CENTRE FOR BASIC SCIENCES 1986

S. N. BOSE NATIONAL

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विज्ञानेन परिपश्यन्ति धीराः

Satyendra Nath Bose National Centre for Basic Sciences

Annual Report 2014-2015

Annual Report 2014-2015

Satyendra Nath Bose National Centre
for Basic Sciences

Publisher

Satyendra Nath Bose National Centre
for Basic Sciences

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Acknowledgement

Annual Report of the 'Satyendra Nath Bose National Centre for Basic Sciences' is a brief representation of its activities of a financial year. The report reflects research activities, administrative activities, academic progress and achievement of young research scholars, development of infrastructure and facilities, and establishment of network with advanced research groups around the world. It's fifth time I have been assigned the job of compilation of Annual Report of the Centre. To prepare the Annual Report, all the faculty members and sections of the Centre spent their valuable time to provide respective data. It is a time bound work to be completed within a short span of time. Thanks to the Annual Report Committee members for their suggestions and coordination. I would like to acknowledge the sincere efforts and labour of my Library staff - Mr. Gurudas Ghosh, Ms. Ananya Sarkar and Mr. Amit Roy without whom the work could not be completed within the stipulated time. Finally, I would like to thank all the members of the Centre for their cooperation in preparation of the Annual Report of the Centre.

Saumen Adhikari
Librarian – cum – Information Officer

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from the Director

Write up

Dean, Faculty

Rabin Banerjee

In the year 2014-2015, the Centre was involved in plenty of academic activities related to scientific collaborations, hosting national and international conferences, workshops etc. In this fiscal year, the total number of publications was 159.

All round the year, we had numerous seminars on various topics delivered by scientists ranging from young graduate students to well established ones. Our ongoing collaborations with various countries like UK, Russia, Germany, Sweden etc. in terms of academic visits and exchange programmes including collaborations in conferences further bolstered the research work at the Centre.

This year several Scientists, Visiting Faculty Members and Post Doctoral Research Associates joined the Centre. Two permanent faculty members met their superannuation during the period.

Rabin Banerjee
Dean, Faculty

Dean, Academic Programme

Amitabha Lahiri

Training the next generation of scientists is an important part of the activities of the Centre. We have a vibrant PhD programme which students join after an M.Sc. in Physics, Chemistry and occasionally also Biology or Applied Mathematics. Students qualify through an interview, after being screened by nationally administered written tests such as CSIR-NET, JEST (Joint Entrance Screening Test, held for admission to 27 research institutes), GATE.

Students were also called for interview after qualifying in the Bose Test for PhD applicants. This is the Centre's own admission test, held at several test centres around India. This year's Bose Test was held on 6th April 2014 in 11 cities around the country. 614 students appeared for the entrance tests to the PhD programmes in Physical (369) and Chemical Sciences (245). In addition, a mid-term admission programme was held this year for students who had qualified in CSIR-NET, UGC-NET, INSPIRE and RGNF programmes.

In the academic year 2014-15, a total of 27 students joined the PhD programme. Of these, 03 joined Astrophysics & Cosmology, 10 joined Condensed Matter Physics and Material Science, 10 joined Chemical, Biological and Macromolecular Sciences and 04 joined Theoretical Sciences.

We also have an integrated PhD programme in Physics called Integrated PhD course (IPhD), conducted in collaboration with the University of Calcutta, which accepts students after their B.Sc. Students qualify for the IPhD programme through the JEST or the BoseTest for IPhD applicants, and an interview. This year 372 candidates appeared in the Bose Test for IPhD applicants. This year a total of 10 students joined the IPhD programme.

The Centre currently has 124 (as on 31st March 2015) students in the PhD programme, and another 19 in the IPhD programme. In the 2014-15 academic year, 32 students received their PhD degrees, and another 06 submitted their PhD thesis. There were 13 more students working as research assistants or fellows in various projects.

In addition 19 students came to the Centre on short term visits, including 18 in the summer research programme.

Courses offered in 2014-15

Integrated Ph.D. Programme in Physical Sciences (IPhD-Ph)

1st Semester:

PHY 101, *Classical Dynamics*, Jaydeb Chakrabarti;

PHY 102, *Mathematical Methods*, Amitabha Lahiri;

PHY 103, *Quantum Mechanics I*, M Sanjay Kumar;

PHY 104, *Computational Methods in Physics I,* Subhrangshu S Manna;

PHY 191, *Basic Laboratory I*, Samir Kumar Pal & Ranjit Biswas.

2nd Semester:

PHY 201, *Statistical Mechanics*, Sakuntala Chatterjee;

PHY 202, *Quantum Mechanics II*, M Sanjay Kumar;

PHY 203, *Electromagnetic Theory*, Subodh K Sharma & Manu Mathur;

PHY 204, *Computational Methods in Physics II*, Amlan Dutta;

PHY 291, *Basic Laboratory II*, Kalyan Mandal & Pratip Kumar Mukhopadhyay.

3rd Semester:

PHY 301, *Atomic & Molecular Physics*, Rajib Kumar Mitra & Manik Pradhan;

PHY 302, *Condensed Matter Physics*, Manoranjan Kumar & Abhijit Mookerjee;

PHY 303, *Advanced Quantum Mechanics & Applications*, Biswajit Chakraborty;

PHY 304, *Project Research II*, Faculty Supervisors;

PHY 391, *Methods of Experimental Physics*, Kalyan Mandal (Coordinator), Barnali Ghosh, A K Raychaudhuri, Rajib Kumar Mitra, Soumen Mondal & Madhuri Mandal.

4th Semester:

PHY 401, *Project Research III*, Faculty Supervisors;

PHY 402, *Seminar Course*, Faculty Experts;

PHY 403, *Astrophysics & Cosmology*, Sandip K Chakrabarti & Soumen Mondal;

PHY 405, *Biological Physics*, Rajib Kumar Mitra;

PHY 406, *Advanced Mathematical Methods,* Samir Kumar Paul;

PHY 409, *Magnetism & Superconductivity*, Arup K Raychaudhuri & Kalyan Mandal;

PHY 412, *Physics of Materials*, Sugata Mukherjee.

Ph.D. Programme

COURSE WORK PROGRAMME

Common to all the departments:

PHY 501, *Research Methodology*, Pratip Kumar Mukhopadhyay & Sanjoy Choudhury;

PHY 502, *Review of the Topical Research*, Faculty Supervisors;

PHY/CB 591, *Project Research*, Faculty Supervisors.

Department of Astrophysics & Cosmology:

PHY 510, *Astrophysics*, Soumen Mondal;

PHY 511, *High Energy Astrophysics around Compact Stars*, Sandip K Chakrabarti.

Department of Chemical, Biological and Macromolecular Sciences:

CB 525, *Instrumental Methods of Analysis*, Samir Kumar Pal;

PHY 526, *Fundamentals of Biophysics*, Rajib Kumar Mitra.

Department of Condensed Matter Physics & Material Sciences:

PHY 601, *Advanced Condensed Matter Physics - Magnetism & Superconductivity*, Ranjan Chaudhury;

PHY 602, *Advanced Condensed Matter Physics - Electronic Structure & Physics of Materials*, Sugata Mukherjee.

Department of Theoretical Sciences:

PHY 507, *Mathematical Methods*, Samir Kumar Paul;

PHY 603, *Statistical Physics*, Shradha Mishra.

Project Research

M. Tech. / M. Sc. Projects

Prediction of Interacting Protein Partner for the Bacterial YfdX Protein, Kathakali Sarkar, St. Xavier's College (Autonomous), Kolkata, Supervisor: Mahua Ghosh

Ph.D. AWARDS

A Study of Quantum Correlations from Different Perspectives, Ashutosh Rai, Supervisor: Archan S Majumdar, in University of Calcutta, on March 14, 2014

Biomolecule-Assisted Synthesis of Nanoparticles and Their Characterization for Potential Application in Biophysical Studies, Nirmal Goswami, Supervisor: Samir Kumar Pal, in Jadavpur University, on March 26, 2014

Numerical Simulation of Spectral and Timing Properties of Galactic Black Holes, Sudip Kumar Garain, Supervisor: Sandip K Chakrabarti, in University of Calcutta, on March 27, 2014

Prepotential Formulation of Lattice Gauge Theories, Indrakshi Raychowdhury, Supervisor: Manu Mathur, in University of Calcutta, on April 4, 2014

Spectroscopic Studies on Structure, Function and Dynamics of Biomolecules in Presence of Other Biologically Relevant Macromolecules, Surajit Rakshit, Supervisor: Samir Kumar Pal, in Jadavpur University, on April 29, 2014

Effects of Curvature and Gravity from Flat Spacetime, Debraj Roy, Supervisor: Rabin Banerjee, in University of Calcutta, on May 5, 2014

Quasistatic and Ultrafast Magnetization Dynamics in Magnetic Nanostructures, Bivas Rana, Supervisor: Anjan Barman, in University of Calcutta, on May 21, 2014

Renormalization Group as a Probe for Dynamical Systems, Amartya Sarkar, Supervisor: Jayanta K Bhattacharjee, in University of Calcutta, on June 2014

Spectroscopic Studies on the Interactions of Biomimetics with Biological Macromolecules, Ranajay Saha, Supervisor: Samir Kumar Pal, in University of Calcutta, on June 19, 2014

Vibrational Properties and Phase Stability of Disordered Alloy, Rajiv Kumar Chouhan, Supervisor: Abhijit Mookerjee, in University of Calcutta, on July 7, 2014

A Study of Dark Energy from Various Approaches, Nilok Bose, Supervisor: Archan S Majumdar, in University of Calcutta, on July 8, 2014

Study of the Effects on Lower Ionosphere Due to Solar Phenomena Using Very Low Frequency Radio Wave

Propagation, Tamal Basak, Supervisor: Sandip K Chakrabarti, in University of Calcutta, on July 8, 2014

Study of Magnetic, Ferroelectric and Magnetoelectric Properties in Bulk and Nanostructured Multiferroics, Rajasree Das, Supervisor: Kalyan Mandal, in University of Calcutta, on July 15, 2014

Magnetic and Optical Studies of Wide Band-Gap Oxide Semiconductors, Shyamsundar Ghosh, Supervisor: Kalyan Mandal, in University of Calcutta, on July 15, 2014

Synthesis of Transition Metal Based Magnetic Nanostructures and Their Characterization for Suitable Applications, Debasish Sarkar, Supervisor: Kalyan Mandal, in University of Calcutta, on July 24, 2014

Magnetism in Dilute Magnetic Semiconductors and Oxides, Hirak Kumar Chandra, Supervisor: Priya Mahadevan, in Jadavpur University, on July 31, 2014

Mean Field Theory and Computer Simulations on Non-Equilibrium Phenomena in Complex Chemical Systems, Amit Das, Supervisor: Jaydeb Chakrabarti, in University of Calcutta, on August 28, 2014

Chern Simons Theory in the Context of 2+1 and 3+1 Quantum Gravity, Rudranil Basu, Supervisors: Samir Kumar Paul & Parthasarathi Majumdar (RKMVU), in University of Calcutta, on August 28, 2014

Study of Magnetocaloric and Magnetotransport Properties of Transition Metal Based Materials, Debabrata Pal, Supervisor: Kalyan Mandal, in University of Calcutta, on August 28, 2014

Understanding Complex Ordering in Transition Metal Oxides, Abhinav Kumar, Supervisor: Priya Mahadevan, in West Bengal University of Technology, on November 13, 2014

Some Applications of Quantum Entanglement, Tanumoy Pramanik, Supervisor: Archan S Majumdar, in University of Calcutta, on November 2014

Spectroscopic Studies on the Biomolecular Recognition of Medicinally Important Ligands, Soma Banerjee, Supervisor: Samir Kumar Pal, in Jadavpur University, on December 2014

Spectroscopic Investigation on Fluorescent Probes in Biologically Relevant and Engineered Environments, Subrata Batabyal, Supervisor: Samir Kumar Pal, in Jadavpur University, on December 2014

Development of Nanoscale Systems for Spin-Wave Propagation, Dheeraj Kumar, Supervisor: Anjan Barman, in University of Calcutta, on January 7, 2015

Investigations in Higher Derivative Field Theories, Biswajit Paul, Supervisors: Rabin Banerjee & Pradip Mukherjee (Barasat Govt. College), in University of Calcutta, on January 2015

Study of Formation of Molecules in the Star Forming Regions Using Continuous Time Random Walk Monte Carlo Simulation, Wasim Iqbal, Supervisor: Kinsuk Acharyya, in University of Calcutta, on January 22, 2015

Interplay of Charge, Orbital and Spin in Correlated Transition-metal Oxides, Santu Baidya, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, on February 17, 2015

Aspects of Unusual Superconductivity, Arghya Dutta, Supervisor: Jayanta K Bhattacharjee, in University of Calcutta, on February 20, 2015

Investigations of Complex Systems: from Granular to Cognitive Systems, Dattatray Pandurang Shinde, Supervisor: Anita Mehta, in University of Calcutta, on March 3, 2015

Properties of Ni-Mn Based Heusler Alloys with Martensitic Transition, Sandeep Singh, Supervisor: Chhayabrita Biswas, in University of Calcutta, on March 2015

Computer Simulation Studies of Multi-Component Melts and Ionic Liquids, Tamisra Pal, Supervisor: Ranjit Biswas, in Jadavpur University, on March 2015

Magnetotransport Properties of Some Disordered Binary and Ternary Alloys, Pampa Pal, Supervisors: Alak K Majumdar (RKMVU) & Abhijit Mookerjee, in University of Calcutta, on March 17, 2015

Ph.D. THESES SUBMITTED

A Study on Characterization and Detection of Quantum Entanglement, Nirman Ganguly, Supervisor: Archan S Majumdar, in University of Calcutta, on June 19, 2014

Thermodynamic Properties of Mesoscopic Systems, Sreemoyee Mukherjee, Supervisor: Prosenjit Singha Deo, in University of Calcutta, on July 22, 2014

Magnetization Dynamics in Magnetic Materials with High Magnetic Anisotropy, Semanti Pal, Supervisor: Anjan Barman, in University of Calcutta, on July 28, 2014

Some Studies of Complex Networks in Multidisciplinary Fields, Abhijit Chakraborty, Supervisor: Subhrangshu S Manna, in Jadavpur University, on July 28, 2014

Study of Relaxation Phenomenon and Functional Properties in Some Ferromagnetic Shape Memory Alloys, Sandeep Agarwal, Supervisor: Pratip Kumar Mukhopadhyay, in University of Calcutta, on September 12, 2014

Study of Electronic, Structural and Magnetic Properties of the Disordered Solids, Ambika Prasad Jena, Supervisor: Abhijit Mookerjee, in University of Calcutta, on September 25, 2014

Investigation of Novel Electric and Magnetic Properties of Perovskite Oxides, Rajib Nath, Supervisor: Arup K Raychaudhuri, in University of Calcutta, on January 22, 2015

Research Scholars - Ph.D. Programme

(By year of joining)

Extended Senior Research Fellow

2009–2010:

- Anupam Giri (UGC) (till 15-05-2014)
- Nirmal Goswami (CSIR) (till 16-04-2014)
- Ranajay Saha (SNB) (till 01-04-2014)
- Subrata Batabyal (SNB) (till 02-06-2014)
- Surajit Rakshit (CSIR) (till 04-07-2014)
- Tamal Basak (CSIR) (till 12-05-2014)
- Semanti Pal (UGC)
- Dheeraj Kumar (CSIR) (till 30-06-2014)
- Sreemoyee Mukherjee (SNB) (till 08-12-2014)
- Tamisra Pal (SNB) (till 09-03-2015)
- Wasim Iqbal (SNB) (till 16-02-2015)

2010–2011:

- Dattatraya P Shinde

Senior Research Fellow

2008–2009:

- Abhijit Chakraborty (SNB) (till 09-10-2014)
- Rajib Nath (SNB) (till 16-02-2015)
- Sandeep Agarwal (SNB) (till 30-06-2014)
- Sandeep Singh (SNB) (till 31-07-2014)

2009–2010:

- Md. Injamamul Arief (CSIR)
- Rabaya Basori (SNB)
- Saikat Debnath (CSIR) (till 18-05-2015)
- Santu Baidya (SNB) (till 02-09-2014)
- Soumi Roy Chowdhury (SNB)
- Urbashi Satpathi (INSPIRE)

2010-2011:

- Animesh Patra (SNB)
- Anirban Karmakar (SNB)
- Anuradha Das (UGC)
- Arindam Lala (CSIR)
- Bipul Kumar Mahato (CSIR) (till 01-06-2015)
- Biswajit Paul (CSIR) (till 14-07-2014)
- Priyanka Chowdhury (UGC)
- Sandipa Indra (UGC)
- Sreeraj T. P (CSIR)
- Subhajit Sarkar (CSIR)
- Susmita Saha (UGC)
- Tanmoy Ghosh (SNB)
- Yendrembam Chaoba Devi (SNB)

2011-2012:

- Arindam Das (UGC)
- Arup Ghosh (SNB)
- Basudeb Mandal (CSIR)
- Ishita Dutta Choudhury (SNB)
- Kallol Mukherjee (CSIR)
- Paramita Saha (SNB)
- Pratik Tarafdar (UGC)
- Rishi Ram Ghimire (TWAS- BOSE)
- Samapan Sikdar (UGC)
- Sayani Chatterjee (CSIR)
- Siddhi Chaudhuri (CSIR)
- Suman Das (CSIR)
- Victor U J Nwankwo (TWAS- BOSE)

2012-2013:

- Abhijit Maity (INSPIRE)
- Abhishek Roy (SNB)
- Ambalika Biswas (SNB)
- Anindita Mondal (SNB)
- Arnab Deb (SNB)
- Arpita Mitra (SNB)
- Aslam Parvej (SNB)
- Chandrima Banerjee (CSIR)
- Chiranjit Ghosh (SNB)
- Gourab Dutta Banik (INSPIRE)
- Hrishit Banerjee (SNB)
- Karan Savio Fernandes (SNB)
- Kartik Samanta (SNB)
- Krishnendu Pal (SNB)
- Monalisa Pal (SNB)
- Nabarun Polley (INSPIRE)
- Nirnay Samanta (SNB)
- Poulami Chakraborty (SNB)
- Rupali Rakshit (SNB)
- Sagar Sarkar (SNB)
- Samim Sardar (SNB)
- Shiladitya Mal (SNB) (till 13-02-2015)
- Somnath Dutta (SNB)
- Subarna Datta (SNB)
- Subrata Dev (SNB)
- Suman Som (SNB)
- Sumanto Chanda (SNB)
- Supriyo Ghosh (SNB)
- Susobhan Choudhury (CSIR)

Junior Research Fellow

2012-2013:

- Suman Aich (SNB)

2013-2014:

- Abir Deogharia (SNB) (till 23-01-2015)
- Arindam Ghosh (SNB)
- Jagabandhu Kumar (SNB) (till 25-09-2014)
- Poonam Kumari (SNB)
- Prasenjit Kar (SNB)
- Raj Kumar Sadhu (SNB)
- Rakesh Das (SNB)
- Ransell Richard Dsouza (SNB)
- Ravindra Singh Bisht (SNB)
- Sankar Das (SNB)
- Shaili Sett (SNB)
- Snehasish Rana (SNB)
- Souvanik Talukdar (SNB)
- Subhadip Chakraborti (SNB)
- Sutapa Dutta (SNB)

2014-2015:

- Anuvab Banerjee (SNB)
- Aritra Narayan Bose (SNB)
- Debasmita Maiti (SNB)
- Ejaj Tarif (SNB)
- Indranil Chakraborty (SNB)
- Juriti Rajbangshi (SNB)
- Mudhumita Saha (SNB)
- Pallabi Paul (SNB)
- Priya Singh (SNB)
- Sudipta Pattanayak (SNB)
- Suraka Bhattacharjee (INSPIRE)
- Joydeep Chatterjee (CSIR)
- Sarowar Hossain (TWAS BOSE)
- Anulekha De (INSPIRE)
- Aratrika Dutta (INSPIRE Applicant)
- Damayanti Bagchi (INSPIRE Applicant)
- Debabrata Ghorai (INSPIRE Applicant)
- Dhrimadri Khata (INSPIRE Applicant)
- Keshab Karmakar (INSPIRE Applicant)
- Mahebub Alam (INSPIRE Applicant)
- Mithun Pal (INSPIRE)
- Samrat Ghosh (INSPIRE Applicant)
- Santanu Pan (INSPIRE)
- Sucheta Mondal (INSPIRE)
- Sandip Saha (RGNF Applicant)

Project Fellows / Assistants / Trainees

2011-2012:

- Shishir Kumar Pandey (Project SRF)

2013-2014:

- Camelia Manna (Project JRF)
- Debal Kanti Singha (Project Assistant)
- Dipanjan Samanta (Project Assistant)
- Suvankar Das (Project Assistant)

2014-2015:

- Debamalya Ghosh (Project Assistant)
- Gobinda Mapdar (Project Assistant)
- Mamta Gautam (Project Assistant)
- Sayan Baral (Project JRF)
- Suchetana Goswami (PROJECT JRF)
- Shounak Datta (Project JRF)
- Soumi Bhuin (Project JRF)
- Somonnita Roy (Project JRF)
- Tuhin K Maji (Project JRF)

Research Scholars–Integrated Ph.D. Programme

Extended Senior Research Fellow

2006–2007:

- Nilok Bose (SNB) (till 01-08-2014)
- Sudip Kumar Garain (till 13/4/2014)

SENIOR RESEARCH FELLOW

2007–2008:

- Arghya Dutta (CSIR)(till 31-07-2014)

2008-2009:

- Sukla Pal (SNB)

2009–2010:

- Arnab Ganguly (SNB)
- Ashutosh Kumar Singh (SNB)
- Biplab Bhattacherjee (SNB)
- Debanjan Polley (SNB)
- Subhasish Chakrabarty (SNB)
- Arghya Das (SNB)

2010–2011:

- Arpan Krishna Mitra (SNB)
- Soumyakanti Bose (SNB)
- Suman Dutta (SNB)

JUNIOR RESEARCH FELLOW

2011–2012:

- Anita Halder (SNB)

- Chandreyee Roy (SNB)
- Debasish Das Mahanta (SNB)
- Shauri Chakrabarty (SNB)
- Sumanta Kundu (SNB)

2012–2013:

- Arkadev Roy
- Ayan Bhattacharjee
- Kausik Chanda
- Monalisa Singh Roy
- Samiran Choudhury
- Saurav Singha
- Sudhanshu Ranjan
- Vibhuti Narayan Rai

Integrated Ph.D Programme

2013–2014:

- Amal Garai
- Ankan Pandey
- Avinash Kumar Chaurasiya
- Debalina Banerjee
- Kumar Neeraj
- Riddhi Chatterjee
- Ritam Basu
- Sanchi Maithani
- Santanu Mandal
- Sourav Kumar Misra

2014–2015:

- Amit Barh
- Ananda Gopal Maity
- Arunava Adak
- Balbant Singh Bisht
- Debsuvra Mukhopadhyay
- Manas Pratim Das
- Neha Jha
- Ruchi Pandey
- Sourav Sahoo

Research Scholars–Part time Ph.D. Programme

Ansuman Dey, Astrophysics & Cosmology, under Archan S. Majumdar

Ambika Prasad Jena, Condensed Matter Physics & Material Sciences, under Abhijit Mookerjee

Arpita Nandi, Astrophysics and Cosmology, under Ramkrishna Das and Soumen Mondal, Current Affiliation: Itachuna Sree Narayan Institution, Hooghly

Asit Kumar Chaudhury, Astrophysics & Cosmology, under Sandip Kumar Chakrabarti, Current Affiliation: LMSM High School, Malda Town.

Manotosh Chakravorty, Condensed Matter Physics and Material Sciences, under Arup Kumar Raychaudhuri, Current Affiliation: School Service, WB

Putul Chakravorty (Malla Chowdhury), Condensed Matter Physics and Material Sciences, under Arup Kumar Raychaudhuri, Current Affiliation: School Service, WB

Samik Roy Moulik, Condensed Matter Physics & Material Sciences, under Barnali Ghosh (Saha), Current Affiliation: Icon Analytical Equipment Pvt. Ltd., Mumbai

Sovik Roy, Astrophysics & Cosmology, under Archan S. Majumdar, Current Affiliation: Techno India, Kolkata.

Shahnewaz Mondal, Condensed Matter Physics and Material Sciences, under Arup Kumar Raychaudhuri, Current Affiliation: School Service, WB

Swarnakamal Mukherjee, Condensed Matter Physics & Material Sciences, under Tanusri Saha Dasgupta

Soumyadipta Pal, Condensed Matter Physics and Material Sciences, under Chhayabrita Biswas / Priya Mahadevan (Co-Supervisor), Current Affiliation: Calcutta Institute of Technology

Dilip Sao, Condensed Matter Physics and Material Sciences, under Prosenjit Singha Deo, Current Affiliation: Durgapur Govt. College

Shirsendu Dey, Theoretical Sciences, under Rabin Banerjee, Current Affiliation: Kalyani Govt. Engineering College

Ruma Das, Condensed Matter Physics and Material Sciences, under Priya Mahadevan, Current Affiliation: Lalbaba College, Belur

Subhadipa Das, Astrophysics & Cosmology, under Archan S. Majumdar, Current Affiliation: Harimohan Ghosh College, Kolkata.

Soumendra Singh, Chemical, Biological & Macro-Molecular Sciences, under Samir K Pal, Current Affiliation: Bose Institute

Abhishek Bagchi, Condensed Matter Physics and Material Sciences, under Pratip K. Mukhopadhyay

Oindrila Ganguly, Condensed Matter Physics and Material Sciences, under Debasish Gangopadhyay

Debmalya Mukhopadhyay, Theoretical Sciences, under Amitabha Lahiri

Amitabha Lahiri

Amitabha Lahiri

Dean, Academic Programme

Extended Visitors' Linkage Programme

Seminar and Colloquia Programme

Memorial Lecture -1
Bose Colloquium - 9
Institute Seminar/ Colloquium - 22
Special Lecture -1
Bose Fest -1

Memorial Lecture

Date	Speaker & Affiliation	Lecture & Title
06.01.15	Prof. S. R. Kulkarni, Principal Investigator, Palomar Transient Factory Director, Caltech Optical Observatories California Institute of Technology, USA	4th S. Chandrasekhar Memorial Lecture The Dynamic Sky

Bose Colloquium

Date	Speaker & Affiliation	Title
16.05.14	Prof. S. Yashonath Solid State and Structural Chemistry Unit, Indian Institute of Science, Bengaluru	Dependence of Diffusion as a function of Diffusant Diameter in Condensed Matter Phases
20.06.14	Prof. P. K. Chattaraj Department of Chemistry and Centre for Theoretical Studies, Indian Institute of Technology, Kharagpur	All-metal aromaticity and conceptual DFT
05.09.14	Prof. Srikanth Sastry Theoretical Sciences Unit, JNCASR, Bangalore	Jamming in sphere packings
24.11.14	Prof .J. Paul Attfield Centre for Science at Extreme Conditions and School of Chemistry, University of Edinburgh	New Orders in Simple Solids
11.12.14	Prof. N. Periasamy Indian Academy of Sciences, Bengaluru	A few interesting photophysical questions
23.01.15	Prof. S. Ramasesha J C Bose National Fellow and Professor, Solid State and Structural Chemistry Unit Indian Institute of Science, Bangalore	Electron Correlations and Excited States of Conjugated Carbon Systems
23.02.15	Prof. Phoolan Prasad Department of Mathematics Indian Institute of Science, Bangalore	Question of Equivalence of Huygens' and Fermat's Methods of Wavefront Construction
27.02.15	Prof. Flavio Seno Dipartimento di Fisica e Astronomia, Universitá di Padova	Exploring the universe of protein folds
09.03.15	Prof. Biman Bagchi Professor, SSCU, Indian Institute of Science Bangalore	Protein folding and unfolding: Bottom-up approach

Special Lecture

Date	Speaker & Affiliation	Title
16.01.15	Mr. Judhajit Dasgupta, DESH Patrika, ABP	Butterflies

Extended Visitors' Linkage Programme

Workshop on Science for Inclusive Growth

4th S. Chandrasekhar Memorial Lecture

Bose Colloquium

S. N. Bose - JAIST School on Quantum Monte Carlo

STATPHYS - Kolkata VIII

NANODAYS 2015

Bose Fest

Students Registration

Welcome Address by Prof. Sibaji Raha, Director

Talk Session

Poster Session

Cultural Programme by Muktangan

Classical Evening Programme

Institute Seminar/Colloquium

Date	Speaker & Affiliation	Title
13.03.15	Dr. Gautam I. Menon The Institute of Mathematical Sciences, Chennai	Active Matter
20.02.15	Prof. Alex Hansen Department of Physics, Norwegian University of Science and Technology, Norway	The Fiber Bundle Model
14.01.15	Prof. Chandrabhas Narayana Chemistry and Physics of Materials Unit, JNCASR, Bangalore	Magnetic Ordering in Multiferroics: A Raman perspective
13.01.15	Prof. John Corbett Department of Mathematics Macquarie University, Sydney, Australia	Understanding quantum weirdness: quantum spatial continua are topologically non-Euclidean
12.01.15	Professor Mukunda P. Das Department of Theoretical Physics, Research School of Physics and Engineering, The Australian National University, Canberra	Are there fundamental theories in low energy physics?
02.01.15	Dr. Hugo Touchette National Institute for Theoretical Physics (NITheP) Stellenbosch, South Africa	Large deviation theory: From mathematics to physics and back
15.12.14	Dr. Hideaki Shirota Department of Nanomaterial Science & Department of Chemistry, Chiba University	Ultrafast Dynamics of Room Temperature Ionic Liquids: A Third Order Nonlinear Spectroscopic Study
15.12.14	Prof. K. Tominaga Kobe University, Japan	Low-frequency motions in condensed phases studied by pulsed terahertz radiation
08.12.14	Dr. S. E. Dutton Cavendish Laboratory, University of Cambridge	Geometrically Frustrated Magnets for Solid State Magnetic Cooling
26.09.14	Dr. Rajdeep Sensarma Department of Theoretical Physics, TIFR Mumbai	Novel Phenomena in Cold Atoms: Ferromagnetic Response of a "High Temperature" Quantum Antiferromagnet
19.09.14	Dr. Abhishek K. Singh Materials Research Centre, Indian Institute of Science, Bangalore	Reversible Tuning of "Electronic Structure" of Semiconducting Transition Metal Dichalcogenides
12.09.14	Dr. Arnab Das Department of Theoretical Physics, IACS, Kolkata	Dynamical Many-body Freezing: Localizing a Quantum System in the Hilbert Space by Periodic Quantum Interference
29.08.14	Dr. Kanchan Garai TIFR Centre for Interdisciplinary Sciences, Hyderabad	Reshaping the aggregation landscape of Amyloid-â by endogenous proteins
22.08.14	Dr. Brijesh Kumar School of Physical Sciences, Jawaharlal Nehru University, New Delhi	Theory of Magnetisation Plateaus in Shastry-Sutherland Model
08.08.14	Dr. Satyabrata Patnaik School of Physical Sciences, Jawaharlal Nehru University, New Delhi	Some exciting developments in superconducting and multiferroic materials
11.07.14	Dr. Moloy Sarkar Assistant Professor, School of Chemical Sciences National Institute of Science Education and Research IOP campus, Bhubaneswar	Understanding the Behavior of Molecules and Materials through Electron Donor Acceptor (EDA) Systems
27.06.14	Dr. Upendra Harbola IPC Department, Indian Institute of Science, Bangalore	Nonequilibrium fluctuating thermodynamics
19.06.14	Dr. S. M. Yusuf Solid State Physics Division, Bhabha Atomic Research Centre, Mumbai	Order-Order Transitions in Magnetism
06.06.14	Dr. Dibyajyoti Banerjee Postgraduate Institute of Medical Education and Research, Chandigarh	Antioxidants: Myth and Reality
23.05.14	Prof. Pinaki Majumdar HRI Allahabad	The Mott transition on frustrated lattices
28.04.14	Dr. Subhankar Bedanta NISER Bhubaneswar, Odisha	Magneto-optic Kerr microscopy for nanomagnetism
11.04.15	Dr. Jayant K Singh Indian Institute of Technology, Kanpur	Phase transitions of nanoconfined fluids

Bose Fest – Annual Science Celebration, 2 - 4 March 2015

Bose Fest showcases the spirit of creativity and science. All academic colleagues are invited for spontaneous participation in the annual science celebration under SCOLP, EVLP.

- All students belonging to 4th and 5th year delivered oral presentations while the rest made poster presentations
- All talks were of 20 (15 + 5) minutes duration
- 26 Talks and 50 Posters were presented by the students at Bose Fest 2015
- The talk sessions were divided into 4 sessions corresponding to the four departments at the Centre.

  Session I commenced with the department of Astrophysics & Cosmology and was chaired by Prof. Debasish Majumdar (Astroparticle Physics & Cosmology, SINP- Kolkata).

