year M Tech course in Biomedical Instrumentation, Department of Applied Optics & Photonics, University of Calcutta, Kolkata
Radioactivity & Radiation Safety, Biophysics and Molecular Biology Department, University of Calcutta, Kolkata

Susanta Lahiri
i. Refresher course in Environmental Sciences: Bio-monitoring, University of Burdwan, January 13, 2016
ii. Refresher course in Environmental Sciences: Green Chemistry: Earn double reward points, University of Burd wan, January 13, 2016
iii. Refresher Course in Chemistry, Lunar Crater, Italian Navigator, Turtle, Elephant and The Actinide Chemistry, University of Calcutta, August 12, 2015
iv. Refresher Course in Chemistry, Radium to Radium- Hundred Years Cycle, University of Cal-

cutta, August 11, 2015
v. Refresher Course in Chemistry, Building The Periodic Table From Marie Curie to today, University of Calcutta, Apr 21, 2015

1.3.6 Miscellany

Susanta Lahiri
Professor JC Ghosh Memorial Award for the year 2014 (bestowed by Indian Chemical Society as recognition of excellence in research in chemical Sciences)

1.4 Computational Science

1.4.1 Summary of Research Activities

The objective of the division is two folds. One of them is the fundamental computational research on basic sciences and the other one is to provide the Central Computer facility to all members of the institute.
Some of the research works which are carried out by the faculties of the division are as follows.
i) Structural Bioinformatics of Nucleic Acids
ii) Molecular Dynamics simulations of biological macromolecules
iii) Quantum chemical studies of biologically important small molecules
iv) Multi-sequence Alignment
v) Optimized gene prediction methodology
vi) Bioinformatics approaches to study Next Generation Sequencing
vii) Evolutionary algorithm for function optimization and pattern matching
The central computer facilities which are available to scatter the need of the members of the installation are the following.
i) E-mail with Internet
ii) Wired and wireless network
iii) Web service
iv) High Performance Servers (HPCs) for number crunching jobs of the Institute members
v) Scientific software
Research Activities - Hybrid evolutionary algorithms are drawing significant attention in recent time for solving numerous real world problems. We have developed a hybrid evolutionary approach for optimizing mathematical functions and Point Pattern Recognition (PPR) problems. The proposed method combines a global search genetic algorithm in a course-to-fine resolution space with a local (Tabu) search algorithm. Such hybridization enhances the power of the search technique by virtue of inducing hill climbing and fast searching capabilities of Tabu search process. The approach can reach the global or near-global optimum for the functions in high dimensional space.
In computational biology, the sequence alignment is an important and challenging task for sequence analysis. Biological sequences can be of variable lengths. We have developed a Genetic Algorithm (GA) based alignment technique for finding the best alignment score of a sequence pair in an optimized way. The genetic based method is implemented into smaller subspaces by breaking a larger space. This is done by decomposing the sequence pair into multiple segments before the alignment. Such decomposition enhances the ability of the search process to reach the global or

near global optimal solution even for longer sequences.
Understanding function of biomolecules often arise from their structural features. Mostly atomic level structural features are derived obtained from X-ray crystallography or NMR spectroscopy but such information is often not available. We use ab initio quantum chemical calculations as well as molecular dynamics simulations to theoretically predict structure and function of different biological macromolecules, such as DNA, RNA, protein. High Speed Local Area Network Wired and Wireless Infrastructure: SINP boasts to have a fully structured network environment in place for more than a couples of decades now. The network is divided into multiple security zones namely, MZ (Militarized zone) and DMZ (de-Militarized Zone) and connected to the Internet via a Firewall/Router. All the internet facing servers are placed in the DMZ. The entire inward access is either via VPN or dual-hop inward secured shell access.
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 as well as physical infrastructures on High Availability mode. Segregation among different users is ensured by both the user account and the hardware address for the sake of wireless security.
Layer 3 IP Virtual LANs are configured and various Access Control Lists (ACLs) are employed to sanitize traffic and to 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 for providing the major Internet facing services namely Web, Proxy, Ftp, Mail, IMAP/POP, DNS, LDAP, secured dual hop inward access etc. All services are authenticated from central LDAP services and the users use same credential to access the available facilities. The Division has also installed a Disaster Recovery set-up to provide continued service from a secondary site in case of declared disaster, such as fire in the main center (Room no. 235 and 237) that may hamper the day-to-day activities. To accommodate the data centre needs of Disaster Recovery (DR) site a modular data centre is installed and presently operational in Room no. 3401. The enhanced set-up ensures all round better availability, security and performance.
At present 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 implementation of a full-fledged Data Centre at the Central server room to house High performance Computing Facilities, CMS Grid Infrastructure, HA Cluster etc. For 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 fulfil the guidelines of a proper DR set-up. Both the projects assume availability of appropriate backup power like DG sets.
New Website for the Institute: The division along with the members of the Website committee worked hand in hand to address the need of a structured CMS (Content Management System) based website for the Institute incorporating modern technology, standards, and UAT and security guidelines. The departmental, personal, different application parts 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 also 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 and 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 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 the CISO in the domain of work.
Software Development: An Application for Electricity Charge Calculation for SINP Quarters was developed and is presently used at the Salary Section. An IT Support Team is formed by the Director to assist the division for development of various Software Applications for the Institute. Some of the applications are:
Online Guest House Management System
Inventory/Stock Management
Intelligent Forms
Module-wise new e-Gov initiative and reuse of old Hardware: The IT Support team has started development of the Salary Module and it is now in the study phase. After the exhaustive identification of all the processes and data either the module would be developed in-house or procurement procedure of the same would start. After implementation of the Salary Module, other modules would be taken up.
The hardware setup for previous e-Gov initiative was lying idle for some time. Initiative is taken to re-use the same for housing the Application Portal and future e-Gov modules. The same infrastructure will be used to provide backup of different administrative sections of the Institute.
New Network Project: Initiative has started to replace the Core, Distribution & Access Switches and components of Campus Wireless LAN with up-to-date modern network components/features. The goal is to step up the backbone to at least 10G of speed. The core switches may be clustered to give an aggregate Core-Distribution bandwidth of 20G. We also plan to extend 1G to the desktop layers. The replacement of active network components is imminent as most of the present switches have already met the End of Support dates. To facilitate the high speed network infrastructure, some passive components (Fiber and Copper) would also be replaced. It is a major project and is in the RFP Document preparation phase.

1.4.2 Publications

1.4.2.1 Publications in Journal

Angana Ray; Swati Panigrahi; Dhananjay Bhattacharyya, A Comparison of Four Different Conformations Adopted by Human Telomeric G-Quadruplex Using Computer Simulations, BIOPOLYMERS **105** (2016) 83

Manas Mondal; Sanchita Mukherjee; Sukanya Halder; et al, Stacking Geometry for Non-canonical G:U Wobble Base Pair Containing Dinucleotide Sequences in RNA: Dispersion-Corrected DFT-D Study, BIOPOLYMERS **103** (2015) 328

1.4.3 Ph D Awarded

Manas Mandal [Dhananjay Bhattacharyya], Structure, Dynamics and Interaction of Nucleic Acids: Theoretical Computational Analysis, CU, October 2015

Chapter 2

Condensed Matter Physics including Surface Physics and NanoScience

2.1 Condensed Matter Physics

2.1.1 Summary of Research Activities

Study on several manganite samples [$La_{1-x}Ca_xMnO_3$ (x=0.52, 0.54, 0.55)] illustrates the method of significant enhancement of MR with the reduction of the particle size in nanometer scale. A model consisted of a charge ordered antiferromagnetic core and a shell having short range ferromagnetic correlation between the uncompensated surface spins in nanoscale regime, explains the observation quite well. The method of several orders of magnitude improvement of the magnetoresistive property will have enormous potential for magnetic field sensor technology [Scientific Reports 6, 20351 (2016)].

The rare coexistence of a Griffiths phase and a geometrically frustrated antiferromagnetism in the non-stoichiometric intermetallic compound $GdFe_{0.17}Sn_2$ (the paramagnetic Weiss temperature θ_p $\sim$-59K) is reported. The compound forms in the $Cmcm$ space group with large structural anisotropy (b/c $\sim$4). Interestingly, all the atoms in the unit cell possess the same point group symmetry (Wycoff position 4c), which is rather rare. It is also shown that substantial difference in GP region may exist between zero field and field cooled measurements - a fact hitherto not emphasized so far. [Scientific Reports 5, 15801 (2015)]

It was shown that the critical behavior of Sherrington-Kirkpatrick model in transverse field (at finite temperature) indicate that the critical Binder cumulant (indicating the universality class of the transition behavior) and the correlation length exponent cross over from their "classical" to "quantum" values at a finite temperature (unlike the cases of pure systems, where such crossovers occur at zero temperature). [Phys. Rev. E 92, 042107 (2015)]

Study of trivalent B-site dopants in CE-CO-OO-I (CE-type antiferromagnet; CO: charge order; OO: orbital order; I: Insulator) manganites at half-filling x = 0.50, using a two-orbital double-exchange

model including super-exchange interactions, Jahn-Teller lattice distortions, and substitutional disorder in two dimensions, show that the magnetic reconstructions around the B-site dopants due to the modified double-exchange and super-exchange interactions control the phase competition in B-site doped manganites. [J. Appl. Phys 119, 033901 (2016).]

The physics of Ionic Hubbard model (IHM) at half filling on a Bethe lattice of infinite connectivity is governed by the competition between the staggered ionic potential Delta and the on-site Hubbard U. It was found that for a finite Delta and at zero temperature, long-range antiferromagnetic (AFM) order sets in beyond a threshold U = U-AF via a first-order phase transition. For U smaller than U-AF the system is a correlated band insulator. IMH show a clear evidence of quantum transition to a half-metal (HM) phase just after the AFM order is turned on, followed by the formation of an AFM insulator on further increasing U. In the three-dimensional parameter space of (U/t, T/t, and Delta/t), as T increases, the surface of first-order transition at U-AF(T,Delta) and that of the second-order transition at U-N(T,Delta) approach each other, shrinking the range over which the AFM order is stable. [Phys. Rev. B 91, 235108 (2015)

Decay of excited-state population and decoherence in hard-core bosons (HCBs) ,are investigated in the regimes of antiadiabaticity and strong HCB-phonon coupling with each site providing a different local optical phonon environment; furthermore, the HCB systems in both models are taken to be initially uncorrelated with the environment in the polaronic frame of reference. In the two-site HCB model, the degree of decoherence and decay of excited state are enhanced by the proximity of the site-energy difference to the eigenenergy of phonons. For the infinite-range model, when the site energies are the same, a quantum-master-equation approach shows that the quantum states of the system do not decohere. [Phys. Rev B. 92, 094302 (2015)]

Phase transitions and the nature of order is studied in a class of classical generalized O(N) nonlinear sigma models (NLS) constructed by minimally coupling pure NLS with additional degrees of freedom in the form of (i) Ising ferromagnetic spins, (ii) an advective Stokesian velocity, and (iii) multiplicative noises.When associated multiplicative noise is not sufficiently long-ranged, the models display a class of unusual phase transitions between stiff and soft phases, where the effective spin stiffness respectively diverges and vanishes in the long wavelength limit at two dimensions (2D), unlike in pure NLS. In the stiff phase, in the thermodynamic limit the variance of the transverse spin (or, the Goldstone mode) fluctuations are found to scale with the system size L in 2D as ln ln L with a model-dependent amplitude, which is markedly weaker than the well-known lnL dependence of the variance of the broken symmetry modes in models that display quasi-long-range order in 2D. [Phys. Rev. E 92, 062133 (2015)]

We ask what happens when two nonequilibrium systems in steady state are kept in contact and allowed to exchange a quantity, say mass, which is conserved in the combined system. Will the systems eventually evolve to a new stationary state where a certain intensive thermodynamic variable, like equilibrium chemical potential, equalizes following the zeroth law of thermodynamics and, if so, under what conditions is it possible? We argue that an equilibriumlike thermodynamic structure can be extended to nonequilibrium steady states having short-ranged spatial correlations, provided that the systems interact weakly to exchange mass with rates satisfying a balance condition-reminiscent of a detailed balance condition in equilibrium. This proposition is proved and demonstrated in various conserved-mass transport processes having nonzero spatial correlations. [Phys. Rev. E 91, 062136 (2015)]

Shubnikovde Haas and de Haasvan Alphen effects are observed in the single crystals of the three-dimensional Dirac semimetal Cd3As2 up to 50 K, traceable at fields as low as 2 and 1 T, respectively. The values of the Fermi wave vector, the Fermi velocity, and the effective cyclotron mass of the charge carrier are close to each other and match well with earlier reports. However, the de Haasvan Alphen effect clearly reflects the existence of two different Fermi surface cross sections along certain directions and a nontrivial Berry's phase, which is the signature of a three-dimensional Dirac fermion in Cd3As2. [Phys. Rev. B 91, 155139 (2015).]

The granular alloy $Co_{0.3}Cu_{0.7}$, synthesized by chemical reduction, a significant temperature dependent exchange bias field is obtained from above 100 K down to 2 K, which suggests that the particles have a Co rich SPM core, surrounded by uncompensated dilute Co spin moments at the surface. If during relaxation certain external conditions are temporarily disturbed, *e.g.*, by lowering the temperature or changing the magnetic field the magnetization also changes accordingly; but as the conditions are restored the magnetization returns to its previous value. Such magnetic memory effect has been studied with various experimental protocols and persists strongly even at room temperature. [RSC Adv. 5, 95695 (2015)]

A nanoscale-area Mach-Zehnder interferometer with co-propagating quantum Hall spin-resolved edge states is realizeand, which demonstrates the persistence of gate-controlled quantum interference oscillations, as a function of an applied magnetic field. Arrays of top-gate magnetic nanofingers are used to induce a resonant charge transfer between the pair of spin-resolved edge states. A simple theoretical model is proposed to account for the pattern of oscillations measured as a function of magnetic field and gate voltage. [Phys. Rev. B 92, 195303 (2015)]

2.1.2 Publications

2.1.2.1 Publications in Books/Monographs & Edited Volumes

A Dutta; G Aeppli; BK Chakrabarti; U Divakaran; TF Rosenbaum; D Sen, Quantum Phase Transitions in Transverse Field Spin Models: From Statistical Physics to Quantum Information, Cambridge University Press, Delhi (2015)

S Biswas; P Ray; BK Chakrabarti, Statistical Physics of Fracture, Breakdown & Earthquake, Wiley-VCH, Berlin (2015)

2.1.2.2 Publications in Journal

Sourav Kundu; SN Karmakar, Detection of base-pair mismatches in DNA using graphene-based nanopore device, NANOTECHNOLOGY **27** (2016) Art No: 135101

Sanjib Banik; Kalipada Das; I Das, Size-induced modification of magneto-transport properties in nanocrystalline $Sm_{0.5}Ca_{0.5}Mno_3$ compound, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **403** (2016) 36

A Midya; P Mandal; Km Rubi†; et al, Large adiabatic temperature and magnetic entropy changes in $EuTiO_3$, PHYSICAL REVIEW **B93** (2016) Art No: 094422

Kalipada Das; I Das, Giant enhancement of magnetocaloric effect at room temperature by the

formation of nanoparticle of $La_{0.48}Ca_{0.52}MnO_3$ compound, JOURNAL OF APPLIED PHYSICS **119**(2016) Art No: 093903

Zarina Ansari†; Susmita Dhara; Bilwadal Bandyopadhyay; et al, Spectral anion sensing and gamma-radiation induced magnetic modifications of polyphenol generated Ag-nanoparticles, SPECTROCHIMICA ACTA PART A-MOLECULAR AND BIOMOLECULAR SPECTROSCOPY **156** (2016) 98

Rajkumar Modak†; B Samantaray; P Mandal; et al, Low Gilbert damping and in-plane magnetic anisotropy in Ni-Mn-Sn thin film with high $L2_1$ order, APPLIED PHYSICS **A122** (2016) Art No: 252

R Roy Chowdhury; S Dhara; B Bandyopadhyay, Evidence of ferromagnetism in vanadium substituted layered intermetallic compounds $RE(Co_{1-x}Vx)_2Si_2$ (RE=Pr and Nd; $0 \leq x \leq 0.35$), JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **401** (2016) 998

M Nandi; P Mandal, Field induced metamagnetic transitions in quasi-one-dimensional Ising spin chain CoV_2O_6, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **400** (2016) 121

Jelena Smiljanic†; Arnab Chatterjee; Tomi Kauppinen†; et al, A Theoretical Model for the Associative Nature of Conference Participation, PLOS ONE **11** (2016) Art No: e0148528

Kalipada Das; P Dasgupta; A Poddar; I Das, Significant enhancement of magnetoresistance with the reduction of particle size in nanometer scale, SCIENTIFIC REPORTS **6** (2016) Art No: 20351

S Roy; N Khan; P Mandal, Giant low-field magnetocaloric effect in single-crystalline $EuTi_{0.85}Nb_{0.15}O_3$, APL MATERIALS **4** (2016) Art No: 026102

Kalpataru Pradhan, Magnetic reconstructions in B-site doped manganites JOURNAL OF APPLIED PHYSICS **119** (2016) Art No: 033901

Arnab Chatterjee; Anindya S Chakrabarti†; Asim Ghosh†; et al, Invariant features of spatial inequality in consumption: The case of India, PHYSICA **A442** (2016) 169

Arnab Chatterjee; Asim Ghosh; Bikas K Chakrabarti, Universality of Citation Distributions for Academic Institutions and Journals, PLOS ONE **11** (2016) Art No: e0146762

Tapas Paramanik; I Das, Near room temperature giant magnetocaloric effect and giant negative magnetoresistance in Co, Ga substituted Ni-Mn-In Heusler alloy, JOURNAL OF ALLOYS AND COMPOUNDS **654** (2016) 399

B Samantaray; N Khan; A Midya...P Mandal, Giant magnetothermal conductivity and magnetostriction effect in the charge ordered $Nd_{0.8}Na_{0.2}MnO_3$ compound, EPL **113** (2016) Art No: 17003

Bikash Kumar Shaw†; Mithun Das†; Anik Bhattacharyya†; Susmita Roy; Prabhat Mandal; et al, Field-induced ferromagnetism due to magneto-striction in 1-D helical chains, RSC ADVANCES **6** (2016) 22980

Kalipada Das; Sanjib Banik; I Das, Large magnetocaloric effect near room temperature in polycrystalline ($La_{0.7}Y_{0.30.7}Sr_{0.3}MnO_3$ compound, MATERIALS RESEARCH BULLETIN **73** (2016) 256

M Khondabi†; H Ahmadvand†; P Kameli†; P Dasgupta; A Poddar, Magnetocaloric and phase coexistence in $La_{0.5}Ca_{0.5-x}Sr_xMnO_3$ manganites, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 233908

Tirthankar Banerjee; Niladri Sarkar; Abhik Basu, Phase transitions and order in two-dimensional generalized nonlinear sigma models, PHYSICAL REVIEW **E92** (2015) Art No: 062133

Kalipada Das; I Das, Training effects induced by cycling of magnetic field in ferromagnetic rich phase-separated nanocomposite manganites, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **395** (2015) 23

Arghya Das; Sayani Chatterjee; Punyabrata Pradhan; PK Mohanty, Additivity property and emergence of power laws in nonequilibrium steady states, PHYSICAL REVIEW **E92** (2015) Art No: 052107

Niladri Sarkar; Abhik Basu, Role of interfacial friction for flow instabilities in a thin polar-ordered active fluid layer, PHYSICAL REVIEW **E92** (2015) Art No: 052306

Srilekha Saha; Santanu K Maiti; SN Karmakar, Conformation dependent magnetotransport in a single handed helical geometry, PHYSICS LETTERS **A379** (2015) 2848

Biswajit Karmakar; Davide Venturelli; Chirolli, Luca; et al, Nanoscale Mach-Zehnder interferometer with spin-resolved quantum Hall edge states, PHYSICAL REVIEW **B92** (2015) Art No: 195303

Satyaki Kar, Magnon dispersion and single hole motion in 2D frustrated antiferromagnets with four-sublattice structures, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **393** (2015) 357

Krishanu Ghosh†; Chandan Mazumdar; R Ranganathan; et al, Griffiths phase behaviour in a frustrated antiferromagnetic intermetallic compound, SCIENTIFIC REPORTS **5** (2015) Art No: 15801

R Ramakumar†; AN Das; S Sil†, Lattice bosons in a quasi-disordered environment: The effects of a superlattice potential on single particle and many particle properties, PHYSICA **A436** (2015) 814

Sudip Mukherjee; Atanu Rajak; Bikas K Chakrabarti, Classical-to-quantum crossover in the critical behavior of the transverse-field Sherrington-Kirkpatrick spin glass model, PHYSICAL REVIEW **E92** (2015) Art No: 042107

Niladri Sarkar, Active-to-absorbing-state phase transition in an evolving population with mutation, PHYSICAL REVIEW **E92** (2015) Art No: 042110

R Roy Chowdhury; S Dhara; B Bandyopadhyay, Effect of Vanadium Substitution of Cobalt in NdCo2Si2, ACTA PHYSICA POLONICA **A128** (2015) 530

S Dhara; R Roy Chowdhury; B Bandyopadhyay, Evidence of Formation of CoxCu1-x Nanoparticles with Core-Shell Structure, ACTA PHYSICA POLONICA **A128** (2015) 533

Sourav Kundu; SN Karmakar, Conformation dependent electronic transport in a DNA double-helix, AIP ADVANCES **5** (2015) Art No: 107122

S Dey†; R Mondal†; SK Dey†; P Dasgupta; A Poddar; et al, Tuning magnetization, blocking temperature, cation distribution of nanosized $Co_{0.2}Zn_{0.8}Fe_2O_4$ by mechanical activation, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 103905

Amit Chatterjee; Punyabrata Pradhan†; P K Mohanty, Cluster-factorized steady states in finite-range processes, PHYSICAL REVIEW **E92** (2015) Art No: 032103

A Dey; MQ Lone; S Yarlagadda, Decoherence in models for hard-core bosons coupled to optical phonons, PHYSICAL REVIEW **B92** (2015) Art No: 094302

Kalipada Das; I Das, A comparative study of magnetic training effect in bulk and nanocrystalline $La_{0.46}Ca_{0.54}MnO_3$ compound, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 084302

Tirthankar Banerjee; Anjan Kumar Chandra; Abhik Basu, Phase coexistence and particle nonconservation in a closed asymmetric exclusion process with inhomogeneities, PHYSICAL REVIEW **E92** (2015) Art No: 022121

Niladri Sarkar; Abhik Basu, Phase transitions and membrane stiffness in a class of asymmetric heterogeneous fluid membranes, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2015) Art No: P08023

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

Chandan Mazumdar; R Nagarajan, Quaternary borocarbides: Relatively high T_c intermetallic superconductors and magnetic superconductors, PHYSICA **C514** (2015) 173

Muzaffar Q Lone; Tim Byrnes†, Suppression of the ac-Stark-shift scattering rate due to non-Markovian behavior, PHYSICAL REVIEW **A92** (2015) Art No: 011401

Sourav Kundu; SN Karmakar, Electronic specific heat of DNA: Effects of backbones and disorder, PHYSICS LETTERS **A379** (2015) 1377

Jun-ichi Inoue; Asim Ghosh; Arnab Chatterjee; Bikas K Chakrabarti, Measuring social inequality with quantitative methodology: Analytical estimates and empirical data analysis by Gini and k indices, PHYSICA **A429** (2015) 184

Sayani Chatterjee; Punyabrata Pradhan†; PK Mohanty, Zeroth law and nonequilibrium thermodynamics for steady states in contact, PHYSICAL REVIEW **E91** (2015) Art No: 062136

Soumen Bag; Arti Garg; HR Krishnamurthy, Phase diagram of the half-filled ionic Hubbard model, PHYSICAL REVIEW **B91** (2015) Art No: 235108

B Samantaray; Akhilesh K Singh†; A Perumal†; R Ranganathan; P Mandal, Spin dynamics and frequency dependence of magnetic damping study in soft ferromagnetic FeTaC film with a stripe domain structure, AIP ADVANCES **5** (2015) Art No: 067157

Upendranath Nandi†; Debnarayan Jana†; Deep Talukdar, Scaling description of non-ohmic direct current conduction in disordered systems, PROGRESS IN MATERIALS SCIENCE **71** (2015) 1

SK Giri; Papri Dasgupta; A Poddar; et al, Tuning of normal and inverse magnetocaloric effect in $Sm_{0.35}Pr_{0.15}Sr_{0.5}MnO_3$ phase separated manganites, JOURNAL OF ALLOYS AND COMPOUNDS **631** (2015) 266

Kalipada Das; I Das, Magnetic field induced insulator-metal transition in nanocrystalline $Pr_{0.67}Ca_{0.33}MnO_3$ compounds: Evidence of large temperature co-efficient of resistance, JOURNAL OF APPLIED PHYSICS **117** (2015) Art No: 175103

Tapas Paramanik; Kalipada Das; Tapas Samanta; et al, Generation of magnetic phase diagram of HoRu2Si2 using magnetocaloric effect, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **381** (2015) 168

A Pariari; P Dutta; P Mandal, Probing the Fermi surface of three-dimensional Dirac semimetal Cd3As2 through the de Haas-van Alphen technique, PHYSICAL REVIEW **B91** (2015) Art No: 155139

Bijoy Daga; PK Mohanty, Phase separation transition of reconstituting κ-mers in one dimension, JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT (2015) Art No: P04004

S Dhara; R Roy Chowdhury; B Bandyopadhyay, Strong memory effect at room temperature in nanostructured granular alloy $Co_{0.3}Cu_{0.7}$, RSC Adv **5** (2015) 95695

Rima Paul; Pintu Sen; I Das, Effect of morphology on the magnetic properties of Gd_2O_3 nanotubes, PHYSICA **E80** (2016) 149

Tapas Paramanik; I Das, Resistivity minima in disordered cluster glass intermetallic compound Dy_5Pd_2: Influence of quantum interference effects, RSC ADV **5** (2015) 78406

Tapas Paramanik; Tapas Samanta; R Ranganathan; I Das, Magnetic and magnetocaloric properties of Dy_5Pd_2: role of magnetic irreversibility, RSC ADV **5** (2015) 47860

Kalipada Das; B Satpati; I Das, The effect of artificial grain boundaries on magneto-transport properties of charge ordered-ferro magnetic nanocomposites, RSC ADV **5** (2015) 27338

2.1.3 Ph D Awarded

Mahashweta Basu [PK Mohanty], MicroRNA co-target networks: structure, universality and evolution, CU, April 2015

Rakesh Chatterjee [Abhik Basu], Non-equilibrium statistical physics and dynamics of low dimensional systems, CU, May 2015

Arindam Midya [Prabhat Mandal], Magnetic and magnetocaloric properties of some rare-earth based compounds, JU, July 2015

Sourish Bandyopadhyay [PK Mohanty], Universalities in Fixed Energy Sandpiles, CU, July 2015

Nazir Khan [Prabhat Mandal], Magnetic Phase Transition And Magneto-electronic Phase Separation In $La_{1-x}Sr_xCoO_3$ Single Crystals, JU, September 2015

Moumita Dey [Sachindranath Karmakar], Some Theoretical Aspects of Spin Transport in Mesoscopic Systems, CU, November 2015

Kalipada Das [Indranil Das], Magnetic, Magneto-transport and Magnetocaloric Properties of Doped Perovskite Manganites, CU, March 2016

2.1.4 Seminars/Lectures given in Conference/Symposium/Schools

Barnana Pal
Acoustic Waves: Advancement and prospects delivered in the DBT sponsored Science Day Seminar, Maulana Azad College, Kolkata, February 29, 2016

Kalpataru Pradhan
Design of Molecular Ferromagnets, Int Symp on Clusters, Cluster-Assemblies and Nanomaterials (ISCAN), IISER Thiruvananthapuram, March 9, 2016

Y Sudhakar
i. Oxide electronics – an answer to the miniaturization challenge?, IISER, Bhopal, September 4, 2015
ii. Oxide double quantum dot: an answer to the qubit problem?, (a) Meeting on quantum information processing and applications, Harish-Chandra Research Institute, Allahabad, India, December 7-13, 2015
(b) Condensed Matter Seminar, Physics Dept, Purdue, February 19, 2016
iii. Oxide systems an answer to the qubit problem?, (a) Material Science Seminar, Argonne National Lab, March 2, 2016
(b) Condensed Matter Seminar, Physics Dept, Univ of Illinois, Urbana-Champaign, March 10, 2016

Indranil Das
Giant enhancement of magnetoresistance in manganite nanostructures, DAE Solid State Physics Symposium (DAE-SSPS), Amity University, Noida, New Delhi, organized by DAE, December 21-25, 2015

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 ∼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.

We have explored the possibility of using low cost room temperature CNT-based gas sensors prepared on plastic substrates to monitor the presence of ammonia in the environment, where NH3 concentrations in the low-ppb range are expected. The detection of ammonia atmospheric concentrations in urban areas has been so far widely overlooked, since its average levels are usually low, i.e. in the 20-30 ppb range. We prepare a very simple sensing material which operates in the ammonia environment of 1 ppb to 1000 ppb and it recovers in normal air environment without any purging of gas.

The development of thin film electrodes capable of storing more energy per unit area has become an urgent issue in order to meet the future demands of the electronic industry. Our work on thin film based electrode materials for energy storage has attracted wide interest because of increasing demand for power and energy in modern electronic devices and electric vehicles. We have fabricated here Mn_2O_3 and Mn_2O_3 Au composite thin films on an indium tin oxide (ITO) substrate by a one-step novel co-electrodeposition technique. From the electron microscopy study, we observed that these two films are morphologically different. The main aim of this study is to understand the effect of the nanostructure and metal integration on the electrochemical charge storage properties

of these two films. Since a charge storage mechanism is possible through faradic redox reaction and non-faradic double layered process, electrochemical characterization and frequency response analysis indicate better charge storage properties of the composite system over pristine Mn_2O_3. The MottSchottky analysis is used for the charge carrier estimation which provides the electronic properties of both the samples.

The crystallization process for thin high-κ dielectric filmsand optimal annealing temperature range in the field of high-κ dielectric-based metal-oxide semiconductor(MOS)technology has been investigated. A differential scanning calorimetry(DSC)technique is employed to understand the thermal behavior of thin high-κ dielectricHfO_2filmsdepositedon Si by radio frequency sputtering. The exothermic trends of the DSCsignal and grazing incidence x-ray diffraction data indicate an amorphous-to-crystalline transition in the high-$_\kappa$ filmsat higher temperatures. The enthalpy-temperature variation indicates a glass temperature (T_g) at $\sim$590C, beyond which an amorphous to m-HfO_2crystalline transition takes place. Further, the Hf-silicate formation, observed inDSCmeasurements and corroborated by Fourier transformed infrared spectroscopy studies, indicates that the process of Hf-silicate formation begins at $\sim$717C. High-frequency capacitancevoltage (CV) and current densityvoltage (JV) characteristics establish thatfilm crystallizationis not the root cause of electrical degradation in the high-κ-basedMOSdevices.Rather, the devicesdegrade due to formation of interfacial Hf-silicate.

Evidence of buried two-dimensional long range antiferromagnetic (AFM) order has been traced in epitaxial monolayer Cr film deposited on Ag(001) substrate under optimized UHV (ultra high vacuum) growth condition. In-plane AFM order of this reduced dimensional system has been probed by Low Energy Electron Diffraction (LEED) where weak intensity c(2 X 2) 'half-order' spots appear and their temperature dependency estimates critical transition temperature (Tc) of this Ising antiferromagnet. In situ photoemission studies revealed physical structure as well as AFM phase persistent in this flat monolayer transition metal film. X-ray Photoemission Spectroscopy (XPS) studies indicates to the multilayer growth mode of Cr at room temperature (300 K) where no half order spots are observed in LEED and monolayer growth mode at elevated temperature (428 K) deposition where long range AFM order of enhanced Cr moments is observed. Ultraviolet Photoemission (UPS) studies point out segregation of monolayer Ag on top of Cr overlayer resulting in 1 ML Ag/1 ML Cr/Ag(100) sandwich structure system. Detailed studies of Angle Resolved PhotoEmission Spectroscopy (ARPES) on this system probe Cr 3d AFM valence band structure which is quite different from the paramagnetic Cr band structure. Optimizing the best growth condition by determining the deposition temperature and effect of post-deposition annealing has been discussed.

Formation of 2D-networked structures of disk-like islands for ultrathin Langmuir-Schaefer (LS) films of thiol-coated Au-nanoparticles (DT-AuNPs) on H-passivated Si substrates is evidenced for the first time, directly from a broad peak in grazing incidence small angle X-ray scattering (GISAXS) data and also from atomic force microscopy (AFM) images. Theoretical modelling of the system, carried out based on density-density and height-height correlation functions, supports well the formation of such structures. It was evident from the analysis that on the surface of water, DT-AuNPs first self-assembled around different points to form disk-like islands of nanometer size and monolayer height, due to the complex balance of long range van der Waals attractions and short-range steric repulsion of the DT-AuNPs, initiated by solvent evaporation and also to optimize the hydrophobic repulsive force of water. The structural information of the LS films, obtained at different surface pressure, actually helps to infer the growth of Langmuir monolayers of DT-AuNPs, which is very important in understanding the self-assembly process of nanoparticles at the air-water interface and in controlling the growth of 2D-networked nanostructures in large areas for exploring new collective phenomena related to the interparticle coupling effect in both in-plane and out-of-plane directions.

The performances of organic electronic devices are significantly associated with their energy level alignment at organic semiconductor/metalelectrode interfaces. The electronic character of an organic semiconducting molecular over-layer on a metal surface can vary from semiconducting to metallic, depending on the nature of the molecular orbitals with respect to the Fermi level of the electrode. The general tendency of extrapolating established models for single crystal substrates to real device substrates is highly misleading. Hence, the importance of metal specific interaction, former lowest unoc-cupied molecular orbital (F-LUMO) and vacuum level (VL) shift have been investigated as a function of thickness of the deposited copper (II) phthalocyanine (CuPc) films by means of photoelectron spectroscopy (XPS and UPS) to understand the interface between CuPc and Cu, Ag, Pt and Au foils sequentially. The entire thickness dependent electronic energy level alignment of CuPc films on all noble metal substrates is explained in terms of a combined effect of partial charge transfer and photoemission final state relaxation energy.
The role of electrochemical Ostwald ripening and the galvanic displacement reaction in uniform particle formation on ion bombarded amorphous (i.e., composed of random atomic spacings) Ge (a-Ge) surfaces compared to crystalline germanium (c-Ge) has been studied. Silver growth on c-Ge and a-Ge substrates by electroless deposition has been studied by atomic force microscopy (AFM), cross-sectional transmission electron microscopy (XTEM), and energy dispersive X-ray spectroscopy (EDX). Introduction of defects can provide a control over particle growth by the galvanic displacement reaction that may offer continuous film growth up to a definite thickness. The possibility of surface diffusion and its consequences have also been studied.
The oxidation dynamics of a copper nanocluster assembled film, containing fractal islands, fabricated by the soft-landing of size-selected copper nanoclusters with an average diameter of 3 nm has been studied. The time evolution of the spontaneous oxidation of the prepared film in air at room temperature (RT) was taken for this purpose. A compositional analysis of the film was carried out in an ultra-high vacuum (UHV) deposition chamber using an in situ X-ray photoelectron spectroscopy (XPS) system. The morphological aspects of the deposited film were studied with a high resolution scanning electron microscope (SEM) and an atomic force microscope (AFM). We report the spontaneous production of highly pure ($\sim$95%) and technologically appealing nanocrystalline Cu_2O within 300 seconds of air exposure. The crystalline structure was probed using high resolution transmission electron microscopy (HRTEM) and the optical properties were studied using a cathodoluminescence (CL) device attached to a SEM. Moreover, we report new results on the localized surface plasmon (LSP) assisted optical effects of an isolated gold decahedron of side edge length 230 nm sitting on a silicon (Si) substrate. Site selective electron beam excitation in a scanning electron microscope (SEM) show multiple resonance peaks in the CL spectra. Analyses of the experimental data with finite-difference time-domain (FDTD) numerical simulation identifies two prominent LSP modes in the visible region apart from a substrate induced LSP mode in the near-infrared (750 nm) region. While the shorter wavelength (560 nm) mode has a mixture of in-plane quadrupolar and out-of-plane quadrupolar charge distribution pattern, the longer wavelength (655 nm) mode has the dipolar charge pattern in both the direction. We also analyze numerically to show the critical size of the side edge length of the decahedron particle where mode mixing is initiated.
Along with various research activities, the Division is extending its resources by installation of a high resolution x-ray scattering setup in Room # 112, SPMS Division, SINP to study the reflectivity and diffraction from thin films and nanomaterials. This x-ray setup is procured from Rigaku, Japan and some unique feature includes. This reflectivity setup with Mo source is the first x-ray reflectivity setup in India. Hypix100K is one of the most advanced pixel detector in the world and this detector works at both the x-ray energy available in this x-ray setup.

2.2.2 Publications

2.2.2.1 Publications in Books/Monographs & Edited Volumes

Alokmay Datta; Smita Mukherjee, Structural and Morphological Evolution in Metal-Organic Films and Multilayers, Taylor and Francis, 2015

Sruti Datta; Paramita Chatterjee; S Hazra, Effect of gold salt concentration in P123-mediated growth of gold nanoparticles, in Nanospectrum: A Current Scenario, Eds S Chakrabarti; P Mukherjee; G G Khan; A Adhikary; P Patra; JK Bal (Allied Publishers Pvt Ltd, New Delhi, 2015, p.132)

2.2.2.2 Publications in Journal

Anupam Roy†; Hema CP Movva†; Biswarup Satpati; et al, Structural and Electrical Properties of $MoTe_2$ and $MoSe_2$ Grown by Molecular Beam Epitaxy, ACS APPLIED MATERIALS & INTERFACES **8** (2016) 7396

Sonu Hooda†; SA Khan†; B Satpati; et al, Effect of ion beam parameters on engineering of nanoscale voids and their stability under post-growth annealing, APPLIED PHYSICS **A122** (2016) Art No: UNSP 227

Suvankar Chakraborty; Krishnakumar SR Menon, LEED and photoemission study of growth and structural evolution of Sn on Ag(001), VACUUM **125** (2016) 106

Biswajit Choudhury†; Sayan Bayan; Amarjyoti Choudhury†; et al, Narrowing of band gap and effective charge carrier separation in oxygen deficient TiO_2 nanotubes with improved visible light photocatalytic activity, Journal of Colloid and Interface Science **465** (2016) 10

K Dan; A Datta; Y Yoshida†; M Roy, Screening out the non-Arrhenius behaviour of nematic-isotropic transition by room temperature ionic liquid, JOURNAL OF CHEMICAL PHYSICS **144** (2016) Art No: 084904

Sk Abdul Kader Md Faruque; Satya Ranjan Bhattacharyya; Anil Kumar Sinha†; Supratic Chakraborty, Study of temperature dependent zirconium silicide phases in Zr/Si structure by differential scanning calorimetry, JOURNAL OF PHYSICS **D49** (2016) Art No: 065102

K Dan; M Roy; A Datta, Entropic screening preserves non-equilibrium nature of nematic phase while enthalpic screening destroys it, JOURNAL OF CHEMICAL PHYSICS **144** (2016) Art No: 064901

Animesh Naskar†; Arun Kumar Guha; Manabendra Mukherjee; et al, Adsorption of nickel onto Bacillus cereus M^1_{16}: A mechanistic approach, SEPARATION SCIENCE AND TECHNOLOGY **51** (2016) 427

DG Phillips II†; WM Snow†; K Babu†; S Banerjee; S Bhattacharya; et al, Neutron -antineutron oscillations: Theoretical status and experimental prospects, PHYSICS REPORTS-REVIEW SECTION OF PHYSICS LETTERS **612** (2016) 1

D Ghosh; AK Shukla; SK Mitra; B Satpati, High-Temperature Corrosion Behavior of Different Regions of Weldment of $_{2.25}$Cr-1Mo Steel in SO_2 + O_2 Atmosphere, JOURNAL OF MATERIALS ENGINEERING AND PERFORMANCE **25** (2016) 421

Nabanita Pal; Eun-Bum Cho†; Astam K Patra†; et al, Ceria-Containing Ordered Mesoporous Silica: Synthesis, Properties, and Applications, CHEMCATCHEM **8** (2016) 285

Nupur Biswas; Sreeja Chakraborty; Alokmay Datta; Munna Sarkar, Mrinmay K Mukhopadhyay; et al, Counterion effects on nano-confined metal-drug-DNA complexes, BEILSTEIN JOURNAL OF NANOTECHNOLOGY **7** (2016) 62

Rana Saha; A Sundaresan; Milan K Sanyal; et al, Neutron scattering study of the crystallographic and spin structure in antiferromagnetic $EuZrO_3$, PHYSICAL REVIEW **B93** (2016) Art No: 014409

Balwinder Kaur†; Rajendra Srivastava†; Biswarup Satpati, Copper nanoparticles decorated polyaniline-zeolite nanocomposite for the nanomolar simultaneous detection of hydrazine and phenylhydrazine, CATALYSIS SCIENCE & TECHNOLOGY **6** (2016) 1134

Mala Mukhopadhyay; S Hazra, Growth of thiol-coated Au-nanoparticle Langmuir monolayers through a 2D-network of disk-like islands, RSC ADVANCES **6** (2016) 12326 and correction, p 16481

P Barik†; A Bhattacharjee; M Roy, Characterization of Dielectric Properties of Developed CdS-Gum Arabic Composites in Low Frequency Region, POLYMER COMPOSITES **37** (2016) 108

Subhasis Das†; Biswarup Satpati; Himani Chauhan†; et al, Seeding of Au on CdSe/CdS nanoplates using Langmuir-Blodgett technique, RSC ADVANCES **6** (2016) 14658

Sonu Hooda†; B Satpati; Tanuj Kumar†; et al, Regrowth of Ge with different degrees of damage under thermal and athermal treatment, RSC ADVANCES **6** (2016) 4576

Priyank Shyam; Smita Chaturvedi; Koushik Karmakar; Arpan Bhattacharya et al, Structural and magnetic investigations on a wet chemically synthesized nanoscale S=1/2 spin chain compound $CuSe_2O_5$, JOURNAL OF MATERIALS CHEMISTRY **C4** (2016) 611

DP Datta†; SK Garg†; T Basu†; B Satpati, Temporal evolution of Ge surface topography under keV ion irradiation: Combined effects of curvature-dependent sputter erosion and atomic redistribution, APPLIED SURFACE SCIENCE **360** (2016) 131

Jayanta Das; Krishnakumar SR Menon, Effects of surface non-stoichiometry on the electronic structure of ultrathin NiO(0 0 1) film, APPLIED SURFACE SCIENCE **359** (2015) 61

Mayukh K Ray; K Bagani; S Banerjee, Effect of interfacial pinning on the thermo-remanent mag-

netization of disorder $Mn_{50}Ni_{38.5}Sn_{11.5}$ alloy, JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS **396** (2015) 26

Subash Chandra Sahu†; Biswarup Satpati; Laxmidhar Besra†; et al, A Bifunctional Nano-Electrocatalyst Based on a Flower-like Gold/Palladium Bimetallic Alloy Nanostructure and Its Graphene Hybrid, CHEMCATCHEM **7** (2015) 4042

A Barman†; CP Saini†; P Sarkar†; B Satpati; SR Bhattacharyya; et al, Self-organized titanium oxide nano-channels for resistive memory application, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 224903

Uttam Kumar Basak; Alokmay Datta, Fractal dimension and complexity in the long-term dynamics of a monomolecular layer, CHAOS SOLITONS & FRACTALS **81** (2015) 534

Balwinder Kaur†; Rajendra Srivastava†; Biswarup Satpati; et al, Biomineralization of hydroxyapatite in silver ion-exchanged nanocrystalline ZSM-5 zeolite using simulated body fluid, COLLOIDS AND SURFACES **B135** (2015) 201

Sumona Sinha; M Mukherjee, Study of metal specific interaction, F-LUMO and VL shift to understand interface of CuPc thin films and noble metal surfaces, APPLIED SURFACE SCIENCE **353** (2015) 540

Manjula Sharma; Milan K Sanyal; Ian Farrer†; AB Dey; A Bhattacharyya; et al, Density dependent composition of InAs quantum dots extracted from grazing incidence x-ray diffraction measurements, SCIENTIFIC REPORTS **5** (2015) Art No: 15732

Sumona Sinha; M Mukherjee, A comparative study about electronic structures at rubrene/Ag and Ag/rubrene interfaces, AIP Advances **5** (2015) Art No: 107204