  Session II included the department of Condensed Matter Physics & Material Sciences and were chaired by Prof. A.K Majumdar (Ramkrishna Mission Vivekananda University) & Prof. Subham Majumdar (Department of Solid State Physics, IACS – Kolkata) on 02.03.15 Session III was devoted to the department of Chemical, Biological & Macromolecular Sciences and was chaired by Prof. Prasun K. Mandal (Department of Chemical Sciences, IISER – Kolkata) while Session IV concluded with the department of Theoretical Sciences and was chaired by Prof. Asit K. De, Theory Division (SINP – Kolkata)
- As a tribute to Prof. Satyendranath Bose and his deeply felt passion for Indian classical music, the legendary santoor maestro Pandit Taun Bhattacharyya accompanied by the renowned Tabla player Shri Abhijit Banerjee was invited to perform at the Centre on 02.03.15
- PHOTO FEST along with the Cultural programme by Muktangan followed by Family dinner was hosted on 03.03.15
- The curtains fell with the prize distribution ceremony for the best oral and poster presentations on 04.03.15

Conferences, Workshops and Extension Programme

Sl. No.	Title of the Event	Conveners	Budget Allocation (Rs.)	Participants				Dates
				Total	India	Abroad	Student	
1.	***C.K Majumdar Memorial Summer Workshop in Physics 2014***	Dr. Saswati Dasgupta (Rammohan College, Kolkata) & Prof. K. Mandal (SNBNCBS)	Total 2,21000/- SNBNCBS Support 1,25,000/-	50	20	—	30	17.06.14 – 27.06.14
2.	***Workshop on Science for Inclusive Growth***	Sri Dipankar Mukhopadhyay (SNBNCBS)	SNBNCBS Support 97,000/-	60	60	—	30	21.10.14
3.	***STATPHYS – KOLKATA VIII***	Dr. A. Chakraborti (JNU), Dr. S.Chatterjee, Dr. Jun-ichi Inoue (Hokkaido University) Dr. P. Pradhan	Total 19.3 lakhs SNBNCBS Support 9.3 Lakhs	130	110	20	80	01.12.14 – 05.12.14
4.	***NANODAYS 2015***	Prof. Priya Mahadevan & Dr. Subhra Jana, (SNBNCBS)	Total 4,83,900/- SNBNCBS 40,7900/-	70	70	—	40	16.02.15 – 18.02.15
5.	***S.N. Bose-JAIST School on Quantum Monte Carlo***	Prof. Priya Mahadevan (SNBNCBS)	Total 4,77,500/- SNBNCBS Support NIL	40	15	20	35	23. 03.15 – 27.03.15

Network Projects And Exchange Programme

Project Title	Investigators	Project Number	Start date	Sanctioned Amount	Remarks	Publication/ Patent/Report
Fabrication of Nano Junction between High T_c and Normal Metal Nano Wires and further Study"	Dr. Barnali Ghosh (Saha) PI (SNBNCBS) Prof. P. K. Mukhopadhyay (Co-PI) (SNBNCBS) Dr. Nilotpal Ghosh (External) VIT, Chennai	SNB/BG/ 14-15/130	26/5/2014	Rs.5 L	Synthesis and characterization of nano junctions done	0
Extension / upgradation of IAPT Midnapore College Centre for Scientific Culture (CSC)"	Prof. P. K. Mukhopadhyay (PI) Dr. P. Dutta (Co-PI) (External, Midnapore College, West Bengal)	SNB/PKM/ 14-15/131	26/5/2014	Rs.5 L	Instruments bought, undergraduate/ postgraduate students are working with these, Physical stock verification conducted on 22/01/15	0

Advanced Post-doctoral Manpower Programme

Post Doctoral Research Associates (PDRA)-10

Sl. No.	Name	RA Status	Mentor / Department
1	Dr. Rohit Kumar	PDRA I	Prof. Amitabha Lahiri/ TS
2	Dr. Sanchari Goswami	PDRA I	Dr. Sakuntala Chatterjee/ TS
3	Dr. Ankita Ghatak	PDRA I	Dr. Barnali Ghosh Saha/CMPMS
4	Dr. Pabitra Mandal	PDRA I	Prof. A. K Raychaudhuri/CMPMS
5	Dr. Lakshmi Maganti	PDRA I	Prof. Jaydeb Chakrabarti/CBMS
6	Dr. Suman Ghosh	PDRA II	Prof. Amitabha Lahiri/ TS
7	Dr. Partha Sarathi Pal	PDRA II	Prof. Sandip Chakrabarti/A&C
8	Dr. Tilak Das	PDRA I	Prof. T. S. Dasgupta/CMPMS
9	Dr. Bipul Das	PDRA I	Prof. A. K Raychaudhuri/CMPMS
10	Dr. Jaivardhan Sinha	PDRA II	Prof. Anjan Barman/CMPMS

Visitor, Associates and Students Programme

Associates and Short Term Visitors

Name of the Visitor	Affiliation	Period of stay		Host Faculty/ Department
		Date From	Date to	
Dr. Nilotpal Ghosh (Associate)	Assistant Professor (Senior) Vellore Institute of Technology, Chennai	30.05.14	16.06.14	Prof. A.K Raychaudhuri & Dr. Barnali Ghosh Saha Condensed Matter Physics & Material Sciences
Dr. Molly De Raychaudhury (Associate)	Lecturer, Department of Physics, West Bengal State University, Barasat	08.07.14	21.07.14	Prof. Jaydeb Chakrabarti Chemical, Biological & Macromolecular Sciences
Dr. B. Rajini Kanth (Associate)	Associate Professor, T. K. R. College of Engineering and Technology, Hyderabad	17.05.14 25.03.15	16.06.14 05.04.15	Prof. P. K Mukhopadhyay Condensed Matter Physics & Material Sciences
Dr. B. C. Paul	North Bengal University, Siliguri	06.12.14	14.12.14	Prof. Archan S. Majumdar Astrophysics & Cosmology
Dr. Raju Roychowdhury	Shanghai Jiao Tong University	06.01.15	16.01.15	Prof. Partha Guha Theoretical Sciences
Dr. Surajit Sen	Associate Professor, Gurucharan College, Silchar	16.06.14	24.06.14	Prof. Gautam Gangopadhyay Theoretical Sciences
Dr. Tushar Kanti Dey	Associate Professor, Gurucharan College, Silchar	16.06.14	24.06.14	Prof. Gautam Gangopadhyay Theoretical Sciences
Dr. Tanumoy Pramanik	Postdoctoral Fellow, Telecom Paris Tech, France	28.07.14	12.07.14	Prof. Archan S. Majumdar Astrophysics & Cosmology
Dr. S.R Hassan	Institute of Mathematical Sciences, Chennai	10.08.14	17.08.14	Dr. Manoranjan Kumar Condensed Matter Physics & Material Sciences
Dr. Sujit Sarkar	Assistant Professor, PPISR, Bangalore	16.12.14	17.12.14	Prof. P.S Deo Condensed Matter Physics & Material Sciences
Prof. Ashok Das	Professor, University of Rochester	18.12.14	26.12.14	Prof. Samir Kumar Paul Theoretical Sciences
Dr. Shashi Srivastava	Max Planck Institute for Physics of Complex Systems	01.01.15	12.01.15	Prof. Partha Guha Theoretical Sciences
Tilak B. Katoch	Scientific Officer, TIFR, Mumbai	09.01.15	26.01.15	Prof. Sandip Chakrabarti Astrophysics & Cosmology
Dr. E. Harikumar	Associate Professor, University of Hyderabad	17.02.15	21.02.15	Prof. Partha Guha Theoretical Sciences
Pritha Dolai	Ph.D student, IIT Madras	02.03.15	14.03.15	Dr. Shraddha Mishra Theoretical Sciences

Summer Research Programme 2014

Sl. No.	Supervisor	Candidate Name	Male /Female	Affiliation	Funded by
1	Punyabrata Pradhan	Soutick Saha	M	CMI, Chennai	INSPIRE
2	Ranjan Chaudhury	Priyanka Ghosh	F	Indian School of Mines Dhanbad	SNBNCBS
3	M.Sanjay Kumar	Anuradha Singla	F	University of Hyderabad	SNBNCBS
4	Manu Mathur	Jyotirish Das	M	University of Hyderabad	SNBNCBS
5	Biswajit Chakraborty	Anindita Maiti	F	IIT, Bombay	IAS
6	Manik Pradhan	Deepankar Singh	M	IIT, Delhi	SNBNCBS
7	Soumendu Datta	Shakti Shankar Ray	M	Indian School of Mines	SNBNCBS
8	Archan S Majumder	Suvendu Biswas	M	Delhi University	SNBNCBS
9	S. K. Pal	Aniruddha Adhikari	M	Calcutta University	SNBNCBS
10	Rajib Kumar Mitra	Karanbir Singh Tiwana	M	IIT, Delhi	SNBNCBS
11	Sugata Mukherjee	Debmalya Halder	M	Indian School of Mines	SNBNCBS
12	Anjan Barman	A. P Sushmitha	F	IIT, Delhi	SNBNCBS
13	Soumen Mondal	Manuja Sharma	F	NIT, Jalandhar	SNBNCBS
14	Jaydeb Chakrabarty	Arnab De	M	University of Hyderabad	INSPIRE
15	Subhra Jana	Aritra Biswas	M	IIT, Kharagpur	SNBNCBS
16	P. K. Mukhopadhyay	Pranam Prakash	M	ISP, CUSAT, Kerala	SNBNCBS
17	T. S Dasgupta	Vishnu P K	M	IISER, Mohali	IAS
18	Kalyan Mandal	Anirban Kundu	M	Visva Bharati University	SNBNCBS

Total Students -18,
IAS - 2, INSPIRE - 2,
Centre funded - 14,
Male - 13, Female - 5

Debashree Bhattacharyya
Co-ordinator, EVLP

Theoretical Physics Seminar Circuit

1. Following topical research workshop/Advanced Research Schools were held under TPSC:

'Physics of Low Dimensional Structures (PLDS 2015) in Sambalpur,Odisha,during 25th March to 27th 2015 jointly organisedÊby Vidyasagar University, Midnapore.About 150 participants attended. A sum of Rs. 2,00,000 lakhs was disbursed from TPSC.'

Sakuntala Chatterjee

Sakuntala Chatterjee
Convener, Theoretical Physics Seminar Circuit

Registrar

Shohini Majumder

Report on Administrative Matters

The Centre has rendered administrative support to its academic activities through its administrative and technical staff members who have very professionally and sincerely carried out their duties for making the various activities of the Centre in the year 2014-2015 successful. Staff comprising of strength of approximately 21 in permanent, 12 in temporary and 44 in contractual category as on 31st March 2015, have functioned effectively under the able leadership of the Director and the Registrar. The smooth running of the day to day activities of the Centre including guest house (Bhagirathi), Creche (Kishalay), security, EPABX, transport, canteen, electrical maintenance, AC maintenance, campus maintenance and various other facilities has been made possible due to the professional services provided by the various services contract agencies working closely with the administrative sections of the Centre. The administrative employees of the Centre have been encouraged to attend various training programmes and workshops all through the year so that their administrative and technical abilities are enhanced. The Centre has maintained a close communication with the Department of Science and Technology and some other ministries and have replied to their various enquiries and Parliamentary Questions. The Centre has also faced various audits conducted by CAG and DST successfully. The Hindi Cell of the Centre has been functioning effectively since April 2008 and substantial work has been undertaken regarding implementation of the Official Language. No cases related to vigilance have been reported during the period of 2014-2015. The Centre has also adhered to the norms of the Right to Information Act and so far has received 6 (six) cases under the said Act in the last financial year all of which has been disposed off. One reported case to the Complaints Committee has been successfully disposed off.

Welfare Measures and Language Policy

Official Language Policy

The Centre paid emphasis on implementation of the Official Language in the year 2014-15. According to Rajbhasha Act, reply to Hindi letters was given in Hindi only. All the Official Registers, Forms, Visiting Cards, Letter heads, and seals are in bilingual format. Advertisements, tender notices, office orders and notices are circulated in Hindi also. Many of the internal notings and signing in the Attendance Register (on the first of every month) is done in Hindi. The Centre has its official website in Hindi and some of the important policy documents of the Centre have been translated in Hindi and have been uploaded in the Centre's website. The Centre has also carried out some correspondences in Hindi with the ministry and other organisations. The Centre is a member of Calcutta Town Official Language Implementation Committee (CALTOLIC) and has a Hindi Implementation Committee which meets regularly. Almost 100% of the administrative staff now possess working knowledge of Hindi and have been successfully trained in the 'Praveen' and 'Pragya' courses of the Department of Official Language, Government of India.

The newsletter of the Centre, published quarterly, contains at least one article in Hindi. Miscellaneous jobs like calendar, greetings cards and banners for different Seminars etc. are done in bi-lingual format.

The year also saw Hindi Diwas being celebrated in great zeal, with the month of September being declared as Hindi month. It was officially inaugurated on 13th September by Prof. A. K. Raychaudhuri, Director in presence of Shri. Naveen Prajapati, Shri. R. N. Saroj and Shri. Vipati of Hindi Teaching Scheme. The hindi mahina was celebrated through screening of Hindi Film "Khoobsurat", staging of an in house Cultural programme by 'Muktangan', Hindi Comedy play "Indra ka Gada" performed by 'Padatik' group, Hindi Essay Competition on Scientific Matter and a Hindi Quiz programme.

The Committee of Parliament on Official Language consisting of eminent Parliamentarians visited the Centre to inspect the use of Hindi language in the day to day official work of the Centre. The Centre had put up a colourful kiosk to display the work done by it in Hindi. The meeting was held on 10th February 2015 at ITC, Sonar Bangla.

The Centre organised a 'Hindi Workshop' on 27th March 2015 at Silver Jubilee Hall. The occasion was graced by Shri. Rajesh Chaturvedi, Deputy General Manager (Rajbhasha), State Bank of India and Shri. Vipati of Hindi Teaching Scheme who spoke on "Tippan (Noting) and Alekhan (Drafting) tatha Bharatiya Bhashao ka Computer par Prayog".

Welfare Measure Policy

Through the Contributory Medical Scheme (CMS), the Centre extends medical facilities (both outdoor and indoor) to all its staff members and their dependents (in case of permanent staff members) and to the students and contractual staff members (as individuals) and reimburses medical bills as per CGHS rates. The Centre has its own medical unit to cater to the requirements of the staff members where Allopathic, Homeopath and Ayurvedic physicians are available for regular consultation. Facilities like oxygen, wheel chair, stretcher, rest bed etc. are readily available apart from First Aid treatments. The Centre also has tie ups under CGHS with some of the renowned hospitals in Kolkata viz. Apollo Gleneagles Hospitals, B. M. Birla Heart Research Centre, Peerless Hospital & B.K.Roy Research Institute, Desun Hospital & Heart Institute, AMRI Hospitals etc who provide cash less indoor hospitalisation facility. Only, AMRI Hospitals provide both indoor and outdoor cash less facility.

The Centre organised a training programme for its staff members on Noting, Drafting and Office Management at 'BOSON' of the Centre from 29th April 2014 to 2nd May 2014, conducted by eminent faculties of IISWBM, Kolkata. The Center observed 'Swachhata Diwas' on 2nd October 2014 and the staff and students took the cleanliness oath.

The Centre has Crèche facilities (Kishlay) for children of staff and students of the Centre.

The Centre houses a modern Guest House by the name of 'Bhagirathi' comprising of 57 air conditioned rooms (including Single Bed, Double Bed & Transit rooms), 5 air conditioned suites and a fully AC Seminar cum Dining Hall and Kitchen with modern facilities and Seminar room. 'Bhagirathi' also has an equipped Doctor's chamber and two Air Conditioned office rooms. The Centre has two hostels by the name 'Radhachura' and 'Krishnachura' and an Essential Staff Quarter (Subarnarekha) which provides hostel accommodation to approximately 32 and 122 students respectively and accommodation facilities for its staff. The students residing in the Centre run their own mess and the hostels have facilities like dining rooms, common rooms etc. The Centre also has some provision of providing accommodation for its Post Doctoral Fellows outside the Centre.

The Centre has modernly equipped Lecture Halls / Seminar Halls namely : Silver Jubilee Hall (120 sitting capacity), BOSON (60 sitting capacity) and FERMION (80 sitting capacity) with latest lecture facilities to cater to the various events organised viz. Lectures, Seminars, Colloquiums, Symposiums, Training programmes, Cultural Programmes, etc.

The members of the Bose Centre family have formed a club called 'Muktangan' to promote various creative activities in the Centre which supports 5 broad activities viz. Performing Arts, Literary Arts, Visual Arts, Sports Activities, Social Outreach. 'Muktangan' organised several programmes under its aegis during the year 2014-15.

While concluding, I would like to express my sincere thanks to the three Deputy Registrars of Administration, Finance and Academic sections and to all the administrative and academic staff members of the Centre for their support and cooperation for smooth running of the administration. I am also grateful to Prof. A.K.Raychaudhuri, former Director (till September 2014), and Prof. Sibaji Raha, present Director (since October 2014) for their valuable guidance and advice.

Shohini Majumder
Registrar

Committees

Governing Body

Dr. Ashutosh Sharma *Chairman*
Secretary
Department of Science & Technology
Government of India, New Delhi

Prof. G. K. Mehta *Member*
Dist. Hon. Prof. IIT Kanpur & Hon. Eminent Scientist
Inter University Accelerator Centre, New Delhi

Prof. T. V. Ramakrishnan *Member*
Emeritus Professor, BHU & Distinguished Associate,
Centre for Condensed Matter Physics, IISc. Bangalore
Banaras Hindu University, Varanasi

Prof. Mustansir Barma *Member*
Distinguished Professor & former Director,
Tata Institute of Fundamental Research
Mumbai

Shri. J.B. Mahapatra *Member*
Joint Secretary & Financial Adviser
Department of Science & Technology, New Delhi

Prof. Sibaji Raha *Member*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Shri Sanjay Mitra, **IAS**, *Member*
Chief Secretary, Government of West Bengal
Kolkata
(represented by Shri. Vivek Kumar, IAS, Secretary, Higher Education Department)

Prof. Santanu Bhattacharya *Permanent Invitee*
Director
Indian Association for the Cultivation of Science
Kolkata

Ms. Shohini Majumder *Non-Member Secretary*
Registrar
S. N. Bose National Centre for Basic Sciences
Kolkata

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Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Dr. Praveen Chaddah *Member*
Former Director
UGC-DAE Consortium for Scientific Research
Indore

Shri. J. B. Mahapatra *Member*
Joint Secretary & Financial Adviser
Department of Science & Technology
New Delhi

Ms. Shohini Majumder *Member Secretary*
Registrar
S. N. Bose National Centre for Basic Sciences
Kolkata

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Former Director
UGC-DAE Consortium for Scientific Research
Indore

Prof. Swarnakanti Ghosh *Member*
Director, NCRA, Pune

Prof. Sanjay Puri *Member*
Professor, JNU, New Delhi

Prof. Amitabha Raychaudhuri *Member*
Professor, Calcutta University, Kolkata

Prof. Dilip G. Kanhere *Member*
Distinguished Professor, University of Pune

Prof. Amalendu Chandra *Member*
Professor, IIT, Kanpur

Prof. Raghavan Varadarajan *Member*
Professor, IISc, Bangalore

Prof. Sibaji Raha *Member*
Director
S. N. Bose National Centre for Basic Sciences

Prof. Rabin Banerjee *Member*
Dean (Faculty)
S. N. Bose National Centre for Basic Sciences

Prof. Amitabha Lahiri *Member*
Dean (Academic Programme)
S. N. Bose National Centre for Basic Sciences

Ms. Shohini Majumder *Member*
Registrar
S. N. Bose National Centre for Basic Sciences

Prof. S. K. Chakrabarti *Permanent Invitee*
Head, Department of Astrophysics and Cosmology
S. N. Bose National Centre for Basic Sciences

Prof. Manu Mathur *Permanent Invitee*
Head, Department of Theoretical Sciences
S. N. Bose National Centre for Basic Sciences

Prof. P. K. Mukhopadhyay *Permanent Invitee*
Head, Department of Condensed Matter Physics
and Material Sciences
S. N. Bose National Centre for Basic Sciences

Prof. Ranjit Biswas *Permanent Invitee*
Head, Department of Chemical, Biological
and Macromolecular Sciences
S. N. Bose National Centre for Basic Sciences

Ms. Nibedita Konar *Non-Member Secretary*
Deputy Registrar (Academic)
S. N. Bose National Centre for Basic Sciences

Building Committee

Prof. Sibaji Raha *Chairman*
Director
S. N. Bose National Centre for Basic Sciences

Ms. Shohini Majumder *Member- Secretary*
Registrar
S. N. Bose National Centre for Basic Sciences

Mr. Asim Sinha *Member*
Chief Engineer (Retired) Electrical, CPWD

Prof. Sibabrata Halder *Member*
Head, Department of Architecture,
Bengal Engineering and Science University, Sibpur

Shri. Ranadhir Dey *Member*
Outstanding Scientist, VECC

Mr. Jnanda Ranjan Bhattacharya *Special Invitee*
Superintending Engineer
S. N. Bose National Centre for Basic Sciences

Mr. Apurba Kanti Sarkar *Special Invitee*
Deputy Registrar (Finance)
S. N. Bose National Centre for Basic Sciences

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Director
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Prof. Rabin Banerjee *Member*
Dean (Faculty)
S. N. Bose National Centre for Basic Sciences

Prof. Amitabha Lahiri *Member*
Dean (Academic Programme)
S. N. Bose National Centre for Basic Sciences

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Head, Department of Theoretical Sciences
S. N. Bose National Centre for Basic Sciences

Prof. S. K. Chakrabarti *Member*
Head, Department of Astrophysics and Cosmology
S. N. Bose National Centre for Basic Sciences

Prof. Ranjit Biswas *Member*
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S. N. Bose National Centre for Basic Sciences

Prof. Pratip Kumar Mukhopadhyay *Member*
Head, Department of Condensed Matter Physics and Material Sciences
S. N. Bose National Centre for Basic Sciences

Ms. Shohini Majumder *Member*
Registrar
S. N. Bose National Centre for Basic Sciences

Mr. Apurba Kanti Sarkar *Member*
Deputy Registrar (Finance)
S. N. Bose National Centre for Basic Sciences

Ms. Nibedita Konar *Member - Secretary*
Deputy Registrar (Academic)
S. N. Bose National Centre for Basic Sciences

Official Language Implementation Committee

Prof. Sibaji Raha *Chairman*
Director
S. N. Bose National Centre for Basic Sciences

Ms. Shohini Majumder *Member*
Registrar
S. N. Bose National Centre for Basic Sciences

Prof. Manu Mathur *Member*
Professor
S. N. Bose National Centre for Basic Sciences

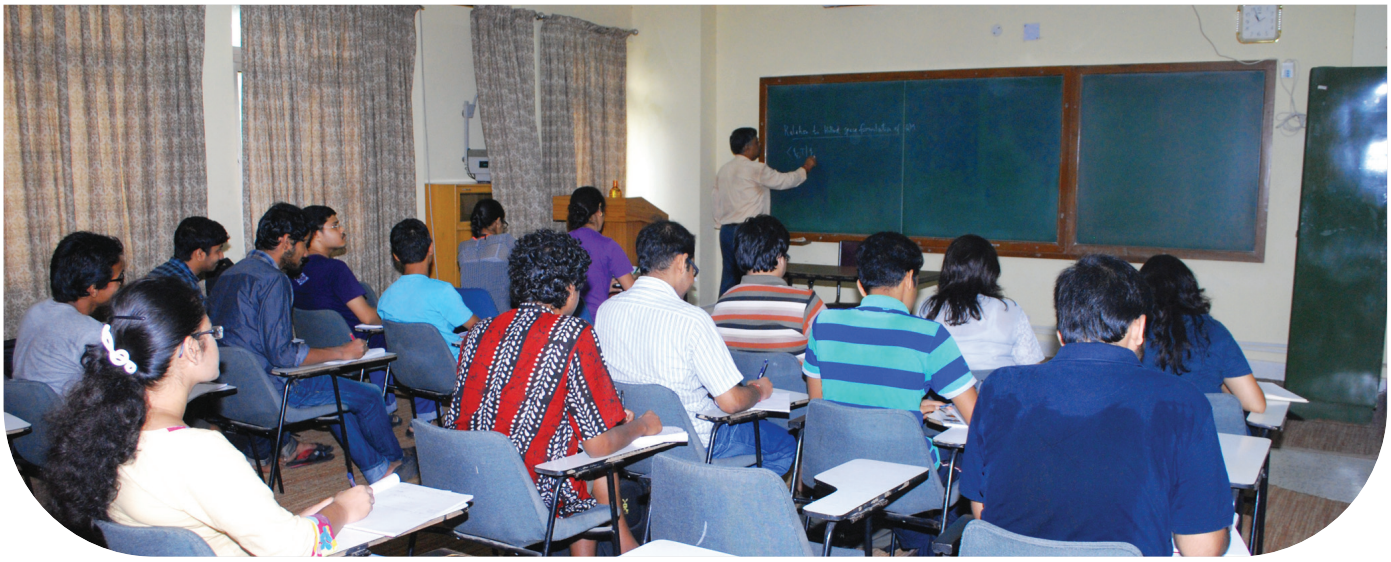
Mr. Apurba Kanti Sarkar *Member*
Deputy Registrar (Finance)
S. N. Bose National Centre for Basic Sciences

Mr. Sirsendu Ghosh *Member*
In-charge, Hindi Cell
S. N. Bose National Centre for Basic Sciences

Mr. Santosh Kumar Singh *Member*
AR (Purchase) & DR (Administration) - Officiating
S. N. Bose National Centre for Basic Sciences

Mr. Prashant Singh *Member*
Part-time Hindi Officer
S. N. Bose National Centre for Basic Sciences

People at the Centre



Academic Members

FACULTY MEMBERS

1	Arup Kumar Raychaudhuri (till 30.09.2014)	Director & Distinguished Professor, CMPMS
2	Amitabha Lahiri	Professor & Dean (AP), TS
3	Anita Mehta	Senior Professor, TS
4	Anjan Barman	Professor, CMPMS
5	Archan S. Majumdar	Professor, A&C
6	Barnali Ghosh	Scientist-E (Technical Cell), CMPMS
7	Biswajit Chakraborty	Professor, TS
8	Gautam Gangopadhyay	Professor, CBMS
9	Jaydeb Chakrabarti	Professor, CBMS
10	Kalyan Mandal	Professor, CMPMS
11	Manik Pradhan	Assistant Professor, CBMS
12	Manoranjan Kumar	Assistant Professor, CMPMS
13	Manu Mathur	Professor & HOD, TS
14	M. Sanjay Kumar	Associate Professor, TS
15	Partha Guha	Professor, TS
16	Pratip Kr. Mukhopadhyay	Professor & HOD, CMPMS
17	Priya Mahadevan	Professor, CMPMS
18	Prosenjit Singha Deo	Professor, CMPMS
19	Punyabrata Pradhan	Assistant Professor, TS
20	Rabin Banerjee	Senior Professor & Dean (Faculty), TS
21	Rajib Kumar Mitra	Assistant Professor, CBMS
22	Ramkrishna Das	Faculty Fellow, A&C
23	Ranjan Chaudhury	Associate Professor, CMPMS
24	Ranjit Biswas	Professor & HOD, CBMS
25	Sakuntala Chatterjee	Assistant Professor, TS
26	Samir K. Pal	Professor, CBMS
27	Samir K Paul	Associate Professor, TS

FACULTY MEMBERS

28	Sandip K. Chakrabarti	Senior Professor & HOD, A&C
29	Sanjoy Choudhury	Scientist-C (Computer Services Cell)
30	Soumen Mondal	Assistant Professor, A&C
31	Subhrangshu Sekhar Manna	Senior Professor, TS
32	Sugata Mukherjee (till 30.11.2014)	Associate Professor, CMPMS
33	Tanusri Saha Dasgupta	Professor & Associate Dean (Faculty), CMPMS

DISTINGUISHED PROFESSOR (EMERITUS)

1	Arup Kumar Raychaudhuri (from 01.10.2014)	CMPMS

EMERITUS PROFESSORS

1	Abhijit Mookerjee	CMPMS
2	Subodh Kumar Sharma	TS

SENIOR VISITING SCIENTIST

1	B. B. Bhattacharya	TS

RESEARCH SCIENTIST

1	Mahua Ghosh	CBMS

BOSE FELLOW

1	Chhayabrita Biswas (till 10.09.2014)	CMPMS

SCIENTIST-D

1	Amitava Moitra	TUECMS
2	Bhushan Omprakash Awasarmol (from 04.08.2014)	TUECMS
3	Biswaroop Mukherjee	TUECMS
4	Chacko Sajeev Sakai (till 01.08.2014)	TUECMS
5	Jaivardhan Sinha (from 31.10.2014)	TUENDT
6	Kaustuv Das	TUENDT
7	Saswati Barman	UNANST

SCIENTIST-C

1	Arabinda Halder (till 30.05.2014)	TUENDT
2	Sudeshna Samanta	UNANST

DST INSPIRE FACULTY MEMBERS

1	Amlan Dutta	CMPMS
2	Partha Mahata	CMPMS
3	Shradha Mishra	TS
4	Soumendu Datta	CMPMS
5	Subhra Jana	CBMS

VISITING FACULTY MEMBERS

1	Madhuri Mandal (from 01.07.2014)	CMPMS
2	Srabanti Ghosh (from 08.10.2014)	CBMS
3	Sugata Mukherjee (from 01.12.2014)	CMPMS

YOUNG SCIENTIST

1	Alo Dutta (from 02.02.2015)	CMPMS

POST DOCTORAL RESEARCH ASSOCIATES

1	Ankita Ghatak (from 06.08.2014)	CMPMS
2	Bipul Das (till 03.08.2014)	CMPMS
3	Bipul Rakshit (till 05.08.2014)	CMPMS
4	Dayasindhu Dey (from 21.01.2015)	CMPMS
5	Goutam Kumar Chandra (from 06.02.2015)	CBMS
6	Jashashree Ray (from 09.03.2015)	CMPMS
7	Lakshmi Maganti (from 03.11.2014)	CBMS
8	Madhuri Mandal (till 30.06.2014)	CMPMS
9	Pabitra Mandal	CMPMS
10	Partha Sarathi Pal	A&C
11	Prasanna Kumar Mondal (till 01.02.2015)	CBMS
12	Rohit Kumar	TS
13	Rajib Nath (from 04.03.2015)	CMPMS
14	Sanchari Goswami	TS
15	Suman Ghosh	TS
16	Swastika Bhattacharya Chatterjee (till 21.07.2014)	CMPMS
17	Tilak Das	CMPMS
18	V. V. Ravi Kishore (till 31.08.2014)	CMPMS

A & C : Department of Astrophysics & Cosmology
CBMS : Department of Chemical, Biological & Macro-Molecular Sciences
CMPMS : Department of Condensed Matter Physics and Material Sciences
TS : Department of Theoretical Sciences
TUECMS : Thematic Unit of Excellence on Computational Materials Science
TUENDT : Thematic Unit of Excellence on Nanodevice Technology
UNANST : Unit for Nanoscience and Technology

Administrative & Technical Staff Members

Shohini Majumder	Registrar
Sugata Mukherjee	Vigilance Officer (till 30th November 2014)
Gautam Gangopadhyay	Vigilance Officer (w.e.f. 1st December 2014)
Saumen Adhikari	Public Information Officer

Other Members

1	Apurba Kanti Sarkar	Deputy Registrar (Finance)
2	Nibedita Konar	Deputy Registrar (Academic) (joined on 1st April 2014)
3	Avijit Ganguly	Campus Engineer cum Estate Officer (till 29th September 2014)
4	Saumen Adhikari	Librarian cum Information Officer
5	Sukanta Mukherjee	Sr. Assistant Registrar (Projects)
6	Santosh Kumar Singh	Assistant Registrar (Purchase) & Officiating as Deputy Registrar (Administration) w.e.f. 5th May 2014
7	Sirsendu Ghosh	Programme Coordinating Officer
8	Tapan Kumar Sen	Senior Programme Assistant
9	Achyut Saha	Personal Assistant to Director
10	Jaydeep Kar	Programme Assistant
11	Prosenjit Talukdar	Programme Assistant
12	Shiba Prasad Nayak	Pump Operator
13	Aditya Pal Choudhury	Project Assistant (superannuated on 31st October 2014)
14	Bijoy Kumar Pramanik	Junior Assistant (Guest House)
15	Bhupati Naskar	Library Stack Assistant
16	Arun Kumar Bhattacharya	Library Stack Attendant
17	Sushanta Kumar Biswas	Driver
18	Pradip Kumar Bose	Tradesman 'A'
19	Partha Chakraborty	Attendant
20	Partha Mitra	Attendant
21	Ratan Acharya	Attendant
22	Swapan Ghosh	Attendant

Personnel with Temporary Status

1	Biman Roy	Attendant (Administration)
2	Dulal Chatterjee	Attendant (Maintenance)
3	Somnath Roy	Attendant (Accounts)
4	Sudhanshu Chakraborty	Attendant (Technical Cell)
5	Sukamal Das	Attendant (Central Registry)
6	Hiralal Das	Cleaner
7	Kartick Das	Cleaner
8	Motilal Das	Cleaner
9	Prakash Das	Cleaner
10	Ramchandra Das	Cleaner
11	Biswanath Das	Cleaner
12	Nimai Naskar	Cleaner

Personnel on Contractual Appointment

1	Sukumar Sarkar	Consultant (Administration)
2	Sunish Kumar Deb	Consultant (Liaison)
3	Dipankar Mukhopadhyay	Project (Advisor)
4	Jnanada Ranjan Bhattacharya	Superintending Engineer
5	Debashree Bhattacharyya	EVLP Co-ordinator
6	Ayan Deb	Assistant Engineer (Electrical) (joined on 2nd March 2015)
7	Sutapa Basu	PS to Registrar
8	Abhijit Ghosh	Junior Computer Engineer
9	Abhijit Roy	Junior Computer Engineer
10	Sagar Samrat De	Junior Computer Engineer
11	Amit Roy	Technical Assistant (Library)
12	Gurudas Ghosh	Technical Assistant (Library)
13	Ananya Sarkar	Technical Assistant (Library)
14	Dipankar Roy	Technical Assistant
15	Shakti Nath Das	Technical Assistant
16	Surajit Mukherjee	Technical Assistant
17	Urmi Chakraborty	Technical Assistant

18	Amit Kumar Chanda	Technical Assistant
19	Ganesh Gupta	Junior Engineer (Electrical)
20	Supriyo Ganguly	Junior Engineer (Electrical)
21	Amitava Palit	Junior Engineer (Civil)
22	Asish Nandy	Junior Engineer (Civil)
23	Lakshmi Chattopadhyay	Junior Engineer (Civil)
24	Chandrakana Chatterjee	Office Assistant
25	Rupam Porel	Office Assistant
26	Mitali Bose	Office Assistant
27	Suvodip Mukherjee	Office Assistant
28	Swarup Dutta	Office Assistant
29	Moumita Banik	Office Assistant
30	Dipanjan Dey	Office Assistant (resigned w.e.f. 13th June 2014)
31	Suvendu Dutta	Office Assistant
32	Siddhartha Chatterjee	Office Assistant
33	Atrayee Bhattacharya	Office Assistant (joined on 1st July 2014)
34	Sonali Sen	Office Assistant
35	Lina Mukherjee	Jr. Office Assistant
36	Debasish Mitra	Telephone Operator
37	Jinia Deb	Telephone Operator (resigned w.e.f. 4th May 2014)
38	Amit Kumar Ghosh	Mechanic
39	Sani Amed Ali Molla	Technician (AC & Refrigeration)
40	Babulal Sardar	Technician (AC & Refrigeration)
41	Arvind Paswan	Driver
42	Gobinda Das	Driver
43	Kalyani Ghosh	Caretaker (Creche)
44	Suranjan Deb	Telephone Technician
45	Prashant Tewari	Hindi Officer (Part –time)
46	Harishikesh Nandi	Glass Blower (Part-time)

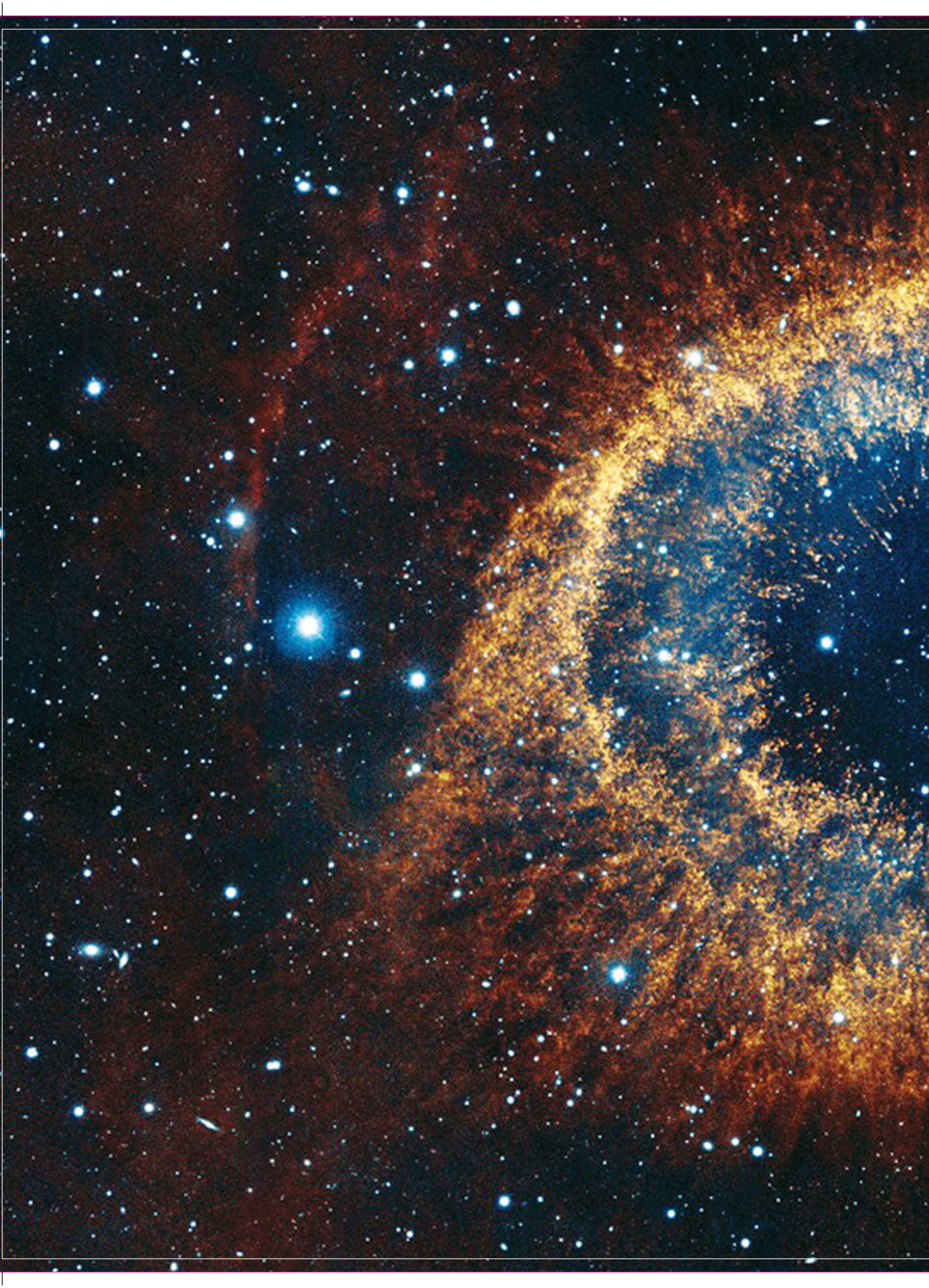
Consultant Physician

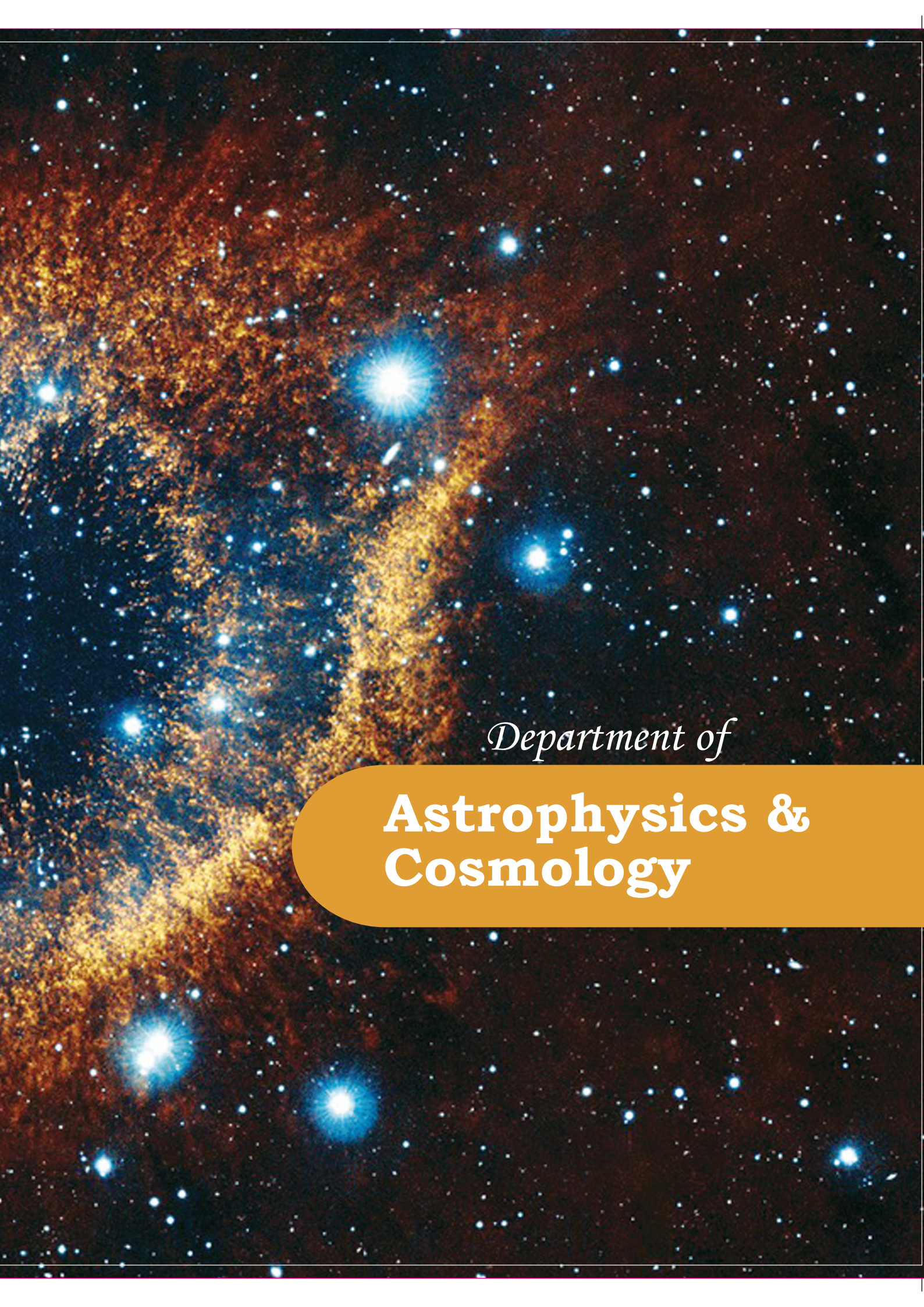
1	Dr. Swapan Kumar Bhattacharyya	Authorised Medical Officer
2	Dr. Sarbani Bhattacharya	Medical Officer
3	Dr. Tridib Kumar Sarkar	Doctor of Homeopathy
4	Dr. Gopal Chandra Sengupta	Doctor of Ayurvedic

Republic Day Celebration-2015

Visit of Dr. Harsh Vardhan, Hon'ble Union Minister for Ministry of Science & Technology & Earth Sciences, Govt. of India at Centre

Tree Plantation in SNBNCBS Campus





Department of

Astrophysics & Cosmology

Department of Astrophysics & Cosmology

Prof. Sandip Kumar Chakrabarti
Head of the Department

Departmental Statistics

Table A: Manpower and resources

Number of faculties	4
Number of Post–doctoral research associate (centre+project)	2
Number of Ph.D students	18
Number of other project staff	0
Number of summer students	6
Projects (ongoing)	2

Table B: Research Activities indicators

Number of research papers in Journals	18
Number of Book-chapters/books	0
Number of other publications	4
Number of Ph.D students graduated (submitted+degree awarded)	9
Number of M.Tech/M.Sc projects	0

Table C: Academic activities and likeage

Number of courses taught by faculties	7	
Number of Visitors (non–associates)	1	
Number of associates	0	
Number of Seminars organized	4	
Number of Conference/Symposia/ Advanced Schools organized	0	
Number of talks delivered by members of department in conferences/Symposia	National	20
	International	7

Most important research highlights

- Fitted RXTE Satellite data of several black hole spectra using Chakrabarti-Titarchuk solution after its implementation in NASA/XSPEC Package
- Numerical simulations established the desegregation of an accretion flow into Keplerian and Sub-Keplerian components in presence of intermediate viscosity
- Theoretically established that Quasi-Periodic Oscillation of X-rays is due to resonance between cooling time scale and in-fall time scale

- Derived a new steering inequality based on a fine-grained uncertainty relation to capture EPR-steering for bipartite systems
- Pointed out how intra-particle entanglement is more useful than inter-particle entanglement to decouple device errors from channel errors in a natural way
- Investigated the emergent universe scenario in the presence of interacting fluids
- Analyzed stellar content of a young cluster NGC~2282, a young cluster in Monoceros constellation, using deep optical BVI and IPHAS photometry along with infrared (IR) data from UKIDSS, and Spitzer-IRAC
- Long term monitoring of MASTER Optical transient J212444.87+321738.3 which was earlier discovered by us
- Analyzed near-infrared (1-2.5 μm) JHK photo-spectroscopic results of the unusually slow nova V5558 Sgr and showed that the spectra changes significantly in the later phase where broad emission lines of HI, HeI, OI, NI are seen
- We performed an analysis of elemental abundances of ejecta of the recurrent nova RS Oph using the CLOUDY photoionization code

Summary of research activities

(a) Relativistic Astrophysics around black holes: We successfully fitted spectra of several black holes using two component advective flow (TCAF) solution of Chakrabarti-Titarchuk. By numerical simulation coupled to radiative transfer process, we show that such TCAF is a stable structure. Theoretically we show that the Centrifugal barrier of accreting matter will oscillate and produce hard X-rays of oscillating intensity if the Comptonization cooling time scale is comparable with the in-fall time scale.