Puspendu Barik†; Ashis Bhattacharjee†; Madhusudan Roy, Preparation, characterization and electrical study of gum arabic/ZnO nanocomposites, BULLETIN OF MATERIALS SCIENCE **38** (2015) 1609

T Basu†; M Kumar; S Nandy; B Satpati; et al, Thickness-dependent blue shift in the excitonic peak of conformally grown ZnO:Al on ion-beam fabricated self-organized Si ripples, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 104903

Madhumita Choudhuri; AN Sekar Iyengar; Alokmay Datta; MS Janaki, Evolution of self-organized two-dimensional patterns of nanoclusters through demixing, PHYSICAL REVIEW **E92** (2015) Art No: 032907

K Dan; M Roy; A Datta, Non-equilibrium phase transitions in a liquid crystal, JOURNAL OF CHEMICAL PHYSICS **143** (2015) Art No: 094501

Debaleen Biswas; Anil Kumar Sinha†; Supratic Chakraborty, Optimization of annealing temperature for high-κ-based gate oxides using differential scanning calorimetry, JOURNAL OF VACUUM SCIENCE & TECHNOLOGY **B33** (2015) Art No: 052205

B Saha†: SK Jana†; S Majumder†; B Satpati; S Banerjee, Selective Growth of Co-electrodeposited Mn_2O_3-Au Spherical Composite Network Towards Enhanced Non-enzymatic Hydrogen Peroxide Sensing, ELECTROCHIMICA ACTA **174** (2015) 853

Arpan Maiti; Achyut Maity; Tapas Kumar Chini, Mode Mixing and Substrate Induced Effect on the Plasmonic Properties of an Isolated Decahedral Gold Nanoparticle, JOURNAL OF PHYSICAL CHEMISTRY **C119** (2015) 18537

Balwinder Kaur†; Rajendra Srivastava†; Biswarup Satpati, Nanocrystalline Titanosilicate-Acetylcholinesterase Electrochemical Biosensor for the Ultra-Trace Detection of Toxic Organophosphate Pesticides, CHEMELECTROCHEM **2** (2015) 1164

Uttam Kumar Basak; Alokmay Datta; Dhananjay Bhattacharyya, Stability and softening of a lipid monolayer in the presence of a pain-killer drug, COLLOIDS AND SURFACES -BIOINTERFACES **B132** (2015) 34

Sk Masiul Islam†; Pranab Biswas†; P Banerji†; S Chakraborty, InAs quantum dots as charge storing elements for applications in flash memory devices, MATERIALS SCIENCE AND ENGINEERING **B198** (2015) 102

P Mishra†; H Lohani†; AK Kundu; Krishnakumar SR Menon; et al, Electronic structure of germanium selenide investigated using ultra-violet photo-electron spectroscopy, SEMICONDUCTOR SCIENCE AND TECHNOLOGY **30** (2015) Art No: 075001

T Mukherjee†; M Mukherjee, Low-energy positron-nitrogen-molecule scattering: A rovibrational close-coupling study, PHYSICAL REVIEW **A91** (2015) Art No: 062706 JUN 16

SK Mahatha; Krishnakumar SR Menon, Growth and photoemission spectroscopic studies of ultrathin noble metal films on graphite, PRAMANA-JOURNAL OF PHYSICS **84** (2015) 1011

T Ghosh; M Bardhan; M Bhattacharya; B Satpati, Study of inelastic mean free path of metal nanostructures using energy filtered transmission electron microscopy imaging, JOURNAL OF MICROSCOPY **258** (2015) 253

BA Assaf†; F Katmis†; P Wei†...Biswarup Satpati; et al, Inducing magnetism onto the surface of a topological crystalline insulator, PHYSICAL REVIEW **B91** (2015) Art No: 195310

Ratan K Saha, A Simulation Study on the Quantitative Assessment of Tissue Microstructure With Photoacoustics, IEEE TRANSACTIONS ON ULTRASONICS FERROELECTRICS AND FREQUENCY CONTROL **62** (2015) 881

Kamala K Nanda†; Smrutirekha Swain†; Biswarup Satpati; et al, Enhanced Photocatalytic Activity and Charge Carrier Dynamics of Hetero-Structured Organic Inorganic Nano-Photocatalysts, ACS APPLIED MATERIALS & INTERFACES **7** (2015) 7970

Uttam Kumar Basak; Alokmay Datta, Dynamics driven by lipophilic force in Langmuir monolayers: In-plane and out-of-plane growth, PHYSICAL REVIEW **E91** (2015) Art No: 042405

Amit Dalui†; Umamahesh Thupakula†; Ali Hossain Khan†; Tanmay Ghosh; Biswarup Satpati; et al, Mechanism of Versatile Catalytic Activities of Quaternary CuZnFeS Nanocrystals Designed by a Rapid Synthesis Route, SMALL **11** (2015) 1829

K Bagani; MK Ray; M Sardar†; S Banerjee, Evidence of power law decay of superexchange coupling in a disordered two-dimensional pi-electron system, PHYSICAL REVIEW **B91** (2015) Art No: 165414

Abhisakh Sarma; Milan K Sanyal; Peter B Littlewood†, Evidence of the charge-density wave state in polypyrrole nanotubes, PHYSICAL REVIEW **B91** (2015) Art No: 165409

S Honda†; B Satpati; S Ojha†; et al, Structural manipulation in Ge by swift heavy ions governed by electron-phonon coupling strength, MATERIALS RESEARCH EXPRESS **2** (2015) Art No: 045903

Debasree Chowdhury; Debabrata Ghose; Safiul Alam Mollick; Biswarup Satpati; Satya Ranjan Bhattacharyya, Nanorippling of ion irradiated GaAs (001) surface near the sputter-threshold energy, PHYSICA STATUS SOLIDI **B252** (2015) 811

Manjula Sharma; Milan K Sanyal; Ajit Katiyar†; et al, Excitation power-independent photoluminescence of inverted quantum hut structures embedded in SiGe superlattice, APPLIED PHYSICS **A119** (2015) 55

Sk Abdul Kader Md Faruque; Debaleen Biswas; Shaibal Saha; Supratic Chakraborty, Development of a linear temperature ramp-based automated system for furnace oxidation of semiconductor wafers, Int J Instrumentation Technology **1** (2015) 259

Paramita Chatterjee; S Hazra, pH-dependent size and structural transition in P123 micelle induced gold nanoparticles, RSC ADVANCES **5** (2015) 69765

Ishani Roy; S Hazra, Solvent dependent ordering of poly(3-dodecylthiophene) in thin films, SOFT MATTER **11** (2015) 3724

2.2.3 Ph D Awarded

Sirshendu Gayen [Milan K Sanyal], Magnetic and Magneto-Transport Properties of Nano-Structured Films, CU, April 2015

Manjula Sharma [Milan K Sanyal], Study of Ge nanostructures embedded in MBE grown Si/Ge multilayers, CU, April 2015

Tanusree Samanta [Manabendra Mukherjee], Structure and dynamics of polyelectrolyte ultrathin films, CU, April 2015

Paramita Chatterjee [Satyajit Hazra], Surfactant-mediated growth of mesoporous and nanostructured films, CU, May 2015

Abhishak Sharma [Milan K Sanyal], Quasi-one-dimensional electronic transport properties of conducting polymer nanowires, CU, July 2015

Anuradha Bhattacharya [Sangam Banerjee], Atomic Force Microscopy beyond topography and electrochemical analysis: Graphene, Zinc Oxide and Bacteria, HBNI, September 2015

Jayanta Das [Krishnakumar SR Menon], Electronic and magnetic structure of Antiferromagnetic thin films, HBNI, December 2015

Sumona Sinha [Manabendra Mukherjee], Study of Electronic and Structural Properties of Organic Semiconducting Thin Films, CU, December 2015

Amlan Rooj [Madhusudan Roy & A Bhattacharjee], Investigation on the thermal decomposition of Ferrocene in different reaction atmospheres, VU, March 2016

2.2.4 Seminars/Lectures given in Conference/Symposium/Schools

Satyajit Hazra
X-ray scattering study of low dimensional systems using synchrotron source, National Workshop on Material Science and Technology, MAC, Kolkata, December 10-12, 2015

Biswarup Satpati
i. Characterization of Nanostructured Materials using Transmission Electron Microscopy, National Seminar on Nanoscience and Nanotechnology (NSNN-2015), Haldia, Institute of Technology, Haldia, West Bengal, India, October 9-10, 2015
ii. Atomic-Scale Characterization of Nanostructured Materials by Transmission Electron Microscopy, Discussion meeting on nanoscale and atomic scale quantum structures and devices, IACS, West Bengal, India, February 16-17, 2016
iii. Material Science Research using Transmission Electron Microscopy, UGC SAP seminar on Recent Development on Materials Science, Vidyasagar University Campus, Midnapore, February 1819, 2016
iv. A Brief Introduction to Nanoscience, District Level Residential Science Camp for School students organized by West Bengal State Council of Science and Technology, Bikna KPS Vidyapith Bikna, Bankura, West Bengal, March 12-14 , 2016

Manabendra Mukherjee
Role of dielectric and metal interfaces in Organic Thin Film Transistor, National Seminar on Nanoscience and Nanotechnology: NSNN 2015, Haldia Institute of Technology, October 9, 2015

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 carried out 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, intermetallic alloys of technological importance and low-dimensional systems, such as nano-crystalline materials are also being studied to explore their properties. Development, characterization and optimization of radiation detectors, model based simulation and cognitive science research to understand the details of visual perception are also being carried out in our laboratories.

In the Positron Annihilation Spectroscopic Laboratory, research on certain new classes of material systems had been undertaken apart from the continuing activities on nanomaterials. Proton-irradiation-induced radiation damage in Bakelite used in the fabrication of electrodes in resistive plate chamber (RPC) detectors was investigated. Additional free volume defects were created, existing defects agglomerated and cross-linking of polymer chains got significantly enhanced due to the irradiation. The idea of zinc vacancies being mainly responsible for stable ferromagnetic ordering in Ma-doped ZnO nanosystems was put to test and got verified from positron annihilation studies. Proton-irradiation was performed on Ti-6Al-4V alloy and positron annihilation studies were continued after the samples are annealed at various temperatures. The stages of vacancy-interstitial recombination and vacancy coarsening are identified. Further experiments are in progress. Positron annihilation and Doppler broadening measurements were carried out on samples of 6H-SiC, polyethylene, Fe and V samples irradiated by high energy gamma rays to various doses. Positron lifetime and Doppler broadening spectroscopy is also utilized to characterize the defects in gamma-irradiated magnesium ferrite nanocrystals of different sizes prepared by sol-gel technique at different temperatures. Similar studies were also carried out on another series of samples in which Mg is successively replaced by Ca.

Positron annihilation studies were carried out on pure and graphene-mixed ZnO nanocrystalline

samples doped with four different cations (Co, Cu, Pd and Cd). Positron lifetimes and their intensities showed defective structures where all atomic sites are not occupied. The defects are surrounded by oxygen ions. The evolution of the free volume defects under aging at room temperature of RPC glass, which is normally used as electrode material in high energy neutrino physics experiments, was recently studied. The free volume defects underwent agglomeration, recombination etc. at various stages of positron and gamma ray irradiation. Positron lifetime data depicted that the sizes and concentrations of defects saturated over a period of time.

Positron annihilation studies are also being continued on natural biopolymers to understand their structural organization as regards to nature of bonding and packing sheet structure using positron annihilation spectroscopy. In order to use a short lived positron emitter: Ga-68 for bio-medical applications, certain bio-active nano-materials have been designed, that could be isotopically exchanged easily since chemical properties of an element are invariant with the change of the isotope of that element. Thus, bio-active nanomaterials, namely: Gallium oxy-hydroxide GaO(OH), also surface-conjugated GaO(OH) with a giant sugar molecule: β-cyclodextrin (CD) have been prepared through a simple wet chemical route such that the same could be suitably used in bio-medical diagnostics as well as therapeutic applications. Several physical methods were used for their characterization *viz:* powder X-ray diffraction pattern of GaO(OH) nano-particles(NPs) for their grain size determination, optical spectroscopic absorption (UV-Vis and FT-IR) and fluorescence properties of these NPs to ascertain surface conjugation, as also their wide band-gap properties. Besides these, morphological properties of these NPs were studied by transmission electron microscopic (TEM) investigation, justifying the elemental constitution through energy dispersive X-ray analysis(EDX). Further, biological cellular uptake of these nano-particles have been demonstrated on cancerous HeLa cells and reported with total fatal effect after 72 hours, with CD templated GaO(OH) nanoparticles, *the fact has not been reported so far.*

Numerous technological applications of Ni-based Zr and Hf intermetallic alloys promoted comprehensive studies in Zr_8Ni_{21}, Zr_7Ni_{10}, Hf_8Ni_{21}, Hf_7Ni_{10} alloys by perturbed angular correlation (PAC) spectroscopy which were not studied earlier. The different phases produced in the samples have been identified by PAC and X-ray diffraction (XRD) measurements. Using ^{181}Hf probe, two non-equivalent Zr/Hf sites have been observed in both Zr_8Ni_{21} and Hf_8Ni_{21} compounds from PAC measurements. In Zr_8Ni_{21}, a definite microstructural change has been observed at 773 K. From present PAC measurements, a third component due to the production of Zr_7Ni_{10} by eutectic reaction from the liquid metals is also observed. The phase Zr_7Ni_{10}, however, is not found from our XRD measurement. In Hf_8Ni_{21}, similar results for the two non-equivalent sites have been found but site fractions are in reverse order. In the Hf-Ni alloy, a different contaminating phase of $HfNi_3$ has been found from PAC measurements but is not found from present XRD measurement. In this material also, a similar microstructural change for the principal component is observed at 1073 K. Density functional theory (DFT) based calculations of electric field gradient (EFG) and asymmetry parameter (η), at ^{181}Ta probe nucleus allowed us to assign the observed EFG fractions to the various lattice sites in $(Zr/Hf)_8Ni_{21}$ compounds. Temperature dependent PAC measurements in Zr_7Ni_{10} and Hf_7Ni_{10} have been performed. Data analysis and interpretation of results are in progress.

Studies on ion back-flow fraction (IBF) in Micromegas detector have been continued in a systematic way to suggest the optimum geometry and operational parameters for its reduction. Both numerical simulation and experimental measurements have been carried out in order to produce improved and reliable results. The distortion in Time Projection Chamber tracking observed by bulk Micromegas endplate could be validated with numerical simulation. The Indo-French collaborative project with the motivation of studying IBF and distortion problems in Micromegas-based TPC has been ended successfully. 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.
The numerical studies on the effect of surface roughness of resistive plates on the performance of RPC have progressed well. Several measurements in this context have been carried out to complement the simulation work. The numerical and experimental studies on the effect of geometry and the artifacts on the timing response of RPC are being carried out presently. The investigation for eco-friendly gas mixtures for operating the RPCs is in progress. As a part of the ageing studies, the effect of water vapour on the RPC response has been studied experimentally.
The neBEM field solver has been improved with the introduction of more rigorous error estimate. It is being applied to investigate the problems of IBF, distortion in Micromegas-based TPC, timing response of RPC etc. 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, we investigated the underlying mechanism of filling-in process at the blind spot and proposed a general computational mechanism for filling-in. Filling-in at the blind spot is a perceptual phenomenon in which the visual system fills the informational void, which arises due to the absence of retinal input corresponding to the optic disc, with surrounding visual attributes. It is known that during filling-in, nonlinear neural responses are observed in the early visual area that correlates with the perception, but the knowledge of underlying neural mechanism for filling-in at the blind-spot is far from complete. In this work, we attempted to present a fresh perspective on the computational mechanism of filling-in process in the framework of hierarchical predictive coding, which provides a functional explanation for a range of neural responses in the cortex. We simulated a three-level hierarchical network and observe its response while stimulating the network with different bar stimulus across the blind spot. We find that the predictive-estimator neurons that represent blind spot in primary visual cortex exhibit elevated non-linear response when the bar stimulated both sides of the blind-spot. Using generative model, we also show that these responses represent the filling-in completion. All these results are consistent with the finding of psychophysical and physiological studies. In this study, we also demonstrate that the tolerance in filling-in qualitatively matches with the experimental findings related to non-aligned bars. We showed that all our results could be explained by taking into account the efficient coding of natural images along with feedback and feed-forward connections that allow priors and predictions to co-evolve to arrive at the best prediction. Our results suggest that the filling-in process could be a manifestation of the general computational principle of hierarchical predictive coding of natural images.
In the laser spectroscopy laboratory, by using different orders of the LaguerreGaussian (LG) beam, we have performed an experimental and theoretical study on the saturation absorption spectroscopy of ^{87}Rb and ^{85}Rb atoms in D_2 transition. The LG beam (optical Vortex beam) has a doughnut shaped intensity distribution and zero intensity with a phase singularity at its centre. We observed narrow line shapes of the Doppler and the hyperfine absorption profiles due to the introduction of the LG beam in comparison to the fundamental Gaussian beam. We found out that the spatially dependent Rabi frequency plays a significant role behind these narrowing phenomena. This LG induced narrow absorption profile may have several significances. It can make the frequency locking of the lasers even more robust. Furthermore, these profiles may have several applications in cold atom trapping, atomic clocks, storage of light experiments, etc. Studies of some basic phenomena like transfer of orbital angular momentum from photon to atoms using the LG beam are in progress.
Monte Carlo simulation of electron transport and its effects on inner shell ionization in heavy ele-

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

3.1.2 Publications

3.1.2.1 Publications in Journal

Rajani Raman; Sandip Sarkar, Predictive Coding: A Possible Explanation of Filling-In at the Blind Spot, PLOS ONE **11** (2016) Art No: e0151194

Bankim Chandra Das; Dipankar Bhattacharyya†; Sankar De, Narrowing of Doppler and hyperfine line shapes of Rb D_2 transition using a Vortex beam, CHEMICAL PHYSICS LETTERS **644** (2016) 212

D Abbaneo†; M Abbas†; M Abbrescia†; S Banerjee; N Majumdar; S Mukhopadhyay; S RoyChowdhury; et al, Design of a constant fraction discriminator for the VFAT3 front-end ASIC of the CMS GEM detector, JOURNAL OF INSTRUMENTATION **11** (2016) Art No: C01023

D Mathur; K Dota; D Dey; S De; et al, Selective breaking of bonds in water with intense, 2-cycle, infrared laser pulses, JOURNAL OF CHEMICAL PHYSICS **143** (2015) Art No: 244310

Jincemon Cyriac†; Rahul Mundiyaniyil Thankachan†; B Raneesh†; PMG Nambissan; et al, Positron annihilation spectroscopic studies of Mn substitution-induced cubic to tetragonal transformation in $ZnFe_{2-x}Mn_xO_4$ (x=0.0-2.0) spinel nanocrystallites, PHILOSOPHICAL MAGAZINE **95** (2015) 4000

A Jash; N Majumdar; S Mukhopadhyay; et al, Numerical studies on electrostatic field configuration of Resistive Plate Chambers for the INO-ICAL experiment, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P11009

Bichitra Nandi Ganguly; Sreetama Dutta; Soma Roy; et al & ISOLDE-Collaboration, Investigation on structural aspects of ZnO nano-crystal using radio-active ion beam and PAC, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION **B362** (2015) 103

Dipankar Bhattacharyya†; Arindam Ghosh†; Amitava Bandyopadhyay†; Satyajit Saha; Sankar De, Observation of electromagnetically induced transparency in six-level Rb atoms and theoretical simulation of the observed spectra, JOURNAL OF PHYSICS **B48** (2015) Art No: 175503

P Bhattacharya; D Bhattacharya; Supratik Mukhopadhyay...Nayana Majumdar; Sandip Sarkar; et al, Investigation of ion backflow in bulk micromegas detectors, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P09017

Bichitra Nandi Ganguly; Ranjini Menon; Nabhiraj P Yalagoud; et al, Depth-resolved slow positron beam analysis of ECR proton and argon implanted graphite and boron nitride system, PHYSICA STATUS SOLIDI B-BASIC SOLID STATE PHYSICS **252** (2015) 2024

Purba Bhattacharya; Supratik Mukhopadhyay; Nayana Majumdar; et al, The effect of spacers on the performance of Micromegas detectors: A numerical investigation, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT **793** (2015) 41

DS Bhattacharya; D Attie†; P Colas†; S Mukhopadhyay; N Majumdar; S Bhattacharya; S Sarkar; et al, Measurement and simulation of two-phase CO2 cooling in Micromegas modules for a Large Prototype of Time Projection Chamber, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P08001

CC Dey; Rakesh Das†; SK Srivastava†, Electric field gradients at Ta-181 probe in ZrNi: Results from perturbed angular correlation and first-principles calculations, JOURNAL OF PHYSICS AND CHEMISTRY OF SOLIDS **82** (2015) 10

Sheela Thimmaiah†; Rajashekhar Fakeerappa Bhajantri†; Padinharu Madathil Gopalakrishnan Nambissan; et al, Positron annihilation and other experimental studies on polycarbonate/MPDMAPP nanocomposite, JOURNAL OF APPLIED POLYMER SCIENCE **132** (2015) Art No: 42053

Anjan Das†; Atis Chandra Mandal†; Soma Roy; PMG Nambissan, Positron annihilation studies of defects and fine size effects in nanocrystalline nickel oxide, JOURNAL OF EXPERIMENTAL NANOSCIENCE **10** (2015) 622

Paramjit Singh†; Rajesh Kumar†; PMG Nambissan, Investigation of in-depth and surface properties of polyethyleneterephthalate thin films after SHI and gamma radiation treatment by means of PALS and AFM studies, VACUUM **115** (2015) 31

AK Bhati†; J Kaur†; N Bansal†...CC Dey, Anomalous magnetic moment at *Ba* in *Au*, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION **B349** (2015) 125

M Salim†; A Jash; R Hasan†; N Majumdar; S Mukhopadhayay, Simulation of efficiency and time resolution of resistive plate chambers and comparison with experimental data, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: C04033

Anjan Das; Atis Chandra Mandal†; PMG Nambissan, Effect of size on momentum distribution of electrons around vacancies in NiO nanoparticles, CHINESE PHYSICS **B24** (2015) Art No: 046102

Ajanta Kundu; Sandip Sarkar, Stochastic resonance in visual sensitivity, BIOLOGICAL CYBERNETICS **109** (2015) 241

Jincemon Cyriac†; Rahul Mundiyaniyil Thankachan†; Nandakumar Kalarikkal; PMG Nambissan, Positron annihilation spectroscopic studies of multiferroic $Bi_{1-x}Pr_xFeO_3$ nanocrystalline com-

pounds, JOURNAL OF PHYSICS: CONFERENCE SERIES **618** (2015) 012012

Rahul Mundiyaniyil Thankachan†; Jincemon Cyriac†; B Raneesh...PMG Nambissan, Cr3+-substitution induced structural reconfigurations in the nanocrystalline spinel compound ZnFe2O4 as revealed from x-ray diffraction, positron annihilation and Mssbauer spectroscopic studies. RSC Advances **5** (2015) 64966

AK Bhati†; J Kaur†; N Bansal†...CC Dey, Anomalous magnetic moment at Ba in Au, Nucl Instrum Meth In Phys Res **B349** (2015) 125

SK Dey; CC Dey; S Saha, Low temperature structural phase transition in hafnium and zirconium tetrafluoride trihydrates, J Phys Chem Solids **91** (2016) 18

SK Dey; CC Dey; S Saha, Low temperature structural modification in Rb_2ZrF_6: Investigations by perturbed angular correlation spectroscopy, J Phys Chem Solids **93** (2016) 145

SK Dey; CC Dey; S Saha, Effects of Zr impurity on microscopic behavior Hf metal, J Phys Chem Solids **95** (2016) 98

Dipankar Bhattacharyya†; Arindam Ghosh†; Amitava Bandyopadhyay; Satyajit Saha; Sankar De, Comparison of electromagnetically induced transparency (EIT) spectra for six-level lambda (Λ) and five-level V-type systems, JOURNAL OF ATOMIC MOLECULAR CONDENSATE AND NANO PHYSICS **2** (2015) Art No. 93

Sankar De; H Tezuka; P Bhatt; et al, Do linear molecules always dissociate along their axis? Intramolecular scattering within Diiodoacetylene, JOURNAL OF PHYSICS: CONFERENCE SERIES **635** (2015) Art No. 032061

3.1.3 Ph D Awarded

Ajanta Kundu [Sandip Sarkar], Stochastic Resonance in Visual Computation, CU, March 2015

Purba Bhattacharya [Supratik Mukhopadhyay], Experimental and Numerical Investigation on Micro-Pattern Gas Detectors, Calcutta University, August 2015

3.1.4 Seminars/Lectures given in Conference/Symposium/Schools

PMG Nambissan
i. Nanoscience using a nuclear spectroscopic probe, National Seminar on Nanoscience and Nanotechnology (NSNN-2015), Haldia Institute of Technology, Haldia, West Bengal, October 9-10, 2015
ii. Electron-positron annihilation spectroscopy to highlight the defect characteristics of pure and Mn-doped NiO nanocrystals, International Conference on Nanomaterials and Nanotechnology (NANO-2015), KS Rangaswamy College of Technology, Tiruchengode, Tamil Nadu, December 7-10, 2015

iii. A novel probe for the investigation of substitution-induced cation redistribution and structural transformation in spinel nanosystems, 3rd International Conference on Nanostructured Materials and Nanocomposites (ICNM 2015) Hindustan College of Science and Technology, Farah, Mathura, Uttar Pradesh, December 12-14, 2015
iv. Positron annihilation studies of substitution-induced structural transformations in spinel oxide nanocrystallites, Int Conf on Nanotechnology (ALIGARH NANO-V) and STRM-Education and Research (STEM-CON-16), Aligarh Muslim University, Aligarh, March 12-15, 2016

Bichitra Nandi Ganguly
Understanding the molecular architecture of herbal polymeric products through Positron Annihilation spectroscopy (PAS), International conference on polymers, MG University, Kottayam, Kerala, 2015

Sankar De
Ion-induced dissociation of Diiodoacetylene,
(a) Workshop on Low Energy Ion Beam (LEIB) facility, Inter-University Accelerator Centre, New Delhi, November, 2015
(b) Topical Conference on Charged Particle Collisions and Electronic processes in Atoms, Molecules and Materials (q-PaCE 2016), Indian School of Mines, Dhanbad, January, 2016

3.2 High Energy Nuclear and Particle Physics

3.2.1 Summary of Research Activities

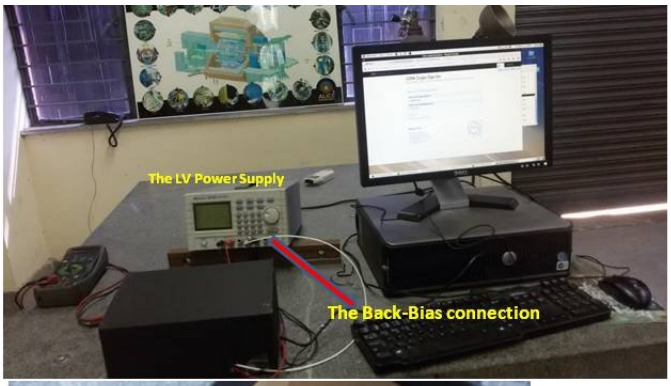
The research activities in High Energy Nuclear and Particle Physics Division can be categorized in four major directions. The details of these activities are given below:
1. ALICE Collaboration activities
The Saha-ALICE group joined the ALICE Collaboration in 1997 and has been one of the founder laboratories who developed the Muon Spectrometer. The group has made critical hardware contributions which have been fabricated indigenously. These are the Muon chambers for the Second Tracking station built entirely in the campus and the MANAS chips for the readout of the 1.1 million channels which were designed at Saha Institute and fabricated at the Semiconductor Complex Laboratory, Chandigarh. These deliverables performed exceedingly well during the Run-I which has led to 26 research publications in reputed journals.
The Run-II Pb-Pb collisions took place during November-December, 2015 at a collision rate which was 20 times higher than in Run-I. This increased collision rates poised a challenge to the Muon Chambers and also to the MANAS chip. During the long shutdown (LS1), the technical team from Saha Intitute carried out detail service works to ensure the smooth functioning of our deliverables.

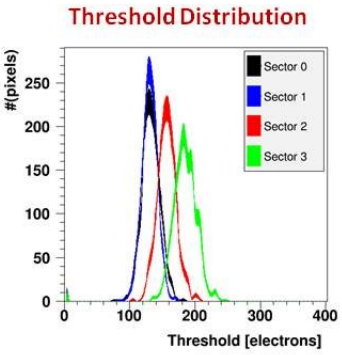
Performance of Hardware Deliverables during Run-II
The satisfactory performance of the Muon Spectrometer at the increased collision rates during Run-II has led to a ten-fold increase in the data volume compared to Run-I. The preliminary plots showing the yields of heavy quark resonances are shown below. This enhanced statistics of Jpsi [(a)] will allow the measurements of the double differential cross-sections which will be essential to identify the recombination effects at LHC energies. The substantial statistics will also allow the first detail study of the suppression of Upsilon [(b)] production at forward rapidity.

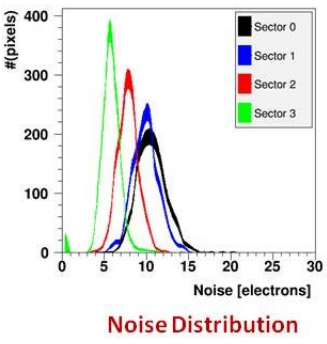
Responsibilities and Data Analysis
Saha Institute took the responsibility for the start-of-run for taking of Pb-Pb data and Physics Analysis Group for Upsilon. Currently, the following Pb-Pb data analysis tasks are being carried out at Saha Institute: (1) Study of the suppression of Upsilon production and (2) Measurement of double differential cross-sections for Jpsi.

ALICE Upgrade: Muon Forward Tracker (MFT)
The physics programme of ALICE after the Long Shutdown 2 (LS2) will be devoted to the high precision measurements of hard probes (heavy flavour hadrons, quarkonia, photons and jets). The MFT will allow ALICE to extend the precision measurements of the heavy quark resonances. The MFT detector will be put upstream of the absorber of the MUON spectrometer i.e. much closer to the Interaction Point (IP) to add the vertexing capability. The Si-tracking detectors of low-material budget will be used in MFT. The basic detection element of the MFT is the pixel sensor which is based on the CMOS monolithic pixel sensor technology.
In this International Collaboration, among 12 participating Institutes, the mechanical and electronics technicians/engineers along with the scientists of Saha Institute and Aligarh Muslim University will constitute the Indian collaboration. The activities had been started in the beginning of 2015. The India-MFT collaboration will be focussing on two areas:

The Pixel characterization Work :
We had received w17-17 pALPIDEV2 chip made with pixel sensor of 30 μm epitaxial layer thickness and corresponding DAQ board from MFT collaboration in August, 2015. The procurement of







hardware and handshaking between hardware and software took three months to formulate a test bench to study the pixel characterization of this chip. The testing of the chip was started from De-

cember, 2015 at SAHA, Kolkata. The update of progress of the work had been regularly presented in WGX Pixel Characterisation meetings. The threshold and noise distribution in four sectors of the chip had been studied with and without back-bias. The adjoining figure shows the threshold and noise distribution of pALPIDEV2 chip along with the set up.

The fabrication of Water-Cooling system of MFT detector:
The cooling system of the MFT detector will be water-cooling system for which the Indian MFT group will be responsible. In view of that, we are procuring the several components made of carbon fibre in order to fabricate a prototype for the cooling solution. The Indian MFT group had attended the WG7 Mechanics & Cooling. The preliminary procedure of fabrication of cooling system had been discussed in the collaboration.

2. QGP Phenomenology
This activity is being pursued for last 16 years with emphasis on the study of anisotropic quark-gluon plasma (AQGP), hadron properties in external magnetic fields. The highlights of these studies in recent times are:
Study of meson properties in external magnetic field using effective Lagrangian approach. In the first part of this project we have studied the pion meson mass and dispersion relations as a function of the external magnetic field.
Study of lepton pair production from anisotropic quark gluon plasma. Calculation of lepton pair yield from the jet-plasma interaction is under study as a first step.

3. 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 during that period. The LHC Run II data taking resumed in mid-2015 successfully and has been delivering useful data. 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 diverse studies of the LHC Phase II tracker development.

Physics Studies and Computing:
Analyses: The SINP-CMS group undertook several analyses from key focus areas of the LHC physics, including search for the Higgs boson and search for dark matter during the run I period (mainly 2011-12 data). We have been contributing to the study of a number of key physics questions with long term involvement, namely: (1) SM Higgs boson studies in the $\gamma\gamma$ decay mode, e.g differential cross-section measurement, and in the 4-lepton decay mode (4e, 4μ, 2e2μ). (2) SM Higgs boson searches in the associated production mode with W where the Higgs boson decays into a pair of t leptons and the W decays to an electron or muon; (3) search for dark matter and extra-dimension; (4) search for compositeness for leptons; (5) inclusive jet production at different energies and event shape studies; (6) Feasibility study to trigger on Bs$\rightarrow \phi\phi \rightarrow$ 4 kaons events at Level 1 using the proposed tracker at LHC PhaseII.
The SINP team continued contributing in almost all the channels during the 2015-16 data taking. The SINP team played a central role in two important publications of CMS in 2016 from dark matter searches and excited lepton searches from 2012 data. Students from SINP were leading analyzers and served as analysis contact persons within the CMS. The bound on dark matter nucleon scattering cross-section obatined from our monophoton analysis appears in the global plot of

dark matter-nucleon scattering cross-section upper bound and the analysis has featured in CERN courier. In 2016, the SINP team is contributing toowards rediscovery and first mass measurements of the Higgs boson from Run II data.

Computing: The SINP-CMS cluster became fully operational in 2013, with the successful hosting of the Asian CMS Data Analysis (CMSDAS) school. The cluster has served significantly for the PhaseII Tracker related simulation studies. In 2016 SINP-CMS has initiated integration with the LHCone network supported under the National Knowledge Network (NKN) and started hosting data for several Run II analyses of the CMS, in which SINP is involved.

Run II Detector Performance related activities:
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 warranted replacement of all existing photodetectors that instrument the current HCAL detectors. It was decided to replace the HPDs with

Silicon PMs (SiPM) and the single anode PMTs with multi-anode PMTs during the LHC Long Shutdown period 1 (LS1, 2013 mid 2015). Such an upgrade also resulted in substantial increase in the number of channels in barrel (HB), endcap (HE) and forward (HF) detectors which in turn demanded higher speed communication. Additionally, finer trigger primitives are required to handle high pile-up. So the back-end electronics has also been rebuilt by replacing VME crates with

μTCA crates and equipping them with μHTR cards.
SINP has made substantial contribution in two broad areas: (i) microTCA based readout cards for HF and (ii) Optical Splitters for barrel and end-cap HB/HE detectors. First set of cards is required for HF.
The Optical splitter (above left) will split the signals between the existing VME based system and μTCA based system (above right) which has been made by Indian groups.
A total of 54 μHTR cards were fabricated 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.

Optical Splitters for HB/HE Upgrade: With the commissioning of new microTCA based electronics at the back-end, it is planned that the traditional VME based electronics is also retained for at least one year to check and compare the performance and trigger calculations. To do that, signals from front-end need to be split. A prototype solution was designed and developed by the Indian groups which was well within the specification. The prototypes worked very well and the HCAL operational groups ordered 6 more of these units and their performance was also consistent good. Eventually, 206 such units have been shipped and installed at CERN.
Optical splitters for LS1 upgrade were crucial for the working of trigger with CMS HCAL back-end electronics. Students and post-doc have played a major role in designing and testing for the last 3 years, to meet our partial commitment towards LS1 upgrade.

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 design allows us to reconstruct tracks with sufficient resolution at Level 1 phase of the trigger system in order to reduce and keep event rate at an acceptable limit which will be a crucial addition to CMS. We have 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 is already a part of the PhaseII tracker Technical Proposal (TP). We have also been studying whether rare processes like Bs$\rightarrow \phi\phi \rightarrow$ 4 kaons can be triggered using the PhaseII tracker. We have made major contribution to the tracker module-test software development and Data Quality Monitoring (DQM) tool used in laboratory and Tracker Beam tests. 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 were two possible designs that were 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. Recently the second option has been selected for the PhaseII CMS endcap calorimeter. We have made significant contribution to the simulation of both these options.
Since the beginning of the CMS-SINP group, SINP members have held positions of responsibilities, both in detector development and Physics analyses within the CMS collaboration. This included major responsibilities as: Simulation and Geometry, Detector Performance Group (HCAL DPG), CMS Data Quality Monitoring (DQM), Upgrade of the back-end electronics of the HCAL. In 2015-16 Members of SINP have served as Physics subgroup convenors, on analysis review committees, internal review committees and as analysis contact persons. During 2015-16 SINP members continued with the co-ordinatorship of the upgrade of HCAL backend electronics and co-convenors of the Higgs decaying to two taus in fully hadronic mode and the PhaseII Tracker beam test data analysis subgroup respectively.

4. Angular momentum generation mechanisms in A∼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 highlights of this research activity during 2015 are:
Identification of novel Staircase bands in odd-Ag isotopes.
A new phenomenological model has been developed to explain the origin of the staircase bands.
Observation of the co-existence of anti-magnetic and collective rotation in 105Pd.

3.2.2 Publications

3.2.2.1 Publications in Journal

Leonard S Kisslinger†; Debasish Das, Review of QCD, quark-gluon plasma, heavy quark hybrids, and heavy quark state production in $p-p$ and $A-A$ collisions, INTERNATIONAL JOURNAL OF MODERN PHYSICS **A31** (2016) Art No: 1630010

J Sethi†; R Palit†; JJ Carroll†; S Chattopadhyay; et al, Low-lying states near the $I^{\pi} = 6^{+}$ isomer in ^{108}Ag, JOURNAL OF PHYSICS **G43** (2016) Art No: 015103

Leonard S Kisslinger†; Debasish Das, J/Psi, Psi (2S) Production in pp Collisions at E=510 GeV, INTERNATIONAL JOURNAL OF THEORETICAL PHYSICS **54** (2015) 2737

A Parmar†; Sonika†; BJ Roy†; T Sinha; et al, Understanding the two neutron transfer reaction mechanism in ^{206}Pb^{18}O,^{16}O^{208}Pb, NUCLEAR PHYSICS **A940** (2015) 167

Biswarup Paul; Mahatsab Mandal; Pradip Roy; Sukalyan Chattopadhyay, Systematic study of charmonium production in p-p collisions at LHC energies, JOURNAL OF PHYSICS **G42** (2015) Art No: 065101

Leonard S Kisslinger†; Debasish Das, Psi and Upsilon Production in proton-proton collisions at E=13TeV, INTERNATIONAL JOURNAL OF MODERN PHYSICS **E24** (2015) Art No: 1550038

3.2.2.2 ALICE Collaboration

ALICE Collaboration, Event-shape engineering for inclusive spectra and elliptic flow in Pb-Pb collisions at $\sqrt{S_{NN}}$=2.76 TeV, PHYSICAL REVIEW **C93** (2016) Art No: 034916

ALICE Collaboration, Centrality dependence of the nuclear modification factor of charged pions, kaons, and protons in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, PHYSICAL REVIEW **C93** (2016) Art No: 034913

ALICE Collaboration, Transverse momentum dependence of D-meson production in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 3** (2016) Art No:

081

ALICE Collaboration, Measurement of D-s(+) product ion and nuclear modification factor in Pb-Pb collisions at $\sqrt{s}$-NN=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 3** (2016) Art No: 082

ALICE Collaboration, Measurement of electrons from heavy-flavour hadron decays in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICS LETTERS **B754** (2016) 81

ALICE Collaboration, Direct photon production in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, PHYSICS LETTERS **B754** (2016) 235

ALICE Collaboration, H^3_λ and $H^3_{\bar{\lambda}}$ production in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, PHYSICS LETTERS **B754** (2016) 360

ALICE Collaboration, Centrality evolution of the charged-particle pseudorapidity density over a broad pseudorapidity range in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76TeV, PHYSICS LETTERS **B754** (2016) 373

ALICE Collaboration, Production of light nuclei and anti-nuclei in pp and Pb-Pb collisions at energies available at the CERN Large Hadron Collider, PHYSICAL REVIEW **C93** (2016) Art No: 024917

ALICE Collaboration, Multiplicity and transverse momentum evolution of charge-dependent correlations in pp, p-Pb, and Pb-Pb collisions at the LHC, EUROPEAN PHYSICAL JOURNAL **C76** (2016) Art No: 86

ALICE Collaboration, Elliptic flow of muons from heavy-flavour hadron decays at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76TeV, PHYSICS LETTERS **B753** (2016) 41

ALICE Collaboration, Forward-central two-particle correlations in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICS LETTERS **B753** (2016) 126

ALICE Collaboration, Pseudorapidity and transverse-momentum distributions of charged particles in proton-proton collisions at $\sqrt{s}$=13 TeV, PHYSICS LETTERS **B753** (2016) 319

ALICE Collaboration, Azimuthal anisotropy of charged jet production in $\sqrt{s_{NN}}$=2.76 TeV Pb-Pb collisions, PHYSICS LETTERS **B753** (2016) 511

ALICE Collaboration, Centrality dependence of pion freeze-out radii in Pb-Pb collisions at$\sqrt{s_{NN}}$ =2.76 TeV, PHYSICAL REVIEW **C93** (2016) Art No: 024905

ALICE Collaboration, Search for weakly decaying (Lambda n)over-bar and Lambda Lambda exotic bound states in central Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, PHYSICS LETTERS **B752** (2016) 267

ALICE Collaboration, Study of cosmic ray events with high muon multiplicity using the ALICE detector at the CERN Large Hadron Collider, JOURNAL OF COSMOLOGY AND ASTROPAR-

TICLE PHYSICS **Issue: 1** (2016) Art No: 032

ALICE Collaboration, Coherent psi (2S) photo-production in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76TeV, PHYSICS LETTERS **B751** (2015) 358

ALICE Collaboration, Centrality dependence of high-$_p$T D meson suppression in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 11** (2015) Art No: 205

ALICE Collaboration, Centrality dependence of inclusive J/psi production in p-Pb collisions at $\sqrt{s_{NN}}$=5.02TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 11** (2015) Art No: 127

ALICE Collaboration, One-dimensional pion, kaon, and proton femtoscopy in Pb-Pb collisions at root(NN)-N-S=2.76 TeV, PHYSICAL REVIEW **C92** (2015) Art No: 054908

ALICE Collaboration, Measurement of charged jet production cross sections and nuclear modification in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICS LETTERS **B749** (2015) 68

ALICE Collaboration, Precision measurement of the mass difference between light nuclei and anti-nuclei, NATURE PHYSICS **11** (2015) 811

ALICE Collaboration, Measurement of jet quenching with semi-inclusive hadron-jet distributions in central Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2015) Art No: 170

ALICE Collaboration, Measurement of charm and beauty production at central rapidity versus charged-particle multiplicity in proton-proton collisions at $\sqrt{s}$=7 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2015) Art No: 148

ALICE Collaboration, Coherent rho(0) photoproduction in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2015) Art No: 095

ALICE Collaboration, Inclusive, prompt and non-prompt J/psi production at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 7** (2015) Art No: 051

ALICE Collaboration, Measurement of jet suppression in central Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, PHYSICS LETTERS **B746** (2015) 1

ALICE Collaboration, Measurement of dijet k(T) in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICS LETTERS **B746** (2015) 385

ALICE Collaboration, Elliptic flow of identified hadrons in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 Tev, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2015) Art No: 190

ALICE Collaboration, Charged jet cross sections and properties in proton-proton collisions at $\sqrt{s}$=7 TeV, PHYSICAL REVIEW **D91** (2015) Art No: 112012

ALICE Collaboration, Rapidity and transverse-momentum dependence of the inclusive J/psi nu-

clear modification factor in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2015) Art No: 055

ALICE Collaboration, Centrality dependence of particle production in p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICAL REVIEW **C91** (2015) Art No: 064905

ALICE Collaboration, Measurement of pion, kaon and proton production in proton-proton collisions at $\sqrt{s}$=7 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 226

ALICE Collaboration, Forward-backward multiplicity correlations in pp collisions at $\sqrt{s}$=0.9, 2.76 and 7 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 5** (2015) Art No: 097

ALICE Collaboration, Inclusive photon production at forward rapidities in proton-proton collisions at $\sqrt{s}$=0.9, 2.76 and 7 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 146

3.2.2.3 CMS Collaboration

CMS Collaboration, Search for dark matter and unparticles produced in association with a Z boson in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D93** (2016) Art No: 052011