(b) Ionospheric perturbations in presence of terrestrial and extra-terrestrial high energy phenomena: We study ionospheric changes due to high energy phenomena by theoretical and observational means assuming the whole earth's ionosphere behaves as a gigantic detector. We show that Very Low Frequency radio Wave Propagation over ice mass is attenuated as compared to the signal passing over the ocean.

(c) Astrochemistry of pre-biotic molecules: We use a hydrodynamical code coupled to a chemical evolution code in presence of ice grains to study how complex bio-molecules such as Adenine is created in interstellar medium (ISM).

(d) We have derived a new steering inequality based on a fine-grained uncertainty relation to capture EPR-steering for bipartite systems. Our steering inequality can experimentally detect all steerable two-qubit Werner states with two measurement settings on each side.

(e) We point out how intra-particle entanglement, can be more useful compared to inter-particle entanglement. In particular, by virtue of its local nature, the amount of Bell-inequality violation in intra-particle entanglement must be measured locally.

(f) Incompatible measurements in quantum theory always lead to Einstein-Podolsky-Rosen (EPR)-Schrödinger steering. Channel steering which is a generalized notion of EPR-Schrödinger steering, has been introduced recently. We have established a connection between lack of joint measurability and channel steering.

(g) We investigated the emergent universe scenario in the presence of interacting fluids. The non-linear equantion of state (EoS) considered in the general theory of relativity for obtaining emergent universe is effectively a cosmological model with a composition of three fluids. We show that the generalized second law of thermodynamics is found to hold good in the emergent universe with interacting fluids.

(h) We present the analysis of the stellar content of a young cluster NGC~2282, a young cluster in Monoceros constellation, using deep optical BVI and IPHAS photometry along with infrared (IR) data from UKIDSS, and Spitzer-IRAC. Based on the radial density profile and stellar surface density analysis using nearest neighborhood method, the radius of the cluster is estimated to be 3.15 arcmin. Based on the optical and near-IR colour-magnitude diagram analyses, the cluster age has been estimated to be in the range of 2 - 5 Myr, which is in agreement with the estimated age from disk fraction Masses.

(i) We performed optical long-term monitoring observations and long-term optical/near-IR spectroscopic observations of the MASTER OT J212444.87+321738.3. The source was monitored in optical I-band and unfiltered CCD (400—900 nm) over 550 days. Interestingly, the source shows the period of about 465 days with variability amplitude of about 4 mag in I-band and 3.4 mag in unfiltered CCD respectively.

(j) Near-IR studies of nova V5558 Sgr: We have analyzed near-infrared (1-2.5 μm) JHK photo-spectroscopic results of the unusually slow nova V5558 Sgr. V5558 Sgr showed a slow climb to maximum that lasted for about 60 days and then underwent at least five strong secondary outbursts. From the optical light curve we derive large t_2 and t_3 values of about 281 and 473 days respectively. The spectra show significant changes in the later phase with the development of strong and broad (~ 1000 km s^{-1}) emission lines of HI, HeI, OI, and NI and some uncommon Fe II emission lines.

(k) Photoionization modeling of RS Oph: We performed an analysis of elemental abundances of ejecta of the recurrent nova RS Oph using the CLOUDY photoionization code We generate synthetic spectra and obtain the best fit model parameters through the $\%^2$minimization technique. The best-fit model parameters are compatible with a hot white dwarf source with TBB of 5.5–5.8 10^5K and roughly constant a luminosity of 6–8 10^{36} ergs s^{-1}. We estimate an ejected mass in the range of 3.4–4.9 10^{-6} M. which is consistent with other observational results. (Das & Mondal, New Astronomy, 2015)

Sandip Kumar Chakrabarti
Head, Department of Astrophysics and Cosmology

Archan Subhra Majumdar

Professor
archan@bose.res.in

Archan S. Majumdar is a theoretical physicist working in the dual fields of

(i) gravitation and cosmology, and

(ii) quantum information and foundations.

- Gravitation & Cosmology: dark energy from various perspectives
- Quantum Information & Foundations: entanglement, nonlocality and uncertainty relations

We have derived a new steering inequality based on a fine-grained uncertainty relation to capture EPR-steering for bipartite systems. Our steering inequality can experimentally detect all steerable two-qubit Werner states with two measurement settings on each side. According to our inequality, pure entangled states are maximally steerable. Moreover, the amount of violation of our inequality for a given state is functionally related to the violation of the CHSH inequality by that state. Finally, we prove that the secret key rate measured in a one-sided device independent quantum key distribution can be used to certify the steerability of the quantum states used in the protocol.

It is known that entanglement helps enhance security of practical quantum key distribution against certain classes of attacks that exploit flaws in the devices. However, bipartite or multipartite entanglement itself is a costly resource. We point out how intra-particle entanglement, which is easily generated using linear optics, can be useful here, comparing and contrasting its usage with conventional, inter-particle entanglement. In particular, by virtue of its local nature, the amount of Bell-inequality violation in intraparticle entanglement must be measured locally. This, in turn, helps decouple device errors from channel errors in a natural way. The amount of Bell-inequality violation observed by Alice determines the error that can be tolerated in the channel. We illustrate these ideas by means of a simple incoherent attack on the channel, augmented by a side channel attack on the devices used.

Incompatible measurements in quantum theory always lead to Einstein-Podolsky-Rosen (EPR)-Schr\"{o}dinger steering. Channel steering which is a generalized notion of EPR-Schr\"{o}dinger steering, has been introduced recently. We have established a connection between lack of joint measureability and channel steering.

We have investigated the emergent universe scenario in the presence of interacting fluids. The non-linear equantion of state (EoS) considered in the general theory of relativity for obtaining emergent universe is effectively a cosmological model with a composition of three fluids. In this work we consider two models to realize viable cosmological scenarios, viz., (i) a two-fluid model with interaction of a pressureless fluid with the fluid having the non-linear EoS needed for the emergent universe, and (ii) a three-fluid model with interaction among the three fluids which originate from the EoS of the emergent universe. It is found that realistic cosmological models in accordance with observations are not ruled out for both the above cases. We further show that the generalized second law of thermodynamics is found to hold good in the emergent universe with interacting fluids.

Future Plan

We will study the effect of quantum statistics on the arrival time distribution of quantum particles computed through the probability current density. In order to investigate the effect of statistics on the weak equivalence principle in quantum mechanics (WEQ), we will compute the mean arrival time for wave packets in free fall. We will also evaluate the effect of spin on the violation of WEQ using a different approach by including an explicit spin-dependence in the probability current distribution, and compare it with the approach using particle statistics.

The emergent universe (EU) is evolved out of a static Einstein universe in the infinite past. Recently assuming interacting

fluids a viable cosmological model is constructed where the observed features of the present universe may be recovered for a universe with a given composition of fluid necessary in the early universe. But it is not clear how the static Einstein Universe in the infinite past required at the initial epoch of an EU scenario came into existence. We will investigate the very early universe in the framework of gravitational instanton to obtain such a static Einstein universe needed for a viable EU scenario.

We will derive a fine-grained uncertainty relation for the measurement of two incompatible observables on a single quantum system of continuous variables, and show that continuous variable systems are more uncertain than discrete variable systems. Using the derived fine-grained uncertainty relation, we will formulate stronger steering criterion. We will further obtain a monogamy relation for our steering inequality which should lead to in principle, an improved lower bound on the secret key rate of a one-sided device independent quantum key distribution protocol for continuous variables.

Considering temporal correlations of particles with arbitrary spin, we will show that the Leggett-Garg inequality can be maximally violated irrespective of the value of spin. We will next consider generalized or unsharp measurements as a method for coarse graining in a quantitative manner, and show that classicality emerges below a precise value of the sharpness parameter. Satisfaction of the Leggett-Garg inequality will be shown to be a necessary and sufficient condition for macroscopic realism.

Publications in Journals

1. T. Pramanik, M. Kaplan and **A. S. Majumdar**, *Fine-grained Einstein-Podolsky-Rosen-steering inequalitites*, Phys. Rev. A, **90**, 050305 (R) (2014).
2. S. Adhikari, D. Home, **A. S. Majumdar**, A. K. Pan, A. Shenoy, R. Srikanth, *Toward secure communication using intra-particle entanglement*, Quant. Inf. Process., **14**, 1451 (2015).
3. M. Banik, S. Das, **A. S. Majumdar**, *Measurement incompatibility and channel steering*, Phys. Rev. A, **91**, 062124 (2015).
4. B. C. Paul and **A. S. Majumdar**, *Emergent universe with interacting fluids and the generalized second law of thermodynamics*, Class. Quant. Grav., **32**, 115001 (2015).

Supervision of Students

Ph.D. Students: Nilok Bose (Ph.D awarded), Tanumoy Pramanik (Ph.D awarded), Nirman Ganguly (Thesis submitted), Priyanka Chowdhury, Subhadipa Das, Siladitya Mal, Pratik Tarafdar, Shounak Datta (Project), Suchetana Goswami (Project)

Project Students: Ritam Basu, "Thermodynamical aspects of quantum information theory"; Suvendu Biswas, "Introduction to general theory of relativity and cosmology"; Riddhi Chatterjee, "A study on cosmology"

Post Doctoral Research Scientist: Amna Ali

Independent Publication of Student/s

1. D. Saha, S. Mal, P. K. Panigrahi, D. Home, *Wigner's form of the Leggett-Garg inequality, the no-signaling-in-time condition, and unsharp measurements*, Phys. Rev. A, **91**, 032117 (2015).

Lectures Delivered

1. "EPR steering and nonlocality of non-Gaussian resources", Quantum 14, INRIM, Turin, Italy, May 2014.
2. "Quantum uncertainty and quantum coherence", Quantum Coherence: theory meets experiment, IACS, Kolkata, July 2014.
3. "Information theoretic applications of quantum uncertainty relations", National Conference on Mathematical Modelling in Theoretical Physics, Heritage Institute of Technology, Kolkata, August 2014.
4. "Does backreaction affect future evolution?", International Conference on Matters of Gravity in the Universe, JMI Delhi, October 2014.
5. "Continuous variable quantum steering and nonlocality", Recent Trends in Information Optics and Quantum Optics, IIT Patna, November 2014.
6. "Witnessing resources for quantum information", ECE Department Colloquium, IISC Bangalore, January 2015.
7. "Backreaction from inhomogeneities and the future evolution of the universe", Exploring the Cosmos, NBU, Siliguri, January 2015.
8. "The dark energy problem and backreaction from inhomogeneities", UGC-DRS National Seminar on 100 years of General Relativity, Utkal University, Bhubaneswar, March 2015.
9. "Witnesses for quantum information processing resources", National Seminar on Recent Trends in Applied Mathematics and its Computational Aspects, Deptt. App. Maths. CU, Kolkata, March 2015.

Courses Taught

PHY 292, PHY 401, PHY 304, PHY 591 (project based courses)

Membership of Committees

Internal Committee: Conference, Workshop and Extension Committee, Faculty Search Committee, Computer Refurbishment Committee, Transport Committee

Sponsored Project

1. DST Project: "Fundamental aspects of quantum theory and quantum information"

Ramkrishna Das

Faculty Fellow
ramkrishna.das@bose.res.in

My research interests lie in the observational studies of variable stars with emphasis on eruptive variables like novae. I use multi-wavelength observational data and model spectra to understand such phenomena. Besides astronomical observations, I am also interested in astronomical instrumentation.

- Spectroscopic and photometric studies of novae
- Study of variable stars
- Modeling of spectra
- Astronomical Instrumentation

1. Near-IR studies of nova V5558 Sgr: We have analyzed near-infrared (1-2.5 μm) JHK photo-spectroscopic results of the unusually slow nova V5558 Sgr. V5558 Sgr showed a slow climb to maximum that lasted for about 60 days and then underwent at least five strong secondary outbursts. From the optical light curve we derive large t_2 and t_3 values of about 281 and 473 days respectively. The spectra show significant changes in the later phase with the development of strong and broad (~1000 km s^{-1}) emission lines of HI, HeI, OI, and NI and some uncommon Fe II emission lines. A recombination analysis of the Brackett lines allows us to constrain the electron density and emission measure during the early optically thick phase and to estimate the mass of the ejecta to be ~ 6.0 x 10^{-4} M_{sun}, assuming a filling factor of unity, from later observations. We have shown why the usual MMRD (maximum magnitude vs. rate of decline) relations cannot be applied to this nova and use an alternative approach to derive a distance estimate of ~1.55 kpc to the nova. In the process we propose a new method to derive the distance and extinction to novae. (Das et al. MNRAS, 2015)
2. Photoionization modeling of RS Oph: We performed an analysis of elemental abundances of ejecta of the recurrent nova RS Oph using the CLOUDY photoionization code. Our primary aim was to find the elemental abundances in the ejecta. We generate synthetic spectra by varying several parameters, the model generated spectra are then matched with the observed emission line spectra obtained at two epochs. We obtain the best fit model parameters through the χ^2minimization technique. The best-fit model parameters are compatible with a hot white dwarf source with T_{BB} of 5.5–5.8×10^5K and roughly constant a luminosity of 6–810^{36}ergs s^{-1}. From the analysis we find the following abundances (by number) of elements with respect to solar: He/H=1.8, N/H=12.0, O/H=1.0, Ne/H=1.5, Si/H=0.4, Fe/H=3.2, Ar/H=5.1, and Al/H=1.0, all other elements were set at the solar abundance. These values show the ejecta are significantly enhanced, relative to solar, in helium, nitrogen, neon, iron and argon. Using the obtained parameter values, we estimate an ejected mass in the range of 3.4–4.9×$10^{-6}$$M_\odot$ which is consistent with other observational results. (Das & Mondal, New Astronomy, 2015)
3. Observations: We have pursued spectroscopic & photometric observations of several astronomical objects (J212444.87+ 321738.3, NGC 2282, HD 220074, HD219485, HD213558, HD 6953 etc.) using national facilities, e.g. 2m Himalaya Chandra Telescope, 1.3m Devasthal Fast Optics Telescope, 1m Sampurnanda Telescope, 1.2m Mt. Abu NIR Telescope etc. We have already analyzed part of these data, interpreted the results and preparing papers. Remaining data analysis is under process.

Future Plan

1. To study photoionization process in novae: Photoionization is a common process in the interstellar medium (ISM) and in circumstellar material (CSM). It happens when gas is being irradiated and ionized by photons from an external source. However, compared with the ISM, the ejecta of novae are very much hotter (typically ~500–5000 K) and are irradiated by a harsh, photodissociating and photoionizing ultraviolet radiation field that is many orders of magnitude stronger than the interstellar radiation field. This makes novae different from other sources. We plan to study photoionization process in novae in more details.

The aim of this study is to check how spectral lines of the elements change with time, luminosity and source temperature. We also aim to study the inter relations between different observable parameters.

2. Distance estimation: In the study of V5558 Sgr we have introduced a new method using the characteristic times to estimate extinction and distance towards a nova simultaneously if a reliable extinction versus distance plot in the nova's direction and a valid MMRD relation for the nova is available. This new approach to derive the extinction and distance to a nova has been tested successfully in case of V5558 Sgr. In continuation I plan to find distance and other properties of all novae observed till date applying this method.

3. Intend to understand the geometry (morphology) and velocity (kinematics) of the material in ejecta of novae. Such morpho-kinematic studies are important as we seek to understand the underlying physics causing novae and the interaction of this ejected material with the companion star.

Publications in Journals

1. **R. K. Das**, D. P. K. Banerjee, A. Nandi, N M Ashok, S. Mondal, *Near-infrared studies of V5558 Sgr: an unusually slow nova with multiple outbursts*, MNRAS, **447**, 806 (2015).
2. **R. K. Das** and A. Mondal, *Abundance analysis of the recurrent nova RS Ophiuchi (2006 outburst)*, New Astronomy, **39**, 19 (2015).

Supervision of Students

Ph.D. Students: Anindita Mondal and Dhimadri Khata (jointly with Dr. Soumen Mondal, SNBNCBS)

Project Student: Sanchi Maithani (IPhD – 3rd semester)

Lectures Delivered

1. "Fundamentals of Astronomical Observations", C. K. Majumdar Memorial Summer Workshop in Physics (CKMMSWP), S. N. Bose National Centre for Basic Sciences, Kolkata, June 18, 2014.
2. "Stellar Evolution", C. K. Majumdar Memorial Summer Workshop in Physics (CKMMSWP), S. N. Bose National Centre for Basic Sciences, Kolkata, June 20, 2014.
3. Invited talk on "Near-Infrared Studies of Novae" at in 'Current Trends in Near-Infrared Astronomy in India', November 25-27, 2014.

Course Taught

1. PH 391 – Advance Level Experiments, 3rd Semester (Jul – Dec, 2014)

Membership of Committees

Internal Committee: Committee to facilitate and initiate the process of land acquisition and construction activities at the proposed site for setting up of astronomical observatory and installation of telescope; Reservation Cell for SCs, STs, Persons With Disabilities and Other Backward Classes; The Seminar and Colloquia Program (SCOLP) Committee

Sponsored Project

1. Co-PI of the internal project entitled "Establishment of Astronomical Observing facilities at the Centre and multi-wavelength observations from the National/International telescopes facilities".

Meeting Organized

1. Member of the organizing committee of Bose Fest 2015 at S N Bose Centre.

Sandip Kumar Chakrabarti

Senior Professor
chakraba@bose.res.in

Prof. Sandip Kumar Chakrabarti received PhD degree from University of Chicago in 1985. He was a R.C. Tolman Fellow at California Institute of Technology (1985-1987) and a ICTP Post Doctoral Fellow at ICTP. He worked at NASA/GSFC in 1994-1995 as a Senior Research Fellow. He has produced over 450 Scientific papers in refereed Journals and Proceedings and supervised 30 PhD students and written/edited several books.

- I work on Astrophysics around black holes including theory and numerical simulations of accretion processes, and spectral and timing properties of radiation emitted from black hole candidates. I also work on ionospheric perturbations by terrestrial and extra-terrestrial high energy processes, Astrobiology/Astrochemistry and high energy astrophysics with low cost balloons.

(a) Relativistic Astrophysics around black holes: Significant achievement in this field includes fitting NASA satellite data from black hole candidates by Chakrabarti & Titarchuk solution and extracting most crucial flow parameters such as the accretion rates of the Keplerian and sub-Keplerian flows, shock location and its strength. Evolutions of the accretion disk geometry and spectral/timing properties in several outburst sources were studied and properly understood in the framework of Two Component Advective flows proposed by us. Our solution is capable of explaining timing properties such as Quasi-Periodic Oscillation frequencies from spectral properties. This feat is unachievable by any other model.

(b) Ionospheric perturbations in presence of terrestrial and extra-terrestrial high energy phenomena: Significant ionospheric changes take place during solar flares, solar eclipses, gamma ray bursts etc. We study these effects extensively both theoretically and observationally. Using Monte Carlo simulations, applied on the upper atmosphere, we show that the injected solar flare spectrum in X-rays could be derived from the perturbation it causes on the Very Low Frequency (VLF) signal amplitude. We use the whole earth to be a detector. We have studied our VLF signals received at Antarctica and showed that the ice mass puts an imprint on the VLF signal amplitude in that the signal is considerably attenuated.

(c) Astrochemistry of pre-biotic molecules: We use a hydrodynamical code and a chemical evolution code to study how complex bio-molecules are created in interstellar medium (ISM). We incorporate grain chemistry also. We show how Deuterium is enriched in ISM. We studied accurately the present abundance of DNA molecular constituent such as Adenine in ISM.

(d) Effects of Space weather on Satellite orbits: Satellites are dragged by atmosphere of Earth and eventually fall back. We explicitly show how solar energetic phenomena may heat up the atmospheric base and puff it up to encroach a satellite orbit dragging it down even further. We computed dragging effects during solar maximum and minimum. We also show how the Mars mission is affected by its interplanetary voyage and during its Martian orbit.

(e) Balloon borne experiments: In collaboration with Indian Centre for Space Physics, a large number balloon borne experiments have been conducted to measure spectra of the solar flares and pulsars. These low-cost units can reach up to about 40 km, and can gather data for several hours. A Gamma Ray Burst has been detected.

Future Plan

We propose to study effects of toroidal magnetic field on the dynamics of the accretion disks and jets. We also wish to recreate X-ray outburst sources by mimicking viscosity variation in the injected accretion flow.

In Ionospheric science we wish to put several antennas all over India to study ionospheric weather and its perturbation, especially before major seismic events. We wish to analyze VLF results obtained before Nepal earthquakes.

In Astrochemistry front, we wish to carry out simulations to study Ortho-para transitions in ISM.

In balloon borne studies, we are in the process of building large area detectors which would be sent to near space (~ 40km) to study radiation from black hole candidates.

Publications In Journals

1. S. Palit, T. Basak, S. Pal, & **S. K. Chakrabarti**, *Theoretical study of lower ionospheric response to solar flares: sluggishness of D-region and peak time delay*, Astrophysics and Space Science, **356**, 19 (2015).
2. A. Das, L. Majumdar, **S. K. Chakrabarti**, and D. Sahu, *Deuterium enrichment of the interstellar medium*, New Astronomy, **35**, 53 (2015).
3. D. Debnath, S. Mondal and **S. K. Chakrabarti**, *Characterization of GX 339-4 outburst of 2010-11: analysis by XSPEC using two component advective flow model*, Mon. Not. R. Astron. Soc., **447**, 1984 (2015).
4. S. Pal, S. Chakraborty and **S. K. Chakrabarti**, *On the use of Very Low Frequency transmitter data for remote sensing of atmospheric gravity and planetary waves*, Advances Sp. Research, **55**, 1190 (2015).
5. S. Sasmal, S. Pal, & **S. K. Chakrabarti**, *Study of long path VLF signal propagation characteristics as observed from Indian Antarctic station, Maitri*, Advances Sp. Research, **54**, 1619 (2014).
6. D. Debnath, **S. K. Chakrabarti**, & S. Mondal, *Implementation of two-component advective flow solution in XSPEC*, Mon. Not. R. Astron. Soc., **440**, L121 (2014).
7. S. Mondal, D. Debnath, & **S. K. Chakrabarti**, *Inference on Accretion Flow Dynamics Using TCAF Solution from the Analysis of Spectral Evolution of H 1743-322 during the 2010 Outburst*, The Astrophysical Journal, **786**, 4 (2014).
8. **S. K. Chakrabarti**, D. Bhowmick, S. Chakraborty, S. Palit, S. K. Mondal, A. Bhattachiaryya, S. Middya, & S. Chakrabarti, *Study of properties of cosmic rays and solar X-ray flares by balloon borne experiments*, Ind. J. Phys., **88**, 333 (2014).
9. S. Mondal, D. Debnath, & **S. K. Chakrabarti**, *Spectral signatures of dissipative standing shocks and mass outflow in presence of Comptonization around a black hole*, Astrophys. & Sp. Sc., **353**, 223 (2014).
10. S. Mondal, **S. K. Chakrabarti**, & D. Debnath, *Is Compton Cooling Sufficient to Explain Evolution of Observed Quasi-periodic Oscillations in Outburst Sources?*, Astrophys. J., **798**, 57 (2015).
11. S. Sasmal, **S. K. Chakrabarti**, & S. Ray, *Unusual behavior of Very Low Frequency signal during the earthquake at Honshu/Japan on 11 March, 2011*, Ind. J. Physics, **88**. 1013 (2014).

Other Publications

1. Debnath, D. & Chakrabarti, S.K., Properties of the Propagating Oscillatory Shock Wave in the Accretion Flows around Few Transient Black Hole Candidates during Their Outbursts, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2423
2. Dipak, D., Chakrabarti, S.K. & Nandi, A., A Comparative Study of the Timing and the Spectral Properties during Two Recent Outbursts (2010 and 2011) of H 1743-322, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2410
3. Garain, S.K., Ghosh, H. & Chakrabarti, S.K.,Effects of Compton Cooling on Outflows in a Two Component Accretion Flow around a Black Hole: Results of a Coupled Monte Carlo-TVD Simulation, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2404
4. Giri, K. & Chakrabarti, S.K. Numerical Simulations of a Two Component Advective Flow for the Study of the Spectral and Timing Properties of Black Holes, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2401

Supervision of Students

Ph.D. Students: S. Garain, T. Basak, S. Ray, L. Majumdar received PhD degrees. S. Mondal, T. Katoch submitted Thesis. Supervising: V. Nwankwo, A. Bhattacharyya, A. Deb, A. Ghosh, A. Roy, S. Chakraborty, A. Banerjee, D. Sahu, S. Nagarkoti, P. Garai

Post Doctoral Research Scientist: Partha Sarathi Pal

Lectures Delivered

1. Astrochemical research: Generation and Storage of Reaction Cross-Sections, Inter-University Accelerator Centre, New Delhi, April, 2014
2. Complete Solution of Black Hole accretion including viscosity and radiative Transfer, Zeldovich Birth Centetary Conference at Space Research institute (IKI), Moscow, June, 2014
3. Programme on Very Low Frequency Radio Waves, 40th COSPAR conference, Moscow University, August, 2014
4. Two Component Advective Flows Around Black Holes: Theory, simulations and observational verifications, 40th COSPAR conference, Moscow University, August, 2014
5. Unique Programme using large rubber Balloons, 40th COSPAR conference, Moscow University, August, 2014
6. Formation of Two Component Advective Flow by Numerical Simulations and Monte-Carlo simulations of their spectral properties,40th COSPAR conference, Moscow University, August, 2014

7. GRBs and Blazars testing General relativity and Cosmology, 40th COSPAR conference, Moscow University, August, 2014
8. Other than above five talks, I was co-author of 35 more papers presented by others at 40th COSPAR conference, Moscow University, August, 2014
9. Chemical Evolution of the Universe and origin of Life, Institute of Culture, Kolkata, August, 2014
10. Accretion Disks Around Black Holes: A review, Hard X-ray Astronomy by ASTROSAT, The International Centre, Goa, September, 2014
11. Accretion Disks Around Black Holes: A review, ARIES, Nainital, October, 2014
12. Chemical Evolution of the Universe and Origin of Life, Dept. Of Atmospheric Chemistry, Calcutta University, November, 2014
13. Two Component Advective Flows, TIFR, Mumbai, December, 2014
14. LAXPC Observations of Stellar Black Holes: Predictions of Two component Advective Flows, TIFR balloon facility, Hyderabad, December, 2014

Academic Visits

1. Visited Department of Astronomy and Astrophysics, TIFR for collaborative work on black hole astrophysics, December, 2014
2. Attended NAAC assessors Interaction meeting, NAAC HQ. Hyderabad, January, 2015

Courses Taught

1. PHY403 (with S. Mondal) Astrophysics (4th Semester)
2. PHY510 (with S. Mondal) Astrophysics (4th Semester)

Membership of Committees

External Committee: Editorial Board Member of Indian Journal of Physics; Editorial board member of Bulletin of Astronomical Society of India; General Secretary of Governing body of Indian Centre for Space Physics; Main Scientific Organizer of 40th COSPAR C0.4 session on Ionospheric Disturbances Observed through very Low Frequency Radio Waves; In Charge, Academic Affairs, Indian Centre for Space Physics

Internal Committee: Member of Consultative Administrative Committee; Head of the Department of Astrophysics and Cosmology; Students Curriculum and Research Evaluation Committee

Sponsored Project

1. Co-Investigator of Astronomical Telescope Facility of S.N. Bose National Centre at Panchet Hills. Purulia.

Soumen Mondal

Assistant Professor
soumen.mondal@bose.res.in

Dr. Soumen Mondal received his Ph.D. degree from Physical Research Laboratory (PRL), Ahemdabad in 2004. He has post doctoral research experience at PRL for a year, and then at National Central University, Taiwan under International Taiwanese-American Occultation Survey (TAOS) program for about two and half years. He joined Aryabhatta Research Institute for Observational Sciences (ARIES), Nainital as a Scientist in 2007 and worked there for four years, and then moved to S N Bose National Centre for Basics Sciences in 2011 as an Assistant Professor.

- Extra-solar planets
- Brown dwarfs and low-mass stars in star-forming regions
- M-Giants and Mira variables
- Small solar system objects
- Astronomical Instrumentation

The young cluster NGC 2282 : a multi-wavelength perspective: We studied the stellar content of a young cluster NGC~2282, a young cluster in Monoceros constellation, using deep optical *BVI* and *IPHAS* photometry along with infrared (IR) data from *UKIDSS*, and *Spitzer-IRAC*. Based on the radial density profile and stellar surface density analysis using nearest neighborhood method, the radius of the cluster is estimated to be 3.15 arcmin. From optical spectroscopic analysis of 8 bright sources, we have identified three early B-type members in the cluster, and among three a new Herbig Ae/Be star B0.5 Ve and a new B5 V star are identified first in this work. From spectrophotometric analyses, the distance to the cluster has been estimated as 1.65 kpc. The median extinction within the cluster area is found to be $A_v \sim 3.9$ mag. Using IR colour-colour criteria and Halpha emission properties, we have identified a total of 152 candidate young stellar objects (YSOs) in the region, of which, 75 are classified as class II, 9 are class I YSOs. Our YSOs catalog also includes 50 Halpha-emission line sources, identified using slitless spectroscopy and IPHAS photometry data. Based on the optical and near-IR colour-magnitude diagram analyses, the cluster age has been estimated to be in the range of 2 - 5 Myr, which is in agreement with the estimated age from disk fraction. Masses of these YSOs are found to be ~ 0.1 – 2.0 Solar mass (Dutta et al. 2015).

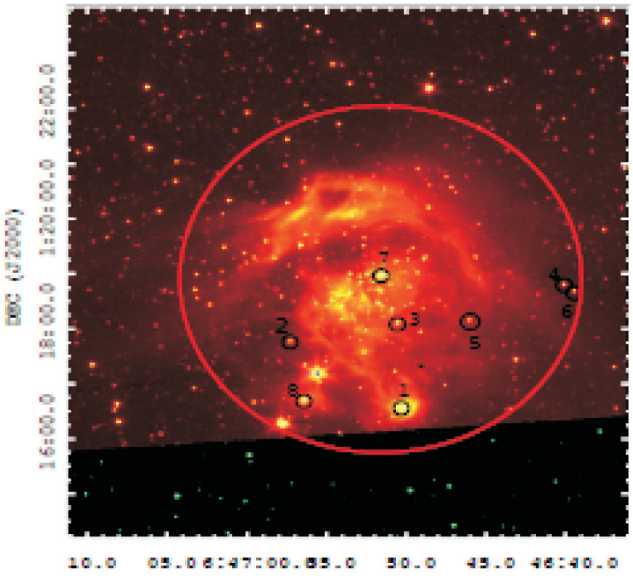


Fig 1: The colour composite image of NGC 2282 of our (blue: K band; green: 3.6μm; red: 4.5μm)

A New Mira variable MASTER Optical Transient J212444.87+321738.3 in Cygnus: We report here discovery of a Mira variable toward the Cygnus from the MASTER optical transient (OT) alert on J212444.87+321738.3. We performed optical long-term monitoring observations and long-term optical/near-IR spectroscopic observations of the MASTER OT J212444.87+321738.3. The source was monitored in optical I-band and unfiltered CCD (400—900 nm) over 550 days. Interestingly, the source shows the period of about 465 days with variability amplitude of about 4 mag in I-band and 3.4 mag in unfiltered CCD respectively. The optical/near-IR spectra shows molecular features of TiO, VO, CO overtone and water bands, which is a signature of cool M-type stars. The NIR spectra indicates the likely O-rich nature. All these observations confirm that the source is a O-rich Mira variable. We have estimated the fundamental parameter of the source e.g. spectral type, distance, luminosity and mass (Mondal et al. 2013; Mondal et al. 2015; Ghosh et al. 2015).

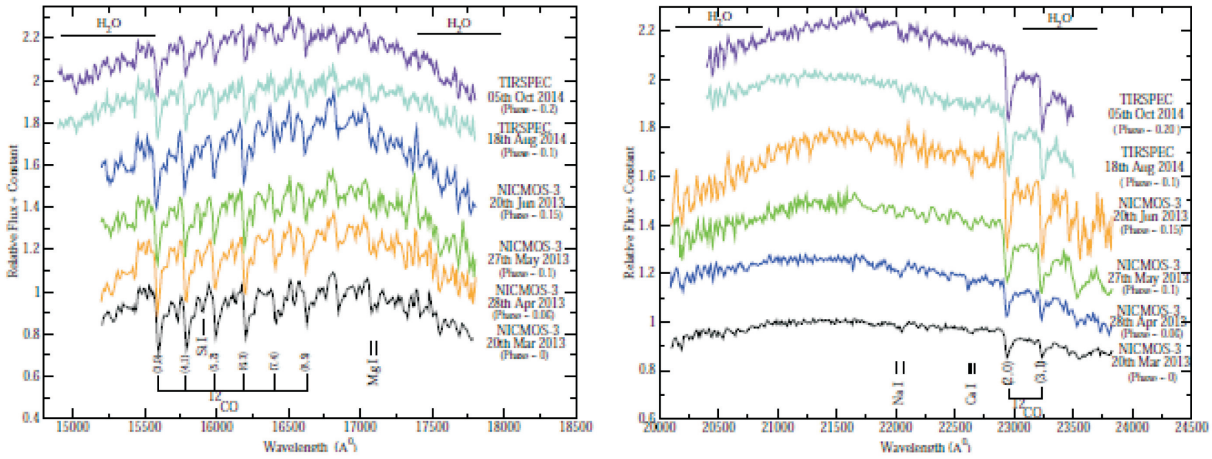


Fig2: The above figure shows NIR (1.48 -2.45 micron) spectra of new Mira variable taken from 1.2m Mt. Abu (NICMOS) and 2m HCT (TIRSPEC) telescope. Several molecular features of CO, H2O and atomic features Na, Ca are visible, which are changing over the pulsational phase of Mira star.