CMS Collaboration, Event generator tunes obtained from underlying event and multiparton scattering measurements, EUROPEAN PHYSICAL JOURNAL **C76** (2016) Art No: 155

CMS Collaboration, Transverse momentum spectra of inclusive b jets in pPb collisions at $\sqrt{s_{NN}}$=5.02 TeV, PHYSICS LETTERS **B754** (2016) 59

CMS Collaboration, Measurements of t(t)over-bar spin correlations and top quark polarization using dilepton final states in pp collisions at $\sqrt{s}$ =8 TeV, PHYSICAL REVIEW **D93** (2016) Art No: 052007

CMS Collaboration, Search for single production of scalar leptoquarks in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D93** (2016) Art No: 032005

CMS Collaboration, Measurement of the charge asymmetry in top quark pair production in pp collisions at $\sqrt{s}$=8 TeV using a template method, PHYSICAL REVIEW **D93** (2016) Art No: 034014

CMS Collaboration, Search for Narrow Resonances Decaying to Dijets in Proton-Proton Collisions at $\sqrt{s}$=13 TeV, PHYSICAL REVIEW LETTERS **116** (2016) Art No: 071801

CMS Collaboration, Search for a Higgs boson decaying into gamma*gamma → ll gamma with low dilepton mass in pp collisions at$\sqrt{s}$=8 TeV, PHYSICS LETTERS **B753** (2016) 341

CMS Collaboration, Search for exotic decays of a Higgs boson into undetectable particles and one or more photons, PHYSICS LETTERS **B753** (2016) 363

CMS Collaboration, Angular analysis of the decay $B^0 \rightarrow K^{*0}\mu^+\mu^-$ from pp collisions at $\sqrt{s}$=8 TeV, PHYSICS LETTERS **B753** (2016) 424

CMS Collaboration, Measurement of the Top Quark Pair Production Cross Section in Proton-Proton Collisions at $\sqrt{s}$=13 TeV, PHYSICAL REVIEW LETTERS **116** (2016) Art No: 052002

CMS Collaboration, Search for the production of an excited bottom quark decaying to tW in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2016) Art No: 166

CMS Collaboration, Study of B Meson Production in p plus Pb Collisions at $\sqrt{s_{NN}}$=5.02 TeV Using Exclusive Hadronic Decays, PHYSICAL REVIEW LETTERS **116** (2016) Art No: 032301

CMS Collaboration, Search for vectorlike charge 2/3 T quarks in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D93** (2016) Art No: 012003

CMS Collaboration, Observation of top quark pairs produced in association with a vector boson in pp collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2016) Art No: 096

CMS Collaboration, Search for a very light NMSSM Higgs boson produced in decays of the 125 GeV scalar boson and decaying into τ leptons in pp collisions at $\sqrt{s}$=8TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2016) Art No: 079

CMS Collaboration, Measurement of differential cross sections for Higgs boson production in the diphoton decay channel in pp collisions at $\sqrt{s}$=8TeV, EUROPEAN PHYSICAL JOURNAL **C76** (2016) Art No: 13

CMS Collaboration, A search for pair production of new light bosons decaying into muons, PHYSICS LETTERS **B752** (2016) 146

CMS Collaboration, Search for neutral MSSM Higgs bosons decaying to mu(+) mu(-) in pp collisions at $\sqrt{s}$=7 and 8 TeV, PHYSICS LETTERS **B752** (2016) 221

CMS Collaboration, Search for resonant t(t)over-bar production in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D93** (2016) Art No: 012001

CMS Collaboration, Measurement of transverse momentum relative to dijet systems in PbPb and pp collisions at $\sqrt{s_{NN}}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 1** (2016) Art No: 006

CMS Collaboration, Reconstruction and identification of tau lepton decays to hadrons and ν^τ at CMS, JOURNAL OF INSTRUMENTATION **11** (2016) Art No: P01019

CMS Collaboration, Pseudorapidity distribution of charged hadrons in proton-proton collisions at $\sqrt{s}$=13TeV, PHYSICS LETTERS **B751** (2015) 143

CMS Collaboration, Production of leading charged particles and leading charged-particle jets at

small transverse momenta in pp collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D92** (2015) Art No: 112001

CMS Collaboration, Search for supersymmetry in the vector-boson fusion topology in proton-proton collisions at $\sqrt{s}$=8TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 11** (2015) Art No: 189

CMS Collaboration, Measurement of the differential cross section for top quark pair production in pp collisions at $\sqrt{s}$=8TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 542

CMS Collaboration, Angular coefficients of Z bosons produced in pp collisions at $\sqrt{s}$=8 TeV and decaying to $\mu^+\mu^-$ as a function of transverse momentum and rapidity, PHYSICS LETTERS **B750** (2015) 154

CMS Collaboration, Search for diphoton resonances in the mass range from 150 to 850 GeV in pp collisions at $\sqrt{s}$=8 TeV, PHYSICS LETTERS **B750** (2015) 494

CMS Collaboration, Study of W boson production in pPb collisions at $\sqrt{S_{NN}}$=5.02 TeV, PHYSICS LETTERS **B750** (2015) 565

CMS Collaboration, Search for neutral MSSM Higgs bosons decaying into a pair of bottom quarks, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 11** (2015) Art No: 071

CMS Collaboration, Search for a charged Higgs boson in pp collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 11** (2015) Art No: 018

CMS Collaboration, Search for a Higgs boson in the mass range from 145 to 1000 GeV decaying to a pair of W or Z bosons, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 10** (2015) Art No: 144

CMS Collaboration, Limits on the Higgs boson lifetime and width from its decay to four charged leptons, PHYSICAL REVIEW **D92** (2015) Art No: 072010

CMS Collaboration, Comparison of the Z/γ^* + jets to γ+ jets cross sections in pp collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 10** (2015) Art No: 128

CMS Collaboration, Search for supersymmetry with photons in pp collisions at $\sqrt{s}$=8 TeV, PHYSICAL REVIEW **D92** (2015) Art No: 072006

CMS Collaboration, Measurements of the Υ(1S), Υ(2S), and Υ(3S) differential cross sections in pp collisions at $\sqrt{s}$=7 TeV, PHYSICS LETTERS **B749** (2015) 14

CMS Collaboration, Measurement of the Z boson differential cross section in transverse momentum and rapidity in proton-proton collisions at 8 TeV, PHYSICS LETTERS **B749** (2015) 187

CMS Collaboration, Search for lepton-flavour-violating decays of the Higgs boson, PHYSICS LETTERS **B749** (2015) 337

CMS Collaboration, Search for resonant pair production of Higgs bosons decaying to two bot-

tom quark-antiquark pairs in proton-proton collisions at 8TeV, PHYSICS LETTERS **B749** (2015) 560

CMS Collaboration, Search for neutral color-octet weak-triplet scalar particles in proton-proton collisions at $\sqrt{s}$=8TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2015) Art No: 201

CMS Collaboration, Evidence for transverse-momentum- and pseudorapidity-dependent event-plane fluctuations in PbPb and pPb collisions, PHYSICAL REVIEW **C92** (2015) Art No: 034911

CMS Collaboration, Measurement of the underlying event activity using charged-particle jets in proton-proton collisions at $\sqrt{s}$=2.76 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 9** (2015) Art No: 137

CMS Collaboration, Search for heavy Majorana neutrinos in $\mu^{\pm}\mu^{\pm}$ + jets events inproton-proton collisions at $\sqrt{s}$=8TeV, PHYSICS LETTERS **B748** (2015) 144

CMS Collaboration, Search for a pseudoscalar boson decaying into a Z boson and the 125 GeV Higgs boson in $l^+l^-b\bar{b}$ final states, PHYSICS LETTERS **B748** (2015) 221

CMS Collaboration, Search for narrow high-mass resonances in proton-proton collisions at $\sqrt{s}$=8 TeV decaying to a Z and a Higgs boson, PHYSICS LETTERS **B748** (2015) 255

CMS Collaboration, Search for the standard model Higgs boson produced through vector boson fusion and decaying to $b\bar{b}$, PHYSICAL REVIEW **D92** (2015) Art No: 032008

CMS Collaboration, Performance of photon reconstruction and identification with the CMS detector in proton-proton collisions at $\sqrt{s}$=8TeV, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P08010

CMS Collaboration, Search for pair-produced resonances decaying to jet pairs in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICS LETTERS **B747** (2015) 98

CMS Collaboration, Constraints on the pMSSM, AMSB model and on other models from the search for long-lived charged particles in proton-proton collisions at $\sqrt{s}$=8TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 325

CMS Collaboration, Constraints on the spin-parity and anomalous HVV couplings of the Higgs boson in proton collisions at 7 and 8 TeV, PHYSICAL REVIEW **D92** (2015) Art No: 012004

CMS Collaboration, Search for third-generation scalar leptoquarks in the t tau channel in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 7** (2015) Art No: 042

CMS Collaboration, Measurement of diffractive dissociation cross sections in pp collisions at $\sqrt{s}$=7 TeV, PHYSICAL REVIEW **D92** (2015) Art No: 012003

CMS Collaboration, Distributions of topological observables in inclusive three- and four-jet events in pp collisions at $\sqrt{s}$=7 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 302

CMS Collaboration, Search for quark contact interactions and extra spatial dimensions using dijet angular distributions in proton-proton collisions at $\sqrt{s}$=8 TeV, PHYSICS LETTERS **B746** (2015) 79

CMS Collaboration, Measurement of the cross section ratio sigma(t t-bar b b-bar) / sigma(t t-bar jj) in pp collisions at $\sqrt{s}$=8 TeV, PHYSICS LETTERS **B746** (2015) 132

CMS Collaboration, Evidence for Collective Multiparticle Correlations in p-Pb Collisions, PHYSICAL REVIEW LETTERS **115** (2015) Art No: 012301

CMS Collaboration, Constraints on parton distribution functions and extraction of the strong coupling constant from the inclusive jet cross section in pp collisions at $\sqrt{s}$=7TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 288

CMS Collaboration, Search for the production of dark matter in association with top-quark pairs in the single-lepton final state in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2015) Art No: 121

CMS Collaboration, Searches for third-generation squark production in fully hadronic final states in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2015) Art No: 116

CMS Collaboration, Search for vector-like T quarks decaying to top quarks and Higgs bosons in the all-hadronic channel using jet substructure, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 6** (2015) Art No: UNSP 80

CMS Collaboration, Search for a standard model Higgs boson produced in association with a top-quark pair and decaying to bottom quarks using a matrix element method, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: UNSP 251

CMS Collaboration; LHCb Collaboration, Observation of the rare $B_s^0 \rightarrow \mu^+\mu^-$ decay from the combined analysis of CMS and LHCb data, NATURE **522** (2015) 68-U146

CMS Collaboration, Performance of electron reconstruction and selection with the CMS detector in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P06005

CMS Collaboration, Search for dark matter, extra dimensions, and unparticles in monojet events in proton-proton collisions at $\sqrt{s}$=8TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: UNSP 235

CMS Collaboration, Nuclear effects on the transverse momentum spectra of charged particles in pPb collisions at $\sqrt{s_{NN}}$=5.02 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: UNSP 237

CMS Collaboration, Study of final-state radiation in decays of Z bosons produced in pp collisions at 7 TeV, PHYSICAL REVIEW **D91** (2016) 29

CMS Collaboration, Search for physics beyond the standard model in final states with a lepton and missing transverse energy in proton-proton collisions at $\sqrt{s}$ = 8 TeV, PHYSICAL REVIEW **D91** (2015) Art No: UNSP 092005

CMS Collaboration, Measurement of jet multiplicity distributions in t(t)over-bar production in pp collisions at $\sqrt{s}$ = 7 TeV (vol 74, 3014, 2014), EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: UNSP 216

CMS Collaboration, Searches for supersymmetry based on events with b jets and four W bosons in pp collisions at 8 TeV, PHYSICS LETTERS **B745** (2015) 5

CMS Collaboration, Searches for supersymmetry using the M-T2 variable in hadronic events produced in pp collisions at 8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 5** (2015) Art No: 078

CMS Collaboration, Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: UNSP 212

ATLAS Collaboration; CMS Collaboration, Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s}$=7 and 8 TeV with the ATLAS and CMS Experiments, PHYSICAL REVIEW LETTERS **114** (2015) Art No: 191803

CMS Collaboration, Measurement of J/psi and psi(2S) Prompt Double-Differential Cross Sections in pp Collisions at $\sqrt{s}$=7 TeV, PHYSICAL REVIEW LETTERS **114** (2015) Art No: 191802

CMS Collaboration, Search for a standard model-like Higgs boson in the mu(+)mu(-) and e(+)e(-) decay channels at the LHC, PHYSICS LETTERS **B744** (2015) 184

CMS Collaboration, Measurement of the inclusive 3-jet production differential cross section in proton-proton collisions at 7 TeV and determination of the strong coupling constant in the TeV range, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 186

CMS Collaboration, Measurement of the Z gamma production cross section in pp collisions at 8 TeV and search for anomalous triple gauge boson couplings, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2015) Art No: 164

CMS Collaboration, Search for physics beyond the standard model in events with two leptons, jets, and missing transverse momentum in pp collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2015) Art No: 124

CMS Collaboration, Search for decays of stopped long-lived particles produced in proton-proton collisions at $\sqrt{s}$=8TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 151

CMS Collaboration, Measurements of differential and double-differential Drell-Yan cross sections in proton-proton collisions at $\sqrt{s}$=8 TeV, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 147

CMS Collaboration, Measurement of the production cross section ratio $\sigma(\chi$ b2(1P))/$\sigma(\chi$ b1(1P)) in pp collisions at $\sqrt{s}$=8TeV, PHYSICS LETTERS **B743** (2015) 383

CMS Collaboration, Search for stealth supersymmetry in events with jets, either photons or leptons, and low missing transverse momentum in pp collisions at 8 TeV, PHYSICS LETTERS **B743** (2015) 503

CMS Collaboration, Search for physics beyond the standard model in dilepton mass spectra in proton-proton collisions at $\sqrt{s}$=8 TeV, JOURNAL OF HIGH ENERGY PHYSICS, **Issue: 4** (2015) Art No: 025

3.2.3 Ph D Awarded

Sreemoyee Sarkar [Pradip Roy & Abhee Kanti Dutt-Mazumder], Transport properties and related phenomena in hot dense plasma, CU, February 2015

Biswarup Paul [Sukalyan Chattopadhyay], Charmonium studies at LHC energies using the ALICE Muon Spectrometer, HBNI, September 2015

Shilpi Jain [Satyaki Bhattacharya], Search for excited electrons in pp collisions with the CMS detector at LHC, CU, November 2015

Sandhya Jain [Satyaki Bhattacharya], Search for large extra dimensions in γ+MET final state in pp collisions with the CMS detector at the LHC, CU, November 2015

Raman Khurana [Satyaki Bhattacharya], Search for Higgs boson in H $\rightarrow$ ZZ $\rightarrow$ 2l2τ decay channel in pp collision with the CMS detector at the LHC, CU, November 2015

Bhawna Gomber [Satyaki Bhattacharya], Search for ADD large extra dimensions in γ+MET using the CMS detector at the LHC, CU, November 2015

Niaz Ahmed Rather [Sukalyan Chattopadhyay], Angular momentum generation mechanismsin mass-100 region, HBNI, December 2015

Palash Khan [Sukalyan Chattopadhyay], Study of Quark-Gluon Plasma by measuring the Upsilon production in p-Pb and Pb-Pb collisions at forward rapidity with ALICE at the LHC, HBNI, December 2015

3.3 Nuclear Physics

3.3.1 Summary of Research Activities

Nuclear Physics
The main thrust of the research activities in Nuclear Physics Division involves the experimental study of low & intermediate energy nuclear physics using different accelerator centres in India and

a few abroad. In addition, members of the division are also actively involved in the setting up of the FRENA facility for nuclear astrophysics research. The other major activities are: theoretical research and developmental activities. Several faculty members of the division actively participated in the summer students programme of the Institute and also undertook teaching courses both in SINP and other neighbouring universities.

Nuclear Structure

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

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

From the comparison of experimental and theoretical results, it is found that there are definite indications of shape coexistence in the high-spin states of ^{153}Ho. The RF-gamma time difference spectra have been useful to confirm the half-lives of isomers in this nucleus. The experimental and calculated lifetimes of these isomers have been compared to follow the coexistence and evolution of shape with increasing spin.

Properties of exotic nuclei have been studied experimentally utilising radioactive ion beam (RIB) facilities from several international accelerator centres. Shell evolution near drip line is one of the most interesting topics in nuclear structure physics. A number of experiments have been performed using RIB facilities at GSI, Darmstadt, ISOLDE, CERN and NSCL, MSU to explore the shell evolution near the drip line and experimental signature of reduced or vanishing shell gap at traditional "magic number" have been observed.

In the theoretical frontiers, to understand the region away from stability, nuclei close to doubly closed ^{132}Sn are being studied within large basis shell model. These nuclei have important implications to understand the synthesis of very neutron-rich nuclei in the Universe. It has been shown that the experimental results for neutron rich Sn isotopes have good agreement with theory in which three-body forces have been included in a realistic interaction. The theoretical results on transition probabilities are discussed to identify the experimental quantities which will distinguish between

different views. Systematic studies of Sn, Te and Sb isotopes with neutron numbers ranging from N=50-82 have been initiated.

Nuclear Reactions:
In order to understand the interplay of the reaction mechanisms in near the Coulomb barrier energies, the fusion excitation functions of ^{6}Li+^{64}Ni and ^{7}Li+^{64}Ni have been measured and compared. While the weak binding of ^{6}Li compared to ^{7}Li dominates the fusion at above barrier energies, in the below barrier region transfer reactions have greater influence on producing enhanced fusion for ^{7}Li than for the fusion of ^{6}Li. Also, to describe the fusion barrier distribution of ^{6}Li+^{64}Ni, coupling to inelastic excitations are found to be sufficient. The reproduction of quasi-elastic barrier distribution function of ^{6}Li+^{64}Ni is observed to be shifted to lower energies relative to the fusion barrier distribution. Coupling to one-nucleon transfer channels reproduces the features of the quasi-elastic barrier distribution including the observed shift from the fusion barrier distribution.
A hybrid model analysis of $^{13}\mathrm{C}(p,\gamma)^{14}\mathrm{N}^{*}$ capture reaction have been completed to describe the low energy excitation function of the reaction. In the hybrid model, resonances have described by one-level Breit-Wigner formula and the non-resonant contribution is generated through the potential model approach using only folded M3Y potential. The resultant astrophysical S-factor from both the models corroborate within the error bar.
The proton/neutron -capture reactions of a number of nuclei which are important for astrophysics scenario, were studied via Coulomb dissociation (CD) at an incident energy of about 400-500 MeV/u. The experimental results are compared to Monte Carlo simulations of the CD process using a semi-classical model.
Improved calculations of the ^{12}C(^{7}Li,t) reaction have been carried out. The SFRESCO version of the program FRESCO has been used to fit the elastic scattering and transfer calculations simultaneously. This has not been done by previous workers. As at 20 MeV strong nuclear diffraction affect the light nucleus scattering, it is very difficult to execute a search program for the potential parameters. This has been successfully performed and improvement in the calculations have been observed.
Quasi-elastic scattering excitation function for the system ^{7}Li+^{159}Tb have been obtained from the measurements at near-barrier to deep sub-barrier energies for the system. Part of the data have been analyzed and quasi-elastic barrier distribution has been extracted. Theoretical calculations have to be done to interpret the results.

Developmental activities:
A prototype of Multi-strip Multi-gap Resistive Plate chamber (MMRPC) with active area 40 cm 20 cm has been developed at SINP, Kolkata. Detailed response of the developed detector was studied with the pulsed electron beam from ELBE at Helmholtz-Zentrum Dresden Rossendorf. Timing resolution of 90ps has been obtained. A reconstructed image of electron beam spot using this detector, demonstrates unique imaging capability.
A preliminary estimate of the lifetime of 6792 keV state of ^{15}O has been obtained using Doppler shift attenuation method (DSAM) from proton capture reaction of a Ta backed implanted Nitrogen target. The dose and composition stoichoimetry of the target determined from Rutherford Backscattering Spectroscopy (RBS) has strong relevance for estimating the stopping power of the recoiling ^{15}O ions.
The possibility of using a Si-PIN diode detector from Bharat Electronics in detection of charged particles, x-rays and gamma rays have been demonstrated. The improvement in the performance after cooling for detecting gammas beyond 100 keV is tested.

3.3.2 Developmental Work

Lifetime of the 6792 keV state in ^{15}O: utilization of the implanted target

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

Abhijit Bisoi†;Indrani Ray; LC Tribedi†; P Banerjee...M Saha Sarkar

3.3.3 Publications

3.3.3.1 Publications in Journal

S Biswas; R Palit; A Navin; M Saha Sarkar; et al, Structure of $^{132}_{52}$ Te$_8$0: The two-particle and two-hole spectrum of $^{132}_{50}$Sn$_{82}$, PHYSICAL REVIEW **C93** (2016) Art No: 034324

Mandira Sinha; Subinit Roy; P Basu; et al, The effect of breakup of Li-6 on elastic scattering and fusion with Si-28 at near barrier energies, INTERNATIONAL JOURNAL OF MODERN PHYSICS **E25** (2016) Art No: 1650003

K Selvakumar†; AK Singh†; Chandan Ghosh†...A Goswami; R Raut; A Mukherjee; U Datta; et al, Evidence for octupole correlation and chiral symmetry breaking in ^{124}Cs, PHYSICAL REVIEW **C92** (2015) Art No: 064307

S Rajbanshi; S Roy†; Somnath Nag†; Abhijit Bisoi; S Chattopadhyay; M Saha Sarkar; A Goswami; et al, Antimagnetic rotation and sudden change of electric quadrupole transition strength in ^{143}Eu, PHYSICS LETTERS **B748** (2015) 387

M Saha Sarkar; S Sarkar†, ^{136}Sn and three-body forces, PRAMANA-JOURNAL OF PHYSICS **85** (2015) 403

P Banerjee; S Ganguly†; MK Pradhan; Md Moin Shaikh; et al, γ-ray spectroscopy of fission fragments produced in ^{208}Pb(^{18}O,f), PHYSICAL REVIEW **C92** (2015) Art No: 024318

M Roy Basu; S Ray; A Bisoi; M Saha Sarkar, Characterisation of a composite LEPS, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: T07002

Ushasi Datta; S Chakraborty; A Rahaman; P Basu; J Basu; et al, Response of multi-strip multi-gap resistive plate chamber, JOURNAL OF INSTRUMENTATION **10** (2015) Art No: P07005

Vishal Srivastava†; C Bhattacharya†; TK Rana†; Subinit Roy; Md M Shaikh, Experimental study of ^{26}Al through the $1n$ pick-up reaction ^{27}Al(d,t), Phys Rev **C91** (2015) 054611

Suprita Chakraborty†; Richard deBoer†; Avijit Mukherjee†; Subinit Roy, Systematic R-matrix analysis of the C-13(p,γ)N-14 capture reaction, PHYSICAL REVIEW **C91** (2015) Art No: 045801

3.3.4 Ph D Awarded

Abhijit Bisoi [Maitreyee Saha Sarkar], Investigation of Interplay of Single Particle and Collective Modes of Excitation in Atomic Nuclei, CU, May 2015

Md Moin Shaikh [Subinit Roy], Impact of break up like processes on Fusion and elastic scattering of weakly bound projectile from medium mass target, CU, March 2016

3.3.5 Seminars/Lectures given in Conference/Symposium/Schools

Maitreyee Saha Sarkar
i. Super Deformed bands in light nuclei, Two-day workshop on Recent Trends in Nuclear Physics, Inter University Accelerator Centre, New Delhi, September 14-15, 2015
ii. Studies in Nuclear Structure relevant to Astrophysics: theoretical and experimental efforts, Int Workshop on "Recent Trends in Nuclear Structure and its Implication in Astrophysics, organized by TIFR, Mumbai and IOP, Bhubaneswar, Puri, January 4-8, 2016

Chinmay Basu
i. Trojan Horse method in Nuclear Astrophysics, Workshop on Recent Trends in Nuclear Physics, IUAC, New Delhi, September 14-15, 2015
ii. The study of 19F(p,a) at Astrophysical energies using Trojan HorseMethod (Fresh Proposal Presentation), 59th Accelerator Users Workshop, IUAC, New Delhi, December 15-19, 2015

Asimananda Goswami
i. Journey through an esoteric path: From IOP Ion beam laboratory to FRENA, Workshop on the use of Low Energy Ion Beams (WIB@2015), Institute of Physics, Bhubaneswar, November 7-9, 2015
ii. Influence of proton and neutron alignment on shears mechanism: A case in mass $\sim$ 140 region, DAE Symposium on Nuclear Physics, Sri Sathya Sai Institute of Higher Learning, Prasanthi Nilayam, December 7-11th, 2015
iii. FRENA: An upcoming facility for Nuclear Astrophysics; Capabilities and Potentials, Int Workshop on Recent Trends in Nuclear Structure and its implication in Astrophysics, Puri, Organized jointly by TIFR and IOP, January 4-8, 2016
iv. Challenges of Experimental Nuclear Astrophysics (4 lectures), Workshop on Nuclear Astrophysics, University of Calcutta, February 9-11, 2016
5. FRENA: An upcoming facility for Nuclear Astrophysics: Simulating stars in the Laboratory, National School cum work shop in Accelerator Physics, Physics Department of Panjab University, Chandigarh, March 15-18, 2016

3.3.6 Teaching elsewhere

Chinmay Basu MSc (Advanced Course in Nuclear Reactions & Nuclear Astrophysics), 25 Lectures, Rajabazar Science College, University of Kolkata, January-March 2016

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 topics in the field of linear and nonlinear wave propagation. Theoretical studies using Lagrange fluid description for various types of waves in unmagnetized and magnetized plasmas have been carried out to understand wave breaking phenomena due to phase-mixing processes. Such studies have relevance to particle acceleration and heating in astrophysical environments and laboratory experiments. Investigations on steady state solutions of Bursian diodes and their stability characteristics in presence of external magnetic fields reveal interesting results that are relevant in the design of fast electron switches. Studies are also being pursued to understand the formation of different types of nonlinear structures such as solitons, double layers and vortices in classical as well as quantum plasmas.

Strongly coupled dusty plasma having a viscoelastic nature supports propagation of longitudinal acoustic and transverse shear modes. These modes exhibit various types of instabilities and coupling phenomena driven by velocity shear, non-Newtonian characteristics including shear thinning and thickening, and density dependent viscosity. Study of vortex formation and its evolution reveal interesting results in presence of collisional drag effects.

Experimental activities are being carried out in the MaPLE (Magnetized Plasma Linear Experiment) device, double Layer Experiment (DLX), glow discharge plasma and the tokamak devices. MaPLE device has been designed to study waves and instabilities in a controlled parameter regime. In order to enhance the density in the MaPLE device that is currently produced by electron cyclotron resonance discharge a quiescent filamentary source has been developed, fabricated, tested and integrated with the machine. This will facilitate study of magnetic electron drift mode.

Double layer experimental device enables studies in radio-frequency produced plasma in presence of diverging magnetic fields. Density profiles in the device vary from peaked to hollow profiles leading to strong density gradients. Study of self-excited drift waves and their characterization has been carried out in various parameter regimes.

Nonlinear dynamic experiments are being carried out in DC glow discharge plasmas having linear

and toroidal configurations revealing a variety of nonlinear phenomena such as homoclinic and inverse homoclinic bifurcation, intermittent chaos, hysterisis, 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 modelling based on plasma fluid models has been carried out to understand the results.

4.1.2 Publications

4.1.2.1 Publications in Journal

Abhijit Ghosh; SK Saha; S Chowdhury; MS Janaki, Observation of upper drift modes in radio frequency produced magnetized plasmas with frequency above ion cyclotron frequency, PHYSICS OF PLASMAS **22** (2015) Art No: 122111

Abhik Mukherjee; MS Janaki; Anjan Kundu, Bending of solitons in weak and slowly varying inhomogeneous plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 122114

Pankaj Kumar Shaw; AN Sekar Iyengar; Md Nurujjaman, Canard and mixed mode oscillations in an excitable glow discharge plasma in the presence of inhomogeneous magnetic field, PHYSICS OF PLASMAS **22** (2015) Art No: 122301

Sourav Pramanik; VI Kuznetsov†; Nikhil Chakrabarti, A study on the steady-state solutions of a Bursian diode in the presence of transverse magnetic field, when the electrons of the injected beam are turned back partially or totally, PHYSICS OF PLASMAS **22** (2015) Art No: 112108

Ashish Adak†; Samiran Ghosh†; Nikhil Chakrabarti, Ion acoustic shock wave in collisional equal mass plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 102307

Pankaj Kumar Shaw; MS Janaki; ANS Iyengar; et al, Antiperiodic oscillations in a forced Duffing oscillator, CHAOS SOLITONS & FRACTALS **78** (2015) 256

Pankaj Kumar Shaw; Debajyoti Saha; Sabuj Ghosh; MS Janaki; ANS Iyengar, Investigation of coherent modes in the chaotic time series using empirical mode decomposition and discrete wavelet transform analysis, CHAOS SOLITONS & FRACTALS **78** (2015) 285

Subir Biswas; Satyajit Chowdhury; Yaswanth Palivela†; Rabindranath Pal, Effect of fast drifting electrons on electron temperature measurement with a triple Langmuir probe, JOURNAL OF APPLIED PHYSICS **118** (2015) Art No: 063302

Sayanee Jana; Debabrata Banerjee; Nikhil Chakrabarti, Stability of an elliptical vortex in a strongly coupled dusty plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 083704

S Pramanik; VI Kuznetsov†; N Chakrabarti, Stability analysis of steady state solutions of Bursian diode in presence of transverse magnetic field, PHYSICS OF PLASMAS **22** (2015) Art No: 082103

Gopi Kishan Sabavath†; Pankaj Kumar Shaw; AN Sekar Iyengar; et al, Experimental investigation of quasiperiodic-chaotic-quasiperiodic-chaotic transition in a direct current magnetron sputtering plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 082121

S Garai; MS Janaki; N Chakrabarti, Coupling of dust acoustic and shear mode through velocity shear in a strongly coupled dusty plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 073706

Abhik Mukherjee; MS Janaki; Anjan Kundu, A new(2+1) dimensional integrable evolution equation for an ion acoustic wave in a magnetized plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 072302

Anwesa Sarkar; Nikhil Chakrabarti; Hans Schamel†, Nonlinear Alfven wave dynamics in plasmas, PHYSICS OF PLASMAS **22** (2015) Art No: 072307

Nikhil Chakrabarti; Samiran Ghosh†, Longitudinal dust acoustic solitary waves in a strongly coupled complex (dusty) plasma, JOURNAL OF PLASMA PHYSICS **81** (2015) Art No: 905810310

Sabuj Ghosh; Pankaj Kumar Shaw; Debajyoti Saha; MS Janaki; ANS Iyengar, Irregular-regular-irregular mixed mode oscillations in a glow discharge plasma, PHYSICS OF PLASMAS **22** (2015) Art No: 052304

Sourav Pramanik; Chandan Maity; Nikhil Chakrabarti, Phase-mixing of ion plasma modes in pair-ion plasmas, PHYSICS OF PLASMAS **22** (2015) Art No: 052303

Pankaj Kumar Shaw; Debajyoti Saha; Sabuj Ghosh; MS Janaki; ANS Iyengar, Intrinsic noise induced coherence resonance in a glow discharge plasma, CHAOS **25** (2015) Art No: 043101

Sourav Pramanik; A Ya Ender†; VI Kuznetsov†; Nikhil Chakrabarti, The transverse magnetic field effect on steady-state solutions of the Bursian diode , PHYSICS OF PLASMAS **22** (2015) Art No: 042110

Subir Biswas; Satyajit Chowdhury; Abhik M Pal; Subhasis Basu; Monobir Chattopadhyay; Nikhil Chakrabarti; Rabindranath Pal, The MaPLE device: A linear machine for laboratory studies of the magnetized plasma physics phenomena, JOURNAL OF PLASMA PHYSICS **81** (2015) Art No: 345810205

4.1.3 Seminars/Lectures given in Conference/Symposium/Schools

Nikhil Chakrabarti
Lagrangian Fluid description to study nonlinear oscillations and waves in plasma, National conference on computational Mathematics and Nonlinear dynamics (CMND-2016), Mathematics Department of VISVA-BHARATI, February 19-21, 2016

MS Janaki
i. Two-stair like model of current sheets, 4th PSSI plasma scholars' colloquium, Jadavpur university, Kolkata, August 7, 2015

ii. Glow discharge plasmas, a plethora of nonlinear dynamical phenomena, National Conference on Emerging Trends in Mathematics and Mathematical Sciences, Calcutta Mathematical Society, December 17, 2015
iii. Phase modulation of ion acoustic solitary waves in weak and slowly varying inhomogeneous plasma, National-level Conference on Emerging Trends in Physics of Fluids & Solids, Jadavpur University, March 4, 2016

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 advanced research in the interface areas spanning High Energy Astrophysics, Cosmology, and Particle & Nuclear physics. During the year under review, members of the Division have carried out research on a variety of topics in AstroParticle Physics observational, experimental and theoretical.

Some highlights are given below:
(i)New world leading results from PICO dark matter direct search experiment :
New results are reported from PICO-2L and PICO-60 dark matter detector located in the SNOLAB underground laboratory. PICO-2L is the 2L bubble chamber of C3F8 with a total exposure of 129 kg-days operated at thermodynamic threshold energy of 3.3 keV. One single nuclear-recoil event was observed in the data, consistent both with the predicted background rate from neutrons and with the observed rate of unambiguous multiple-bubble neutron scattering events. The chamber exhibits the excellent electron-recoil and alpha decay rejection. These data provide the most stringent direct detection constraints on weakly interacting massive particle (WIMP)-proton spin dependent scattering to date for WIMP masses < 50 GeV/c^2. PICO-60 dark matter detector, a bubble chamber filled with 36.8 kg of CF3I, is the largest bubble chamber to search for dark matter to date. Stringent limits on weakly interacting massive particles interacting via spin-dependent proton and spin-independent processes are set, and most interpretations of the DAMA/LIBRA modulation signal as dark matter interacting with iodine nuclei are ruled out.

(ii) High Energy Gamma Ray Astronomy: (a) The scientists of APC Division are taking lead role in various software and hardware activities as regards to the calibration of the telescopes as part of the future Cerenkov Telescope Array (CTA) project. The calibration system has been designed and partially assembled at SINP and is currently being tested at TIFR in collaboration

with scientists at TIFR. A few members of the APC division have joined the Major Atmospheric Gamma Imaging Cerenkov (MAGIC)[1] telescope collaboration in 2015 (which forms the core group within the CTA consortium) in order to augment their research activities both in hardware and software, as part of the Galactic Physics working group, taking the responsibility of carrying out the absolute light calibration of the MAGIC telescopes using both Monte Carlo simulations and the telescopic data.
We have carried out analysis of middle-aged mixed-morphology (MM) supernova remnants (SNRs) interacting with molecular clouds using Fermi, X-rays and TeV gamma-ray data. We analyzed the gamma-ray data of the Large Area Telescope on board the Fermi Gamma-Ray Space Telescope and detected G349.7+0.2 in the energy range of 0.2-300 GeV with a significance of 13 sigma, showing no extended morphology. Modeling of the gamma-ray spectrum revealed that the GeV gamma-ray emission dominantly originates from the decay of neutral pions, where the protons follow a broken power-law distribution. To search for features of radiative recombination continua in the eastern and western regions of the remnant, we analyzed the X-ray data of G349.7+0.2 from Suzaku satellite and found no evidence for overionized plasma.
(iii) Core Collapse Supernovae and Neutron Stars:
The role of lambda hyperons on supernova explosion mechanism and the evolution of protoneutron star (PNS) was studied using a general relativistic one dimensional core collapse supernova model. The lambda hyperon equation of state (EoS) of Banik, Hempel and Bandyopadhyay was used as microphysical input in these simulations. This investigation involving an exotic matter EoS which is compatible with 2 solar mass neutron stars, is the first of its kind. It was demonstrated that lambda hyperons appeared just after core bounce and its population became significant as the PNS evolved. The PNS collapsed to a black hole due to mass accretion. Furthermore, the long duration evolution of the PNS with enhanced neutrino heating in the supernova simulation with 20 solar mass progenitor was studied. This led to a successful supernova explosion and the PNS evolved to a stable neutron star at the end of 4 sec. The implications of those findings were discussed in the light of no show of a neutron star in SN1987A.

(iv) Theoretical research on Dark Matter:
The particle nature for dark matter in the Universe has been explored extensively by proposing new theoretical models. The possible indirect (and direct) signatures of dark matter have then been explained using them. A new theory for two component dark matter model has been proposed that simultaneously explain the excess gamma ray emission from Galactic Centre, the excess gamma rays from dwarf galaxies, the 3.55 keV X-ray line from several galaxy clusters as well as more importantly, the recent evidence of self interaction among dark matter from Abell cluster. It is also found out that, in order to explain the indirect signatures of dark matter (Galactic Centre gamma ray excess (GeV), X-ray line (keV)) and the self interaction signatures of dark matter, within the framework of the particle dark matter models where the proposed dark matter can interact with Higgs (Higgs portal models), the dark matter should be nonthermal in nature. A thermal dark dark matter cannot explain all of them together in such class of models. In addition, a thorough numerical analysis has been carried out for indications of dark matter signatures from extra galactic sources.

(v) Extended scaling and residual flavor symmetry in the neutrino Majorana mass matrix :
The residual symmetry approach, along with a complex extension for some flavor invariance, is a powerful tool to uncover the flavor structure of the 3x3 neutrino Majorana mass matrix (M_ν)

[1] http://wwwmagic.mppmu.mpg.de

towards gaining insights into neutrino mixing. We utilize this to propose a complex extension of the real scaling ansatz for M_ν which was introduced some years ago. Unlike the latter, our proposal allows a nonzero mass for each of the three light neutrinos as well as a nonvanishing θ_{13}. A major result of this scheme is that leptonic Dirac CP-violation must be maximal while atmospheric neutrino mixing need not be exactly maximal. Moreover, each of the two allowed Majorana phases, to be probed by the search for nuclear neutrinoless double beta decay, has to be at one of its two CP-conserving values. There are other interesting consequences such as the allowed occurrence of a normal mass ordering which is not favored by the real scaling ansatz. Our predictions will be tested in ongoing and future neutrino oscillation experiments at T2K, DUNE.
The third international conference on Advances in Astroparticle Physics and Cosmology (AAPCOS) was successfully organised at SINP during 14-17 October, 2015.

5.1.2 Publications

5.1.2.1 Publications in Journal

Rome Samanta; Mainak Chakraborty; Ambar Ghosal, Evaluation of the Majorana phases of a general Majorana neutrino mass matrix: Testability of hierarchical flavour models, NUCLEAR PHYSICS **B904** (2016) 86

Debasish Majumdar; Kamakshya Prasad Modak; Subhendu Rakshit, A two-component dark matter model with real singlet scalars confronting GeV gamma-ray excess from galactic centre and Fermi bubble, PRAMANA-JOURNAL OF PHYSICS **86** (2016) 343

Anirban Biswas; Debasish Majumdar; Probir Roy, Dwarf galaxy gamma-excess and 3.55 keV X-ray line in a nonthermal Dark Matter model, EPL **113** (2016) Art No: 29001

ML Ahnen; S Ansoldi; LA Antonelli...B Banerjee...A Chatterjee...P Majumdar; et al, Very high-energy gamma-ray observations of novae and dwarf novae with the MAGIC telescopes, ASTRONOMY & ASTROPHYSICS **582** (2015) Art No: A67

Prasanta Char; Sarmistha Banik; Debades Bandyopadhyay, A Comparative Study of Hyperon Equations of State in Supernova Simulations, ASTROPHYSICAL JOURNAL **809** (2015) Art No: 116

Amit Dutta Banik; Debasish Majumdar, Extension of minimal fermionic dark matter model: a study with two Higgs doublet model, EUROPEAN PHYSICAL JOURNAL **C75** (2015) Art No: 364

Kamakshya Prasad Modak; Debasish Majumdar, Confronting Galactic and Eextrgalactic gamma-Raya Observed ny FERMI-LAT with Annihilating Dark Matter in an Inert HIGGS Double Model, ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES **219** (2015) Art No: 37

Ambar Ghosal; Rome Samanta, Probing texture zeros with scaling ansatz in inverse seesaw, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 5** (2015) Art No: 077

T Ergin†; A Sezer†; L Saha; P Majumdar; et al, Searching for overionized plasma in the gamma-ray-emitting supernova remnant G349.7+0.2, ASTROPHYSICAL JOURNAL **804** (2015) Art No: 124

Anirban Biswas; Debasish Majumdar; Probir Roy, Nonthermal two component dark matter model for Fermi-LAT gamma-ray excess and 3.55 keV X-ray line, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 4** (2015) Art No: 065

Amit Dutta Banik; Debasish Majumdar, Low energy gamma ray excess confronting a singlet scalar extended inert doublet dark matter model, PHYSICS LETTERS **B743** (2015) 420

Debades Bandyopadhyay, Physics of Neutron Stars: From the Core to the Crust, Astronomical Society of India Conference Series **12** (2015) 23

PICO Collaboration, Dark matter search results from the PICO-60 CF_3I bubble chamber, PHYSICAL REVIEW **D93** (2016) Art No: 052014

PICO Collaboration, Improved dark matter search results from PICO-2L Run 2, PHYSICAL REVIEW **D93** (2016) Art No: 061101

NuSTAR Team; VERITAS Collaboration; MAGIC Collaboration, Multiwavelength study of quiescent states of mrk 421 with unprecedented hard x-ray coverage provided by nustar in 2013, ASTROPHYSICAL JOURNAL **819** (2016) Art No: 156

MAGIC Collaboration, Limits to dark matter annihilation cross-section from a combined analysis of MAGIC and Fermi-LAT observations of dwarf satellite galaxies, JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS **Issue: 2** (2016) Art No: 039

MAGIC Collaboration; Fermi-LAT Collaboration, Very high energy gamma-rays from the universe's middle age: detection of the z=0.940 blazar pks 1441+25 with magic, ASTROPHYSICAL JOURNAL LETTERS **815** (2015) Art No: L23

NuSTAR Team; MAGIC Collaboration; VERITAS Collaboration; et al, First Nustar observations of mrk 501 within a radio to tev multi-instrument campaign, ASTROPHYSICAL JOURNAL **812** (2015) Art No: 65

PICO Collaboration, Dark Matter Search Results from the PICO-2L C3F8 Bubble Chamber, PHYSICAL REVIEW LETTERS **114** (2015) Art No: 231302

5.1.3 Ph D Awarded

Chandrachur Chakraborty [Debades Bandyopadhyay], Lense-Thirring precession in strong gravitational field, HBNI, June 2015

Susmita Kundu [Pijushpani Bhattacharjee], Phase-Space Structure of the Dark Matter Halo of Milky Way from Rotation Curve Data and Implications for Neutrino Signal from WIMP Annihila-

tion in Sun, HBNI, August 2015

5.1.4 Seminars/Lectures given in Conference/Symposium/Schools

Pratik Majumdar
i. Exploring the Universe in TeV gamma-rays, Astronomy Seminar, IISc, Bengaluru, November 24, 2015
ii. Origin of cosmic rays through the eyes of TeV gamma-rays), Free Meson Seminar, Theory Dept, TIFR, Mumbai, November 26, 2015

Debades Bandyopadhyay
i. Probing Neutron Star Interior With the SKA, "Neutron Star: A Pathfinder Workshop, NCRA, TIFR, Pune, January 14-15, 2016
ii. Physics of Dense Matter in Neutron Stars, Nuclear Physics Meet, Institute of Physics, Bhubaneswar, June 26-30, 2015
iii. Black hole formation in failed core collapse supernova simulations with hyperon equations of state, Frankfurt Institute for Advanced Studies, Germany, June 23, 2015
iv. Core Collapse supernova simulations with a new hyperon equation of state compatible with two solar mass neutron star, Annual NewCompStar Conference 2015, Budapest, Hungary, June 15-19, 2015

Mala Das
i. Gamma background rejection with superheated liquid detector for dark matter search, DAE-BRNS Nuclear Physics Symposium, Sri SatyaSai Institute of Higher Learning, Puttaparthi, December 10, 2015
ii. Alpha-neutron discrimination with superheated droplet detector, 28th National Symposium on Radiation Physics (NSRP-20), Mangalore University, Mangalore, October 28, 2015