Future Plan

1. Astronomical Observing facilities of S. N. Bose Centre: At S. N. Bose Centre, recently we (I am as a PI of the project) have initiated to establish the World-class Astronomical observing facility. This project envisages establishing initially a small one-meter (1m)-class relatively wide-field telescope. Recently, we got the approval for 2 hectares land at Panchet hill-top, Purulia (about 220 km from the Centre) for this Astronomical Observatory site from the Forest department of Govt. Of India and state Govt. of West Bengal. Our project is of relatively low-cost and will focus on a few primary science programs. Scientific motivations for our telescope encompass forefront problems in Astronomy and Astrophysics ranging from Extra-solar planets to Black-hole astrophysics.

2. On-going long-term Scientific programs:

(i) Spectrophotometric studies of late M-type stars (dwarfs and giants) and Miras: Spectrophotometric studies of low-to-intermediate mass stars represent vital test of theoretical models of stellar evolution, structure, and atmospheres. In stellar evolution, low-to-intermediate main-sequence stars evolve to red giant branch (RGB) through Asymptotic Giant Branch (AGB) before planetary nebulae. Optical/Near-IR spectrophotometric studies of these RGB/AGB objects are undertaken to understand their atmospheres and pulsation. Furthermore, studies of M dwarfs have been recognized as promising targets in the search for small extra-solar planets.

(ii) Multi-wavelength studies of Galactic star-forming regions: Galactic star-forming regions provide us crucial information about star-formation process, stellar evolution and stellar structure etc. Young star clusters are born in such giant molecular clouds (GMCs) after gravitational collapse, which are mainly located at dense spiral arms of our Milky way. Multi-wavelength studies of such regions provide census of Young Stellar Objects, their fundamental parameters e.g., masses, ages, effective temperatures, circumstellar disks around them (if any) etc. We are studying of these regions in optical, near infrared (near-IR) and mid infrared (mid-IR) wavelengths.

(iii) Photometric variability studies and characterization of very-low mass (VLM) stars and brown dwarfs: To provide comprehensive observations and in-depth study of the physical properties of Very Low Mass (VLM) objects and brown dwarfs in galactic field as well as in young star-forming regions, we have started an observational program using the National telescope facilities.

3. Astronomical Instrumentation: With our expertise in the

Optical/IR instrument design and development, we are working to establist an Astronomical Instrumentation Laboratory at the Centre for building the state-of-art backend instruments for the telescopes. We are optical designing phase of one multi-channel imaging photometer, and one fibre-fed low-intermediate resolution spectrograph for our own telescope and other national facility telescope as a visitor instrument.

4. Establishing roll-off roof observatory: Recently, we are building a roll-off roof observatory at roof-top of the Centre to house the 8 inch Meade telescope and 14 inch Robotic telescope with Planewave optical tube assembly (OTA) on German equatorial mount from paramount ME-II. The 8 inch telescope will be used to train the students, e. g., IPhD students, project students through specific observing short-term projects. The 14 inch telescope will be used for scientific observations of bright objects and seeing measurement at the new site.

Publication in Journal

1. R. Das, D. P. K. Banerjee, A. Nandi, N. M. Ashok, & **Soumen Mondal**, *Near-infrared studies of V5558 Sgr: an unusually slow nova with multiple outbursts*, Monthly Notices of the Royal Astronomical Society , **447**, 806, (2015).

Supervision of Students

Ph.D. Students: Supriyo Ghosh; Somnath Dutta; Anindita Mondal (Co-Supervisor with Dr. R. K. Das); Samrat Ghosh; Dhrimadri Khata (Co-Supervisor with Dr. R. K. Das); Saurav Singha

Project Students: Manuja Sharma (NIT, Jalandhar); Saurav Mishra (2nd yr. IPhD)

Lectures Delivered

1. Invited talk on ``Photometric Variability in Ultracool Dwarfs: Understanding of Evolving Weather Patterns'' at Current Trends in Near Infrared Astronomy in India" held at TIFR balloon facility, Hyderabad during 25-27 Nov 2014
2. Attended working meeting on "Planning for science with TMT: challenging and capabilities" held at ARIES, Nainital during 5-6 Nov, 2014
3. Invited talk on ``Star and Planet formation'' at CKM memorial workshop in Physics 2014, held at SNBNCBS, Kolkata during July 2014

Courses Taught

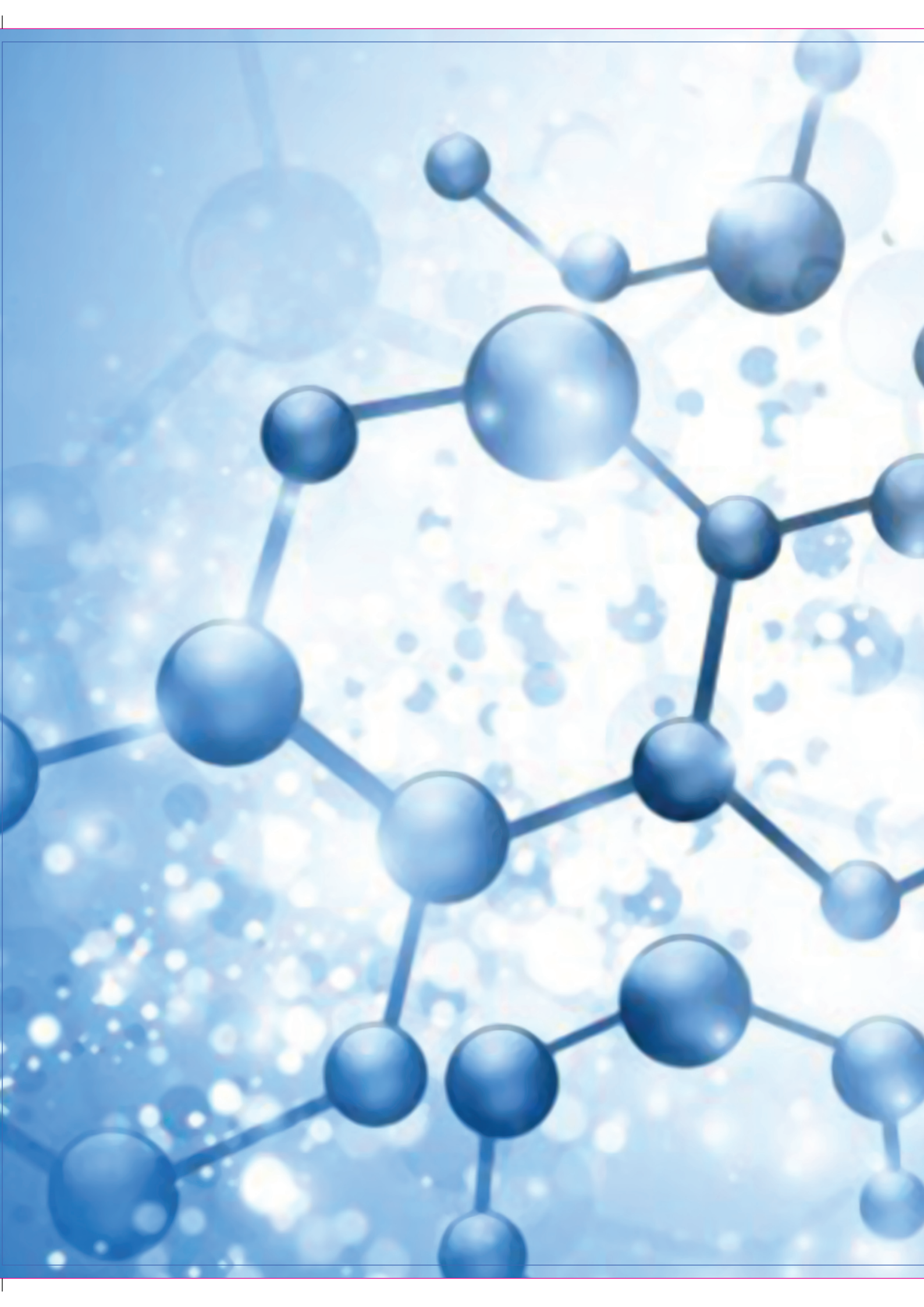
1. Course teaching for IPh. D. on Astrophysics (Course No. PHY 403) during (4th Semester)
2. Course teaching for Ph. D. on Astrophysics (Course No. PHY 510)

Membership of Committees

Internal Committee: Member in Board of Studies; Member in Students' Curriculum & Research Evaluation Committee (SCREC) ; Advisory committee member of Technical Cell and Computer cell; Member in Project and Patent cell; Member in Library Committee

Sponsored Project

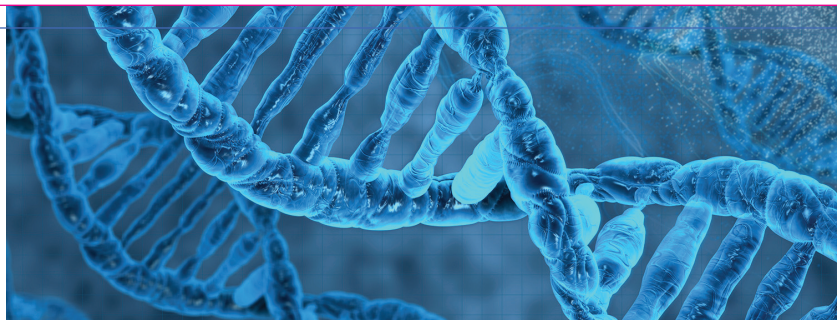
1. Internal project entitled "Establishment of Astronomical Observing facilities at the Centre and multi-wavelength observations from the National/International telescopes facilities" as a PI.



Department of

Chemical Biological & Macro-Molecular Sciences

Department of Chemical Biological & Macro-Molecular Sciences



Ranjit Biswas
Head of the Department

Department profile indicators:

Table A: Manpower and resources

Number of faculties	6+2
Number of Post–doctoral research associate (centre+project)	7
Number of Ph.D students	34
Number of other project staff	2
Number of summer students	6
Projects (ongoing)	11

Table B: Research Activities indicators

Number of research papers in Journals	45
Number of Book-chapters/books	2
Number of other publications	2
Number of Ph.D students graduated (submitted+degree awarded)	10
Number of M.Tech/M.Sc projects	2

Table C: Academic activities and likeage

Number of courses taught by faculties	6	
Number of Visitors (non–associates)	0	
Number of associates	0	
Number of Seminars organized	23	
Number of Conference/Symposia/ Advanced Schools organized	3	
Number of talks delivered by members of department in conferences/Symposia	National	9
	International	6

Most important research highlights

- Nonequilibrium thermodynamic response of a voltage gated Potassium ion channel has been studied.
- Quantum chemical calculations on calcium ion coordination to an isolated loop of Calmodulin have been performed.
- Thermodynamics of metal ion induced conformational changes on functions of protein complexes has been explored.
- Clinical feasibility of a residual gas analyzer (RGA) system coupled with a high vacuum chamber (Figure 1) for accurate evaluation of the ^{13}C-enriched glucose breath test exploiting $^{13}CO_2/^{12}CO_2$ isotope ratios in the diagnosis of PD and T2D has been studied.

- THz time domain spectroscopy (TTDS) study has been conducted for studying the interaction between urea and water.
- Dielectric relaxation (DR) measurements in the frequency range, have been carried out for deep eutectic solvents.
- Experimental studies involving Biological Physics, Bio-Nano Interface, Biomimetics and biomedical instrumentation have been carried out.
- A clay based nanocomposite has been developed through selective modification of the outer surface of HNTs with an organosilane to make the nanocomposite a novel solid-phase adsorbent to capture toxic gases from the atmosphere.

Summary of research activities

Electromagnetically induced transparency (EIT) in lambda, cascade and vee type three-level systems have been studied where the Hamiltonian and the Lindblad term of each configuration are expressed in the su(3) representation. When the EIT condition is achieved at resonance, the population oscillation shows which of the bare states are contributing to form the dark state. Our study reveals that the dark state for the lambda and cascade system effectively coincides with the lowest bare state of that system, while for the vee system, it is a maximally superposed state of the middle and upper bare states.

Analytical form has been derived for the effective interaction forces between two solvophobic solutes, mediated by the solvent. The effective force is attractive for short ranges, which decreases linearly with surface-to-surface separations between the solutes and repulsive in the long range falling off as $1/s^4$. The attraction originates from the unbalanced Laplace force at the liquid–gas interface, generated by the repulsive interaction with the solvent particles. We illustrate with the Lennard–Jones solvent that the effective forces capture experimental observations on hydrophobic species in aqueous solution. We discuss the general implication of our results in the context of hydrophobic collapse.

Stability of coordination of metal ion into the metal ion binding pocket of an EF-hand protein has been investigated by quantum chemical calculations.

Type 2 diabetes has become one of the most pressing human health concerns all over the world and therefore, an accurate and fast pragmatic diagnosis of pre-diabetes (PD) prior to the onset of type 2 diabetes (T2D) is vital. Recently, we have demonstrated the clinical feasibility of a residual gas analyzer (RGA) system coupled with a high vacuum chamber (Figure 1) for accurate evaluation of the ^{13}C-enriched glucose breath test exploiting $^{13}CO_2/^{12}CO_2$ isotope ratios in the diagnosis of PD and T2D. This RGA-based methodology exhibited a diagnostic sensitivity of 100% and specificity of ~95%, thus suggesting a valid and sufficiently robust alternative diagnostic tool for routine clinical practices for sorting out diabetes.

Short chain polyethylene glycols exhibit an unusual phenomenon of facilitating thermal unfolding of human serum albumin. Associated hydration structure has been determined by using far-infrared and THz spectroscopic technique and compared the results with some associated well known protein stabilizing osmolytes.

Dielectric relaxation (DR) measurements in the frequency range, , have been carried out for neat molten acetamide, and six different (acetamide + electrolyte) deep eutectic solvents (DESs) for investigating ion effects on DR dynamics in these ionic DESs.

Experimental biophysical studies and in the adjoining interdisciplinary areas have been carried out that ranges from molecular recognition of small ligands/drugs by biological macromolecules to complicated protein-DNA, Protein-Protein complexation. A few low cost spectroscopic gadgets for the biomedical/environmental usage have been developed and a few patents have been received.

A clay based nanocomposite has been developed through selective modification of the outer surface of HNTs with an organosilane to make the nanocomposite a novel solid-phase adsorbent to capture toxic gases from the atmosphere at standard ambient temperature and pressure.

Ranjit Biswas
Head, Department of Chemical, Biological and Macromolecular Sciences

Gautam Gangopadhyay

Professor
gautam@bose.res.in

Gautam Gangopadhyay and his group are working here in the broad area of Chemical Physics. It includes statistical mechanical modelling of reaction kinetics for example, enzyme catalysis in a network of oligomeric enzyme, ion-channels. They are working on nonlinear dynamical characterization of various ion channels. They are also interested in quantum nonadiabatic molecular properties theoretically through conduction and spectroscopic tools.

We have studied the nonequilibrium thermodynamic response of a voltage gated Potassium ion channel using a stochastic master equation. For a constant external voltage, the system reaches equilibrium indicated by the vanishing total entropy production rate, whereas for oscillating voltage the current and entropy production rates show dynamic hysteretic behavior. Here we have shown quantitatively that although the hysteresis loop area vanishes in low and high frequency domains of the external voltage, they are thermodynamically distinguishable. At very low frequency domain, system remains close to equilibrium whereas at high frequency it goes to a nonequilibrium steady state associated with a finite value of dissipation function. At such steady state, the efficiency of the ion-conduction can also be related with the nonlinear dependence of the dissipation function on the power of the external field.

We discussed the electromagnetically induced transparency (EIT) in lambda, cascade and vee type three-level systems where the Hamiltonian and the Lindblad term of each configuration are expressed in the su(3) representation. When the EIT condition is achieved at resonance, the population oscillation shows which of the bare states are contributing to form the dark state. Our study reveals that the dark state for the lambda and cascade system effectively coincides with the lowest bare state of that system, while for the vee system, it is a maximally superposed state of the middle and upper bare states.

Future Plan

1. Probing kinetic drug binding mechanism in voltage-gated sodium ion channel using open state versus inactive state blockers: Based on our studies on the kinetics and nonequilibrium thermodynamics of open state and inactive state drug binding mechanisms can be studied using different voltage protocols in sodium ion channel. We have found that for constant voltage protocol, open state block is more efficient in blocking ionic current than inactive state block. In presence of open state drug block the process initially for a long time remains entropy driven and then becomes free energy driven. But in presence of inactive state block the process entirely remains entropy driven until the equilibrium is attained. For oscillating voltage protocol we can study the inactive state blocking in damping the oscillation of ionic current. One can study the pulse train analysis to show that all the properties of inactive states.
2. Quantum conduction through molecular systems: For a long time we are exploring the structural and dynamical properties of molecular systems through quantum models of molecular processes. Recently we have developed the methodology to calculate the thermal and electrical conduction properties for simple quantum systems. Using these methods we shall study the effect of nonadiabatic molecular properties in conduction problems.

Publications in Journals

1. Surajit Sen, Tushar Kanti Dey, Mihir Ranjan Nath and **Gautam Gangopadhyay**, *Comparison of electromagnetically induced transparency in lambda, cascade and vee three-level systems*, Journal of Modern Optics, **62**, 166–174 (2015).
2. T. K. Dey, A. Gangopadhyay and **G. Gangopadhyay**, *A Noisy Nutrient Induced Instability in Phytoplankton Blooms*, Int. J. Curr. Res. Acad. Rev., **3**, 51-59 (2015).

Supervision of Students

Ph.D. Students: Krishnendu Pal, Snehasish Rana, Anirban Karmakar

Project Student: P. Das

Lectures Delivered

1. Propensity approach to nonequilibrium thermodynamics of a chemical reaction network at Stat Physics Kolkata, VIII (1-5 Dec'2014).
2. Approach to nonequilibrium thermodynamics of enzyme catalysis reaction network Theoretical Chemistry Conference (18-21 Dec'2014), Mumbai.

Academic Visit

1. Visited JNU to deliver a Talk at JNU on 20.11.2014 and exchanged ideas and views on reaction network thermodynamics with Prof. Pradipta Bandyopadhyay

Course Taught

1. Post MSc course on Stochastic Processes in Physics and Chemistry

Membership of Committees

Internal Committee: Working as the Vigilance Officer of the Centre; Project Cell, SAC and EVLP (VASP)

Jaydeb Chakrabarti

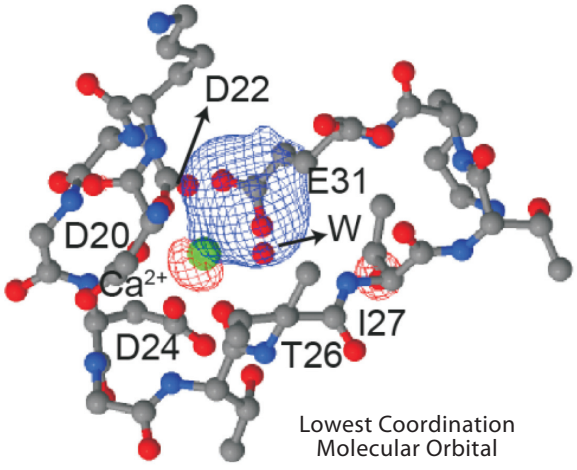
Professor
jaydeb@bose.res.in

Dr. Jaydeb Chakrabarti received his Ph.d from IISc, Bangalore in 1995. He has Postdoctoral experience from 1995 to 1998 at AMOLF, Amsterdam and TUE, Eindhoven, The Netherlands. He was a Visiting Scientist at IGKAR, Kalpakkam during 1999. He joined the Centre in November 1999.

- Work in the areas of soft condensed matter physics including computational biology. Primarily interested in application of statistical mechanics in systems as diverse as biomolecules to colloids including both static and dynamic properties

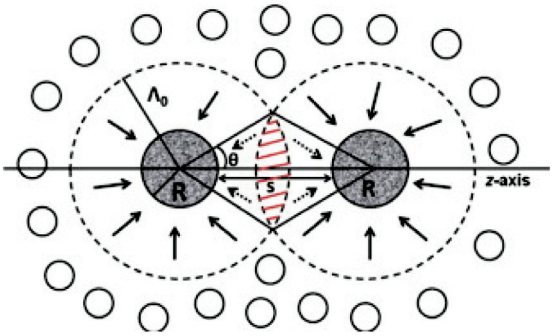
1. We perform density functional theory (DFT) based quantum chemical calculations on calcium ion coordination to an isolated loop of Calmodulin. We show that the coordination molecular orbitals in the ground state, having contributions from the valence orbitals of the metal ion and the loop atoms, bring out the roles of the coordinating and the non-coordinating residues to stabilize the coordination geometry in agreement to the mutational studies.

   The coordinating molecular orbitals are observed to be robust under various truncations of the binding loop and capping at the terminal residues.



Lowest Coordination Molecular Orbital

2. We derive an analytical form for the effective interaction forces between two solvophobic solutes, mediated by the solvent. The effective force is attractive for short ranges, which decreases linearly with surface-to-surface separation s between the solutes and repulsive in the long range falling off as $1/s^4$. The attraction originates from the unbalanced Laplace force at the liquid–gas interface, generated by the repulsive interaction with the solvent particles. We illustrate with the Lennard–Jones solvent that the effective forces capture experimental observations on hydrophobic species in aqueous solution. We discuss the general implication of our results in the context of hydrophobic collapse.



Future Plan

I. Projects on biomacromolecules:

1. Identification of binding sites using conformational thermodynamics.
2. Equilibrium aspects of cooperative binding

3. Dynamics of dihedral fluctuations to understand cooperative phenomena.
4. Statistical mechanical model for molecular recognition processes.
5. Quantum chemical calculations to extract ground state stability and functional aspects of metalloprotein.

II. Projects on biophysical modelling:

1. Statistical mechanical model of collapse of macromolecules with competing interactions.

III. Projects on Colloids:

1. Dynamical response of non-equilibrium colloidal system.
2. Dynamic response of colloids under confinement.
3. Equilibrium and dynamic properties of macromolecules in a crowded environment.

Publications in Journals

1. Manas Mondal, Devapriya Choudhury, **Jaydeb Chakrabarti**, Dhananjay Bhattacharyya, *Role of indirect readout mechanism in TATA box binding protein-DNA interaction*, Journal of Computer-Aided Molecular Design **29**(3): 283-295 (2015)
2. **J. Chakrabarti** and Suman Dutta, *Analytical form of forces in hydrophobic collapse*, Chem Phys Lett, **620**, 109-113 (2015)
3. Samapan Sikdar, **J. Chakrabarti** and Mahua Ghosh, *A microscopic insight from conformational thermodynamics to functional ligand binding in proteins*, Molecular BioSystems, **10**, 3280-3289 (2014)
4. Samapan Sikdar, Mahua Ghosh, Molly De Raychaudhury and **J. Chakrabarti**, *Quantum chemical studies on the role of residues in calcium ion binding to Calmodulin*, Chem Phys Lett, **605-606**, 103-107(2014)
5. Atanu Ghosh, T. Pradeep and **Jaydeb Chakrabarti**, *Coalescence of atomically precise clusters on graphenic surfaces*, J. Phys. Chem. C, **118**(25) 13959–13964 (2014)

Supervision of Students

Ph.D. Students: Samapan Sikdar, Suman Dutta and Sutapa Dutta

Post Doctoral Research Scientist: Lakshmi Maganti

Lectures Delivered

1. Microscopic Calculation of Conformational Thermodynamics in Bio-Macromolecular Complexes, School of Physical Sciences (SPS), JNU, March 12, 2015.
2. Dynamical heterogeneity in a binary charged colloid under external electric field, 2nd Indian Statistical Physics Community Discussion Meeting 13-15 February, 2015.
3. Microscopic calculation of conformational thermodynamics in bio-macromolecular complexes, Theoretical Sciences Unit of JNCASR, 12th February 2015.
4. Microscopic calculations of Conformational Thermodynamics in Biomacromolecular Complexes, StatPhys-Kolkata-VIII SNBNCBS, December 1 – 5, 2014.

Course Taught

1. PHY101, Classical Mechanics, Autumn 2014

Membership of Committees

Internal Committee: Project Cell

Sponsored Projects

1. "Microscopic calculations of metal ion binding to proteins" " in the subject area of Physical Sciences, funded by DST, Government of India
2. "Computational Material Science-Thematic unit of excellence", (Co-PI), DST funded
3. "UNANST-II", (Co-PI), DST funded

Meeting Organized

1. CIIB, December 2014, Bose Institute, Kolkata

Mahua Ghosh

Research Scientist
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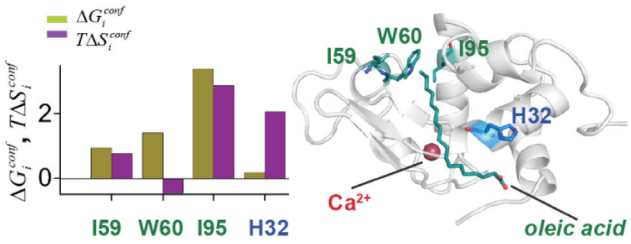
Dr. Mahua Ghosh received her PhD from TIFR, Mumbai. She then worked as a postdoctoral researcher at Ontario Cancer Institute, Canada, and NIEHS, National Institute of Health, USA, before joining I.I.S.E.R Kolkata as an Assistant Professor. She has been at Satyendra Nath Bose National Centre for Basic Sciences since 2010.

- My research interests primarily involve understanding of the molecular basis in biological system by their biophysical, structural and functional characterizations. Quantitative experimental and computational studies on Protein-protein, protein-ligand, lipid-protein interactions

1. A state of the art fully functional and self-sufficient "Protein Expression and Purification" facility is developed in the Centre. Many proteins of bacterial origin related to multidrug resistance activity have already been expressed, purified and characterized.

2. We show that the thermodynamics of metal ion induced conformational changes aid to understand the functions of protein complexes. This is illustrated in case of a metalloprotein, alpha-lactalbumin (aLA), a divalent metal ion binding protein. We use the histograms of dihedral angles of the protein, generated from all-atom molecular dynamics simulations, to calculate the conformational thermodynamics. The thermodynamically destabilized and disordered residues in different conformational states of a protein are proposed to serve as binding sites for ligands. This is tested for β-1,4-galactosyltransferase (β4GalT) binding to the Ca^{2+}-aLA complex where the binding residues are known. Among the binding residues, the C-terminal residues like aspartate (D) 116, glutamine (Q) 117, tryptophan (W) 118 and leucine (L) 119 are destabilized and disordered and can dock β4GalT onto Ca^{2+}-aLA.

   No such thermodynamically favourable binding residues can be identified in case of the Mg^{2+}-aLA complex. We apply similar analysis to oleic acid binding and predict that the Ca^{2+}-aLA complex can bind to oleic acid through the basic histidine (H) 32 of A2 helix and the hydrophobic residues, namely, isoleucine (I) 59, W60 and I95 of the interfacial cleft. However, the number of destabilized and disordered residues in Mg^{2+}-aLA is less, and hence, the oleic acid binding to Mg^{2+} bound aLA is less stable than that to the Ca^{2+}-aLA complex. Our analysis can be generalized to understand the functionality of other ligand bound proteins.



alpha-Lactalbumin-oleic acid complex

3. We looked into the stability of coordination of metal ion into the metal ion binding pocket of an EF-hand protein by quantum chemical calculations.

Future Plan

The following projects are undertaken:

- Biophysical characterization and antibiotic interactions of a bacterial yfdX protein from *S.*Typhi, STY3178 using fluorescence, CD and NMR.
- Chemical denaturant induced unfolding and stability of STY3178 using CD, fluorescence and NMR.
- Reversible thermal folding of STY3178 using CD, fluorescence and computational methods.
- Sequence specific resonance assignments of STY3178 using heteronuclear triple resonance NMR experiments.

- Divalent ion induced changes in STY3178 using CD, fluorescence, mass spectrometry and MD simulations.
- SDS induced conformations of small heat shock protein HspH and its chaperonic activity.
- Protein-Protein interaction of beta barrel membrane protein STY3179 with soluble yfdX protein STY3178.
- Prediction the missing protein fragment conformation using conformational thermodynamics approach for Tropinin C a calcium binding EF hand protein.

Publications in Journals

1. Samapan Sikdar, J. Chakrabarti and **Mahua Ghosh**, *A microscopic insight from conformational thermodynamics to functional ligand binding in proteins*, Molecular BioSystems, **10**, 3280-3289 (2014)
2. Samapan Sikdar, **Mahua Ghosh**, Molly De Raychaudhury and J. Chakrabarti, *Quantum chemical studies on the role of residues in calcium ion binding to Calmodulin*, Chem Phys Lett, **605-606**, 103-107(2014)

Supervision of Students

Ph.D. Students: Paramita Saha and Samapan Sikdar

Project Student: Kathakali Sarkar from Department of Biotechnology, St. Xavier's College, Kolkata

Sponsored Projects

1. "Structural and Functional Characterization of small Heat Shock Proteins from *Bradyrhizobium japonicum*" in the subject area of Life Sciences, funded by DST, Government of India.
2. "Microscopic calculations of metal ion binding to proteins" in the subject area of Physical Sciences, funded by DST, Government of India.

Manik Pradhan

Assistant Professor
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Dr Manik Pradhan is currently a faculty member at S. N. Bose Centre. After completing MSc (2000) in Physics from the University of Calcutta and M.Tech in Cryogenic Engineering (2002) from the IIT, Kharagpur, he joined at the University of Bristol, UK as a *Dorothy Hodgkin Postgraduate Fellow* (2005-2008) for pursuing his PhD work on laser spectroscopy. Subsequently, having been awarded a prestigious *Isaac Newton Trust Fellowship* from Trinity College, he moved to the University of Cambridge, UK, for his first postdoctoral work (2008-2010). Hereafter, he came to work as a *Postdoctoral Research Associate* (2010-2011) in Stanford University, USA. He also worked as a *Visiting Research Fellow* (2004-2005) at the Institute of Atomic and Molecular Sciences (IAMS), Academia Sinica, Taiwan. His research group currently focuses on the cutting-edge research in interdisciplinary areas involving quantum cascade laser spectroscopy, biomedical optics and clinical diagnostics.

- Cavity Ring-Down Laser Spectroscopy
- Biomedical Optics and Clinical Diagnostics using Exhaled Breath Analysis
- High-Resolution Quantum Cascade Laser Spectroscopy
- Evanescent Wave Ring-down spectroscopy for studying interfacial dynamics in condensed phase and Biophotonics

Type 2 diabetes has become one of the most pressing human health concerns all over the world and therefore, an accurate and fast pragmatic diagnosis of pre-diabetes (PD) prior to the onset of type 2 diabetes (T2D) is vital. Recently, we have demonstrated the clinical feasibility of a residual gas analyzer (RGA) system coupled with a high vacuum chamber (Figure 1) for accurate evaluation of the ^{13}C-enriched glucose breath test exploiting $^{13}CO_2/^{12}CO_2$ isotope ratios in the diagnosis of PD and T2D. This RGA-based methodology exhibited a diagnostic sensitivity of 100% and specificity of ~95%, thus suggesting a valid and sufficiently robust alternative diagnostic tool for routine clinical practices for sorting out diabetes.

Moreover, by monitoring the oxygen-18 (^{18}O)-isotopic fractionations of breath CO_2 using a high-resolution optical cavity-enhanced absorption spectroscopy technique, we have also shown that individuals with T2D exhibited considerably higher isotopic enrichments of ^{18}O in breath CO_2 compared with PD during a 2h-oral glucose tolerance test, whereas a noticeable depletion of ^{18}O in breath CO_2 was evidenced for non-diabetic control patients (Figure 2). These results were well correlated with the changes in carbonic anhydrase activities (CA) measured in erythrocytes. Our findings suggest the breath $C^{18}O^{16}O$ regulated by the CA activity as a potential biomarker for sorting out early-stage PD and T2D, and thus may specifically track the progression of PD earlier than the commencement of T2D in a non-invasive way and opening a new avenue for treating T2D.

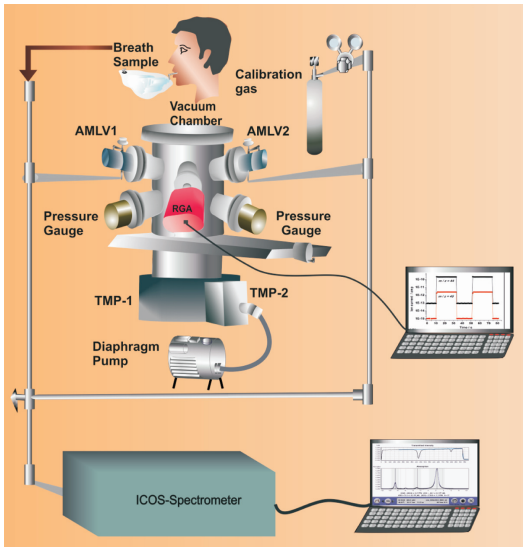


Figure 1: RGA-MS system for diabetes detection using human breath analysis

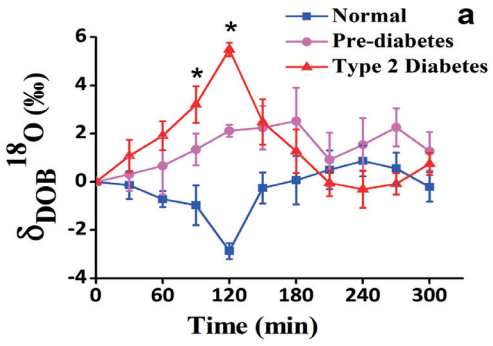
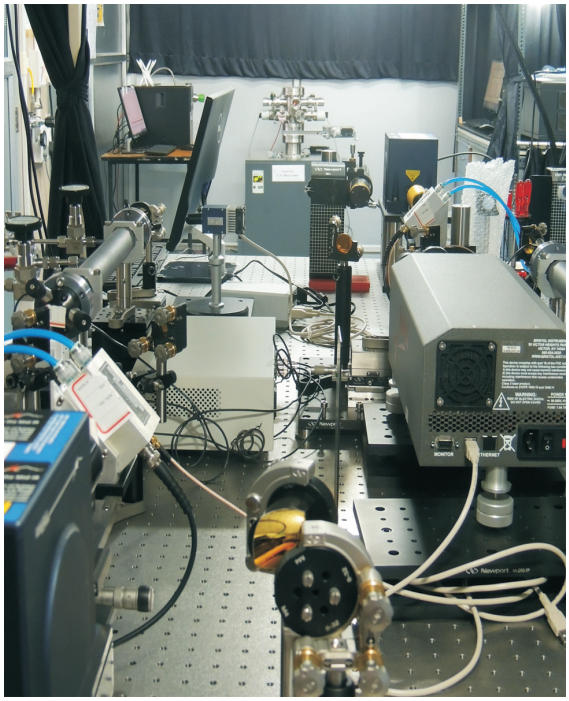


Figure 2: Oxygen-18 (^{18}O)-isotopic fractionations of breath CO_2

Future Plan

We are currently developing a quantum cascade laser (QCL) based cavity ring-down spectroscopy technique for biomedical and environmental science applications.



Quantum Cascade Laser Cavity Ring-down set up is being developed

Publications in Journals

1. C. Ghosh, G. Banik, A. Maity, S. Som, A. Chakraborty, C. Selvan, S. Ghosh, S. Chowdhury and **M. Pradhan**, *Oxygen-18 isotope of breath CO_2 linking to erythrocytes carbonic anhydrase activity: a biomarker for pre-diabetes and type 2 diabetes*", Scientific Reports (Nature Publishing Groups), **5**, 8137 (2015).
2. S. Jana, S. Das, C. Ghosh, A. Maity, and **M. Pradhan**, *Halloysite nanotubes capturing isotope selective atmospheric CO_2*, Scientific Reports (Nature Publishing Groups), **5**, 8711 (2015).
3. C. Ghosh, A. Maity, G. Banik, S. Som, A. Chakraborty, C. Selvan, S. Ghosh, B. Ghosh, S. Chowdhury and **M. Pradhan**, *Non-invasive ^{13}C-glucose breath test using residual gas analyzer-mass spectrometry: a novel tool for screening individuals with pre-diabetes and type 2 diabetes*, J. Breath. Res., **8**, 036001 (2014).
4. Suman Som, Abhijit Maity, Gourab Dutta Banik, Chiranjit Ghosh, Sujit Chaudhuri, Sunil Baran Daschakraborty, Shibendu Ghosh and **Manik Pradhan**, *Excretion kinetics of ^{13}C-urea breath test: influences of endogenous CO_2 production and dose recovery on the diagnostic accuracy of Helicobacter pylori infection*, Anal Bioanal Chem., **406**, 5405 (2014).
5. A. Maity, S. Som, C. Ghosh, G. Banik, S. Daschakraborty, S. Ghosh, S. Chaudhuri, and **M. Pradhan**, *Oxygen-18 stable isotope of exhaled breath carbon dioxide as a non-invasive marker of Helicobacter pylori infection*, J. Anal. At. Spectrom., **29**, 2251 (2014).
6. Gourab D. Banik, Abhijit Maity, Suman Som, Chiranjit Ghosh, Sunil B. Daschakraborty, Sujit Chaudhuri, Shibendu Ghosh and **Manik Pradhan**, *Diagnosis of small intestinal bacterial overgrowth in irritable bowel syndrome patients using high-precision stable $^{13}CO_2/^{12}CO_2$ isotope ratios in exhaled breath*, J. Anal. At. Spectrom. **29**, 1918 (2014).