Debasish Majumdar
i. WHEPP XIV (Workshop on High Energy Physics Phenomenology), Indian Institute of Technology, Kanpur, December 2015
ii. Proposed new research problems and extensive discussion sessions among this group seminars, DAE-BRNS Symposium on Nuclear Physics, Puttapurthy, AP, December 2015
iii. Dark Matter, WAPP (Winter Workshop on Astroparticle Physics), Bose Institute, Darjeeling, December, 2015

5.1.5 Honours and Distinctions

Debades Bandyopadhyay
Awarded Alexander von Humboldt Fellowship from May to July, 2015

5.1.6 Teaching elsewhere

Debasish Majumdar
Dark Matter (2 lectures), Department of Physics, Assam Universiy, Silchar, October 2015
Introduction to Dark Matter (3 lectures), School on Astroparticle Physics, Bose Institute, Darjeeling Campus, December 2015
Dark Matter (8 lecture), Winter School on Beyond the Standard Model Physics, Department of Physics, Banaras Hindu University, Varanasi, January 2016
Introduction to Dark Matter (4 lecture), National Level School on Gravitation and Astroparticle Physics, Central University of Himachal Pradesh, Dharamshala, March 2016

5.2 Theory

5.2.1 Summary of Research Activities

a) Particle Physics Phenomenology
Searching for new physics using the neutral triple electroweak gauge bosons productions are important in distinguishing physics arising from the potential beyond SM candidates at the LHC and hence studies of the RS scenario bear equal importance. The triple gauge bosons (VVV) results have been merged with VVV+jet in Madgraph framework to have a better description of the distribution and also included decay of Z bosons to lepton pairs. Kinematical distributions matched to parton showers show deviation from the SM as a result of the RS model. Uncertainties as a result of the factorization and renormalization scales are also presented. Three-loop massless QCD corrections to the quark and gluon form factors of pseudo-scalar operators which are important ingredient to precision Higgs phenomenology— ultimately allowing to bring the gluon fusion cross section for pseudo-scalar Higgs production to the same level of accuracy that has been accomplished for scalar Higgs production.
Flavor-changing neutral current decays of the top quark have been analyzed within the framework of the Standard Model and the Constrained Minimal Supersymmetric Standard Model (with and without R-parity).

b) Non-perturbative Studies of Quantum Field Theories
A local non-perturbative gauge-fixing proposal is being studied for lattice gauge theories. Because of a no-go theorem this cannot be pursued in the usual Becchi-Rouet-Stora-Tyutin (BRST) scheme. An equivariant BRST (eBRST) symmetric theory where the gauge-fixing is carried out in the coset G/H of the group G leaving the theory H gauge-invariant. On the lattice, gauge fields self-interact even for the $U(1)$ theory if the lattice gauge fields are group-valued. As a beginning, the non-perturbatively gauge-fixed $U(1)$ theory has been thoroughly studied for strong gauge couplings. It is found that a new universality class emerges at a phase transition from a regular ordered phase to a spatially modulated ordered phase. The continuum theory from the regular ordered phase contains only free massless photons for the pure gauge theory and the longitudinal gauge degrees of freedom are decoupled, as desired. Detailed study of the phase diagram has been obtained and a tricritical point has been found which appears to be the only candidate in this theory for any possible non-trivial physics. Codes from scratch are being prepared for the non-perturbative case, where a four-ghost term is present in the eBRST approach.
By relating the functional averages of a generic scalar operator in simulations with open and pe-

riodic boundary conditions respectively for SU(3) lattice gauge theory, it is shown that the scalar glueball mass and the glueball to vacuum matrix element can be extracted very efficiently from the former.

c) Gravity and Cosmology
Previous calculations of black hole entropy in loop quantum gravity had led to a dominant term proportional to the area eigenvalue, but there was always a correction involving the logarithm of this eigenvalue. It has now been found that the calculations actually yield an entropy proportional to the area eigenvalue with a logarithmic correction involving the classical area.
Aspects of research in cosmology and its connection with particle physics have been explored. In particular, the issue of finite time curvature singularity has been explored in f(R) gravity models for late time cosmology. The production of non-thermal gravitinos in a class of hybrid inflation models have been explored, and it was shown that the produced dark matter from the decay of gravitinos does not pose any threat to this class of inflation models. How the inflationary observables are related to the modulus mass in thermal history of the Universe has been also explored.

d) Strings
The effect of charged excitations (deformations) in AdS spacetime on the laws of entanglement thermodynamics has been studied. It is found that 'boosted' AdS-blackhole spacetimes give rise to a first law of entanglement which includes charge density at second order. The thermodynamic quantities have to be appropriately 'renormalized' at second order due to higher order quantum corrections to the subsystem length. The calculation is done in the regime where thermal temperature is much smaller than 'entanglement' temperature. Further the effects of asymmetry in entanglement entropy for different strip subsystems of the CFT are studied. Two different strip like systems, one parallel to the boost and the other perpendicular, are studied perturbatively and entanglement asymmetry is quantified. Especially for AdS-wave solutions the entanglement entropy asymmetry becomes optimum.
An effective thermodynamic description is explored and analyzed, within the context of gauge-string duality, for systems that are in a steady-state. It is demonstrated that an open string equivalence principle governs the corresponding thermodynamic behavior.
The above description is explored further, addressing issues of holographic renormalization and conformal anomaly in certain examples of a holographic steady-state system. The universal contribution to the free energy, in (1+1)-dimension, is shown to possess a natural meaning in terms of the heat dissipation. A three-dimensional (super) Yang-Mills theory is analyzed, in details, in the presence of a fundamental flavor sector at non-vanishing chemical potential, or a non-vanishing charge density. A candidate ground state for this system is obtained, which is characterized by a non-relativistic hyperscaling violating configuration, with specific values for the various exponents. An explicit interpolating solution between the UV and the IR is also obtained.
Decoupling of gravity on the non-susy Dp branes has been shown by studying the graviton scattering on them. This decoupling, which is the origin of AdS/CFT correspondence, is known for the BPS branes. However, similar decoupling occurs also for non-susy branes were not known. This in turn indicates that it is very likely that AdS/CFT should work also for the non-supersymmetric background. This has been shown numerically for a generic non-susy background and analytically only in some special cases. From certain non-susy D3 brane solution an interpolating solution has been constructed which interpolates between an AdS5 black hole and AdS5 soliton. Two cases were considered – in one case dilaton remained constant and in other case it did not. In the latter case, the solution also interpolates via a so-called 'soft wall' gravity solution of AdS/QCD model.

e) QCD at Finite Temperature and Density and QGP Phenomenology. At present the relativistic heavy-ion collision experiments in RHIC BNL and LHC CERN are operational. These experiments have provided us wealth of information in understanding the properties of hot and dense matter and the theoretical predictions. .Thermodynamics of hot and dense QCD matter have been studied in perturbative hard thermal loop with isospin chemical potential. Electromagnetic spectral properties within nonperturbative QCD models have been studied in QCD medium. In addition, the modification of QCD formalism of hot and dense matter in presence of magnetic field has been initiated, which can be applied appropriately to investigate various properties of QGP in non-central heavy-ion collisions.

f) Nuclear Theory
The nuclear symmetry energy and its density dependence is deduced by comparing the available data on the electric dipole polarizability of ^{68}Ni, ^{120}Sn, and ^{208}Pb with the predictions of the Random Phase Approximation, using a representative set of nuclear energy density functionals. The calculated values of dipole polarizability are used to validate different correlations involving dipole polarizability, the symmetry energy at the saturation density, the corresponding slope parameter and the neutron skin thickness, as suggested by the Droplet Model. A subset of models that reproduce simultaneously the measured polarizabilities in ^{68}Ni, ^{120}Sn, and ^{208}Pb are found to be instrumental in the determining density dependance of symmetry energy and neutron skin thickness in several nuclei.

g) Mathematical Physics
Supersymmetric analogues of polarized spin reversal operators (SAPSRO) are used to construct a novel class of exactly solvable spin Calogero models associated with the BC_N root system. The strong coupling limit of such spin Calogero models yields BC_N type of Polychronakos-Frahm (PF) spin chains with SAPSRO. An exact expression for the partition functions of these PF spin chains is obtained by using the freezing trick. It is found that these partition functions obey an extended boson-fermion duality relation. Some spectral properties of these PF spin chains, like level density distribution and nearest neighbour spacing distribution, are also studied.
Exploiting hidden dimensions in integrable systems a new type of quasi-higher dimensional quantum nonlinear Schroedinger field model is constructed and solved exactly by the algebraic Bethe ansatz. A novel notion of dual integrable hierarchy is introduced, discovering intriguing Hamiltonian structures.

5.2.2 Publications

5.2.2.1 Publications in Books/Monographs & Volumes Edited

Kumar S Gupta; Siddhartha Sen, Many-Body Physics, Topology and Geometry, World Scientific Publishing Co (2015)

5.2.2.2 Publications in Journal

Jens O Andersen†; Najmul Haque†; Munshi G Mustafa; et al, Three-loop hard-thermal-loop perturbation theory thermodynamics at finite temperature and finite baryonic and isospin chemical potential, PHYSICAL REVIEW **D93** (2016) Art No: 054045

Anton F Faedo†; Arnab Kundu; David Mateos†; et al, Three-dimensional super Yang-Mills with compressible quark matter, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 3** (2016) Art No: 154

Aritra Bandyopadhyay; Najmul Haque†; Munshi G Mustafa; et al, Dilepton rate and quark number susceptibility with the Gribov action, PHYSICAL REVIEW **D93** (2016) Art No: 065004

P Banerjee; B Basu-Mallick; N Bondyopadhaya; C Datta, Supersymmetric analogue of BC_N type rational integrable models with polarized spin reversal operators, NUCLEAR PHYSICS **B904** (2016) 297

Dipankar Das†; Ujjal Kumar Dey†; Palash B Pal, S_3 symmetry and the quark mixing matrix, PHYSICS LETTERS **B753** (2016) 315

R Shyam; H Lenske†, *barpp* annihilation into *barDD* meson pair within an effective Lagrangian model, PHYSICAL REVIEW **D93** (2016) Art No: 034016

Rudranil Basu; Max Riegler†, Wilson lines and holographic entanglement entropy in Galilean conformal field theories, PHYSICAL REVIEW **D93** (2016) Art No: 045003

Palash B Pal, Reduction Formulae for Symmetric Products of Spin Matrices, REPORTS ON MATHEMATICAL PHYSICS **77** (2016) 35

Jean Avan†; Vincent Caudrelier†; Anastasia Doikou†; Anjan Kundu, Lagrangian and Hamiltonian structures in an integrable hierarchy and space-time duality, NUCLEAR PHYSICS **B902** (2016) 415

Kumar Das; Koushik Dutta; Anshuman Maharana†, Inflationary predictions and moduli masses, PHYSICS LETTERS **B751** (2015) 195

X Roca-Maza†; X Vinas†; M Centelles†; BK Agrawal; et al, Neutron skin thickness from the measured electric dipole polarizability in ^{68}Ni, ^{120}Sn, and ^{208}Pb, PHYSICAL REVIEW **C92** (2015) Art No: 064304

Goutam Das; Prakash Mathews, Neutral triple vector boson production in Randall-Sundrum model at the LHC, PHYSICAL REVIEW **D92** (2015) Art No: 094034

Taushif Ahmed†; Thomas Gehrmann†; Prakash Mathews; et al, Pseudo-scalar form factors at three loops in QCD, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 11** (2015) Art No: 169

Ashok K Das; Pushpa Kalauni†, Proper time method in de Sitter space, PHYSICAL REVIEW **D92** (2015) Art No: 104037

Chowdhury Aminul Islam; Sarbani Majumder; Munshi G Mustafa, Vector meson spectral function and dilepton rate in the presence of strong entanglement effect between the chiral and the Polyakov loop dynamics, PHYSICAL REVIEW **D92** (2015) Art No: 096002

Anjan Kundu, Construction of classical and quantum integrable field models unravelling hidden possibilities, PRAMANA-JOURNAL OF PHYSICS **85** (2015) 899

Rohit Mishra; Harvendra Singh, Perturbative entanglement thermodynamics for AdS spacetime: renormalization, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 10** (2015) Art No: 129

Ashok K Das; J Frenkel†, Derivation of the fluctuation-dissipation theorem from unitarity, MODERN PHYSICS LETTERS **A30** (2015) Art No: 1550163

Shibaji Roy, Non-susy D3 brane and an interpolating solution between AdS_5 black hole, AdS_5 soliton and a 'soft-wall' gravity solution, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 10** (2015) Art No: 113

Siddhartha Sen†; Kumar S Gupta; J MD Coey†, Mesoscopic structure formation in condensed matter due to vacuum fluctuations, PHYSICAL REVIEW **B92** (2015) Art No: 155115

Gautam Bhattacharyya; Tsutomu T Yanagida†; Norimi Yokozaki†, Focus point gauge mediation with incomplete adjoint messengers and gauge coupling unification, PHYSICS LETTERS **B749** (2015) 82

Stefan Antusch†; Koushik Dutta, Nonthermal gravitino production in tribrid inflation, PHYSICAL REVIEW **D92** (2015) Art No: 083503

Anjan Kundu, Construction and exact solution of a nonlinear quantum field model in quasi-higher dimension, NUCLEAR PHYSICS **B899** (2015) 1

Dipankar Das, New limits on tan β for 2HDMs with Z_2 symmetry, INTERNATIONAL JOURNAL OF MODERN PHYSICS **A30** (2015) Art No: 1550158

Arnab Kundu, Effective temperature in steady-state dynamics from holography, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 9** (2015) Art No: 042

Kumar S Gupta; E Harikumar†; Tajron Juric†; et al, Noncommutative scalar quasinormal modes and quantization of entropy of a BTZ black hole, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 9** (2015) Art No: 025

Koushik Dutta; Sukanta Panda†; Avani Patel†, Curvature singularity in $f(R)$ theories of gravity, PHYSICAL REVIEW **D92** (2015) Art No: 063503

B Basu-Mallick; C Datta; F Finkel†; et al, Rational quantum integrable systems of D-N type with polarized spin reversal operators, NUCLEAR PHYSICS **B898** (2015) 53

A Ghosh; P Mitra, Quantum and classical areas of black hole thermodynamics, CLASSICAL AND QUANTUM GRAVITY **32** (2015) Art No: 165006

C Mondal; BK Agrawal; JN De, Constraining the symmetry energy content of nuclear matter from nuclear masses: A covariance analysis, PHYSICAL REVIEW **C92** (2015) Art No: 024302

Ayan Chatterjee†; Avirup Ghosh, Quasilocal rotating conformal Killing horizons, PHYSICAL REVIEW **D92** (2015) Art No: 044003

N Alam; A Sulaksono; BK Agrawal, Diversity of neutron star properties at the fixed neutron-skin thickness of ^{208}Pb, PHYSICAL REVIEW **C92** (2015) Art No: 015804

ALM Britto†; Ashok K Das; J Frenkel†, Generalized fluctuation-dissipation theorem in a soluble out of equilibrium model, PHYSICAL REVIEW **D92** (2015) Art No: 025020

Dipankar Das; Anirban Kundu†, Two hidden scalars around 125 GeV and $h \to \mu\tau$, PHYSICAL REVIEW **D92** (2015) Art No: 015009

JN De; SK Samaddar; BK Agrawal, Reassessing nuclear matter incompressibility and its density dependence, PHYSICAL REVIEW **C92** (2015) Art No: 014304

Neelam Shubhchintak; R Chatterjee; R Shyam; et al, Coulomb breakup of ^{37}Mg and its ground state structure, NUCLEAR PHYSICS **A939** (2015) 101

Ashok Das; Jorge Gamboa; Miguel Pino, Cosmological kinetic mixing, PHYSICAL REVIEW **D91** (2015) Art No: 123528

Elena Caceres†; Arnab Kundu; Juan F Pedraza†; et al, Weak field collapse in AdS: introducing a charge density, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 6** (2015) Art No: 111

Baishali Chakraborty; Kumar S Gupta; Siddhartha Sen†, Coulomb screening in graphene with topological defects, EUROPEAN PHYSICAL JOURNAL **B88** (2015) Art No: 155

Dipankar Das; Ipsita Saha†, Search for a stable alignment limit in two-Higgs-doublet models, PHYSICAL REVIEW **D91** (2015) Art No: 095024

Neymar Cavalcante†; Saulo Diles†; Kumar S Gupta; et al, Entropy from scaling symmetry breaking, EPL **110** (2015) Art No: 48002

Somdeb Chakraborty; Parijat Dey; Sourav Karar; Shibaji Roy, Entanglement thermodynamics for an excited state of Lifshitz system, JOURNAL OF HIGH ENERGY PHYSICS **Issue: 4** (2015) Art No: 133

Abhishek Chowdhury; A Harindranath; Jyotirmoy Maiti, Correlation and localization properties of topological charge density and the pseudoscalar glueball mass in SU(3) lattice Yang-Mills theory, PHYSICAL REVIEW **D91** (2015) Art No: 074507

Arindam Mazumdar; Kamakshya Prasad Modak, Deriving super-horizon curvature perturbations from the dynamics of preheating, JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS **Issue: 4** (2015) Art No: 053

Avik Banerjee; Arnab Kundu; Sandipan Kundu†, Flavour Fields in Steady State: Stress Tensor and Free Energy, JOURNAL OF HIGH ENERGY PHYSICS **1602** (2016) 102

Abhishek Chowdhury; A Harindranath; Jyotirmoy Maiti, Physical observables from boundary artifacts: scalar glueball in Yang-Mills theory, JOURNAL OF HIGH ENERGY PHYSICS **1602** (2016) 134

Taushif Ahmed†, Goutam Das, Prakash Mathews; et al, Spin-2 Form Factors at Three Loop in QCD, JOURNAL OF HIGH ENERGY PHYSICS **1512** (2015) 084

5.2.3 Ph D Awarded

Somdeb Chakraborty [Shibaji Roy], Probing Strongly Coupled Anisotropic Quark-Gluon Plasma via Holography, CU, June 2015

Dipankar Das [Gautam Bhattacharyya], Implications of the Higgs discovery on Physics Beyond the Standard Model, CU, September 2015

Parijat Dey [Shibaji Roy], Applications of AdS/CFT to non-relativistic systems, CU, August 2015

Baishali Chakraborty [Kumar S Gupta], Aspect of Quantization in Lower Dimension, University of Calcutta, February 2016

5.2.4 Seminars/Lectures given in Conference/Symposium/Schools

Bijay K Agrawal
i. The journey from terrestrial nuclei to extraterrestrial neutron stars, BITS Pilani Goa Campus, 22nd March, 2016
ii. Numerical Optimization and Error Analysis, "CNT lectures on Selected Topics in Nuclear Theory"(STNT2016)" (3 lectures), Variable Energy Cyclotron Centre, Kolkata, 15th-25th February, 2016
iii. Sensitivity of symmetry energy content of nuclear matter to the properties of neutron rich systems, Recent Trends in Nuclear Structure and its implication in Astrophysics 2016, Puri, January 4-8, 2016
iv. Probing the nuclear symmetry energy, Academic session of the Annual function of Alumni Association, Institute of Physics, 3rd September 2015
v.Nuclear Physics Meet 2015, Institute of Physics, Bhubaneswar June 26th-30th June,2015

Gautam Bhattacharyya
i. Naturally light uncolored and heavy colored superparticles,
(a) DESY Theory seminar, DESY, Hamburg, September 2015; (b) Institute for Theoretical Physics, University of Gottingen, September 2015; (c) Physics Department, TU Dortmund, Germany, October 2015; (d) Free Meson seminar at Department of Theoretical Physics, TIFR, Mumbai, November 2015
ii. 2HDM scalar potential and the role of symmetries, Kavli IPMU, University of Tokyo, Japan, May 2015
iii. The hierarchy problem and physics beyond the standard model,

(a)Annual Meeting of Indian Academy of Sciences (Bangalore), IISER, Pune, November 2015
(b) Colloquium at Department of Theoretical Physics, TIFR, Mumbai, November 2015
(c) Conference 'Pheno1@IISERM', Chandigarh, April 2016
iv. An Overview of Electroweak Precision Tests,
(a)Physics Department, Univ of Calcutta, February 2016
(b)Pedagogic Lecture for students in 'Sangam at HRI 2016', HRI, Allahabad, February 2016

Arnab Kundu
i. Three dimensional super Yang-Mills with compressible matter, National Strings Meeting, IISER, Mohali, December 2015
ii. Probe Branes and Steady State in Gauge-String Duality;
(a)University of Barcelona, November, 2015; (b) University of Geneva, October, 2015; (c)Max Planck Institute, Munich in October, 2015
iii. Coping with Strong Coupling: Lessons from Gauge-String, Duality, IACS, Kolkata, May 2015

Kumar S Gupta
i. The Inverse-Square interaction and scaling anomaly in quantum systems, International Institute of Physics, UFRN, Natal, RN, Brazil, September 24, 2015
ii. Topological defects and quantum dynamics, UNB, Brasilia, Brazil, September 10, 2015

P Mitra
i. Subtleties of fermion Measure, Professor Shyamal Sengupta Memorial Lecture 2015, Vivekananda Hall, Jadavpur University, April 16, 2015
ii. Log correction to Black Hole Entropy, Field theoretic aspects of Gravity XI, SNBNCBS, February 22-26, 2016

Prakash Mathews
i. Two-loop QCD amplitudes for Higgs → b + bbar + g, 12th International Symposium on Radiative Corrections (Applications of Quantum Field Theory to Phenomenology) and LoopFest XIV (Radiative Corrections for the LHC and Future Colliders), University of California, Los Angeles, USA, June 2015
ii. Pseudo-scalar form factors at three loops in QCD, Frontiers in High Energy Physics, The Institute of Mathematical Sciences, Chennai, March 22-25, 2016

Anjan Kundu
Asymmetric Skyrmion in Anisotropic Ferromagnet as Generalized Analytic Function with Helimagnetic Application, TIFR Theory Seminar, TIFR Mumbai, November 19, 2015

Koushik Dutta
i. 'Symphony of space-time', Recent Trends in Physics, Utkal University, March, 2016
ii. 'Cosmic Inflation', Advances in Astroparticle Physics, Sambalpur University, February 2016
iii. Ramanujan Conclave Meeting, IIT, Indore, December, 2015
iv. Moduli and Gravitions in Inflation, Progress in High Energy Physics and Cosmology, Dibrugarh, November 2015
v. Inflation, Moduli and Some Issues, CosmoAstroDiscussions, IOP Bhubaneswar, October, 2015,
vi. Relating Inflationary Predictions to Moduli Mass,
(a) Topical Conference on Gravitation and Cosmology, IISER, Kolkata, September 2015
(b) String Pheno 2015, June 2015

(c) PLANCK, University of Ionia, Greece, June 2015
(d) Theory Seminar: EPFL, Lausanne, Switzerland, June 2015
vii. A relation between non thermal history of the Universe and Inflation, Theory Seminar: University of Granada, May 2015
viii. 'Solving' A Few Problems in Big Bang Cosmology, Presidency University, November 2015
ix. Known and Unknown in the Beginning of Hot Big Bang, Colloquium: Indian Institute of Astrophysics, May 2015

Palash Baran Pal
i. Renormalization(3 lectures), Workshop on Recent developments in quantum field theory, Banaras Hindu University, February 2426, 2016
ii. Tests of time-reversal violation, The conference on Exploring Fundamental Physics using Atomic Systems (EFPAS 2015), Physical Research Laboratory, Ahmedabad, May 68, 2015
iii. Chiral optics and the third electromagnetic constant, The conference "Light & Photons" to celebrate the International Year of Light (IYL 2015), Indian Association for Cultivation of Science, Kolkata, April 28, 2015
iv. Tests of time-reversal violation, CTS Seminar, Indian Institute of Technology, Kharagpur, August 26, 2015

Munshi Golam Mustafa
i. Thermodynamics of Hot and Dense Deconfined Matter in HTL Resummed Perturbation Theory, 2nd Heavy-Ion Collisions in the LHC and Beyond, Quy Nhon, Vietnam, July 26-31, 2015
ii. QCD and its Application to the Hot and Dense matter created in Heavy-ion Collisions, Students' Day, 6th Asian Triangular Heavy-Ion Collisions (ATHIC)" India International Centre, New Delhi, February 15-19, 2016

5.2.5 Teaching elsewhere

Koushik Dutta
Thermal History of the Universe (Set of Lectures), ISI Kolkata, January, 2016

Palash Baran Pal
Problems of transliteration, (2 lectures), Refresher course organized by the Department of Linguistics, Jadavpur University. September 12, 2015

Munshi Golam Mustafa
i. Classical Electrodynamics, (Integrated M Sc-Ph D, 1st semester), Bose Institute, August-December 2015
ii. Finite temperature Field theory (10 Lectures), High Energy Physics SERB school by DST, Govt. of India, November 16-December 5, 2015, BITs, Pillani, Rajsthan
iii. on " Finite temperature Field theory (10 Lectures), High Energy Physics SERB school by DST, Govt of India, November 16-December 5, 2015, BITs, Pillani, Rajsthan

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. The 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 each PhD students' annual progress and renewals of fellowships following the recommendation of doctoral committees. CARE office acts as the office of Dean, students' welfare, HBNI, SINP.