Other Publications

1. *"Breath analysis by residual gas analyzer-mass spectrometry: a non-invasive method for screening individuals with pre-diabetes and type 2 diabetes"* C. Ghosh, S. Chowdhury, S. Ghosh, and M. Pradhan, ***In. J. Clin. Biochem.,*** 29, 1, 97 **(2014)**
2. *"^{18}O-isotope of Breath CO_2: a potential non-invasive marker of H. pylori infection",* A. Maity, S. Daschakraborty, S. Chaudhuri and M. Pradhan, ***In. J. Clin. Biochem.,*** 29, 1, 62-63 **(2014)**

Supervision of Students

Ph.D. Students: Gourab Dutta Banik, Abhijit Maity, Suman Som, Chiranjit Ghosh, Anulekha De and Mithun Pal

Project Student: Deepankar Singh (B.Tech), IIT Delhi

Membership of Committees

Internal Committee: Various Thesis, Interview and Technical Cell Committees

Sponsored Projects

1. Ministry of Earth Sciences (MoES): 2013-2017, **Title: "**Development of a mid-IR Cavity Ring-down Spectrometer for High-Precision Real-Time Continuous Monitoring of Multiple Trace Gases and Stable Isotopic Species in the Atmosphere".
2. Department of Biotechnology (DBT), RGYI Scheme: 2013-2016, **Title:** "Cavity Ring-Down Spectroscopy for Real-Time Breath Analysis: a Next-Generation Diagnostics in Modern Medicine".

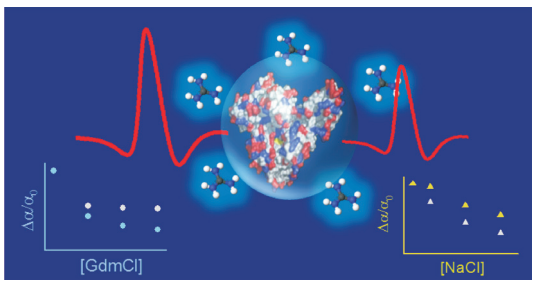
Rajib Kumar Mitra

Associate Professor
rajib@bose.res.in

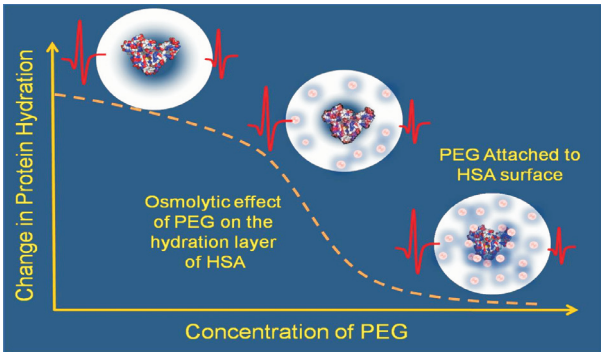
Dr. Rajib Kumar Mitra carried out Ph.D. work at Indian Statistical Institute, Kolkata (Ph.D. degree awarded by Jadavpur University in 2005). He joined S.N. Bose National Centre for Basic Sciences as a Post Doctoral fellow in 2006, selected as a Bose Fellow in 2007. He worked as a BOYSCAST Fellow at Ruhr University, Germany during 2009-2010. He joined the centre as an Assistant Professor in August, 2010.

- Terahertz Spectroscopy, Time resolved fluorescence spectroscopy, Hydration dynamics, Biophysics, Protein folding, Self-assembled systems (micelles, reverse micelles, lamellae, vesicles etc.), Nanomaterials

1. Our group has address a very fundamental question in biophysics that whether urea acts as a water 'structure breaker' and its consequence towards its unique property to denature proteins. Our study using THz time domain spectroscopy (TTDS) study confirms that urea does perturb the extended solvation layer around itself which supports the strongly debated "water structure breaker" debate of urea during its protein denaturation process. We extended this study to another protein denaturing agent guadinidinium hydrochloride (GdmCl) and comparison of its results with normal salt (e.g. NaCl) concludes that the change in the collective hydration dynamics around the salts plays a definite role during the protein denaturation process of GdmCl.



2. Short chain polyethylene glycols exhibit an unusual phenomenon of facilitating thermal unfolding of human serum albumin. We determine the associated hydration structure using far-infrared and THz spectroscopic technique and compared the results with some associated well known protein stabilizing osmolytes.



3. We have investigated the thermodynamic parameters associated with the dissociation of small ligands from DNAs (of different sequences and vis-à-vis different binding modes) calorimetrically and observed that the dissociation is universally entropy driven irrespective of the ligand-binding specificity.

4. Our study has identified that the collective hydrogen bonded network of water inside reverse micellar (RM) water pool is dependent on the charge of the RM surface**.** We have observed that enzyme kinetics in RM waterpool can be regulated by mixing of surfactants.

5. We have made an combined THz spectroscopic and MD simulation study to understand the non-monotonic nature of the hydration dynamics in water and 1, 2-diemthoxyethane (DME) mixture as water evolves from being a solute to a solvent as a function of the concentration of the mixture.

6. We have investigated the change in the hydration dynamics in the vicinity of ions (following a Hofmeister series) and correspondingly their ability to stabilize or destabilize proteins.

7. We have prepared single wall carbon nanotube (SWNT)/PVA composite films via a slow drying process with a constant thickness with varying SWNT length and SWNT weight fraction in the polymer. THz conductivity spectra are obtained for those films in transmission geometry in the frequency range of 0.3-2.0 THz. It is explicitly shown that real conductivity of such films can be tuned up to 80% in a controlled manner by carefully choosing the length and weight fraction of SWNT's.

Future Plan

1. Development of a broadband THz facility (~10 THz) using optical rectification (OR) technique. This facility could be coupled with a scanning mode through which THz imaging could be realized.
2. We will investigate how the individual amino acids of varying hydrophobicity interact with water and how progressive addition of amino acids (through peptide links) modifies such interactions.
3. We will address a very fundamental question: does the hydration structure of the L-isomers of amino acids differ from those of the corresponding D-isomers, which in turn makes the L-isomers the chosen one by the nature?
4. We will determine real time kinetics of protein folding/unfolding process and the associated change in their hydration structure in presence of molecular crowding agents. The real time folding kinetics would be estimated by coupling stopped-flow equipment with CD spectrometer, while the real time dynamics change would be estimated by coupling the stopped flow equipment with THz time domain setup.
5. Development of efficient optical devices for THz applications which involves THz polarizers, optical filters etc. Some specific studies include: study of the EMI shielding properties of different carbon nanotube (i.e. single walled, multi-walled and varying the diameter of carbon nanotubes) – polymer composites and model their composite a.c. conductivity spectra; study the EMI shielding properties of CNT-polymer composites via mixing nanoparticles in the composite; Anisotropic conductivity and polarization property of electrically aligned CNT-polymer composite will also be studied in THz frequency range; polarization behavior and anisotropic conductivity of aligned highly conducting (e.g. gold) nanoparticles.

Publications in Journals

1. D. Polley, A. Barman, and **R. K. Mitra**, *Controllable terahertz conductivity in single walled carbon nanotube/polymer composites*, J. App. Phys., **117**, 023115 (2015).
2. N. Samanta, D. Das Mahanta, and **R. K. Mitra**, *Collective Hydration Dynamics of Guanidinium Chloride Solutions and its Possible Role in Protein Denaturation: A Terahertz Spectroscopic Study*, Phys. Chem. Chem. Phys., **16**, 23308-23315 (2014).
3. N. Samanta, D. Das Mahanta, and **R. K. Mitra**, *Does Urea Alter the Collective Hydrogen-Bond Dynamics in Water? A Dielectric Relaxation Study in the Terahertz-Frequency Region*, Chem. Asian J., **9**, 3457-3463 (2014).
4. N. Samanta, D. Das Mahanta, S. Hazra, G. S. Kumar and **R. K. Mitra**, *Short Chain Polyethylene Glycols Unusually Assist Thermal Unfolding of Human Serum Albumin*, Biochimie, **104**, 81-89 (2014).
5. A. Patra, T. Q. Luong, **R. K. Mitra**, and M. Havenith, *The Influence of Charge on the Structure and Dynamics of Water Encapsulated in Reverse Micelles*, Phys. Chem. Chem. Phys., **16**, 12875-12883 (2014).
6. A. Das, and **R. K. Mitra**, *Does the Optimum Hydrophilic Lipophilic Balance Condition Affect the Physical Properties of Mixed Reverse Micelles? A Spectroscopic Investigation*, J. Phys. Chem. B, **118**, 5488-5498 (2014).

Other Publication

1. Polley, D., Patra, A., Barman, A. and Mitra, R.K., "Modulating Conductivity of Au/CNT Composites in THz Frequency Range: A THz Resistor", Conference Proceedings, 39th International Conference on Infrared, Millimeter and THz Waves, The University of Arizona, Tucson, USA, September 14-19, 2014.

Supervision of Students

Ph.D. Students: Animesh Patra, Arindam Das, Nirnay Samanta, Debanjan Polley, Debasis Das Mahanta

Project Student: Neeraj Kumar

Lecture Delivered

1. Urea and guanidinium chloride Act as 'Water Structure Breakers': the Debate Revisited, National Institute of Technology, Sikkim, 23-24 January, 2015.

Courses Taught

1. PHY 301, Atomic and Molecular Physics, 3rd Semester (Aug-Dec 2014)
2. PHY 405, Biological Physics, 4th Semester (Jan-July, 2015)

Membership of Committees

Internal Committee: Syllabus Modification Committee, Technical Cell Working Group, Technical Cell Advisory Committee, CWEP Committee

Sponsored Projects

1. Water encapsulated in mixed reverse micelles: modulation of its structure, dynamics and activity (funded by CSIR).
2. Real Time Structure and Solvation Dynamics of Proteins during Folding/Unfolding in Crowded Environment (funded by DST).

Ranjit Biswas

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Ranjit Biswas and his group perform experiments, carry out computer simulations and develop analytical theory in our group to study relaxation dynamics in condensed phases that include deep eutectics, ionic liquids, binary aqueous and other solvent mixtures, complex sugars etc. They aim to build up molecular-level understanding via integrating theory, simulations and experiments.

- Our research has led to the development of first molecular theories for (i) dynamics in ionic liquids (ILs) and (IL+ polar solvent) mixtures, (ii) dielectric relaxation in neat ILs, (iii) first experimental measurements and theoretical understanding of interactions and dynamics in deep eutectic solvents, and (iv) heterogeneity in aqueous alcohol mixtures

We have carried out molecular dynamics simulations on orientational relaxation and hydrogen bond dynamics of molten acetamide. Signatures for orientational jumps have been detected with jump barrier estimated to be ~0.7k_BT. Simulated orientational relaxations indicate deviations from hydrodynamics and this deviation has been ascribed to the detected orientational jumps. Simulated free energy surfaces obtained at various distances between the rotating acetamide and its initial and final H-bond acceptors have been found to be symmetric double-well in nature at the transition state. These results are summarized in *J. Phys. Chem. B*, **2015**, *119*, 274-283.

Micro-heterogeneity in aqueous solutions of 2-butoxyethanol (BE), a system with closed loop miscibility gap, has been explored via absorption and time-resolved fluorescence measurements of a dissolved dipolar solute, coumarin 153 (C153), in the water-rich region at various BE mole fractions ($0 \leq X_{BE} \leq 0.25$) in the temperature range, ($278 \leq T/K \leq 320$). Evidences for both alcohol-induced H-bond strengthening and subsequent structural transition of H-bond network have been observed. Analyses of steady state and time-resolved spectroscopic data for these aquoeus mixtures, and comparisons with the results for aqueous solutions of ethanol (EtOH) and tertiary butanol (TBA) indicate alcohol aggregation in BE/water mixtures is driven by hydrophobic interaction with no or insignificant role for criticality-driven concentration fluctuations preceding phase separation. No asymptotic critical power law dependence for relaxation rates of the type, $K \propto (|T-T_c|/T_c)^{\gamma}$ with γ denoting universal critical constant, has been observed for both solute's rotational relaxation and population relaxation rates in these mixtures upon either approaching to critical concentration or critical temperature. These results are published in J. Chem. Phys. 2015, 142, 204501/1-8.

Dielectric relaxation (DR) measurements in the frequency range, ($0.2 \leq \nu/GHz \leq 50$), have been carried out for neat molten acetamide, and six different (acetamide + electrolyte) deep eutectic solvents (DESs) for investigating ion effects on DR dynamics in these ionic DESs. Electrolytes used are: lithium salts of bromide (LiBr), nitrate ($LiNO_3$) and perchlorate ($LiClO_4$); sodium salts of perchlorate ($NaClO_4$) and thiocyante (NaSCN), and potassium thiocyanate (KSCN). With these electrolytes acetamide forms DESs approximately at 80:20 mole ratio. Simultaneous fits to the measured permittivity (ε') and loss (ε'') spectra of these DESs at ~293 K require a sum of four Debye (4-D) processes with relaxation times spread over pico-second to nanosecond regime. In contrast, DR spectra for neat molten acetamide (~354 K) depict 2-D relaxation with time constants ~50 ps and ~5 ps. For both the neat and ionic systems, the undetected dispersion, $\varepsilon_\infty - n_D^2$, remains to be ~3 - 4. Upon comparison, measured DR dynamics reveal pronounced anion and cation effects. Estimated static dielectric constants (ε_0) from fits for these DESs cover the range, $12 < \varepsilon_0 < 30$, and are remarkably lower than that (ε_0~64) measured for molten acetamide at ~354 K. Hydrodynamic effective rotation volumes (V_{eff}) estimated from the slowest DR relaxation time constants vary with ion identity and are much smaller than the molecular volume of acetamide. These results are summarized in *J. Phys. Chem. B* **2015**, *119*, 8063-8071.

Future Plan

We would like to carry out (i) further dielectric relaxation and dynamic fluorescence measurem ents of other deep eutectics, (ii) simulation studies of orientational relaxation of deep eutectics, (iii) experimental and theoretical study for understanding aqueous complex sugar solutions, (iv) build up a potential energy landscape view of transport properties of IL and deep eutectics, and (v) computational studies of coulomb systems.

Publications in Journals

1. Sandipa Indra and **Ranjit Biswas**, *Heterogeneity in (2-Butoxyethanol + Water) Mixtures: Hydrophobicity-Induced Aggregation or Criticality Driven Concentration Fluctuations?*, Journal of Chemical Physics, **142**, 204501/1-8 (2015).
2. Kallol Mukherjee, Anuradha Das, Samiran Choudhury, Anjan Barman and **Ranjit Biswas**, *Dielectric Relaxations of (Acetamide + Electrolyte) Deep Eutectic Solvents in the Frequency Window, 0.2: Anion and Cation Dependence*, Journal of Physical Chemistry B, **119**, 8063-8071 (2015).
3. Satya N. Tripathy, Zaneta Wojnarowska, Justyna Knapik, Hideaki Shirota, **Ranjit Biswas** and Marian Paulch, *Glass Transition Dynamics and Conductivity Scaling in Ionic Deep Eutectic Solvents: The Case of (Acetamide+Lithium Nitrate/Sodium Thiocynate) Melts*, Journal of Chemical Physics, **142**, 184504/1-10 (2015).
4. Anuradha Das, Suman Das, and **Ranjit Biswas**, *Density Relaxation and Particle Motion Characteristics in a non-Ionic Deep Eutectic Solvent (Acetamide + Urea): Time-Resolved Fluorescence Measurements and All-Atom Molecular Dynamics Simulations*, Journal of Chemical Physics, **142**, 034505/1-10 (2015).
5. Suman Das, **Ranjit Biswas**, and Biswaroop Mukherjee, *Reorientational Jump Dynamics and Its Connections to Hydrogen Bond Relaxation in Molten Acetamide: An All-Atom Molecular Dynamics Simulation Study*, Journal of Physical Chemistry B, **119**, 274-283 (2015).
6. **Ranjit Biswas**, Anuradha Das, and Hideaki Shirota, *Low-Frequency Collective Dynamics in Deep Eutectic Solvents of Acetamide and Electrolytes: A Femtosecond Raman-Induced Kerr Effect Spectroscopic Study*, Journal of Chemical Physics, **141**, 134506/1-11 (2014).
7. Harun Al Rasid Gazi, Hemant K Kashyap and **Ranjit Biswas**, *Solvent Sorting in (Mixed Solvent + Electrolyte) Systems: Time-Resolved Fluorescence Measurements and Theory*, Journal of Chemical Sciences, **127**, 61-70 (2015).
8. Tamisra Pal and **Ranjit Biswas**, *Stokes Shift Dynamics in (Non-Dipolar Ionic Liquid + Dipolar Solvent) Binary Mixtures: A Semi-molecular Theory*, Journal of Chemical Physics, **141**, 164502/1-10 (2014).
9. Sandipa Indra and **Ranjit Biswas**, *Hydrogen Bond Dynamics of Water in Presence of an Amphiphile, Tetramethylurea: Signature of Confinement-Induced Effects*, Molecular Simulation, **41**, 471- 482 (2015).
10. Tamisra Pal and **Ranjit Biswas**, *Slow Solvation in Ionic Liquids: Connections to Non-Gaussian Moves and Multi-Point Correlations*, Journal of Chemical Physics, **141**, 104501/1-12 (2014).

Supervision of Students

Ph.D. Students: Sandipa Indra, Suman Das, Kallol Mukherjee, Juriti Rajbanshi, Ejaj Tarif, Atanu Baksi, and Kaushik Chanda

Project Student: Navya Batta Laxmi (Summer Project funded by Science Academy)

Lectures Delivered

1. Invited Talk at the International Conference Advances in Spectroscopy and Chemical Dynamics held at the IACS, Kolkata, during Dec 12-14, 2014 entitled "*Spatio-temporal Heterogeneity in (Acetamide + Electrolyte) Deep Eutectics: Fluorescence Measurements and All-Atom Computer Simulations*".
2. Invited talk at Indo-Japan meeting held at Nara, Japan, during Nov 25-27, 2014 entitled "*Heterogeneity in (Amide + Electrolyte) Deep Eutectics: Experiments and Simulations*."
3. Invited Talk at the International Conference Advances in Photochemistry 2014 held at Thiruvananthapuram during November 09-13, 2014 entitled "*Dielectric Relaxation and Stokes Shift Dynamics in (Amide + Electrolyte) Deep Eutectics: Exploring the Interrelationship*".

Course Taught

1. PHY 191 (jointly with Prof. Samir K. Pal)

Membership of Committees

Internal Committee: SCOLP, SCRE, HoD/CBMS

Sponsored Project

1. "Jump Dynamics in Ionic Liquids and Non-exponential Relaxation" funded by the CSIR, with grant no: 01(2811)/14/EMR-II (Co-PI: Dr. Biswaroop Mukherjee).

Meeting Organized

1. International Conference entitled "Advances in Spectroscopy and Chemical Dynamics" held at the IACS, Kolkata, during Dec 12-14, 2014 (Co-organizer).

Samir Kumar Pal

Professor
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Prof. Samir Kumar Pal's group is involved in the investigation of key ultrafast time scales, which are recognized to be very relevant and important in the field experimental nanoscience-technology, Biophysics and biomedical instrumentation. They have more than 170 research papers published in various international peer-reviewed journals, more than 14 patent applications, 5 extramural research funding and 5 book chapters to describe their activities concisely.

- Ultrafast Spectroscopy of Molecules and Nanomaterials, Solar Devices, Biomedical Instrumentation

In S.N. Bose National centre our research activities are mainly in the field of experimental Biological Physics, Bio-Nano Interface, Biomimetics and biomedical instrumentation. Our activities and future direction are briefly mentioned in the following section.

Research in the field of Experimental Biophysics: Our research activities in the field of experimental Biophysics are interdisciplinary in nature that applies the theories and methods of physics. The studies included under the umbrella of biophysics range from molecular recognition of small ligands/drugs by biological macromolecules to complicated protein-DNA, Protein-Protein complexation.

Research in the field of Experimental Nano-physics and Bio-nano Interface: The interface between the biological sciences and nanoscience constitutes one of the most interesting and technologically promising frontiers in modern science. Our group is involved in the synthesis of various bio-nano conjugates. Selective attachment of inorganic semiconductor/metal quantum dots (QD) to various biological macromolecules is the key feature of the nano-conjugates.

Research in the field of Experimental Biomimetics: Our activities in the area of biomimetic systems, which are very useful to understand the complex biomolecular systems and works excellent as templates for the synthesis of nano-materials are also evident from our publications.

Research in the field of Biomedical Instrumentation: Finally our heartiest effort to bring the frontier research to common people in our society in terms of lost cost spectroscopic gadgets for the biomedical/environmental usage are obvious from our publications in allied science journals and patents.

Future Plan

1. **Plan on Experimental Biophysics:** Understanding of the ultrafast biomolecular processes (with nanosecond resolution) including early event of molecular recognition and structural events in proteins and DNA by using microfluidic/nanofluidic techniques attached to our existing picosecond/femtosecond facility will be one of focus areas of my group. Our preliminary works in this direction already reflects some promise for our future activities.
2. **Plan on Bio-nano Interface:** Non-invasive control of biological function by using magnetic field to the nanomagnets encapsulated in biological macromolecules would be our aim in near future. Exploration of the photo-processes in various nanomaterials including ZnO for the better dye sensitized solar cell application would also be our aim in our future studies.
3. **Plan on Biomimetics Studies:** Understanding the complex biomolecular reaction in chemically controllable environments of physiologically relevance will be the future activities. Synthesis of various nano-materials by solution routes for the biological application will also be our future works.
4. **Plan on Biomedical Instrumentation Studies:** Bringing science to the reach of common people in the form of technology is the motivation.

Publications in Journals

1. N. Polley, S. Saha, S. Singh, A. Adhikari, S. Das, B. Roy Choudhury and **S. K. Pal**, *Development and Optimization of a Non-contact Optical Device for Online Monitoring of Jaundice in Human Subjects*, J. Biomed. Optics, **20**, 067001 (2015).

2. S. Chaudhuri, S. Sardar, D. Bagchi, S. Singha, P. Lemmens and **S. K. Pal**, *Sensitization of an Endogenous Photosensitizer: Electronic Spectroscopy of Riboflavin in the Proximity of Semiconductor, Insulator and Metal Nanoparticles*, J. Phys. Chem. A, **119**, 4162 (2015).
3. N. Polley, S. Singh, A. Giri, P. K. Mondal, P. Lemmens and **S. K. Pal**, *Ultrafast FRET at Fiber Tips: Potential Applications in Sensitive Remote Sensing of Molecular Interaction*, Sensors and Actuators B: Chemical, **210**, 381 (2015).
4. S. Sardar, P. Kar, S. Sarkar, P. Lemmens and **S. K. Pal**, *Interfacial Carrier Dynamics in PbS-ZnO Light Harvesting Assemblies and their Potential Implication in Photovoltaic/ Photocatalysis Application*, Solar Energy Materials and Solar Cells, **134**, 400 (2015).
5. S. Sardar, S. Chaudhuri, P. Kar, S. Sarkar, P. Lemmens and **S. K. Pal**, *Direct Observation of Key Photoinduced Dynamics in a Potential Nano-delivery Vehicle of Cancer Drugs*, Phys. Chem. Chem. Phys., **17**, 166 (2015).
6. S. Singh, N. Polley, A. Mitra and **S. K. Pal**, *Spark Spectrometry of Toxic Smokes: Towards a Portable, Inexpensive and High-resolution Environment Monitoring Instrument*, Clean Technologies and Environmental Policy, **16**, 1703 (2014).
7. N. Goswami, S. Chaudhuri, A. Giri, P. Lemmens and **S. K. Pal**, *Surface Engineering for Controlled Nanocatalysis: Key Dynamical Events from Ultrafast Electronic Spectroscopy*, J. Phys. Chem. C, **118**, 23434 (2014).
8. S. Sardar, P. Kar and **S. K. Pal**, *The Impact of Central Metal Ions in Porphyrin Functionalized ZnO/TiO_2 for Enhanced Solar Energy Conversion*, J. Mat. NanoSci., **1**, 12 (2014).
9. P. Kar, S. Sardar, E. Alarousu, J. Sun, Z. S. Seddigi, S. A. Ahmed, E. Y. Danish, O. F. Mohammed and **S. K. Pal**, *The impact of the metal ions in the porphyrin-based applied materials for visible-light photocatalysis: Key information from ultrafast electronic spectroscopy*, Chemistry: A European Journal, **20**, 10475 (2014).
10. S. Banerjee, S. Chaudhuri, A. K. Maity, P. Saha and **S. K. Pal**, *Role of Caffeine in DNA Recognition of a Potential Food-Carcinogen Benzo[a]pyrene and UVA induced DNA damage*, J. Mol. Recog., **27**, 510 (2014).
11. S. Chaudhuri, S. Batabyal, N. Polley and **S. K. Pal**, *Vitamin B_2 in Nanoscopic Environments under Visible Light: Photosensitized Antioxidant or Phototoxic Drug?*, J. Phys. Chem. A, **118**, 3934 (2014).

Supervision of Students

Ph.D. Students: Samim Sardar, Susobhan Choudhury, Nabarun Polley, Siddhi Chaudhuri, Prasenjit Kar, Damayanti Bagchi, Priya Singh, Soumendra Singh (External)

Project Student: Aniruddha Adhikari

Post Doctoral Research Scientists: Srabanti Ghosh, Nirmal Goswami, Soma Banerjee, Surajit Rakshit, Anupam Giri, Prasanna Mondol

Lectures Delivered

1. Invited talk National conference Nanosci 2014 at IASST, December 2014 Guwahati, Assam
2. Invited talk National Conference Nanodays 2015, SNBNCBS, Feb 2015
3. Invited talk International conference REACH 2015, March 2015, NEHU, Shillong, Meghalaya
4. Invited Talk International conference KAUST solar future, November 2014, at KAUS, Saudi Arabia

Course Taught

1. PHY 191, CB 525

Membership of Committees

Internal Committee: Pest Control Committee, Chairman

Patents Submitted/Received

1. Citrate functionalized Mn3O4 nano-particle based sustainable therapeutic catalytic agent for hyperbilirubinemia. (Dr. S.K. Pal and others), Patent Application No: 1267/KOL/2014 dated 4-12-2014
2. A solar power driven wearable cooling kit (Dr. S.K. Pal and others), Patent Application No.: 1329/KOL/2014 dated 19-12-2014

Srabanti Ghosh

Visiting Assistant Professor
srabanti.ghosh@bose.res.in

Dr. Srabanti Ghosh received her Ph.D. in Chemical Science (2010) from Jadavpur University and UGC-DAE CSR, Kolkata centre. From 2010 to 2012, she worked as a Research Associate in Indian Association for the Cultivation of Science. She received Postdoctoral Fellowship (2012-2014), Marie Curie Cofund, RBUCE-UP in LCP, Université de Paris-Sud, France.

- Materials chemistry: Colloidal and radiolytic synthesis and biomedical applications of hybrid nanomaterials
- Semiconductor nanocomposites, conducting polymer and Graphene based nanocomposites
- Material for clean energy applications: Electrocatalysis, Fuel Cell with special emphasis on non-precious metal catalyst, Bipolar cathode for alkaline fuel cells
- Heterogeneous catalysis, Solar light harvesting and Dye sensitized solar cells

One of the significant challenges for the commercialization of direct ethanol fuel cells (DEFC) is the preparation of active, robust, and low-cost catalysts.

(i) We have developed a facile and reproducible method for the synthesis of Pd assembled nanostructures in a hexagonal mesophase formed by a quaternary system (Pd-doped water, surfactant, oil, and cosurfactant) via photo irradiation.

(ii) The formation of Pd nanostructures in the confined region of hexagonal mesophases further supported with water relaxation dynamics study using solvation probe. The mesophases can be doped by high concentrations of palladium salt (0.1 M) without any disturbance of the structure of the mesophases which allows the high yield and clean synthesis of Pd nanostructures without using any toxic chemicals.

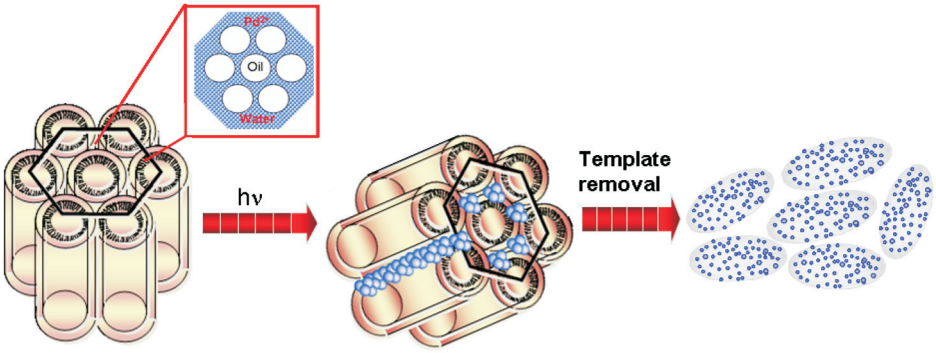
(iii) Electrochemical measurement confirms that the as-prepared catalysts exhibit significant electrocatalytic activity for ethanol oxidation in alkaline solution.

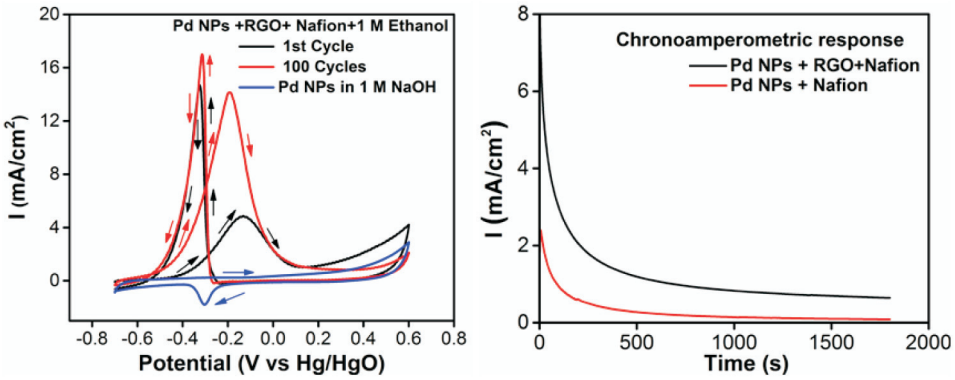
(iv) Additionally, we present an alternative strategy using reduced graphene oxide nanosheets in combination with nafion (a proton conducting phase) as a support, revealing the pronounced impact on dramatically enhanced electrocatalytic activity and stability of Pd nanostructures compared to nafion alone. This unique combination allowed the effective dispersion of the Pd nanostructures that is connected with an enhancement of the catalytic activity.

(v) The electrochemically active surface area (ECSA) of Pd/RGO-Nafion (192 m^2g^{-1}) is about 4.6 times greater than that of Pd/Nafion (40 m^2g^{-1}) electrode. Interestingly, the superiority of Pd/RGO-Nafion in terms of current density (7166 $mA{\cdot}cm^{-2}{\cdot}mg^{-1}$) is obvious, being nearly 4.4 times higher than that of previously reported Pd nanowires (1327 $mA{\cdot}cm^{-2}{\cdot}mg^{-1}$) synthesized in hexagonal mesophases.

(vi) After 500 s, the order of activity in the chronoamperometric (CA) measurements were similar, however, Pd/RGO-Nafion catalyst exhibited the highest limiting as well as the initial current, showing the highest activity than the Pd/ Nafion catalysts. Moreover, Pd/RGO-Nafion exhibits a lower degradation rate during the reaction progress, which demonstrates its improved stability for ethanol electro-oxidation.

Our approach paves the way towards the rational design of practically relevant catalysts with both the enhanced activity and durability of electrocatalysts for fuel cell applications.





Future Plan

After addressing the synthesis and characterization of oxides based materials and metal nanostructures, we will move forward with its application activities. In particular, manganese based oxides materials for battery and fuel cell applications.

Research Activity

(i) In-situ chemically deposited Pt nanoparticles incorporated reduced graphene oxide as an efficient counter electrode for dye-sensitized solar cells.

(ii) Removal of dye from aqueous solution using Gold NPs@ Graphene Oxide Nanosheets and investigation of kinetics and adsorption behavior.

(iii) A Solution-Processed new technique for the synthesis of Mn_2O_3 nanospheres for charge storage and electrocatalysis application.

(iv) Synthesis of assembled Graphene supported Mn_2O_3 nanostructured materials for electrocatalytic water oxidation.

Publications in journals

1. Prasenjit Kar, Samim Sardar, **Srabanti Ghosh**, Bo Liu, Peter Lemmens, Omar F. Mohammed and Samir Kumar Pal, *Nano Surface Engineering of Mn_2O_3 for Potential Light-harvesting Application*, Journal of Materials Chemistry C (2015) DOI: 10.1039/C5TC01475A.

2. **Srabanti Ghosh**, Hynd Remita, Prasenjit Kar, Susobhan Choudhury, Samim Sardar, Patricia Beaunier, Partha Sarathi Roy, Swapan Kumar Bhattacharya and Samir Kumar Pal, *Facile synthesis of Pd nanostructures in hexagonal mesophases as a promising electrocatalyst for ethanol oxidation*, Journal of Materials Chemistry A, **3**, 9517–9527 (2015).

Book Published

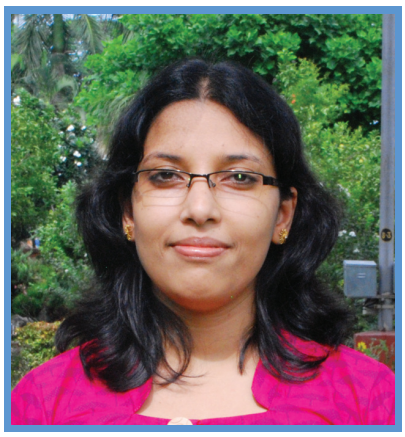
Srabanti Ghosh, Surface Chemistry of NanoBioMaterials Surface Functionalized Hybrid Nanomaterials: Implications in Biosensing and Therapeutics" Applications of NanoBioMaterials (Volume I-XI) Volume III: (2015) \Elsevier\Volume 3\11.

Award / Recognition

CSIR-Senior Research Associateship (Scientists' Pool Scheme) (2015-2018)

Subhra Jana

DST-INSPIRE Faculty
subhra.jana@bose.res.in



Subhra Jana received her Ph.D. in Chemistry from Indian Institute of Technology Kharagpur, India in 2009. After completing her Ph.D, she joined as a postdoctoral research associate in the Department of Chemical Engineering, The Pennsylvania State University, University Park, USA. She is currently working as a DST INSPIRE faculty in S. N. Bose National Centre for Basic Sciences, Kolkata. At present, her research group focuses on solution phase synthesis and potential applications of alloy, intermetallics and hybrid nanomaterials.

Colloid and Surface Science

- Colloidal Synthesis of Nanoscale Alloy and Intermetallics
- Chemistry of Inorganic-Organic Hybrid Nanomaterials
- Fabrication of Metal-Semiconductor Nanocomposites
- Low Temperature Chemical Routes to d-d Hollow Intermetallics
- Environmental and Catalytic Applications

At S. N. Bose National Centre for Basic Sciences, I am actively involved in developing a research laboratory, where I would like to carry out colloidal synthesis of d block metals, alloys and intermetallics for catalysis and spectroscopy. The current research area is the synthesis of inorganic-organic hybrid nanomaterials for catalysis, spectroscopy, and selective removal of organic solid, liquid and gaseous pollutants.

A clay based nanocomposite has been developed through selective modification of the outer surface of HNTs with an organosilane to make the nanocomposite a novel solid-phase adsorbent to capture toxic gases from the atmosphere at standard ambient temperature and pressure. The adsorption of three major abundant isotopes of CO_2 ($^{12}C^{16}O_2$, $^{13}C^{16}O_2$, and $^{12}C^{16}O^{18}O$) from the ambient air by amine functionalized HNTs has been explored using an optical cavity-enhanced integrated cavity output spectroscopy (Figure 1). CO_2 adsorption/desorption cycling measurements demonstrate that the adsorbent can be regenerated at relatively low temperature and thus, recycled repeatedly to capture atmospheric CO_2. The amine grafted halloysite shows excellent stability even in oxidative environments and has high efficacy of CO_2 capture, introducing a new route to the adsorption of isotope selective atmospheric CO_2.

Additionally, functionalization of HNTs by these organosilanes facilitates to immobilize metal NPs over the surface where HNTs behave as a solid support and organosilane acts as linker molecule and thus lead to the easy formation of HNTs/metal NCs, which in turn develops environmentally benign and low-cost heterogeneous catalysts (Figure 2). This procedure demonstrates an added advantage for the efficient separation and recycling of the catalyst once the reaction completed, which is still a challenging task in homogeneous catalysis from both the economical and ecological point of view. The clay based nanocatalysts are relatively green catalysts, environmentally benign in nature.

Future Plan

Proposed plan has been summarized below:

- ✓ Solution-based methods to synthesize new inorganic-organic hybrid nanocomposites and nanoscale alloys
- ✓ After selective surface modification, nanocmposites will be used as an adsorbent for CO_2 capture from atmospheric air.
- ✓ Preparation of size- and shape-tunable plasmonic alloy nanoparticles for surface-enhanced Raman spectroscopy studies.
- ✓ Utilize these nanocomposites as well as nanoscale alloys as heterogeneous catalysts in various chemical and photochemical reactions.

Publications in Journals

1. **S. Jana**, S. Das, C. Ghosh, A. Maity, M. Pradhan, *Halloysite Nanotubes Capturing Isotope Selective Atmospheric CO_2*, Sci. Rep. (Nature Publishing Group), **5**, 8711 (2015).

2. S. Das and **S. Jana**, *A Facile Approach to Fabricate Halloysite/ Metal Nanocomposites with Preformed and In-situ Synthesized Metal Nanoparticles: A Comparative Study of Their Enhanced Catalytic Activity*, Dalton Trans. (Royal Society of Chemistry), **44**, 8906 – 8916 (2015).
3. **S. Jana** and S. Das, *Development of Novel Inorganic-Organic Hybrid Nanocomposites as a Recyclable Adsorbent and Catalyst*, RSC Adv. (Royal Society of Chemistry), **4**, 34435-34442 (2014).

Supervision of Students

Ph.D. Student: Sankar Das

Project Student: Aritra Biswas

Lecture Delivered

1. Invited speaker and chairperson: Third International Conference on Recycling and Reuse of Materials (*ICRM-2014*) at Kottayam, India.

Membership of Committees

Internal Committee: Member of Seminar and Colloquia Programme (SCOLP) and interview committees

Award / Recognition

1. Editorial Board Member of Scientific Reports (*Nature Publishing Group*), 2015

Sponsored Projects

1. DST/IFA12-CH-60; Low Temperature Chemical Routes to Alloys, Intermetallics, and Hybrid Nanomaterials.
2. SB/SS/1259/14-15: Financial assistance received from the Department of Science & Technology

Meeting Organized

1. A Convenor of NANODAYS 2015 – A National Conference on Nanoscience, held on 16-18 February, 2015.

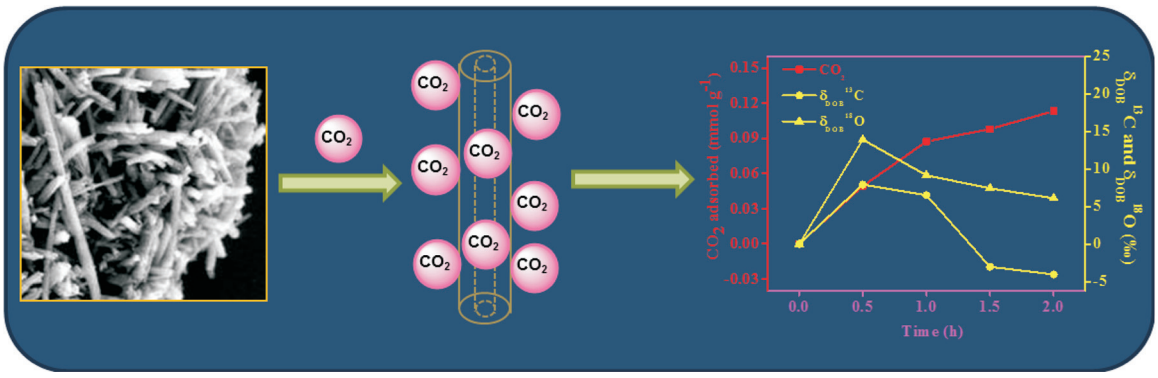


Fig.1: Schematic presentation of atmospheric CO_2 capture by a clay based nanocomposites at standard ambient temperature and pressure, followed by the adsorption kinetics of three major abundant isotopes of CO_2 present in the ambient air. The adsorption of $^{13}CO_2$ and ^{18}O of CO_2 are expressed as $\delta_{DOB}{}^{13}C‰$ and $ä_{DOB}{}^{18}O‰$.

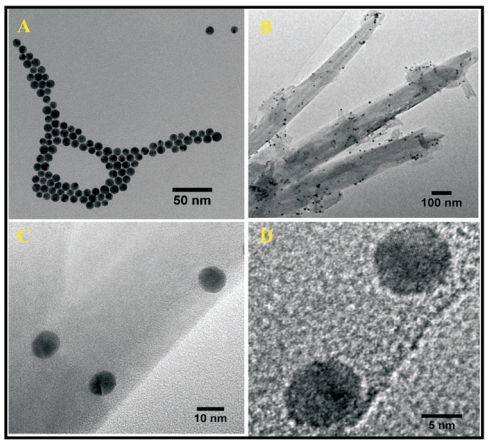
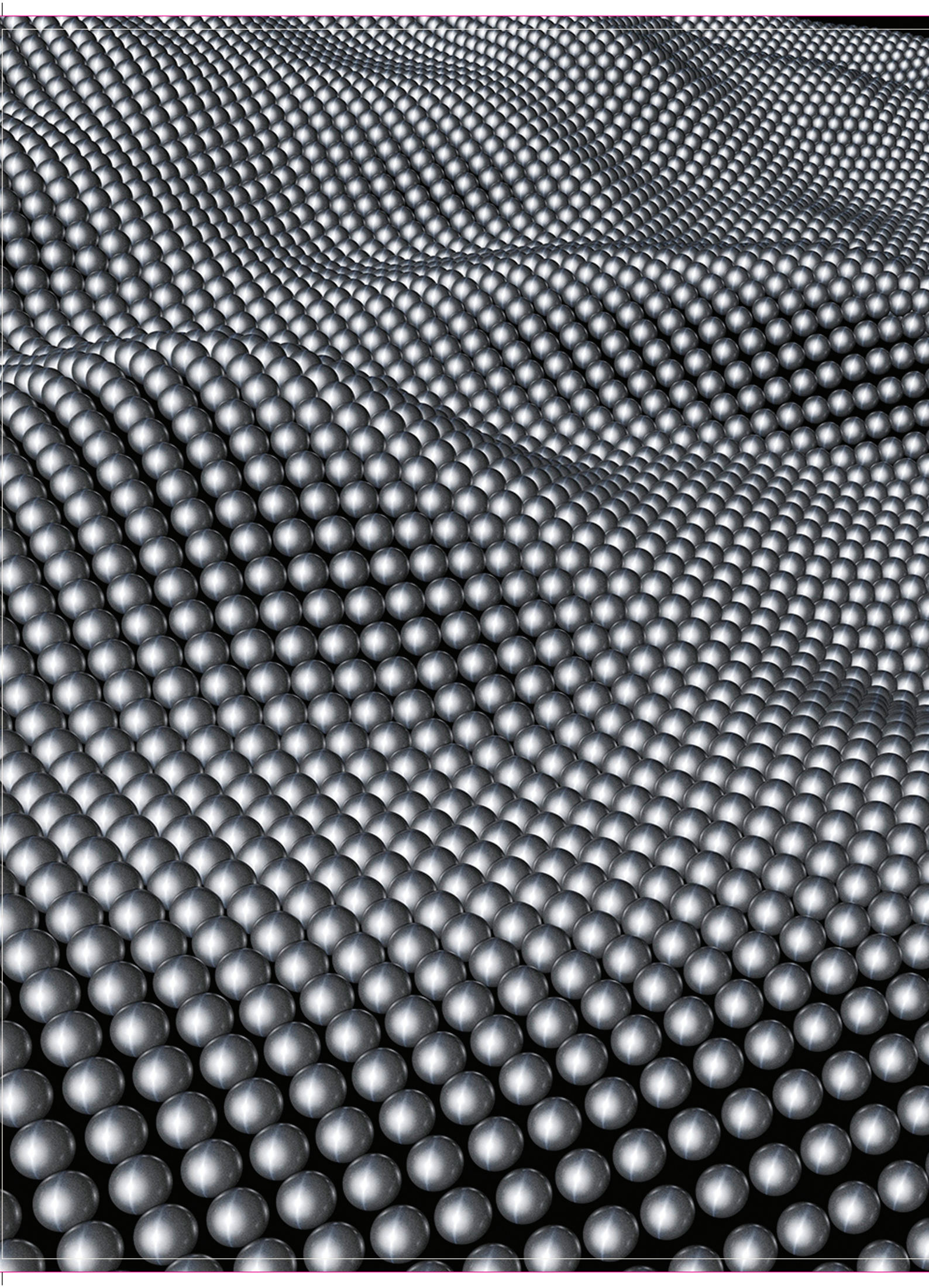
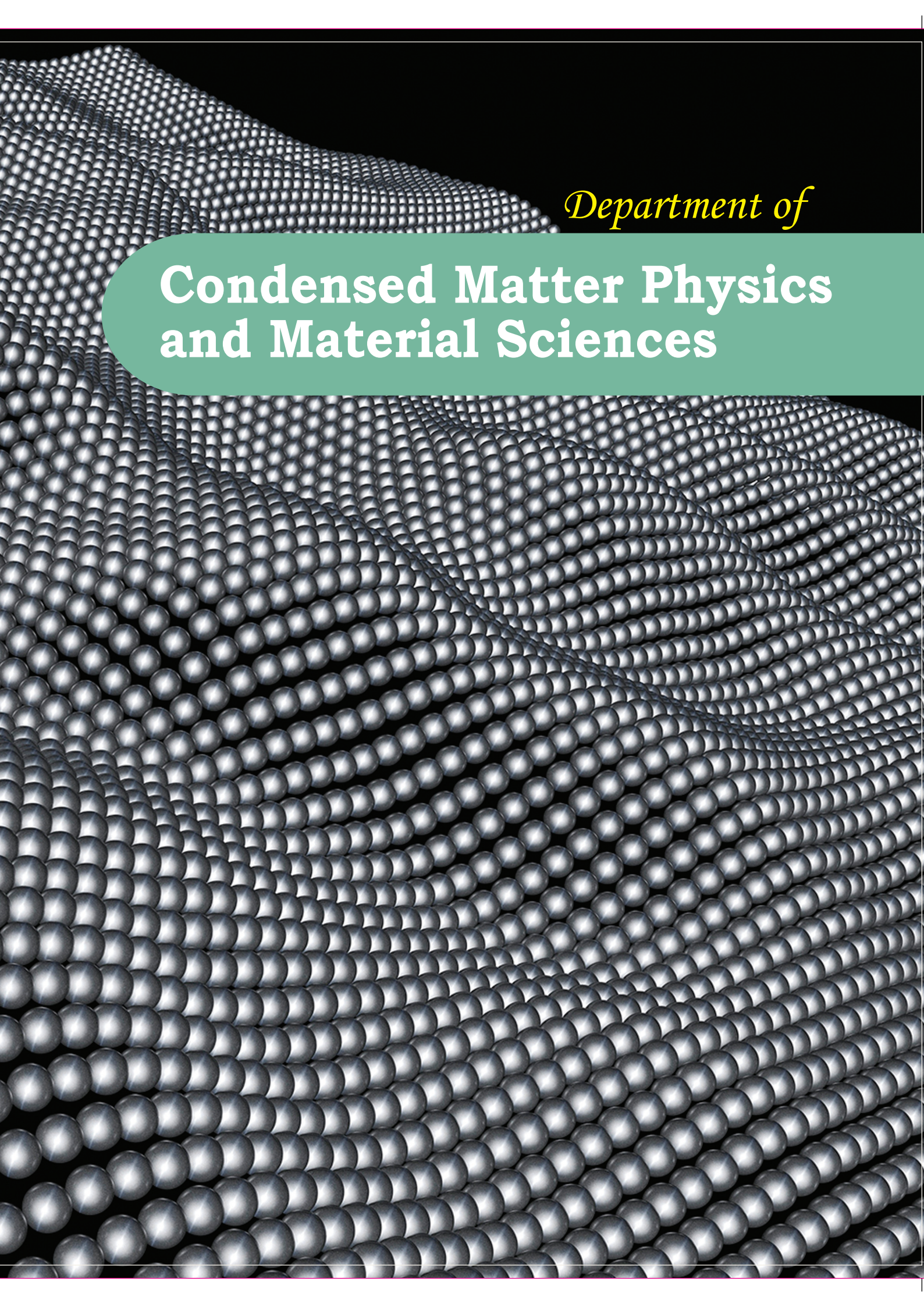


Fig.2: (A) TEM images of (A) Au nanoparticles before and (B-D) after immobilization over the surface of surface modified HNTs at different magnifications.

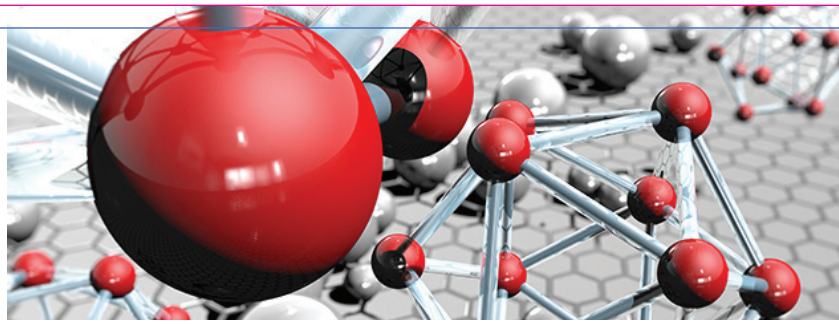




Department of

Condensed Matter Physics and Material Sciences

Department of Condensed Matter Physics and Material Sciences



Pratip Kumar Mukhopadhyay
Head of the Department

Department profile indicators:

Table A: Manpower and resources

Number of faculties	11 (permanent)
Number of Post–doctoral research associate (centre+project)	11
Number of Ph.D students	58
Number of other project staff	7 (student) + 7 (academic staff)
Number of summer students	7
Projects (ongoing)	17 (External Fund) + 3 (INSPIRE)

Table B: Research Activities indicators

Number of research papers in Journals	72
Number of Book-chapters/books	1
Number of other publications	15
Number of Ph.D students graduated (submitted+degree awarded)	16
Number of M.Tech/M.Sc projects	0

Table C: Academic activities and likeage

Number of courses taught by faculties	9	
Number of Visitors (non–associates)	2	
Number of associates	2	
Number of Seminars organized	12	
Number of Conference/Symposia/ Advanced Schools organized	3	
Number of talks delivered by members of department in conferences/Symposia	National	20
	International	12

Most important research highlights

The department works on both theoretical and experimental aspects of condensed matter physics, but there is no formal separation between the two. Main contributions from the department are as follows -

- In the theoretical division –
- The biggest group of the faculty work on the electronic band structure calculations, as applied to diverse problems. These include

properties of disordered graphene and silicene, other low dimensional materials in search of quantum phase transitions, looking for magnetism in a few monolayers, metallic nano clusters, 2-D thermal conductivities, spin crossovers in metalorganic complexes, magnetization dynamics of nano dots etc.

- The other group worked on modeling of mechanical properties and dislocations, mesoscopic systems, calculation of Cooper pair instability etc.

- In the experimental division –

- A major proportion of research work involves studying various properties of nano particles, thin films, magnetic nanodots, complex oxides etc. These include ultrafast Kerr effect, photo response in oxides, attempts for biological use, nanofabrication and nanolithography etc.

- The remaining group works on aspects like magnetocaloric effects, super capacitors, magnetorheological effects etc.

Most important research highlights

As stated above, this department works on a wide spectrum of problems. It is well nigh impossible to make justice to everything in a short summary of these in a report. The faculty pages are there for full exposition, this is only an attempted summary of their work.

Prof. A. Mookerjee and his group focused on real space approach to the density functional theory to solve various problems of electronic bandstructures in low dimensional materials, disorders, etc.

Dr. A. Dutta worked on modeling of mechanical properties of solids in low dimension and with disorder, dislocation, anelasticity etc.

Prof. A. Barman and his group worked on various aspects of magnetooptic Kerr effect on thin films, nano dots and antidotes and the like. These are for use in spintronic and similar devices. They also found vortex transistors in nano dimensions.

Prof. A. K. Raychaudhuri and his group worked on various aspects of single nano wires of metals and semiconductors. One important work was on photoresponse of ZnO for use in light detectors.

Dr. B. Ghosh Saha and her group various aspects of nano wires of various oxide materials, including photoresponses of these materials.

Prof. K. Mandal and his group worked on various aspects of nano materials, magnetic Heusler alloys, multi ferroic materials etc. Their work on supercapacitors was highlighted by the publishing journal.

Dr. M. Mandal worked with synthesis of magnetic nanoparticles with an idea for use in medical applications, like hypothermia, drug delivery etc.

Dr. M. Kumar and his group worked on theoretical aspects of electronic properties of low dimensional materials, metal inorganic complexes and similar interesting problems.

Prof. P. K. Mukhopadhyay and his group worked in various aspects of smart materials. While the magnetocaloric effects and complicated magnetic structures were studied, band structure calculations were done on some materials. Finally magnetorheological effects were studied on nano and microstructure fluids.

Prof. P. Mahadevan and her group worked on various theoretical aspects of DFT based as well as model Hamiltonians to look for the existence of ferromagnetism in ultra thin limit, ferroelectricity from microscopic considerations etc.

Prof. P. S. Deo and his group worked on mesoscopic systems. One of their interesting finds was negative partial density of states in some such cases.

Dr. R. Chaudhury and his group worked on various microscopic theories and associated problems, like instability of cooper pairings in 2-D systems, spin stiffness of strongly correlated t-J models etc.

Dr. S. Barman worked on magnetization dynamics of nano dots arrays, thermal conductivities of thin film semiconductors etc.

Dr. S. Dutta worked at the structural, magnetic and electronic properties of nano clusters, with an aim to find a good material for photocatalysis for hydrogen storage and other such applications.

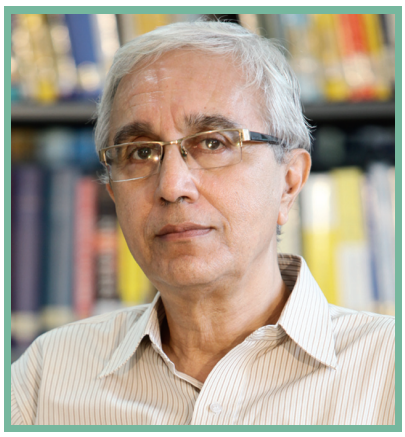
Dr. S. Mukherjee and his group worked on theretical investigations of electronic and thermal properties of two dimensional nano materials.

Prof. T. Saha Dasgupta and her group worked on various theoretical aspects of complex materaials, strongly correlated systems, nano magnetic and functional metallorganics. One of their important work was on spin crossover transition in a complex material.

Pratip Kumar Mukhopadhyay
Head, Department of
Condensed Matter Physics
and Material Sciences

Abhijit Mookerjee

Emeritus Professor
abhijit@bose.res.in



Professor Abhijit Mookerjee has been interested in the study of disorder in solids: chemical, thermal and topological: both static and dynamic. The ASR technique was introduced by him and his theoretical work has been in close collaboration with experimentalists.

- I have worked on electronic properties of disordered graphene and silicene. These materials have both local chemical disorder like dopants and voids as well as extended defects. Our study was mainly to see the effect of disorder and whether it can be used to control the D properties of these systems.

  We have adopted a fully real space approach as periodicity of the ion-core potential is destroyed by disorder. We have successfully modified our earlier augmented space codes to be compatible with the problem. We have also married our ASR with first-principles LMTO approach, so that our results are fully first-principles DFT based. Both density of states and resistance of graphene flakes in a circuit have been fully studied.

Future Plan

We will continue with graphitic materials. We shall also begin work on randomly time fluctuating potentials.

Publications in Journals

1. Suman Chowdhury, Santu Baidya, Dhani Nafday, Soumyajyoti Halder, Mukul Kabir, Biplab Sanyal, Tanusri Saha-Dasgupta, Debnarayan Jana and **Abhijit Mookerjee**, *A real-space study of random extended defects in solids: Application to disordered Stone–Wales defects in grapheme*, Physica E, **61**, 191-197 (2014).
2. Pratip Kumar Mukhopadhyay, Tanmoy Ghosh and **Abhijit Mookerjee**, *Interesting magnetic behavior of Fe: Al disordered alloys*, Physica B: Condensed Matter, **448**, 226-228 (2014).
3. Soumendu Datta, Radhashyam Banerjee and **Abhijit Mookerjee**, *Enhanced magnetism of Cu_n clusters capped with N and endohedrally doped with Cr*, J. Chem. Phys., **142**, 024309 (2015).
4. Priyadarshini Parida, Biplab Ganguli and **Abhijit Mookerjee**, *Electronic and magnetic properties at rough and sharp transition metal–metal interfaces: an augmented space approach*, J. Magn. Magn. Mat., **381**, 422 (2015).
5. Tanmoy Ghosh, Ambika Prasad Jena and **Abhijit Mookerjee**, *Effects of chemical ordering and composition on the magnetic properties of disordered FeAl alloys*, J. of Alloys and Compounds, **639**, 583-587 (2015).
6. Pratip Kumar Mukhopadhyay, Tanmoy Ghosh and **Abhijit Mookerjee**, *Interesting magnetic behavior of Fe: Al disordered alloys*, Physica B: Condensed Matter, **448**, 226 (2014).
7. Tanmoy Ghosh, Ambika Prasad Jena, Biplab Sanyal, Hirosuke Sonomura, Takashi Fukuda, Tomoyuki Kakeshita, P. K. Mukhopadhyay and **Abhijit Mookerjee**, *Effect of short range ordering on the magnetism in disordered Fe:Al alloy*, Journal of Alloys and Compounds, **613**, 306 (2014).

Book Published

Chapter 16 – "Calculation of bandgaps in nanomaterials using Harbola-Sahni and van Leeuwen-Baerends potentials" by P. Singh, M.K. Harbola and A. Mookerjee, Pages 407–418, 2015, In "Modeling, Characterization, and Production of

Nanomaterials: Electronics, Photonics and Energy Applications" A volume in Woodhead Publishing Series in Electronic and Optical Materials, Edited by: V Tewary and Y Zhang, ISBN: 978-1-78242-228-0

Supervision of Students

Ph.D. Students: Prashant Singh: now obtained PhD, RA at Aemes Lab. USA; Rajiv Singh: now obtained PhD, RA at Univ. Ohio, USA; A.P. Jena: submitted PhD; Suman Chaudhuri (CU); Banasri Sadhukhan (PU); Subhodeep Banerjee (IACS)

Project Students: Msc Projects of Sattwik Sarkar, Afroze Ahsan and Rajendra Ruk of Presidency University

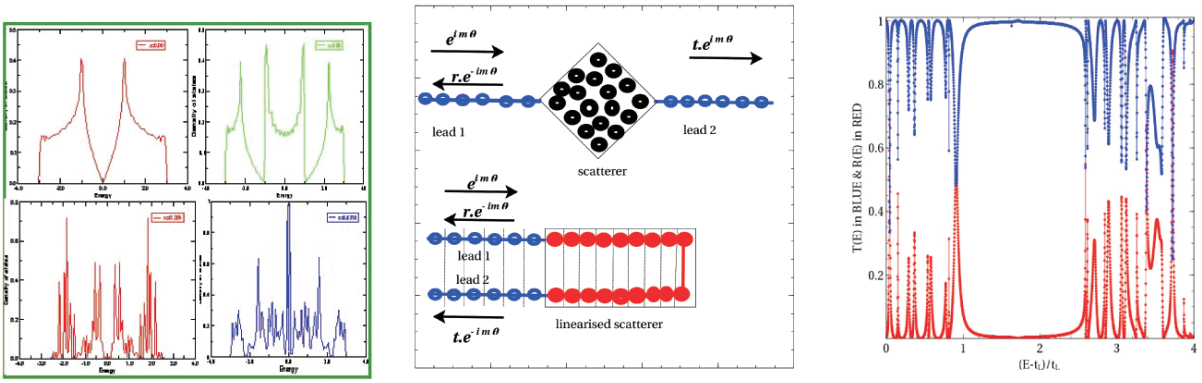


Fig: Density of states and resistance of disordered graphene

Amlan Dutta

DST-INSPIRE Faculty
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Amlan Dutta is presently working in the field of theoretical and computational material science. His primary research interests include dynamics of line defects and the associated crystal plasticity. Apart from exploring the fundamental aspects of solid state physics, he also ventures into the domain of industrial applications.

- Fundamental aspects of crystal plasticity and behavior of dislocations. Both molecular dynamics simulations and analytical modeling are used for this purpose. In particular, statistical modeling of dislocation pinning and MD simulations of nanostructures have been carried out. These include sintering of nanoparticles and Rayleigh-like instability of nanowires.

Pinning statistics - Here we propose a new statistical approach, where the statistics of pinning of dislocations by idealized spherical obstacles is explored by taking into account the generalized size-distribution of the obstacles along with the dislocation density within a three-dimensional framework. The application of this approach, in combination with the knowledge of fundamental dislocation-obstacle interactions, has successfully been demonstrated for dislocation pinning at nanovoids in neutron irradiated type 316-stainless steel in regard to both conservative and non-conservative motions of dislocations.

Rayleigh-like instability in nanowires - We demonstrate through molecular dynamics simulations, the formation of instability induced patters in ultrathin copper nanowires. This patterning is the outcome of Rayleigh-like instability, which causes alterations in surface morphology of the systems. Although the notion of Rayleigh instability is conventionally associated with liquid columns, the present study reports a similar phenomenon during the solid state annealing of metallic nanowire. This process is found to be mediated by enhanced surface diffusivity. In addition, the instabilities introduced during annealing exert shear load on the crystal, which is large enough to nucleate partial dislocations. This causes plastic slip of the crystal, which is shown to be closely associated with instability induced surface pattering. Finally, the migration of atoms on the surface of the nanowires is shown to be subdiffusive in nature.

Nanoparticle sintering - This study proposes the use of principal component analysis as a robust method of reducing the effective dimensionality of a multivariate time-series dataset, to analyze the underlying kinetics of a process studied by molecular dynamics simulations. As a proof of concept, this technique has been applied to explore the mechanism of neck formation during the sintering of two gold nanoparticles. It is found that the method of dimensionality reduction provides an intuitive and simple one-dimensional representation of this complex process, using which the quantities like rate of the process, thermodynamic forces and effective inertia can be evaluated. Both isothermal sintering and linear heating have been simulated and the fundamental differences between the kinetics of these two cases have been highlighted.

Future Plan

Thermal collapse of hollow metallic nanotubes - Previous analytical studies have predicted that a hollow nanostructure may collapse under the effect of thermal activation and internal surface tension. We are attempting to observe this effect through direct MD simulations of metallic nanotubes and investigate this phenomenon at the atomistic scales of length and time. Emphasis will be on estimating the timescales of different stages of this process.

Hypervelocity impact of nanoclusters on metallic surfaces - Such studies have become relevant on account of advent in cluster beam technologies. I shall investigate the features of surface-damage caused by high speed nanoclusters on metallic

surfaces. Both crystalline and glassy solids will be investigated. Finally, nano-indentation simulations will be used to investigate the effect of impact on surface hardness.

Measurement of elastic behavior of amorphous-crystalline silicon nanocomposites – Composites made of amorphous silicon medium containing crystalline silicon nanoparticles are of immense technological importance. Atomistic simulations will be used to study the elastic properties of such materials. In particular, the particle-medium interface will be investigated through simulation data and micromechanical modeling.

Publications in Journals

1. **A. Dutta**, M. Bhattacharya, and P. Barat, *Statistics of dislocation pinning at localized obstacles*, J. App. Phys., **116**, 143510 (2014).
2. **A. Dutta**, Swastika Chatterjee, A. K. Raychaudhuri, Amitava Moitra, and T. Saha-Dasgupta, *In-silico investigation of Rayleigh instability in ultra-thin copper nanowire in premelting regime*, J. App. Phys., **115**, 244303 (2014).
3. **A. Dutta**, *Kinetics of neck formation during nanoparticle sintering: approach of dimensionality reduction*, Rev. Adv. Mat. Sci., **39**, 25 (2014).

Other Publications

1. M. Bhattacharya, A. Dutta, and P. Barat, Stick slip response of dislocation core, TMS 2014 Annual Meeting Supplemental Proceedings, 257 (2014).
2. A. Dutta, M. Bhattacharya, and P. Barat, Statistical estimation of dislocation pinning at precipitates, voids and bubbles, EPD Congress 457 (2014).

Supervision of Student

Ph.D. Student: Suvankar Das

Course Taught

1. PHY204, Computational Methods in Physics II, 2nd Semester

Membership of Committees

Internal Committee: SCOLP committee

Anjan Barman

Professor
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Prof. Barman obtained Ph.D. in Materials Science from IACS (Jadavpur University) in 1999. He worked as postdoctoral fellow at Technion, Israel, University of Exeter, UK, University of Leeds, UK and University of California Santa Cruz between 1999 and 2006. He worked as a faculty member at University of South Carolina and IIT Delhi between 2006 and 2009 before joining S. N. Bose National Centre for Basic Sciences in 2009. His present interest is in Magnonics and Spintronics, including experimental and simulation studies of high frequency magnetization dynamics in magnetic thin films, multilayers, nanowires, nanoparticles and patterned nanostructures.

- Magnetic thin films, multilayers and patterned nanostructures; ultrafast magnetization dynamics; inelastic light scattering, magnonics; spintronics, micromagnetic simulations

During the last year, we focused on the following broad problems:

a. We developed a number of novel two-dimensional magnonic crystals with in-plane and perpendicular magnetic anisotropy. These include arrays of ferromagnetic nanodots, antidots and nanowires/nanostripes. We demonstrated a broad tunability in magnonic bands by tailoring the shapes of the nanodots, lattice symmetry, lattice constant as well as the base material. In the antidot lattices with perpendicular anisotropy we observed localization of spin wave modes around defect induced potentials around the antidots, which interact by tunnelling exchange.

b. We demonstrated a novel method of controlling the spin wave frequencies and Gilbert damping by focused and controlled Ga^+ ion irradiation of ferromagnetic/non magnetic bilayers, which caused dislocation defects and controlled intermixing at the interface. By using this interface engineering we demonstrated both an enhancement and reduction of damping behavior in $Ni_{80}Fe_{20}$/Au, $Ni_{80}Fe_{20}$/Cr and $Ni_{80}Fe_{20}$/Pt bilayers. A competition between two-magnon scattering, spin pumping and interfacial d-d hybridization led to the above properties, which was carefully modified by ion irradiation to achieve this control.

c. We investigated the effect of spin torque from the spin Hall effect in Pt/$Ni_{81}Fe_{19}$ rectangular bilayer film using time-resolved magneto-optical Kerr microscopy. Current flow through the stack resulted in a linear variation of effective damping up to ±7%, attributed to spin current injection from the Pt into the $Ni_{81}Fe_{19}$. The spin Hall angle of Pt was estimated as 0.11±0.03. The modulation of the damping depended on the angle between the current and the bias magnetic field. These results demonstrate the importance of optical detection of precessional magnetization dynamics for studying spin transfer torque due to spin Hall effect.

d. We investigated FePt/NiFe and Co/NiFe exchange spring bilayers by using Brillouin light scattering and time-resolved Kerr microscope. The interfacial coupling and the spin twist structure are found to affect the spin waves significantly.

e. We demonstrated a giant amplification in magnetic vortex based transistor (MVT) achieved by introducing geometrical asymmetry in a three vortex sequence. The resulting asymmetry in core to core distance in the three vortex sequence led to giant amplification of the MVT output. A cascade of antivortices travelling in different trajectories including a nearly elliptical trajectory through the dynamic stray field is found to be responsible for this amplification. This asymmetric vortex transistor is further used for fan out operation, which gives large and nearly equal gains in two output branches. This giant amplification in magnetic vortex gyration in magnetic vortex transistor is proposed to be maintained for a large network of vortex transistor. The above observations promote the magnetic vortex transistors to be used in complex circuits and logic operations.

Future Plan

a. **Development of magnonic devices for on-chip microwave communications:** We plan to develop magnonic waveguides with integrated filters, attenuators and phase shifters based on spin wave band gap manipulation and spin wave interference effects. We will combine advanced lithographic technique with integration with microwave chip to develop prototype devices. The high frequency characterization of the devices will also be done in our laboratory.

b. **Investigation and control of spin Hall effect:** We will investigate spin Hall effect in a number of ferromagnetic/nonmagnetic heavy metal bilayers. The spin Hall effect will be studied by current controlled modulation of damping studied by time-resolved Kerr microscopy and spin torque ferromagnetic resonance technique. We will further locally control the spin Hall effect using focused ion beam irradiation by modifying the local spin-orbit coupling, at the bilayer interface.

c. **Investigation of spin wave non-reciprocity for logic devices:** We will investigate the non-reciprocity of the amplitude of Damon-Eshbach spin waves for applications in spin wave logic devices. This non-reciprocal behavior is a consequence of the asymmetric distribution of excitation field and by engineering the excitation field and the non-uniform magnetization of the samples we will try to increase spin wave non-reciprocity.

d. **Investigation of interfacial Dzyaloshinskii-Moriya interaction:** We will study domain-wall (DW) motion induced by magnons in the presence of the Dzyaloshinskii-Moriya interaction (DMI). The DMI exerts a torque on the DW when spin waves pass through the DW, and this torque represents a linear momentum exchange between the magnon and the DW. The DMI effect in a number of ferromagnetic/non-magnetic bilayers will be studied from the asymmetry in the dispersion of spin wave frequency, amplitude and linewidth with wave-vector by Brillouin light scattering.

Publications in Journals

1. S. Pal, J. W. Klos, K. Das, O. Hellwig, P. Gruszecki, M. Krawczyk, and **A. Barman**, *Optically Induced Spin wave Dynamics in $[Co/Pd]_8$ Antidot Lattices with Perpendicular Magnetic Anisotropy*, Appl. Phys. Lett., **105**, 162408 (2014).
2. A. Ganguly, R.M. Rowan-Robinson, A. Haldar, S. Jaiswal, J. Sinha, A. T. Hindmarch, D. A. Atkinson, **A. Barman**, *Time-Domain Detection of Current Controlled Magnetization Damping in Pt/$Ni_{81}Fe_{19}$ Bilayer and Determination of Pt Spin Hall Angle*, Appl. Phys. Lett., **105**, 112409 (2014).
3. J. A. King, A. Ganguly, D. M. Burn, S. Pal, E. Sallabank, T. P. A. Hase, A. T. Hindmarch, **A. Barman** and D. Atkinson, *Local Control of Magnetic Damping in Ferromagnetic/Non-magnetic Bilayers by Interfacial Intermixing Induced by Focused Ion-Beam Irradiation*, Appl. Phys. Lett., **104**, 242410 (2014).
4. B. K. Mahato, B. Rana, D. Kumar, S. Barman, S. Sugimoto, Y. Otani, and **A. Barman**, *Tunable Spin Wave Dynamics in Two-Dimensional $Ni_{80}Fe_{20}$ Nanodot Lattices by Varying Dot Shape*, Appl. Phys. Lett., **105**, 012406 (2014).
5. **A. Barman** and A. Haldar, *Time-domain study of magnetization dynamics in magnetic thin films and micro- and nanostructures*, Solid State Physics, **65**, pp. 1-108 (2014).
6. A. Haldar, C. Banerjee, P. Laha, and **A. Barman**, *Brillouin light scattering study of spin waves in NiFe/Co exchange spring bilayer films*, J. Appl. Phys., **115**, 133901 (2014).
7. S. Pal, S. Barman, O. Hellwig and **A. Barman**, *Effect of Spin-Twist Structure on the Spin-Wave Dynamics in $Fe_{55}Pt_{45}/Ni_{80}Fe_{20}$ Exchange Coupled Bi-Layers with Varying $Ni_{80}Fe_{20}$ Thickness*, J. Appl. Phys., **115**, 17D105 (2014).
8. C. Banerjee, S. Saha, S. Barman, O. Rousseau, Y. Otani and **A. Barman**, *Width Dependent Transition of Quantized Spin-Wave Modes in $Ni_{80}Fe_{20}$ Square Nanorings*, J. Appl. Phys., **116**, 163912 (2014).
9. D. Polley, **A. Barman**, and R. K. Mitra, *Controllable Terahertz Conductivity in Single Walled Carbon Nanotube/Polymer Composites*, J. Appl. Phys., **117**, 023115 (2015).
10. J. S. Roy, T. P. Majumder, R. Dabrowski, B. K. Mahato and **A. Barman**, *Optical behaviour of CdS nanorods dispersed in liquid crystal*, Adv. Mater. Lett., **6**, 47 (2015).
11. R. K. Upadhyay, N. Soin, S. Saha, **A. Barman** and S. S. Roy, *Fast and facile preparation of CTAB based gels and their applications in Au and Ag nanoparticles synthesis*, Materials Chemistry and Physics, **156**, 105 (2015).
12. G. Dwivedi, M. Kumar, P. Shahi, **A. Barman**, S. Chatterjee, and A. Ghosh, *Low Temperature Magnetic and Transport Properties of LSMO-PZT Nanocomposites*, RSC Advances, **5**, 30748 (2015).
13. S. Saha, S. Barman, S. Sugimoto, Y. Otani, and **A. Barman**, *Tunable Picosecond Spin Dynamics in Two Dimensional Ferromagnetic Nanodot Arrays with Varying Lattice Symmetry*, RSC Advances, **5**, 34027 (2015).

Other Publications

1. Fabrication and Characterization of 2-D Magnetic Antidot Arrays for Application in Magnonic Crystals, N. Porwal, D. Polley, S. Pal, P. Laha, A. Barman, P. K. Datta, International Conference on Fibre Optics and Photonics, M4A. 71, 2014. (http://dx.doi.org/10.1364/PHOTONICS.2014.M4A.71)
2. Modulating Conductivity of Au/CNT Composites in THz Frequency Range: A THz Resistor, D. Polley, A. Patra, A. Barman and R. K. Mitra, J. Infrared, Millimeter and Terahertz Waves, (2014). DOI:

Supervision of Students

Ph.D. Students: Dheeraj Kumar, Semanti Pal, Bipul K. Mahato, Susmita Saha, Arnab Ganguly, Debanjan Polley, Kallol Mukherjee, Chandrima Banerjee, Samiran Chowdhury, Sucheta Mondal, Santanu Pan

Project Students: Samiran Chowdhury (SNB), Kaushik Chanda (SNB), Avinash K. Chaurashiya (SNB), Kumar Neeraj (SNB), A. P. Susmitha (IIT Delhi)

Post Doctoral Research Scientists: Jaivardhan Sinha, Arabinda Haldar

Lectures Delivered

Plenary Talks

1. Investigation Of Spin Dynamics Using All-Optical Techniques, A. Barman, Durham UKIERI Workshop on Magnetization Processes, Durham University, UK, 19-20 Mar., 2015.
2. Microwave Applications of Magnetic Metamaterials, A. Barman, Spintronics and Advanced Magnetic Materials, TEQIP Workshop, IIT Hyderabad, 15-16 Nov., 2014.
3. All-Optical Excitation and Detection of Ultrafast Spin Dynamics in Magnetic Thin Films and Nanostructures, A. Barman, IONS-Asia 6, Optical Society of America, IIT Kharagpur, 10-12 Dec., 2014.