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 Utsab 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 of-

fice also prints all posters requested by SINP students and faculties for participating in conference/workshops/symposia.

OUTREACH LECTURE:

Palash Baran Pal
i. The Physics Nobel Prize of 2015
(a)Colloquium, Variable Energy Cyclotron Center, Calcutta, December 11, 2015
(b)Physics Department seminar, Barasat Government College, December 4, 2015
ii. Geometry of our universe, 1-day seminar on the centenary of the General Theory of Relativity organized by the Physics Department, Maulana Azad College, Calcutta, November 28, 2015
iii. Doirghyer porimap (Measurement of length), Chemistry departmental re-union of the Jadavpur University, March 2, 2016
iv. Kyalendarer rohosyo (The mystery of calendars)
(a)Serampore College, Srirampur, February 8, 2016
(b)Chatra Nandalal Institution, Srirampur, December 14 2015
(c)Foundation Day Celebrations at the Indian Association for Cultivation of Science, Calcutta, July 29 2015
v. The history and mystery of calendars, the Professor-X series of lectures, St. Xavier's College, Mumbai, January 19, 2016
vi. Matter and energy, M C Kejriwal Vidyapeeth, Liluah, Howrah, August 10, 2015

Koushik Dutta
Which Way the Train Will Go?, SINP Outreach Programme, Rahara Ramkrishna Mission, February, 2016

6.1.1 The Post-M Sc Associateship Course 2014-15

1. Anway Pradhan, Optical and structural correlation of quaternary quantum wells grown by Metalorganic Vapor Phase Epitaxy (Satyaban Bhunia)
2. Suman Mukherjee, Preliminary investigation of InAs/GaAs quantum dots grown by Metalorganic Vapor Phase Epitaxy (Satyaban Bhunia)
3. Subha Samanta, Chaotic Dynamics in nonlinear systems (MS Janaki and AN Sekar Iyengar)
4. Bankim Chandra Das, Saturation Absorption Spectroscopy: A Vortex Beam Approach (Sankar De)
5. Bipasha Paul, Novel phenomena in oxide heterostructure (Sudhakar Yarlagadda)
6. Avik banerjee, Gauge-Gravity Duality, Causal Structures and the Open String Metric (Arnab Kundu)
7. Debraj Das, Cosmological perturbation theory (Amit Ghosh)
8. Gourab Bhattacharjee, Energy Loss Fine Structure (Biswarup Satpati)
9. Ratnadwip Singha, Bose-Einstein condensation in organic and inorganic compounds (Prabhat Mandal)
10. Arghya Mukherjee, Charmonium production in hadron hadron collosion (Pradip K Roy)

Mr. Avik Banerjee in PMSC (Physics) was recepient of
1) Best performance award in PMSc (Physics) for the session 2014-2015
2) Prof. A. P. Patra Memorial Prize in PMSc (Physics) for the session 2014-2015

In 2015 Post-Msc (Physics) stream is divided into two separate streams:
1) Theoretical Physics Stream
2) Experimental Physics Stream.

6.1.1.1 Post MSC (Theoretical Physics Stream) of Session 2015-2016

In Theoretical Physics following seven students were admitted for the session 2015-2016
1.AVIK BANERJEE
2. ARITRA DAS
3. AUGNIVA RAY
4. SAMANWAYA MUKHERJEE
5. MADHURIMA PANDEY
6. SAJAD AHMAD BHAT
7. SOURAV CHAKRABORTY

Basic Courses (Compulsory) in First Trimester (August-November)
1) Advanced Quantum Mechanics (Amit Ghosh)
2) Advanced Statistical Mechanics (Pradeep Mohanty)
3) Quantum Field Theory I (Asit K De)
4) Research Methodology: a) Numerical Methods and Alogorithms b) Research Ethics c) Attending seminar/colloquium (Arti Garg, Kalpataru Pradhan, Debades Bandyopadhyay and Bijay agrawal)

Advanced Courses (optinal) in Second Trimester (Dec-Mar):
Quantum Field Theory-II (Asit K De)
Particle Physics (Palash B Pal)
Advanced Condensed Matter-I (Arti Garg & Kalpataru Pradhan)
Astro-Particle Physics-I (Debashis Majumdar)
Geometry and gravity (Amit Ghosh)

6.1.1.2 Experimental Physics Stream 2015-16 (Students joined on March 3, 2015)

THIRD TERM: Student:- Project Title (Supervisor) Division
1. Abhijit Roy:- Electron Energy Loss Spectrometry (EELS) Analysis of the Electronic Structure and Microstructure of Metals (Biswarup Satpati) SPMSD
2. Mantu Modak:- Observation of positive exchange bias on Fe54Ni26Cr20 (Sangam Banerjee) SPMSD
3. Sangeeta Das:- Performance of low cost photodiodes in nuclear spectroscopy (Maitreyee Saha Sarkar) NPD

The courses taken by the students during the first and second terms are merged with that of the batches of students who have joined in August.
The following students have successfully completed Post-MSc course in March 2016: 1. Sangeeta Das, 2. Abhijit Roy and 3. Mantu Modak

Experimental Physics Stream 2015-16 (Students joined on August 1, 2015) The following students have joined Post-MSc course in August 2015. Those who have joined with external

fellowships are indicated in bracket.
1. JHUMA GHOSH (UGC-NET)
2. SRIDHAR TRIPATHY (DST-INSPIRE)
3. BIBHUTI BHUSAN JENA
4. MOUMITA DAS
5. DEBABRATA BHOWMIK
6. SAJAD ALI
7. WADUT SHAIKH
8. ABHISHEK RAKSHIT
9. SNEHAL MANDAL
10. APURBA DUTTA
11. PRASANT KUMAR ROUT
12. SHUBHANKAR ROY
13. ARPITA DAS

Post M Sc First Term courses and course teachers:
1. Research Methodology: Asimananda Goswami (NPD), Krishnakumar S R Menon (SPMS), Debasish Das (HENPP)
2. Statistical Mechanics: Bikas Kanti Chakrabarti (CMP)
3. Quantum Mechanics: Anjali Mukherjee (NPD), Satyajit Saha (ANPD)
4. Computational and Numerical Methods including C++ programming: Supratik Mukhopadhyay (ANPD), Nayana Majumdar (ANPD), Debasish Das (HENPP)
5. Condensed Matter Physics: Manabendra Mukherjee (SPMS), Biswajit Karmakar (CMP)
6. Nuclear, High Energy and Astroparticle Physics: Chinmay Basu (NPD), Satyaki Bhattacharya (HENPP), Mala Das (APC)
7. Short Experiments in various Research Laboratories opted by the students and under supervision of the following faculty members: Bichitra Ganguly (ANPD), P.M.G. Nambissan (ANPD), Supratic Chakraborty (SPMS), Maitreyee Saha Sarkar (NPD), Alokmay Datta (SPMS), Biswarup Satpati (SPMS), Indranil Das (CMP), Satyajit Hazra (SPMS), Mrinmay Kumar Mukhopadhyay (SPMS), Krishnakumar S. R. Menon (SPMS), Prabhat Mandal (CMP), Tinku Sinha (HENPP), Sukalyan Chattopadhyay (HENPP), and Manabendra Mukherjee (SPMS)

Post M Sc Second and Third Term courses and course teachers:
1. Numerical Techniques in Physics Analysis: Supratik Mukhopadhyay (ANPD), Sandip Sarkar (ANPD)
2. Particle Physics for Experimentalists: Satyaki Bhattacharya (HENPP)
3. Recent trends in Condensed Matter Physics and Material Science -I: Biswarup Satpati (SPMS)
4. Recent trends in Condensed Matter Physics and Material Science -II: Prabhat Mandal (CMP)
5. Advanced Particle Detectors: Debasish Das (HENPP), Maitreyee Nandy (CSD), Nayana Majumdar (ANPD), Supratik Mukhopadhyay (ANPD)

In addition, reading courses on specific or advanced topics related to chosen areas of project work are offered to individual students by various faculty members.

6.1.1.3 Post M.Sc. (Biophysical Sciences) Session 2014-15

Review: Students, Review Topic (Supervisor)
1. DIPAYAN BOSE, Substrate specificity of molecular chaperones (Abhijit Chakrabarti)
2. SARAN CHATTOPADHYAYA, Strength in Numbers - A Megakaryocyte Story, (Subrata Banerjee)
3. SUDESHNA PAL, Elucidation of metabolic reprogramming associated with non-alcoholic fatty liver disease (NAFLD), (Soumen Kanti Manna)

The following 3 (three) students have successfully completed the Post M.Sc. (Biophysical Sciences) Course in 2014-15 session.
1. Dipayan Bose, 2. Saran Chattopadhyaya, 3. Sudeshna Pal
The following student has been awarded the best student award for session 2014-15 in Biophysical Sciences Course.
1. Sudeshna Pal

The following students have joined on August 2015 in Post M.Sc. (Biophysical Sciences) course for the session 2015-16:
1. DIBYASREE CHOUDHURY, 2. KATHAKALI SARKAR, 3. KAUSHIK CHANDA, 4. PAYEL MONDAL, 5. RAJDEEP DAS, 6. SAMRAT BASAK, 7. SANDIP KUMAR DE, 8. SATYABRATA MAITI, 9. SAUVIK SARKAR, 10. SAYAK MUKHOPADHYAY, 11. SHWETA SINGH, 12. SUPARNA SAHA, 13. TANAYA ROYCHOWDHURY, 14. TANUSHREE CHAKRABORTY, 15. TASNIM AHMED, 16. TULIKA CHAKRABORTTY.

Basic Courses (Compulsory) August-November
1. Biochemistry and Chemical Biology (BCB) (40 lectures by Abhijit Chakrabarti, Sangram Bagh and Debashis Mukhopadhyay
2. Molecular & Cell Biology (MCB) (40 lectures by Oishee Chakrabarti, Subrata Banerjee, chandrima Das, Kaushik Sengupta, and Partha Saha)
3. Chemical Physics (CPH) (20 lectures by Montu Hazra, Padmaja Mishra, and Dulal Senapati).
4. Spectroscopy and Nanoscience (SPN) (20 lectures by Samita Basu and Dulal Senapati)
5. Computer Programming & Bioinformatics (CPB) (40 lectures by Gautam Garai and Dhananjay Bhattacharyya)
6. Macromolecular Structure & X-ray crystallography (MMX) (20 lectures by Rahul Banerjee, Dhananjay Bhattacharyya, Udayaditya Sen and Sampa Biswas)
7. Radiochemistry & Radiation Physics (RRP) (12 lectures by Susanta Lahiri & 8 lectures by Maitreyee Nandi)
Research Methodology (Compulsory) August-November
i. Laboratory Visit/Practical: ii. Biochemical and Molecular Biology Techniques (by Debashis Mukhopadhyay, Partha Saha and H Raghuraman)
iii. Spectroscopy and Imaging methods (by Padmaja Mishra, Montu Hazra, Dulal Senapati, Kaushik Sengupta)
iv. Good Laboratory Practices, Radiological safety, Ethics of scientific research, Writing of scientific articles and project proposals.
v. Research colloquium: During the first term from August to November, each faculty working in the area of Biophysical Sciences presents the scientific work being carried out in his/her laboratory. Purpose of the colloquiums is to provide an overview of on-going scientific research related to the subject area in the Institute to the new students. Typically, two colloquiums about one hour each

are scheduled in a week.

Advance Courses December-July
Each course consists of 20 lecture hours. Each student has to opt for 4 courses in total
1. Topics in Cell Biology - II (Kaushik Sengupta, Oishee Chakrabarti & Partha Saha)
2. Topics in Cell Biology II (Subrata Banerjee & Chandriam Das)
3. Membrane Biophysics and Structural Dynamics of Membrane Proteins (H. Raghuraman)
4. Chromatography and Mass Spectrometry (Soumen Kanti Manna)
5. Synthetic Biology: 21st Century Biological Engineering (Sangram Bagh)
6. Macromolecular Crystallography (Udayaditya Sen & Sampa Biswas)
7. Advanced biophysical Spectroscopy and imaging (Samita Basu, Padmaja Mishra & Montu Hazra)
8. Drug Discovery: Modern Day Approach (Munna Sarkar)
9. Multi Scale Modeling (Dhananjay Bhattacharyya)
10. C programming language and its application in Bioinformatics (Gautam Garai)
11. Trace Analysis (Susanta Lahiri)

Review/Project work December-July
Each student has to do a literature review and laboratory work on a particular research topic under the supervision of a faculty in addition to their advance courses.

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 about 1000 SINP members it has about 600 users from outside SINP like the university of Calcutta, Jadavpur university, Viswa Bharati, IACS, IICB, ISI Kolkata, WBUT, CMERI, Guwahati university, North-Eastern Hill university, Patna university, etc. The annual report of the library during 2015-16 is as follows.

Collections
Library has a huge collection of books, e-books and non-book materials. Last year, we added 177 technical books, 77 non-technical books, 432 e-books and online subscription of 8 Nature 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 fund during the current XII-th plan period. More than 3000 online journals as well as online archives (full-text pdf) available in our library website.

CHAPTER 7
Administration

Chapter 7

Administration

7.1 Governing Council

Chairman:

Dr Sekhar Basu
Chairman, Atomic Energy Commission &
Secretary to the Government of India
Department of Atomic Energy

Members:

Smt Chitra Ramachandran
Joint Secretary(R&D)
Government of India
Department of Atomic Energy

Shri RA Rajeev
Joint Secretary (Finance)
Government of India
Department of Atomic Energy

Prof Sudhakar Panda
Director, Institute of Physics
Bhubaneswar

Prof Mustansir Barma
TIFR Centre for
Interdisciplinary Science
Hyderabad

Prof Amitava Raychaudhuri
Palit Professor of Physics
University of Calcutta

Prof NR Das
University of Calcutta

Prof Dilip Kumar Maity
University of Calcutta

Shri Vivek Kumar
Principal Secretary
Higher Education Department
Government of West Bengal

Prof Ajit Kumar Mohanty
Director
Saha Institute of Nuclear Physics

7.2 Audited Accounts

7.2.1 Balancesheet

SAHA INSTITUTE OF NUCLEAR PHYSICS

Balance Sheet as at 31st March, 2016

CAPITAL FUND & LIABILITIES	Schedule	2015-16	2014-15
CORPUS / CAPITAL FUND	1	184352025.63	829785622.17
RESERVE & SURPLUS	2		
EARMARKED FUNDS / ENDOWMENT FUNDS	3	6909446.00	7786406.00
SECURED LOANS & BORROWINGS	4		
UNSECURED LOANS & BORROWINGS	5		
DEFFERED CREDIT LIABILITIES	6		
CURRENT LIABILITIES AND PROVISIONS	7	2475322021.59	2416555042.78
TOTAL		2666583493.22	3254127070.95
ASSETS			
FIXED ASSETS			
Gross Block	8	4107123110.91	4029593697.68
Less : Accumulated Depreciation	8	2319377171.23	2116441448.13
		1787745939.68	1913152249.55
INVESTMENTS- FROM EARMARKED/ ENDOWMENT FUNDS	9		
INVESTMENTS- OTHERS	10	3510000.00	21260458.00
CURRENT ASSETS, LOANS & ADVANCES	11	875327553.54	1319714363.40
TOTAL		2666583493.22	3254127070.95
SIGNIFICANT ACCOUNTING POLICES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(Anirban Banerjee)
Registrar

In terms of our attached Report of even date
For K. Sharma & Co
Chartered Accountants
FRN 302045E

(K. K. Sharma)
Partner
Membership No. 005313
1/B, Old Post Office Street, Room No.8, (First Floor),
Kolkata - 700 001
Dated :-31st August, 2016

K. SHARMA & CO. KOLKATA-1 CHARTERED ACCO. SINCE

(Ajit Kumar Mohanty)
Director

7.2.2 Income & Expenditure Account

SAHA INSTITUTE OF NUCLEAR PHYSICS

Income & Expenditure Account for the year ended 31st March, 2016

	Schedule	2015-16	2014-15
INCOME : -			
Income from Sales/Services	12	642897.00	1107430.00
Grants	13	883584669.27	853872883.19
Fees / Subscriptions	14		
Income from Investments	15		
Income from Royalty, Publication	16		
Interest Earned	17	3758762.12	1916347.00
Other Income	18	4586786.83	4851594.00
Increase / Decrease in stock of finished goods and works-in-progress	19		
Excess of Expenditure over Income transferred to Capital Fund		708452967.77	
		1601026082.99	861748254.19
EXPENDITURE : -			
Establishment Expenses	20	1164789486.60	242330105.10
Other Administrative Expenses	21	233272243.29	244398086.00
Expenditure on Grants, Subsidies	22		
Interest	23	28630.00	23104.09
Depreciation	8	202935723.10	230560580.77
Excess of Income over Expenditure transferred to Capital Fund			144436378.23
		1601026082.99	861748254.19

The Schedules referred to above form part of these Accounts

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(Anirban Banerjee)
Registrar

In terms of our attached Report of even date
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1/B, Old Post Office Street, Room No.8, (First Floor),
Kolkata - 700 001
Dated :-31st August, 2016

K. SHARMA & CO. KOLKATA-1 CHARTERED ACCOUNTANTS

(Ajit Kumar Mohanty)
Director

7.2.3 Receipts & Payments

SAHA INSTITUTE OF NUCLEAR PHYSICS

Receipts & Payments Account for the year ended 31st March, 2016

Receipts	2014-15	2015-16	Payments	2014-15	2015-16
Opening Balance b/f :-					
Cash in hand		54,196.00	Establishment Expenses	61,50,92,373.10	64,63,64,724.60
Current Account Balances	17,84,89,162.43	93,31,16,961.18	Administrative Expenses	24,02,83,961.00	22,97,08,845.29
			Bank Charges	23,104.09	28,630.00
Grant-in-aid received from DAE :-			Assets	11,39,92,035.45	7,79,74,871.23
Recurring	75,00,00,000.00	80,00,00,000.00	Expenses paid for ongoing projects of other agencies	7,29,25,720.01	70,37,87,800.38
Non-Recurring	30,00,00,000.00	35,00,00,000.00	HBA & Other Advances paid	13,39,379.00	11,28,190.00
			Investment		
Grant received from other agencies			Margin Money deposit	10,09,99,000.00	3,57,93,800.00
for on going projects	14,61,54,579.00	3,16,59,775.88	Other Deposit	1,54,000.00	1,01,78,000.00
HBA & Other Advance recovery	37,31,372.00	32,46,616.00	Advances paid	2,35,96,230.66	2,29,33,658.00
Realisation of Margin Money Deposit	8,43,13,000.00	5,07,49,300.00	Last Year's provision paid	78,50,760.00	42,45,658.00
Realisation from other Deposit	61,70,41,546.00	1,77,50,458.00	Last Year's current liabilities paid	21,29,299.60	
Realisation of other advances	2,45,83,961.33	2,26,93,172.00	Pension Fund Payments	6,31,972.00	
Interest Received	19,16,347.00	37,58,762.12	Closing Balance c/f :-		
Income Receipts	59,59,024.33	52,29,683.50	Cash in hand	54,196.00	16,82,322.00
Liabilities (Deposits)		86,91,557.00	Current Account Balances	93,31,16,961.18	49,31,23,982.18
Pension Fund Receipts					
	2,11,21,88,992.09	2,22,69,50,481.68		2,11,21,88,992.09	2,22,69,50,481.68

(V. P. Mishra)
Accounts Officer

(N. Sanyal)
Dy. Controller of Accounts

(Anirban Banerjee)
Registrar

(Ajit Kumar Mohanty)
Director

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(K. K. Sharma)
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Dated :-31st August, 2016

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Chapter 9

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