Invited Talks

4. Nanoscale Magnonics: A New Paradigm Towards All-Magnetic Computation, A. Barman, Nanodays 2015, Kolkata, 16-18 Feb., 2015.
5. Nanoscale Magnonics in Ferromagnetic Antidot Lattices, A. Barman, Indo-Japan Workshop on Magnetism at Nanoscale, NISER Bhubneswar, 10-12 Jan, 2015.
6. Optically Induced Spin Waves in Two-Dimensional Patterned Nanostructures, A. Barman, IEEE ICMM Conference, Sendai, Tohoku, Japan 29th June – 2nd July, 2014.

Academic Visits

1. Tohoku University, Japan (July 2014)
2. Durham University, UK (March 2015)

Courses Taught

1. PHY292 Project Based Course I, 2014-15
2. PHY 304 Project Based Course II, 2014-15

Membership of Committees

Internal Committee: Member of Admission Committee, Member of Works Committee, Member of NPEP committee of EVLP, Member of Faculty Search Committee, Member of Technical Cell Advisory Committee, Co-ordinator of the Theme Unit of Excellence on Nanodevice Technology

Patent Submitted/ Received

1. A Micro or Nanoscale Magnetic Material for Filtering Microwave or Submillimeter Waveband Signals, Inventors: D. Kumar and A. Barman, Patent Application No. 3800/DEL/2014, Country: India.

Awards / Recognitions

1. Editorial Board Member of ***Scientific Reports*** (Nature Publishing Group)
2. Chaired a session in Durham UKIERI Workshop on Magnetization Processes, Durham University, UK, 19-20 Mar., 2015
3. Chaired a session in Indo-Japan Workshop on Magnetic Nanomaterials, NISER, Bhubneswar, 9-12 Jan, 2015
4. Chaired a Session in Condensed Matter Days 2014, University of Calcutta, 27-29 Aug., 2014
5. Chaired the *Spin Torque Oscillators and Spin Wave I* session in IEEE ICMM conference in Sendai, Japan, 29th June to 2nd July 2014

Sponsored Projects

1. Nano-Engineered Magnetic Materials for Spintronic Applications, Funding agency: UKIERI DST Thematic Partnership 2012.
2. Advanced Spectro-Microscopy for Novel Materials, Funding agency: S. N. Bose National Centre for Basic Sciences
3. Thematic Unit of Excellence on Nanodevice Technology, Funding Agency: Nano Mission, DST

Meeting Organized

1. Indo-Japan Workshop on *Magnetism at the Nanoscale* under DST-JSPS S&T Programme, NISER Bhubneswar, 9-12 Jan., 2015

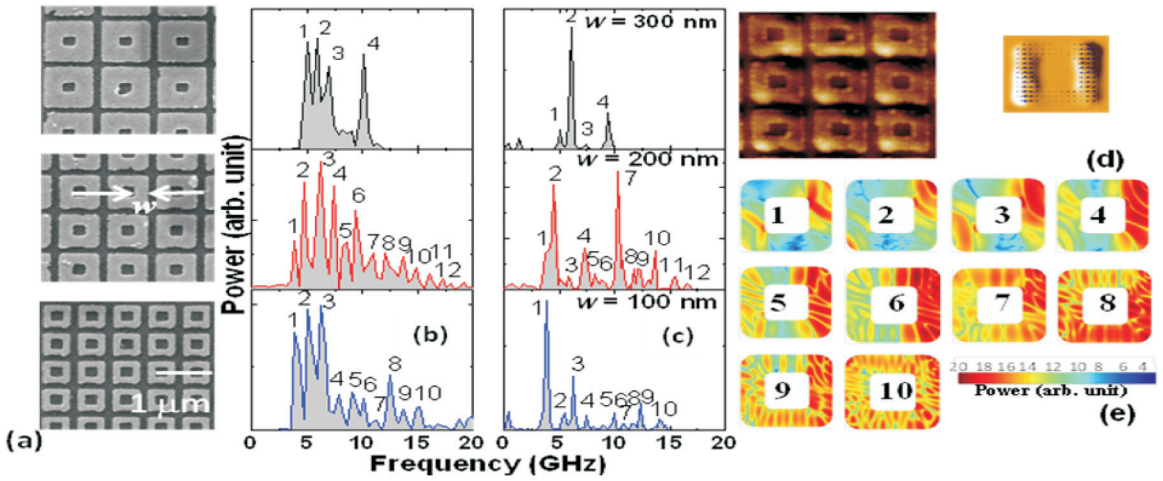

Fig. 1 (a) Scanning electron micrographs of $Ni_{80}Fe_{20}$ nanoring arrays with different ring width. (b) Measured spin wave spectra showing a large variation in spin wave bandwidth and number of modes in nanorings with variation of ring width. (c) Experimental and (d) simulated magnetic force microscope images showing asymmetric onion state. (e) The power profiles of spin wave modes showing lower frequency quantized modes residing near pole regions and higher frequency azimuthal modes in the nanoring with width (w) of 100 nm.

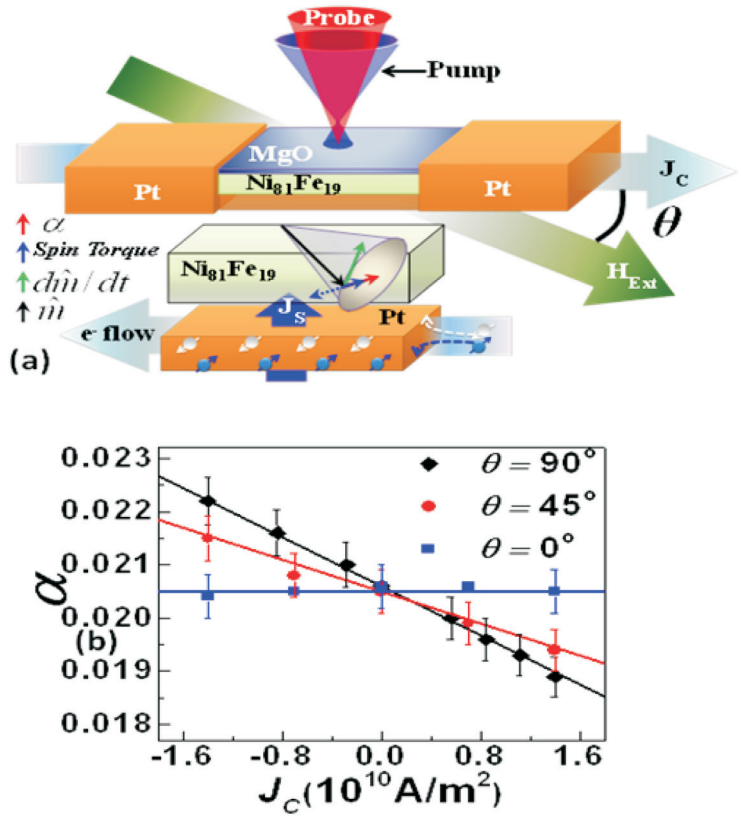

Fig. 2 Schematic of the experimental setup for all-optical measurement of spin Hall spin torque induced modulation of Gilbert damping and estimation of spin Hall angle. (b) Modulation of damping with applied DC current at different orientation of bias magnetic field.

Arup Kumar Raychaudhuri

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Prof. Raychaudhuri obtained his Ph.D from Cornell University. Prior to joining Bose Centre in 2004, he worked at Max Planck Institute, Stuttgart as Humboldt Fellow, Indian Institute of Science, Bangalore as Professor and at National Physical Laboratory, New Delhi as Director. His research interests cover a broad canvas of condensed matter physics and materials science.

- Nanomaterials, Nanofabrication and Nanolithography, Opto-electronic and Transport properties of single nanowires of metals and semiconductors,Physics of correlated oxides
- Some of the specific problems investigated: Optical response in single nanowire of Si, Enhancing photoresponse in ZnO by synergy of illumination and gating, physics of manganites
- Research Keywords: Nanomaterials, Nanolithography, Correlated electron systems, Optoelectronics

We observed at room temperature resistive state switching with hysteresis, in a thin film of $GdMnO_3$ grown on $NdGaO_3$ substrate. The switched states have a resistance ratio $\approx 10^3$. The switching occurs between a high resistance polaronic insulating state and a low resistance metallic state. The resistance state transition has been ascribed to an electronic mechanism that originates from co-existing phases (created by charge disproportionation) that can undergo a percolative transition enabled by the applied bias.

We fabricated an optical detector made from a single nanowire (diameter ≈80-100nm) of boron-doped Si, with typical electrode spacing of ≈1 μm using electron-beam lithography. A high responsivity, of the order of 10^6 A W^{-1}, was observed with peak responsivity in the near-infrared region. The responsivity was found to be polarization dependent and increases with increasing bias and decreasing nanowire diameter. Finite element based optical simulation was proposed to explain the diameter dependent performance of a single nanowire.

We observed a large mobility enhancement in electric double layer gated n-ZnO ultraviolet photodetector by synergy of gate and illumination. We studied these phenomena using a photo Hall investigation, where we measured Hall effect in presence of illumination and gate. The effect arises from a synergy between the illumination and the field effect (FE), leading to large enhancement of the channel conductivity and the photo response. We proposed that large carrier density created by the simultaneous presence of the illumination and the FE leads to neutralization of some of the oxygen charged vacancies which in turn reduce potential scattering leading to the enhanced mobility.

The above observation was made also on a FET made from nanostructured ZnO film as channel. The mechanism of passivation of charged defects by gate induced carriers has been validated by observation of gate controlled Photoluminescence, where the passivation of charged defect states by gate induced carriers led to suppression of visible photoluminescence.

We have demonstrated a simple method to increase the conductance of CuTCNQ nanorod film using graphitic oxide overlayer. The electrical conductance of CuTCNQ are then modified by graphitic oxide (GO) by dispersing it onto film of CuTCNQ nanorods. The conductance of the nanorod film is increased by approximately one order in magnitude. Increase in conductance occurs due to electronic charge transfer from graphitic oxide to CuTCNQ which has been corroborated from the observed frequency shift of C=N stretching mode as seen in Fourier Transform Infrared Spectroscopy.

We studied evolution of low field magnetoresistance (MR) of Gadolinium as the grain size in the sample is changed from few microns to the nanoscopic regime. The low field MR has a clear effect on varying grain size. In large grain sample (few μm), the magnetic domains are controlled by local anisotropy

field determined mainly by the magnetocrystalline anisotropy. The low field MR clearly reflects the temperature dependence of the magnetocrystalline anisotropy. For decreasing gain size, the contribution of spin disorder at the grain boundary increases and enhances the local anisotropy field.

Future Plan

We have developed the use of solid electrolytes ($LiClO_4$) in Polyethylene Oxide (PEO) as a gate dielectric for controlling physical properties of oxides. Presence of a solid electrolyte as a gate dielectric creates a nano-gap capacitor through the electric double layer (EDL) and can induce large surface charge exceeding 10^{13} /cm^2 on oxide surfaces which enables control of their physical properties.

We will explore the kinetics of carrier relaxation through mid gap defects states by inducing charge in ZnO by using EDL gate as well as illumination by band gap and sub-band gap light.. We will also explore the feasibility of exploring the control of grain boundary depletion by EDL gate and study it by using impedance spectroscopy.

The technique of EDL gate will also be used to control phases and induce insulator –metal transition in complex oxides by electrostatic carrier doping. Complex correlated oxides like $La_{1-x}Ca_xMnO_3$ and $NdNiO_3$ will be investigated.

We will also explore charge and resistance fluctuation neat the metal-insulator transition in correlated oxide VO_2.

Our group in recent years have acquired the capability to work with single nanowires and nanotubes so that electrical connections can be made on them for electrical and opt-electronic measurements using nanolithography tools. We plan to investigate the following nanowires using this capability in the year to come. This includes (a) Y junction Carbon nanotube (b) Charge transfer complex nanowires Cu;TCNQ, (c) Ge nanowires and (d) manganite nanowire (along with the group of Dr.Barnali Ghosh and (e) metal nanowires.

Publications in Journals

1. K. Das, S. Samanta, Prashant Kumar, K.S. Narayan and **A. K. Raychaudhuri**, *Fabrication of Single Si Nanowire Metal-Semiconductor-Metal Device for Photodetection*, IEEE Transactions on Electron Devices, **61**, 1444 (2014).
2. Rajib Nath, **A. K. Raychaudhuri**, Ya M Mukovskii, N. Andreev, Vladimir Chichkov, *Room temperature resistive state switching with hysteresis in $GdMnO_3$ thin film with low threshold voltage*, Applied Physics Letters, **104**, 183508 (2014).
3. Amlan Dutta, Swastika Chatterjee, **A. K. Raychaudhuri**, Amitava Moitra, and T. Saha-Dasgupta, *In-silico investigation of Rayleigh instability in ultra-thin copper nanowire in premelting regime*, Journal of Applied Physics, **115**, 244303 (2014).
4. K. Das, S. Mukherjee, S. Manna, S. K. Ray and **A. K. Raychaudhuri**, *Single Si nanowire (diameter = 100 nm) based polarization sensitive near-infrared photodetector with ultra-high responsivity*, Nanoscale, **6**, 11232 (2014).
5. Subarna Datta, Sudeshna Samanta, Barnali Ghosh and **A. K. Raychaudhuri**, *Low-Frequency Resistance Fluctuations in a single nanowire (diameter ˜ 45nm) of a complex oxide and its relation to magnetic transitions and phase separation*, Applied Physics Letters, **105**, 073117 (2014).
6. L. Pagliari, M. Dapiaggi,F. Maglia,T. Sarkar, **A. K. Raychaudhuri**, T. Chatterji, M. Carpenter, *Strain heterogeneity and magnetoelastic behaviour of nanocrystalline half-doped La, Ca manganite, $La_{0.5}Ca_{0.5}MnO_3$*, J.Phys.: Condensed Matter, **26**, 435303 (2014).
7. Manotosh Chakravorty and **A. K. Raychaudhuri**, *Magnetoresistance of polycrystalline Gadolinium with varying grain size*, Journal of Applied Physics, **117**, 034301 (2015).
8. Shahnewaz Mondal, Rishi Ram Ghimire and **A. K. Raychaudhuri**, *Mobility enhancement in Electric Double Layer gated n-ZnO ultraviolet photodetector by synergy of gate and illumination: A photo Hall study*, Appl. Phys.Letts, **106**, 041102 (2015).
9. Rishi Ram Ghimire, Shahnewaz Mondal and **A. K. Raychaudhuri**, *Synergistic ultraviolet photoresponse of a nanostructured ZnO film with gate bias and ultraviolet illumination*, Journal of Applied Physics, **117**, 105705 (2015).

Supervision of Students

Ph.D. Students: Rajib Nath (submitted),0020 Rabeya Basori (submitted), Rishi Ghimire, Ravindra Nath Bisht, Shaili Seth, Vibhuti Narayan Rai

Post Doctoral Research Scientists: Kaustuv Das, Sudheshna Samanta, Bipul Das, Pabitra Mandal

Lectures Delivered

1. Fabrication and electronic and optoelectronic experiments on single nanowire devices of functional materials, EMN Summer 2014, Cancun, Mexico, June 2014.
2. Physics of nano world: Some physics issues at nanoscale, Academic Staff College, University of Calcutta, Kolkata, India, July 2014.
3. Electronic and opto-electronic experiments on single functional nanowires: A new paradigm of electronic materials, Science Academies' Lecture Workshop on PHYSICS OF ELECTRONIC MATERIALS, St. Xaviers College ,Kolkata, India, August 2014.
4. Exploring magnetism in single nanowires: Challenges and some solutions, ICMAGMA 2014, Pondicherry University, Pondicherry, India, September 2014.

5. Experiments and devices based on single functional nanowires, 5th MRS China-India-Singapore Trilateral Conference on Advances in Nanomaterials, Shenyang, China, September 2014.

6. The World of Small Things: A brief tour, THE HOMI JEHANGIR BHABHA MEDAL LECTURE INSA Annual Meeting, Visva Bharati, Santiniketan, India, October 2014.

7. Design of Experiments: Some recurring themes, Indian Academy of Sciences Refresher Course on Experimental Design, Midnapore College, Midnapore, India, October 2014.

8. Single Nanowire devices: Concept, fabrication and applications, Oxford Instruments Nanotechnology Seminar (BTNT) SINP, November 24, 2014, SINP, Kolkata, India, November 2014.

9. Control of functional oxides by Electric Double Layer (EDL) Gate, CTMAT 2014 November 19, 2014, VECC, Kolkata, November 2014.

10. Electrical and Opto-electronic measurements on a single nanowire: Solid State Physics at a new scale, 59th DAE-SSPS, VIT, Vellore, India, December 2014.

11. Electrical and Optoelectronic measurements with a single nanowire, TRANSPORT PROPERTIES IN LOW DIMENSIONAL SYSTEMS: EXPERIMENT AND SIMULATION, Institute of Advanced Study in Science and Technology, Guwahati, India, December 2014.

12. Computational Materials Science: An Experimentalist's Views and Expectations, SERB School on Density Functional Theory and beyond, M.S. University , Baroda, December 2014.

13. Innovation and invention: Lessons from materials, FOUNDATION DAY ORATION, Tezpur University, Tezpur, India, January 2015.

14. Single nanowire devices: Techniques and Physics issues, NANO DAYS 2015 SNBNCBS, Kolkata,India, February 2015.

15. Physical measurements on a single nanowire: Materials Science at a new scale, Materials Research Society of India AGM, University of Rajasthan, Jaipur, India, February 2015.

16. Ultra-high response optical detectors made from single functional nanowires: Science and Techniques, ICONN2015, SRM University, Kattankulathu, India, February 2015.

Courses Taught

1. PHY 391: Experimental Methods in Physics, Fall 2014
2. PHY 409: Magnetism and Superconductivity, Spring 2015

Membership of Committees

External Committee: National Science and Engineering Board (DST); Board of Governors IIT, Kanpur (Till December 2014); Executive Council, NEHU, Shillong; Governing Body, Inter University Accelarator Centre, New Delhi; Council Indian National Science Academy (till December 2014); Sectional committee VI- INSA; Programme Advisory Committee, Solar Energy Research Initiative (DST); Programme Management Committee ,SERIUS, Indo-US Science and Technology Forum; Chair, Project Monitoring Committee, DEITY

Internal Committee: Governing Body, Finance committee (Till September 30, 2014).

Awards / Recognitions

1. Distinguished Materials Scientist of the Year (MRSI)
2. Homi Jehangir Bhabha Medal (INSA)

Sponsored Projects

1. Unit for Nanoscience (Nanomission)
2. Theme Unit of Excellence in Nanodevice Technology (Nanomission)
3. J.C.Bose National Fellowship (SERB)

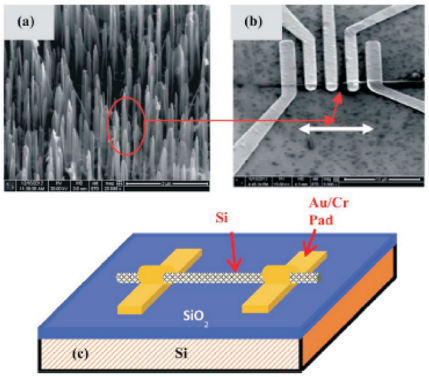


Fig.1: A single Si nanowire photodetector based on a nanowire of diameter 80nm. Leads fabricated by electron beam lithography

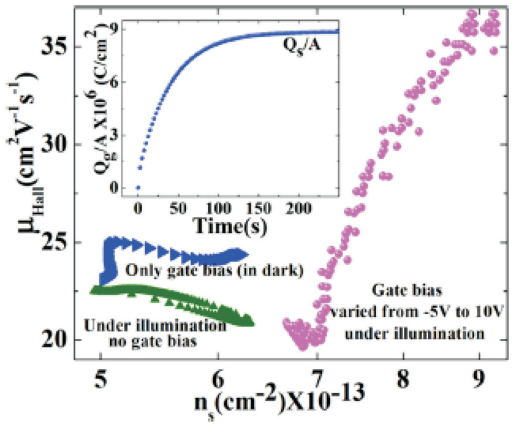


Fig.2: μ_{Hall} vs n_s under illumination, with applied gate bias in dark and with presence of both gate bias and under illumination as measured by photo Hall effect. The Inset shows the time evolution of the stored charge per unit area (Q_g/A) at the gate capacitor when a bias step is applied at the gate

Barnali Ghosh (Saha)

Scientist – E
barnali@bose.res.in

Dr. Barnali Ghosh (Saha) received her Ph.D. from University of Kalyani in 1998. She did her postdoctoral work at IISC Bangalore, and then joined at Satyendra Nath Bose National Centre for Basic Scineces in 2004 as a visiting Faculty Fellow and also as a scientist under Women Scientist Scheme (DST sponsored). On February, 2011, she has joined as Research Scientist (Scientist-D) at Satyendra Nath Bose National Centre For Basic Sciences. Now she is working as Scientist-E, since August 2013 at this centre. Her research interest is Physics of Complex oxide systems and in nano materials.

- Fabrication of single nanowire device of multifunctional perovskite oxide systems by using different lithographic techniques and transport measurement on single nanowire
- Synchrotron x-ray study in complex oxides of bulk and nanocrystals/nanowires
- Neutron Diffraction Study on complex oxide nanowires
- Growth of binary and complex oxide nanowires and thin films by using different techniques like; wet chemistry and pulsed laser deposition methods
- Cross-sectional TEM study in binary and complex oxide nanowires, nanocrystals and thin films
- Study of Photoresponse in binary oxide systems

The nature of work has two distinct regions:

a) Academic nature: Research activities along with Ph.D students under CMPMS department

b) Administrative nature: Handling central equipment facilities under Technical Cell as Scientist I/C of the cell

a) Academic work:

Experiment with single nanowire devices: Nano fabrication

The 1D nano structure of multifunctional oxides of manganites grown by hydrothermal method. Magneto-transport, structural study was done on ensemble of nanowires which shows phase separation. Measurement of low frequency resistance noise spectroscopy on a single strand of a nanowire (NW) (diameter ~ 45 nm) (shown in Fig 1a) shows that noise spectroscopy in a single NW can cleanly detect the magnetic transitions including the phase-coexistence which was observed in ensemble of nanowires. The single nanowire based device was made by e- beam and ion beam lithography and measurement done using four probe method.

Study of Photo response in binary oxides:

Room temperature photo response of thin film of WO_3 is dependent on defect states and their passivation. The film surface morphology "tunes" that leading to a change in response. Tuning of growth parameters during growth of films of binary oxide WO_3 on different substrates controls the film surface morphology and its impact on the photo response behaviour is the key observation of the study. The process results two morphologically different films like nanocrystalline and other with defect structure (needle like growth) .When compared the photo conductivity behaviour under light illumination one shows distinct photocurrent ON/OFF states, where as the other with defect structure shows persistent photocurrent with low relaxation time. We have presented an approach, modification of photocurrent by controlling the film surface morphology.

Structural evolution of complex oxide nanocrystals (<50nm) using synchrotron x-ray diffraction measurements:

One of the most interesting questions that has been investigated in recent years in nanomaterials is the stability of crystallographic phases and resulting physical properties on reducing the size of nanoparticles /crystallites. We wanted to do structural investigation on manganite nanowires to see stability of crystallographic phases under size reduction at low temperatures. Investigaion on half doped manganite nanowire (LSMO, x=0.5)) shows existence of phase co-existence by magnetic measurement.The nanowires showed a paramagnetic (PM) to FM transition at T_C~315K (close to that

seen in the bulk) followed by an antiferromagnetic (AFM) transition at T_N 210 K. Analysis of the anisotropy field (H_K) measured in NWs shows phase co- existence of FM and AFM phases below T_N and cooling leads to growth of the FM phase within the AFM phase. To understand the crystallographic structure study using synchrotron X-ray diffraction facility at Photon factory, KEK, Japan was done, it has been observed that the charge ordered half doped manganite nanowires of LSMO shows a structural transition from tetragonal to orthorhombic at the anti ferromagnetic transition temperature (T_N) while cooling from ambient temperature, interestingly. Below T_N both the crystallographic phase co-exist and from magnetic measurement also it has been seen that both the magnetic phase coexist.

b) Administrative work:

Work done other than research activities:

As a Scientist in-change of Technical cell, I have to be actively involved in the instrumental facility management and equipment installation. All the major instrumental facilities at our centre are under Technical cell, which looks after the overall running of the facilities. Technical Cell functions as a section and I am Scientist in-charge of the Cell. I/C of Technical Cell act as head of the section.

The major activity comes under the sections the following:

i) Maintenance of equipments;

ii) Purchase and installation of new instruments;

iii) Up-gradation of existing instruments under Technical cell

iv) Have to supervise smooth inflow of consumables and supplies that is needed for smooth running of the facility.

v) Also involved in the appointment and job allotment of Technical staffs associated with Technical Cell

As the major instruments are central facility instrument of S.N Bose centre, the users are mainly internal users but we have 20% of the available time for external users also on payment basis.

Future Plan

1) **Study of photoresponse of binary oxide thin film device by gate and illumination in electric double layer field effect transistors**

With the miniaturization of electronic devices, it is essential to achieve higher carrier density when operated at lower voltage in field-effect transistors (FETs). It is quite challenging to achieve high charge carrier in conventional FETs. To overcome this problem, electric double-layer technology with ultra-high charge-carrier accumulation at the semiconductor channel/ electrolyte interface has been creatively introduced into transistor. A work on EDL gate control device on thin film of binary oxide has been initiated by growing thin film by pulsed laser deposition and making the device by optical lithography technique.

2) **Study of the thin film or nanowire interface with the substrate by using Cross sectional Transmission electron microscopy:**

The thin film and nanowire of complex and binary oxides grown by Pulsed laser deposition. The cross section of the film has been done by focused ion beam assisted lithography technique and finally the structural study by transmission electron microscopy and simulation of the data for understanding the crystal structure at the interface.

3) **Study of crystallographic structure by Neutron diffraction experiment of complex oxide nanowire/ nano crystals:**

The Nuclear and magnetic structural study of hydrothermally grown nanowires will be done using Neutron diffraction experiment at ILL Grenoble, France and using reitveld refinement method the analysis will be done.

4) **Transport measurement of single nanowire devices.**

The single nanowire based device of complex oxide nanowires will be made by using electron beam and ion beam lithography and transport measurement by using four probe technique.

Publications in Journals

1. Subarna Datta, Sudeshna Samanta, **Barnali Ghosh**, and A. K. Raychaudhuri, *Low-frequency resistance fluctuations in a single nanowire (diameter ≈ 45nm) of a complex oxide and its relation to magnetic transitions and phase separation*, Applied Physics Letters, **105**, 073117, (2014).

2. Samik Roy Moulik, Sudeshna Samanta, and **Barnali Ghosh**, *Photoresponse in thin films of WO_3 grown by pulsed laser deposition*, Applied Physics Letters, **104**, 232107 (2014).

3. Nilotpal Ghosh, Subarna Datta and **Barnali Ghosh,** *Size dependence in magnetic memory, relaxation and interaction of $La_{0.67}Sr_{0.33}MnO_3$*, Journal of Magnetism and Magnetic Materials, **382**, 277–282 (2015).

4. Chiranjit Ghosh, Abhijit Maity, Gourab Dutta Banik, Suman Som, Arpita Chakraborty; Chitra Selvan, Shibendu Ghosh, **Barnali Ghosh**, Subhankar Chowdhury, Manik Pradhan, *Non-invasive ^{13}C-glucose breath test using residual gas analyzer-mass spectrometry: a novel tool for screening individuals with pre-diabetes and type 2 diabetes*, J. Breath Res., **8**, 036001 (2014).

5. Nilotpal Ghosh, Sudeshna Samanta, Barnali Ghosh, Observation of ZBCP Above T_c at Au/$Y_1Ba_2Cu_3O_{7-\ddot{a}}$ Heterostructure with a Nano Hole: A Possible Evidence for the Cooper Pairs above T_c, Jl. Superconductivity and Novel Magnetism, **27**, 1245-1248, (2014).

Supervision of Students

Ph.D. Students: Subarna Datta, Samik Roy Moulik (part time)

Post Doctoral Research Scientist: Ankita Ghatak

Lectures Delivered

1. "Modern Tools and Techniques for Nanofabrication: Single nanowire devices", EMD 2014 Workshop, NIT Durgapur, India, 20-24 September, 2014.
2. "Investigation on Nano-Structured Complex Oxides: Techniques & Some Physics Issues", TransLES-2014, Guwahati, India, 11-13 December, 2014.

Academic Visits

1. Research Proposal No: 2013-IB-020, Accepted for Synchrotron Radiation Experiments at BL-18B, Indian Beamline, Photon Factory (PF), KEK, High Energy Accelerator research Organization, 1-1, Oho, Tsukuba-Shi, Ibaraki-ken, 305-0801, Japan., visit during May 28 –June 1, 2014.
2. Research proposal No: proposal no. 831, Accepted for neutron beam time at the instrument resi at Heinz Maier-Leibnitz Zentrum (MLZ), Lichtenbergstr. 1, 85747 Garching, Germany, visit during September 8-18, 2014,

Course Taught

1. PHY391, "Methods of experimental physics", Third Semester Course

Membership of Committees

External Committee: Referee of journals: i) Journal of Material Science and Engineering B, ii) Journal of Applied Physics, iii) Solid State Communications

Internal Committee: Various committees related to Technical cell, Various purchase committees

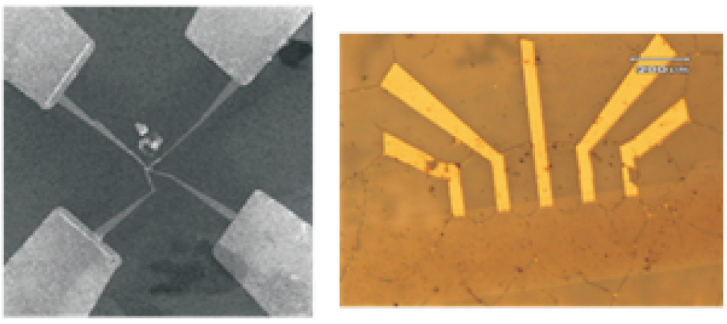


Fig1 a) Cr/Au contact pads made for single nanowire connections

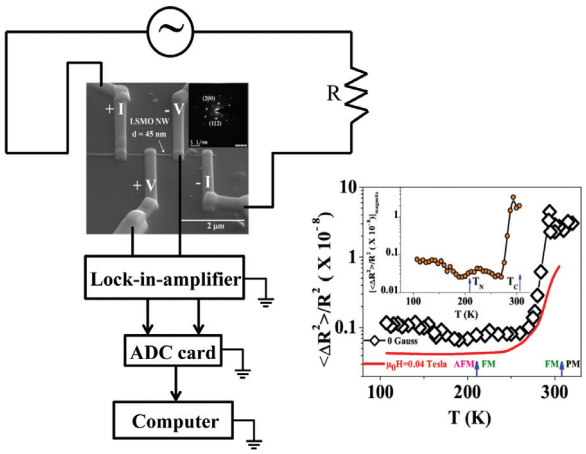


Fig1 b) 1/f noise spectroscopy study on a single nanowire based device of half doped manganite system

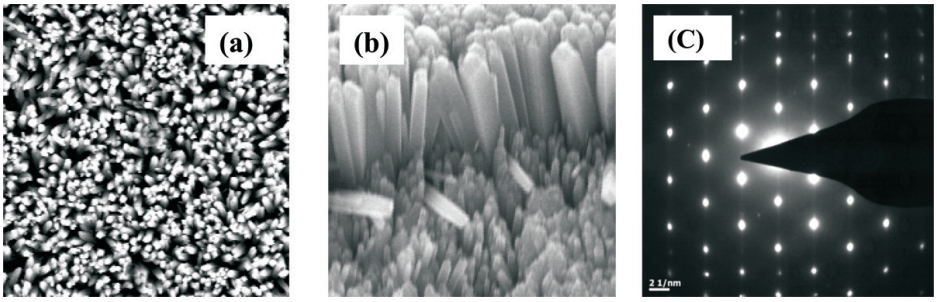


Fig 2(a). Binary oxide nanowires: a) top view b) side view c) selected area diffraction pattern of a nanowire

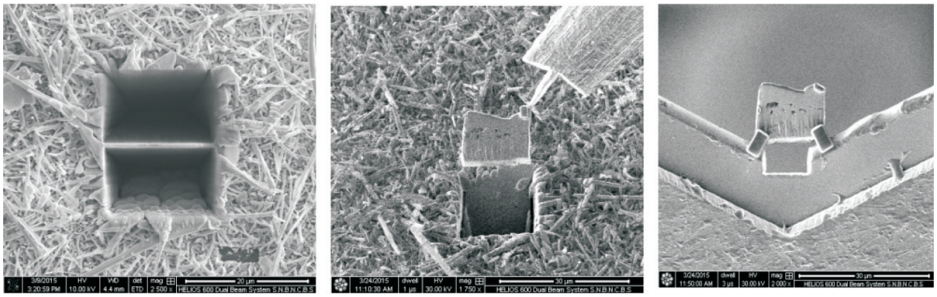


Fig 2(b). Different steps of cross sectional sample preparation using Focused ion beam lithography for TEM analysis at our laboratory

Kalyan Mandal

Professor
kalyan@bose.res.in

Prof. Kalyan Mandal was a student of Ramkrishna Mission (Asansol), Presidency College (Calcutta) and Calcutta University. He received his Ph.D. degree in Physics from Indian Institute of Technology (Kharagpur). He also worked in Queen's University (Canada), Instituto de Magnetismo Aplicado (Spain), IFW-Dresden (Germany), Durham University (UK) and Osaka University (Japan).

- Multifunctional magnetic nanomaterials
- Magnetocaloric effect in Heusler alloys
- Multiferroic materials
- Supercapacitors

I. Designing 1D Co-Ni/Co_3O_4-NiO core/shell nano-heterostructure electrodes for high-performance pseudocapacitor

Novel 1D Co-Ni/Co_3O_4-NiO core/shell nano-heterostructures with remarkable pseudocapacitance has been demonstrated as a high-performance supercapacitor electrode (Fig.1). The nano-heterostructures are fabricated by combining simple electrochemical deposition of Co-Ni alloy Nanowires followed by controlled oxidation.

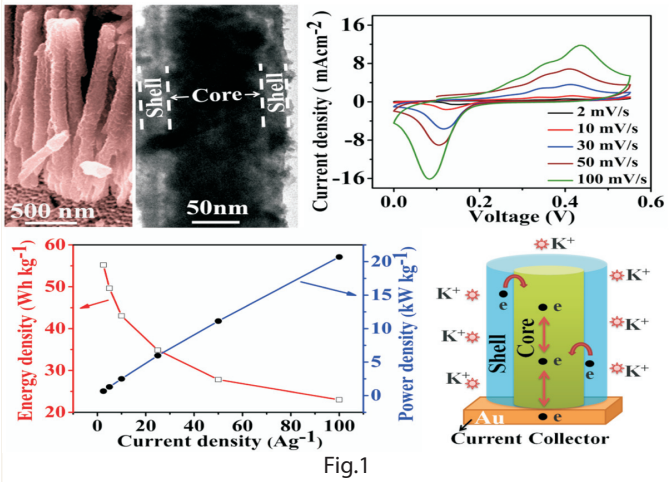


Fig.1

The unique nano-architectural design of the nano-heterostructures electrode having large rough surface area coupled with the presence of two highly redox active materials with short ion diffusion path grown on the highly conducting metal alloy channel facilitating the faster charge transport helps to achieve enhanced electrochemical properties suitable for the supercapacitor applications. The nano-heterostructures exhibit high specific capacitance nearly 1415 F g^{-1} at a current density of 2.5 A g^{-1}, high energy and power density, good capacitance retention and long cyclicality. The high quality electrochemical performance of core/shell hybrid nanostructures electrode shows its potential as an alternative electrode for forthcoming supercapacitor devices.

II. Phase diagram and magnetocaloric properties of Fe-doped Mn-rich Mn-Ni-Fe-Sn alloys

We have studied (Fig.2) the magnetic and magnetocaloric properties (magnetic entropy change; ΔS_M and Mn_2NiSn refrigerant capacity; RC) of Mn-rich (~ 50 at%) Fe-doped Mn_2NiSn off-stoichiometric Heusler alloys by varying the Ni/Fe and Mn/Fe ratios. The martensitic transition temperature is found to decrease when Ni is replaced by Fe, but an opposite result is observed in the case of the replacement of Mn by the same element. In both the cases, it follows the conventional valence electron concentration (*e/a* ratio) dependence (proportional). Substitution of Fe significantly affected the ferro/antiferro interactions in both the austenite and martensite phases of these alloy series. The ferromagnetic correlations in the austenite phase increases when Ni is replaced by Fe, but decreases when Mn is replaced by the same element. This is because of the weakening of ferromagnetic interaction in the austenite phase due to the decrease in Mn-content. In the case of martensite phase, antiferromagnetic interaction is found to reduce with increasing Fe concentration for both the

alloy series. Large values of ΔS_M is obtained with high RC in the samples doped with a smaller at% of Fe (1-2 %). These materials can be a good candidate as magnetic refrigerant for the possible use in environment friendly refrigeration technology as they show enhanced magnetocaloric effect, as well as are solid, non-toxic and economically cheap also.

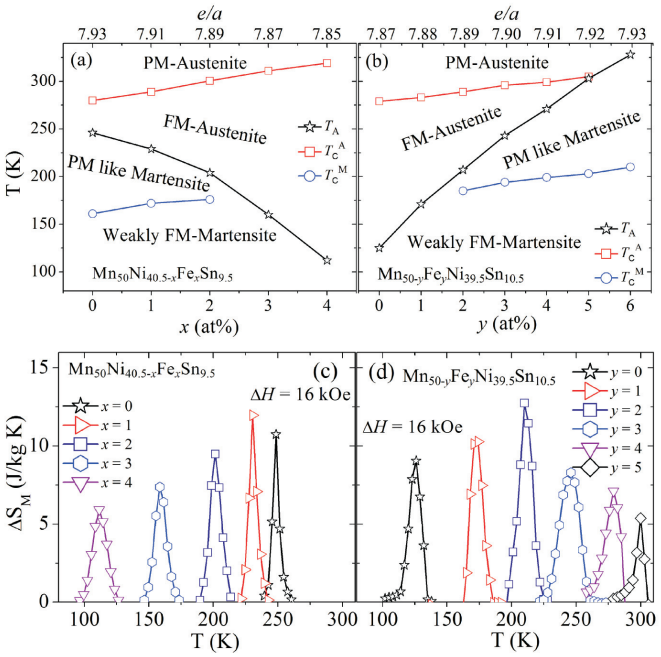


Fig.2

Future Plan

Frequency response of various iron oxide nanoparticles and nano hollow spheres will be studied in details. Surface functionalisation of those samples will be performed using various ligands having different head and tail to introduce multifunctionalities. Efforts will be made to increase the magnetic, ferroelectric and magnetoelectic properties of $BiFeO_3$ by doping. Our activities on magnetocaloric effects and supercapacitors will be continued.

Publications in Journals

1. D. Sarkar, **K. Mandal** and M. Mandal, *Detail study on ac-dc magnetic and dye absorption properties of Fe_3O_4 hollow spheres for biological and industrial application*, Journal of Nanoscience and Nanotechnology, **14**, 2307 (2014).
2. A. Ghosh and **K. Mandal**, *Effect of structural disorder on the magnetocaloric properties of Ni-Mn-Sn alloy*, Applied Physics Letters, **104**, 031905 (2014).
3. A. Chaudhuri and **K. Mandal**, *Study of structural, ferromagnetic and ferroelectric properties of nanostructured barium doped Bismuth Ferrite*, Journal of Magnetism and Magnetic Materials, **353**, 57 (2014).
4. A. K. Singh, B. Das, P. Sen, S. K. Bandyopadhyay and **K. Mandal**, *Effect of alpha-Particle Irradiation on the Magnetic Properties of Ni Nanowires*, IEEE Transaction on Magnetics, **50**, 2302104 (2014).
5. B. Das, D.ÊSarkar, M.ÊMandal, P. Das, **K. Mandal**, *DNA Engineered Tri-Functional Ni–Au Nano-Chain: Understanding of Its Formation and Novel Magnetic Properties*, Journal of Nanoscience and Nanotechnology, **14**, 2599 (2014).
6. B. Das, M. Mandal, **K. Mandal** and P. Sen, *Influence of alumina membrane on magnetic properties for thermally annealed CoPt alloy nanowires*, Colloids and Surfaces A: Physicochemical and Engineering Aspects, **443**, 398 (2014).
7. S. Ghosh, G. G. Khan, **K. Mandal**, S. Thapa, P. M. G. Nambissan, *Positron annihilation studies of vacancy-type defects and room temperature ferromagnetism in chemically synthesized Li-doped ZnO nanocrystals*, Journal of Alloys and Compounds, **590**, 396 (2014).
8. D. Pal, A. Ghosh and **K. Mandal**, *Large inverse magnetocaloric effect and magnetoresistance in nickel rich $Ni_{52}Mn_{34}Sn_{14}$ Heusler alloy*, Journal of Magnetism and Magnetic Materials, **360**, 183 (2014).
9. A. K. Singh and **K. Mandal**, *Effect of Aspect Ratio and Temperature on Magnetic Properties of Permalloy Nanowires*, Journal of Nanoscience and Nanotechnology, **14,** 5036 (2014).
10. R. Rakshit, M. Mandal, M. Pal and **K. Mandal**, *Tuning of magnetic properties of $CoFe_2O_4$ nanoparticles through charge transfer effect*, Applied Physics Letters, **104**, 092412 (2014).
11. A. K. Singh, D. Sarkar, G. G. Khan and **K. Mandal**, *Hydrogenated NiO nanoblock architecture for high performance pseudocapacitor*, ACS Applied Materials & Interfaces, **6**, 4684 (2014).
12. M. Pal, R. Rakshit, M. Mandal and **K. Mandal**, *Surface Modification of alpha-Fe_2O_3 Nanoparticles to Develop as Intrinsic Photoluminescent Probe and Unprecedented Photocatalyst*, IEEE Transaction on Magnetics, **50**, 5200404 (2014).
13. A. K. Singh, D. Sarkar, G. G. Khan and **K. Mandal**, *Designing one dimensional Co-Ni/Co_3O_4-NiO core/shell nano-heterostructure electrodes for high-performance pseudocapacitor*, Applied Physics Letters, **104**, 133904 (2014).
14. M. Pal, R. Rakshit and **K. Mandal**, *Surface modification of $MnFe_2O_4$ nanoparticles to impart intrinsic multiple fluorescence and novel photocatalytic properties*, ACS Applied Materials & Interfaces, **6**, 4903 (2014).
15. S. Ghosh, P.M.G. Nambissan, S. Thapa, and **K. Mandal**, *Defect dynamics in Li substituted nanocrystalline ZnO: A spectroscopic analysis*, Physica B: Condensed Matter, **454**, 102 (2014).
16. M. Pal, R. Rakshit and **K. Mandal**, *Facile functionalization*

of Fe_2O_3 nanoparticles to induce inherent photoluminescence and excellent photocatalytic acivity, Applied Physics Letters, **104**, 233110 (2014).

17. D. Sarkar, A. K. Singh, G. G. Khan and **K. Mandal**, *TiO_2/ZnO core/shell nano-heterostructure arrays as photo-electrodes with enhanced visible light photoelectrochemical performance*, RSC ADVANCES, **4**, 55629 (2014).
18. A. Ghosh and **K. Mandal**, *A Comparative Study of Magnetocaloric Properties Between Ni-rich and Mn-rich Ni-Mn-Sn Alloys*, IEEE Transaction on Magnetics, **50**, 2504304 (2014).

Other Publications

1. A. K. Singh and K. Mandal, "High performance supercapacitor electrodes based on metal/metal oxide core/shell nano-heterostructures" DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, **1665**, 050003.
2. R. Rakshit, M. Pal and K. Mandal, "Terahertz conductivity study of magnetite nanostructures", DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, **1665**, 050007.
3. A.K. Singh, G.G. Khan, B. Das, K. Mandal, "Growth and Magnetic characterization of 1D Permalloy Nanowires using self developed AAO Templates" International Conference on Materials Science and Technology (ICMST 2012), IOP Publishing IOP Conf. Series: Materials Science and Engineering, 2015, **73**, 012125.
4. A. Ghosh and K. Mandal, " Magnetocaloric effect in Mn-rich Mn-Fe-Ni-Sn alloys", DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, **1665**, 030015.
5. A. Chaudhury and K. Mandal, "Enhancement of ferromagnetic and dielectric properties of nanostructured barium doped bismuth fabricated by facile hydrothermal route" DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, **1665**, 050022.

Supervision of Students

Ph.D. Students: Ph.D. degree awarded: Rajasree Das, Shyamsundar Ghosh, Debasish Sarkar; Presently working for Ph.D. dissertation: Ashutosh Kumar Singh, Arup Ghosh, Rupali Rakshit, Monalisa Pal

Project Students: Anirban Kundu, Summer project entitled, "Development of cobalt ferrite nanoparticles as intricsic fluorescent probe and excellent catalyst"

Post Doctoral Research Scientist: Madhuri Mandal

Lectures Delivered

1. "Magnetic nanomaterials" in C. K. Majumdar Memorial Summer Workshop in Physics-2014"on 25 June 2014.
2. "Terahertz Conductivity of Magnetite Nano-cavities", at Osaka University, Japan on 21 October 2014.
3. "Surface functionalization of transition metal oxide nanoparticles" in Nanodays-2015 on 17 February 2015.

Academic Visit

1. Visiting Professor, Osaka University, Osaka, Japan, October-December, 2014

Courses Taught

1. PHY 291, Basic Laboratory, Second Semester 2014
2. PHY 391, Advanced Laboratory, Third Semester 2014
3. PHY 409, Superconductivity and Magnetism, Fourth Semester 2014

Membership of Committees

External Committee: Member of Executive Committee, Magnetics Society of India; Member, Executive Committee of Material Research Society of India (Kolkata Chapter); Member, Board of Judges, Young Physicists' Colloquium – 2014; Member, Board of Judges, Research Scholar Day 2014, CGCRI, 20 August 2014; Ph.D. Viva-Voce examiner of many students

Internal Committee: Library Committee, Visitors Associates and Students Programme Committee, SCRE Committee and many other committees of SNBNCBS

Awards / Recognitions

1. Visiting Professorship from Osaka University, Japan in 2014
2. Best Poster award in "59th DAE Solid State Physics Symposium" held in VIT, Vellore during 16-20 December 2014
3. Best Poster award in the conference "Nanodays-2015" held in Kolkata during 16-18 February 2015

Sponsored Project

1. Study of magnetocaloric effect

Meeting Organized

1. C. K. Memorial Summer workshop in Physics – 2014, 17-26 June 2014 in S.N. Bose National Centre for Basic Sciences

Madhuri Mandal

Visiting Faculty Fellow
madhuri@bose.res.in

Dr. Madhuri Mandal has expertise on synthesis of several kinds of nanoparticles and cell culture, spectroscopy, catalysis etc. She has completed her Ph.D from IIT, Kharagpur then completed 2 years Postdoctoral research in University of Alabama, USA. Currently she is working in S.N.Bose Centre, Kolkata as Visiting Faculty Fellow.

- Synthesis, characterization and engineering of magnetic nanoparticles for biological application like hyperthermia, drug release, biosensor etc. Studies on temperature dependent drug release activity of different particles with change of many parameters like pH, size, shape of particles etc. Some studies show promising results which give an idea of applicability of these materials in the field of hyperthermia, drug release etc.

It is already known that under AC magnetic field, magnetic particles generate heat. This heat release depends on magnetic properties of the particles. We have exploited this property to release the drug in a control manner by applying external magnetic field. Drug release activity by this method has been studied for two different sized particles at two different temperatures. It has been observed that drug release is activated with increase of temperature and with decrease of particle size.

Future Plan

Our future goal is to study interaction of these particles with cancer cells as well as with normal cells. For this purpose we will functionalize the particles with different cancer cell receptor molecules and attach the particles with cancer cells and normal cell and see selective attachment properties of the particles and cell viability test will also be done.

Publications in Journals

1. Ankita Ghatak, Gouranga H. Debnath, **Madhuri Mandal** and Prasun Mukherjee, *Lanthanide cation-induced tuning of surface capping properties in zinc sulfide nanoparticles: an infrared absorption study*, RSC Adv., **5**, 32920 (2015).
2. Monalisa Pal, Rupali Rakshit, **Madhuri Mandal**, and Kalyan Mandal, *Surface Modification of α Fe_2O_3 Nanoparticles to Develop as Intrinsic Photoluminescent Probe and Unprecedented Photocatalyst*, IEEE Transactions on Magnetics, **50**, 5200404 (2014).

Supervision of Students

Ph.D. Student: Debasish Sarkar

Project Student: Kaushik Baishya

Course Taught

1. PHY 391

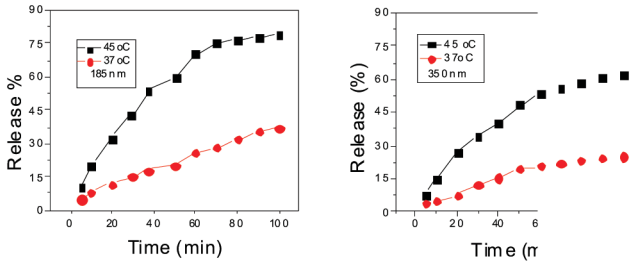
Membership of Committees

External Committee: Life member of 'Magnetic Society of India'

Sponsored Project

1. Project Title: Preparation of Magnetic Nanoparticles and Proper Bio- Functionalization for their Use in Drug Delivery and Release, Funding Agency: DST, New Delhi, PI: Dr. Madhuri Mandal

Release of drugs for 185 nm and 350 nm particles at two different temp.



Manoranjan Kumar

Assistant Professor
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Manoranjan Kumar received his Phd degree from IISc Bangalore in 2009. He was a postdoctoral research associate at Princeton University USA from 2009 to 2012. He joined as assistant professor at S N Bose centre in 2012. His broad area of interest is strongly correlated systems in condensed matter.

- My broad area of current research interest includes study of electronic properties of low dimensional materials and quantum phase transitions in various systems.

1. Our theoretical studies are mainly focused on effect of strong electron correlations in the materials. Recently our studies are more focused in the magnetic systems. Many interesting phenomena like a dimmer, Vector chiral (VC), multipolar and magnon condensation etc. occur in these systems. VC phase is one of the most desired phases of a multiferroics system and quadrapolar phase is very similar to superconductivity, where two electrons form a cooper pair whereas in quadrapolar phase two magnons condense to form a basin. Our recent studies on frustrated $J_1 - J_2$ one dimensional chains gave many new understanding like

a. Dimer phase in these 1 dimensional systems is confined to the very limited parameter regime.

b. In large J_2/J_1 limit, ground states of odd ms sectors are degenerates. Therefore, these magnetic states are not energetically favorable and leads to magnon pairing in these systems.

c. Chiral Vector phase is restricted to very limited parameter space.

2. The cooperativity in spin-crossover phenomena observed in metal-organic polymeric complexes is one important phenomenon and these materials have potential application in the device industry. We have tried to understand the microscopic origin of this cooperativity in terms of elastic interactions and magnetic degrees of freedom. The Monte Carlo simulation of the model Hamiltonian with the magnetic superexchange interactions and elastic interactions shows that magnetic interactions between localized magnetic moments plays crucial role in cooperativity. We have calculated the transition temperature, which is consistent with the experimental results.

Publications in Journals

1. H Banerjee, **Manoranjan Kumar** and T Saha-Dasgupta, *Cooperativity in spin-crossover transition in metalorganic complexes: Interplay of magnetic and elastic interactions*, Physical Review B, **90** (17), 174433 (2014).

2. Debal Kanti Singha, Saurav Bhattacharya, Prakash Majee, Sudip Kumar Mondal, **Manoranjan Kumar** and Partha Mahata, *Optical detection of submicromolar levels of nitro explosives by a submicron sized metal–organic phosphor material*, J. Mater. Chem. A, **2**, 20908 (2014).

Supervision of Students

Ph.D. Students: Aslam Parvej, Hrishit Benerjee (in collaboration with Prof. Tanusri Saha Dasgupta), Rakesh Das, Debasmita Maiti

Project Student: Sanjib Kumar Das (summer project)

Post Doctoral Research Scientist: Dayasindhu Dey

Lectures Delivered

1. Invited speaker in International Workshop and symposium on Frustrated Magnetism at JNU, New Delhi

2. Invited speaker Workshop on computational chemistry, IACS (IACS)

3. International Conference on Magnetic and Optical Molecular Materials (ICMOMM) IISc Bangalore

Academic Visit

1. IISc Bangalore for two days

Course Taught

1. PHY302 Condensed Matter Physics

Membership of Committees

Internal Committee: Member of various screening and other committees

Sponsored Project

1. Ramanujan fellowship DST

Meeting Organized

1. The S.N.Bose-JAIST quantum Monte Carlo school, 23 to 28 March 2015, at S N Bose Centre Kolkata (in collaboration with Prof. P. Mahadevan and Prof. Maezono).

Pratip Kumar Mukhopadhyay

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Lab works of Professor Pratip Kumar Mukhopadhyay are on smart materials, the new age materials that are now in the forefront of research worldwide. His main focus is on magnetic field induced effects in such materials, in both solids and complex fluids. The old interest on magnetism in disordered alloys is also alive.

1. Magnetism (and others) of metallic alloys –
   a) Functional properties, like magnetocaloric effects, of Ferromagnetic Shape Memory Alloys
   b) Theory and experiments on various interesting disordered alloys
2. Magnetic field induced rheological property changes
3. Development of body armors with smart materials

The long term interest in the lab is on smart materials. This means that they are something better adapted to work in specialized areas where ordinary materials will not be able to work on. The focus is on developing smart materials that can actually deliver a product for real life use. We are working on both magnetic and nonmagnetic, solid as well as fluid materials for various uses, from household items to the military.

In case of ferromagnetic shape memory alloys we did substitutions of various elements in a prototype Ni_2Mn-AlZ system, where Z was varied between Sn, Sb and In. There was a mixture of these in the Z elemental sites, thus the system was made quasi ternary. The idea was to enhance the properties of the alloy so that it became more mechanically workable, as well as tune the magnetic properties so that the magnetic changes accompanying the structural transitions were substantial – so that the magnetocaloric effects would be large enough to be useful. During the work we also found interesting frustrated phases at low temperatures, manifested in spin glass relaxations and good amount of exchange bias effects in them in the lower temperature.

In case of disordered magnetic alloys, we are working on basically iron based binary alloys, made with various elements. The idea is that not only they show interesting magnetic phases, there are also structural aspects to it. We are doing first principles calculations on these too, and trying to correlate with our own data.

We did a lot of work on magnetorheological fluids. We made various metallic alloy nano particles with various capping agents that insulates the metallic particles against oxidation or corrosion (both degrade the physical properties of the particles) as well as give various shapes to the composite that were tested for their effectiveness for magnetorheological properties. We also found how the rheological properties get modified under magnetic fields of various strengths.

On ordinary rheological fluids, in which there is a DRDO granted project work in making a smart body armor through these, we are making some progress. We had also made a few useful instruments for field testing these materials under bullet firing, namely light gate arrays, nano second timers, model rheometers etc.

Finally, we also started working on the discovery effect of photomicroactuation. A new student joined in January and he is busy setting up of the apparatus.

Future Plan

As stated in the previous entry, we are vigorously pursuing work on various smart materials. We are trying to develop materials which will be actually useful for everyday use. This will continue, and more and more avenues will be explored.

Publications in Journals

1. Sandeep Agarwal and **P. K. Mukhopadhyay**, *The effect of Al replacement and heat treatment on magnetocaloric properties of Ni_2Mn-Sn ferromagnetic shape memory alloys*, J. Alloy. Compd, **608**, 329 (2014).

2. Sanjay Singh, S. W. D'Souza, K. Mukherjee, P. Kushwaha, S. R. Barman, Sandeep Agarwal, **P. K. Mukhopadhyay**, Aparna Chakrabarti, and E. V. Sampathkumaran, *Magnetic properties and magnetocaloric effect in Pt doped Ni-Mn-Ga*, Appl. Phys. Lett, **104**, 231909 (2014).
3. Sandeep Agarwal, Enric Stern-Taulats, Lluís Mañosa, **P.K. Mukhopadhyay**, *Effect of low temperature annealing on magneto-caloric effect of Ni–Mn–Sn–Al ferromagnetic shape memory alloy*, Journal of Alloys and Compounds, **641**, 244–248 (2015).
4. Mayukh K. Ray, K. Bagani, **P. K. Mukhopadhyay** and S. Banerjee, *Origin of cluster spin glass and nuclear Schottky anomaly in $Mn_{50}Ni_{38.5}Sn_{11.5}$ alloy*, EPL, **109**, 47006 (2015).

Supervision of Students

Ph.D. Students: Sandeep Agarwal (CSIR) – Since graduated; Tanmoy Ghosh (SNB); Md. Injamamul Arief (CSIR); Md. Sarowar Hussain (TWAS, Italy); Abhisekh Bagchi (CSIR/SRF)

Project Students: Dipanjan Samanta; Pranam Prakash (CUSAT, Kochi; Summer Project 2014)

Independent Publication of Students

1. Tanmoy Ghosh, Ambika Prasad Jena, Abhijit Mookerjee, *Effects of chemical ordering and composition on the magnetic properties of disordered FeAl alloys*, Journal of Alloys and Compounds, **639**, 583–587 (2015).

Lectures Delivered

1. Studies of temperature dependence in some ferrofluids - ICMAGMA, Puducherry University, September 2014
2. Smart materials, the new cutting edge technology - Midnapur College, January 2015

Courses Taught

1. PHY501, Research Methodology, Fall 2014
2. PHY291, Basic Laboratory II, Spring 2015

Membership of Committees

External Committee: Member, APS; Life Member, Indian Science Congress; Member of governing body of Magnetic Society of India; International advisory board member of ICFSMA international conference series

Internal Committee: Convenor, Project Cell; Convenor, Technical Committee; Chairman, Internal Standing Committee; Ex officio chairman, Departmental Purchase Committee; member of various thesis committees; Ex officio member, SCRE; Ex officio member, CAC; Ex officio member, AC and BoS for CU-Ph.D. course; Ex officio member, APMP; Convenor and chairman, NPEP/EVLP; Incharge, Mechanical Workshop; Chairman, Liquid Helium Plant Committee

Awards / Recognitions

1. Referee for various international and Indian journals
2. Chairman for a session in "Nano Days 2015"

Sponsored Projects

1. Feasibility study of development of synthetic body armour based on smart fluids - DRDO, August 2013 –
2. Upgradation of microscope for use in the photomicroactuation experiments – Centre's project, 2014

Priya Mahadevan

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Priya Mahadevan is a Condensed Matter theorist working on understanding how materials behave using both ab-initio as well as model Hamiltonian calculations.

- Understand the mechanism of ferroelectricity from microscopic considerations
- Search for ferromagnetism at the ultrathin limit

In Phys. Rev. B 90, 125109 (2014) we have considered the example of $SrRuO_3$. This is both metallic and ferromagnetic in the bulk. Since $SrRuO_3$ involves a 4d transition metal atom, which have wide bands, the expectation was that when ultrathin films were grown on a substrate, it would retain its metallicity down to the ultrathin limit. However, it was shown experimentally that below four monolayers of $SrRuO_3$, the system was insulating. Our earlier work were found to support this view and showed that lattice distortions drove the insulating state at the three monolayers limit. In this work we consider the three monolayers limit and examine if one can retain metallicity and stop the metal to insulator transition by subjecting the films to compressive strain. This was indeed found to be the case and a modest compressive strain of 1\% was found to be sufficient. The metallic state at the three monolayers limit was found to be highly confined in two dimensions and was found to be completely spin polarized.The insulating state obtained in the absence of any strain however, was found to have a surprising origin. The lattice distortions of the RuO_6 octahedra result in a level ordering in which the dxz, dyz orbitals are at a lower energy compared to the dxy orbitals. Indeed we find such a level ordering in the majority spin channel when we examine the density of states. However, one finds a reversal of the level ordering in the down spin channel. This is traced to the differences in the exchange splitting between the dxy and the dxz/dyz orbitals which arises from the superlattice geometry that one has in which the dxy orbitals have wider bands associated with them than the dxz and dyz orbitals. Under compressive strain one can change the relative contributions of the energy gain arising from hopping with respect to that from the intraatomic exchange interaction. This can be used to control which orbital is occupied in the minority spin channel. This then has been used to bring a crossover to a spin polarized metallic state with the fourth electron occupying the dxz and dyz levels. So this demonstrates that the ultrathin limit serves as a playground for manipulating various atomic interaction strengths and allows one to arrive at unusual aspects of the electronic structure which are not found in the bulk limit.

Future Plan

Ferroelectricity is usually expected in insulating materials, as the free conduction band electrons present in a metal are expected to screen the internal electric fields resulting from the presence of a dipole. This still remains the general expectation even today, inspite of the fact that, going as far back as 1965, Anderson and Blount talked about the possibility of a ferroelectric metal. Experiments on oxygen doping in $BaTiO_3$ were shown to have metallic transport and ferroelectricity coexisting. More recently, $LiOsO_3$ was shown experimentally to be the first realization of a ferroelectric metal. This questions our basic understanding of ferroelectricity where long range Coulomb interactions are believed to play an important role in stabilizing the ferroelectric ground state. We have started with the classic example of $BaTiO_3$ and tried to understand the microscopic interactions which result in ferroelectricity being stabilized. We will then extend these ideas to $LiOsO_3$.

Publications in Journals

1. Kapil Gupta, Basudeb Mandal and **Priya Mahadevan**,

Strain-induced metal-insulator transition in ultrathin films of $SrRuO_3$, Phys. Rev. B, **90**, 125109 (2014).

2. T. Basu, V.V. Ravi Kishore, S. Gohil, K. Singh, N. Mohapatra, S. Bhattacharjee, B. Gonde, N.P. Lalla, **Priya Mahadevan**, S. Ghosh and E.V. Sampathkumaran, *Displacive-type ferroelectricity from magnetic correlations within spin-chain*, Sci. Rep., **4**, 5636 (2014).

Supervision of Students

Ph.D. Students: Saikat Debnath, Ruma Das, Basudeb Mandal, Shishir Kumar Pandey, Sagar Sarkar, Joydeep Chatterjee and Arkadev Roy

Post Doctoral Research Scientist: Bipul Rakshit, V. Ravi Kishore

Lectures Delivered

1. Invited talk at ICOMM, SSCU IISc Bangalore, March 2015.
2. Invited talk at CTCMP, NISER Bhubaneshwar, February 2015.
3. Invited talk at MRSI AGM, University of Rajasthan Jaipur, February 2015.
4. Invited talk at DAE-Solid State Physics Symposium-2014, VIT Vellore, December 2014.
5. Invited talk at DST-SERC school on Density Functional Theory and Beyond: Computational Material Science, MS University Baroda, December 2014.
6. Invited talk in Symposium on Multiscale Modeling of Materials and Devices, BARC, Mumbai, October 2014.
7. Invited talk at Solid State and Structural Chemistry Unit, IISc Bangalore, September 2014.
8. Invited talk at RRCAT, Indore, July 2014.
9. Invited talk at the Indian Academy of Sciences meeting, IISc Bangalore, July 2014.
10. Talk at IFF Forchungzentrum, Julich, June 2014.

Academic Visits

1. Indo-Austria project, University of Vienna, Vienna, June 2014.
2. Indo-US project, IISc Bangalore, Bangalore, January 2015.

Membership of Committees

Internal Committee: Various thesis committees of the centre, CWEP, SCOLP

Award / Recognition

1. MRSI Medal 2015

Sponsored Projects

1. Indo-Austria project (2014-2016).
2. DAE project on Functional transition metal oxides (2014-2017).

Meetings Organized

1. Nanodays 2015, Feb 17-19, S.N.Bose centre.
2. S.N.Bose-JAIST workshop on Quantum Monte Carlo, Mar 23-27, S.N.Bose centre.

Prosenjit Singha Deo

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Prof. Prosenjit Singha Deo did his PhD from Institute of Physics, Bhubaneswar, in 1996. He did a couple of post docs in Europe and then joined S.N. Bose Centre in 1999.

- The hierarchy of density of states in mesoscopic systems. Spontaneous symmetry breaking in quantum mechanics

We have shown for the first time that partial density of states in mesoscopic systems can become negative. This can have many counterintuitive consequences. We have also shown that a quantum many fermion system can undergo a spontanous symmetry breaking in internal frame which is not a phase transition. It can happen by virtue of Fermi statistics in presence as well as in absence of Coulomb interaction.

Future Plan

We will try to formulate partial density of states in presence of Coulomb interaction and see what role is played by negative partial density of states.

Supervision of Students

Ph.D. Students: Sreemoyee Mukherjee submitted her thesis and defended successfully. Urbashi Satpathy is continuing.

Academic Visit

1. Visited Dibrugarh University from 15 nov to 30 nov 2014

Ranjan Chaudhury

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Dr. Ranjan Chaudhury received his Ph.D. (Science) from TIFR, Mumbai (Bombay University) in 1988; he was a Post-doctoral & collaborating Visiting Scientist at ICTP (Trieste, Italy), McMaster University (Hamilton, Canada), University of Minnesota (Minneapolis, USA) , LEPES-CNRS (Grenoble, France) & BLTP-JINR (Dubna, Russia); Faculty at S.N. Bose Centre since 1994. His Awards/Honours include : NSTS scholarship awarded by NCERT (1976); Biography selected and published in Marquis Who's Who in the World, New Jersey, USA (1999 & 2011) and in Marquis Who's Who in Asia, New Jersey, USA (2007); Awarded International Scientist of the Year for 2007 by IBC, Cambridge, Great Britain (2007); Visiting Professor at AUST (Abuja, Nigeria) under NMI (Washington DC, USA) during 2009-2010; Member of American Chemical Society since 2010; Fellow of Minnesota Supercomputer Institute since 1992; Member of Rayonnement du CNRS since 1995.

- Microscopic theoretical investigation of Cooper's pairing instability in 2D lattice system and exploration of its role in bringing about superconductivity in quasi-2D systems, have been carried out in collaboration with S. Roy Chowdhury (my Ph.D. student at SNBS).
- Inelastic neutron scattering experimental results for quasi-2D XY-anisotropic quantum Heisenberg antiferromagnet have been analysed with the help of Berezinskii-Kosterlitz-Thouless theory in collaboration with Dr. S.K. Paul (SNBS) and S. Sarkar (our Ph.D. student at SNBS).
- The spin stiffness constants for strongly correlated t-J model in 1D and 2D have been theoretically calculated and studied as functions of hole doping concentration in collaboration with S. Bhattacharjee (my Ph.D. student at SNBS).
- The interplay between superconductivity and structural transition in A-15 compounds has been studied with the help of generaized Ginzburg-Landau theory in collaboration with Priyanka Ghosh (my summer student at SNBS and M.Sc. Student at ISM (Dhanbad)).
- A synthesis between earlier developed formalism of mine for investigating superconductivity in multi-layered materials and that developed by Professor M.P. Das (ANU, Canberra) recently for treating pairing in multi-band system, has been initiated.

(I) The overdoped phases of quasi-2D high-Tc cuprates are not investigated as much as the corresponding underdoped phases with regard to superconductivity in particular. It is believed though that the overdoped phase obeys Fermi liquid-like phenomenology, unlike the underdoped regime. Nevertheless, the microscopic mechanism for superconductivity is not so clear in the overdoped phase too. After the very successful application of our lattice calculation for Cooper's one pair problem to the quasi-1D organic superconductors, we took up the pairing problem on a 2D tight binding lattice. Assuming a s-wave pairing mediated by a combination of electronic and phononic mechanisms in a Fermi liquid-like background on the lattice, we calculated various physical quantities like coherence length and coupling constant. Our estimates for these agree quite well with those from both Eliashberg theory based calculations of Newns et al and experiments. Furthermore, our analysis brings out quite clearly that the electronic mechanism is a more likely candidate for pair formation in the overdoped phase and that the nature of pairing is in between a 'real-space like pairing' and 'momentum-space like pairing'.

(ii) The existence of a large central peak in the constant-q scan of the inelastic neutron scattering data for the spin ½ layered XY-anisotropic antiferromagnet La_2CuO_4 at room temperature and above obtained by Endoh and others, has always been a mystery. My earlier phenomenological work on this problem involving an extension of the classical Berezinskii-Kosterlitz-Thouless (BKT) theory could explain this important feature of the neutron data; however some striking anomaly appeared in the quantitative analysis, which seemed to be of quantum origin. To take this study further more systematically, we calculated the dynamical structure function for both in-plane and out-of- plane spin components with momentum transfer vector lying in the Cu-O plane with the help of a semi-classical treatment of the extended BKT theory for antiferromagnets. This

calculation too confirms the existence of a genuine central peak due to the mobile vortices and anti-vortices above BKT transition temperature, for this experimental system. Nevertheless, our theoretical results, convoluted with a realistic spectral window function for comparison with the experimental ones, display certain unphysical features like negative values of intensity and vigorous oscillations above a certain energy. These indicate the limitations of even the semi-classsical treatments of the ideal vortex/anti-vortex (meron/anti-meron) gas for 2D XY-anisotropic quantum antiferromagnetic model and emphasize the need for a full quantum treatment of the problem.

(iii) The strongly correlated t-J model is a very well known model in theoretical condensed matter physics, particularly for the problem of high temperature superconductivity of the lightly doped quantum antiferromagnets like cuprates. My earlier microscopic theoretical works on this model corresponding to both 1D and 2D lattices, brought out the analytical structure and features of both dynamical spin susceptibility in the superconducting phase and the spin stiffness in the normal phase for low-dimensional strongly correlated systems. This motivated us to explore in more details both the analytical results and their numerical manifestations for this model. Starting from a Gutzwiller projected Fermi Sea with strictly no double fermionic occupancy condition on each site and making use of Hubbard operators, we derived the expressions for the spin stiffness constants for the t-J model for both 1D and 2D lattices, as a function of hole doping concentration. In both the cases, the stiffness contants decrease monotonically with doping concentration. Furthermore, with the conjecture that the calculated spin stiffness constant in reality represents effective antiferromagnetic coupling between the spin degrees of freedom in the doped phase, we compared our results with the experimental ones for doped cuprates obtained by Birgeneau and collaborators by neutron scattering. The latter result displays in fact a variation of the intra-layer spin-spin correlation length with doping concentration. With the help of some other type of theoretical works based on Monte Carlo calculations and renormalization group analysis done by other research groups, we could replot the above experimental data as a variation of the effective exchange constant with doping concentration. This newly obtained experimental result agrees very well with our theoretical result for 2D both qualitatively and quantitatively. This work of ours also establishes firmly the validity of the conjecture regarding the spin stiffness constant.

(iv) In A-15 superconductors it is observed experimentally that a Peierl's structural transition is followed by superconductivity, as temperature is lowered. This motivated us to explore the interplay and possible coexistence between the dielectric gap emerging from the structural transition and the superconducting gap. In analogy with a phenomenological model proposed earlier by Blount and Varma along the line of Ginzburg-Landau theory to study the competition between superconductivity and ferromagnetism in magnetic superconductors, we designed a similar model for our problem here. Assuming a homogeneous situation for simplicity, our calculations show that depending upon the relative positions of the structural transition temperature and the superconducting transition temperature, the two order parameters viz. superconducting and dielectric can have very different behaviours as functions of temperature leading to varied consequences. Our results are in good qualitative agreement with the experimental results from real systems like Vanadium based alloys and Niobium based alloys belonging to the A-15 family.

Future Plan

(I) To complete the ongoing work on the understanding of the superconductivity of the multi-layered-multi-band systems within a generalized pairing theory, with a view to applying it to real systems like cuprates and pnictides.

(ii) Determination of the full quantum mechanical dynamical structure function of 2D XY-anisotropic ferromagnetic and antiferromagnetic spin models, using a synthesis of our coherent state based approach and the quantum simulation based technique. Besides, the magnon-vortex interplay for antiferromagnetic models would also be taken up for investigation.

(iii) To refine and extend my recent work on quantum modelling of DNA mutations to explore the phenomenon of DNA melting and microwave effects for DNA.

Publications in Journals

1. Soumi Roy Chowdhury and **Ranjan Chaudhury**, *Investigation of fermionic pairing on tight binding lattice for low dimensional systems – Fermi liquid vs. Luttinger-Tomonaga liquid*, Physica B, **465**, 60 (2015).
2. **Ranjan Chaudhury**, *Tautomeric mutation in DNA. A theoretical comparative study and synthesis between various proposed quantum models*, Nanostructures, Mathematical Physics and Modelling, **12**(1), 85 (2015).

Supervision of Students

Ph.D. Students: Soumi Roy Chowdhury (SRF), Subhajit Sarkar (SRF), Suraka Bhattacharjee (JRF).

Project Student: Priyanka Ghosh (Summer Project Student from ISM, Dhanbad) during May-July, 2014

Lecture Delivered

1. "On Superconductivity --- Mysteries and Challenges", C.K. Majumdar Memorial Summer Workshop in Physics at SNBS, Kolkata, June 2014.

Course Taught

1. PHY 601, Advanced Condensed Matter Physics (Magnetism and Superconductivity with excitations in solids), Spring Semester

Awards / Recognitions

(I) Received "Bharat Gaurav" award from IIFS (New Delhi) in 2014.

(ii) Received "Best Citizens of India" award from International Publishing House (New Delhi) in 2015.

Saswati Barman

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Dr. Saswati Barman obtained her Ph.D. from University of Exeter, UK in May 2006. During 2009-2013, she worked as Visiting Faculty Fellow at S. N. Bose National Centre for Basic Sciences. Presently she is working here as a scientist in 'Unit on Nanoscience' project.

- Magnetization dynamics in nanodot and antidot arrays, magnetic vortex dynamics, thermal Conductivity of semiconductors

We have investigated thermal conductivity of $In_xGa_{1-x}N$ films over a wide range of temperature by using both Debye's and Callaway's model within the single mode relaxation time approach. We find that the mass disorder scattering contribution in determining total thermal conductivity is nearly 100 % near the thermal conductivity peak region and the contribution is very high throughout the whole temperature range studied here. The mass disorder scattering has very significant contribution at both the thermal conductivity peak region and at higher temperature region. As the In content increases, the thermal conductivity decreases until 50 % In content and beyond that it increases with the increase in In content with a sudden jump near 90% In content. The boundary scattering contribution is significant at low temperature region and N-drift scattering contribution increases with increase in temperature.

Future Plan

We will study logic operations by using magnetic vortices. The logic operations will be achieved via vortex gyration mediated information signal transfer mechanism in chain of magnetic vortices, working as magnetic vortex transistor under special conditions. Manipulation of amplification of vortex transistor will also be obtained by varying the material parameters and geometrical parameters. We also propose to study fan-in and fan-out operations by using magnetic vortex transistors.

We plan to study spin polarized current and magnetic field driven domain wall dynamics. Domain wall type depends upon the geometrical parameters of the nanowire. The domain wall motion and velocity will be affected by the geometrical parameters, direction of the applied field and current.

Publications in Journals

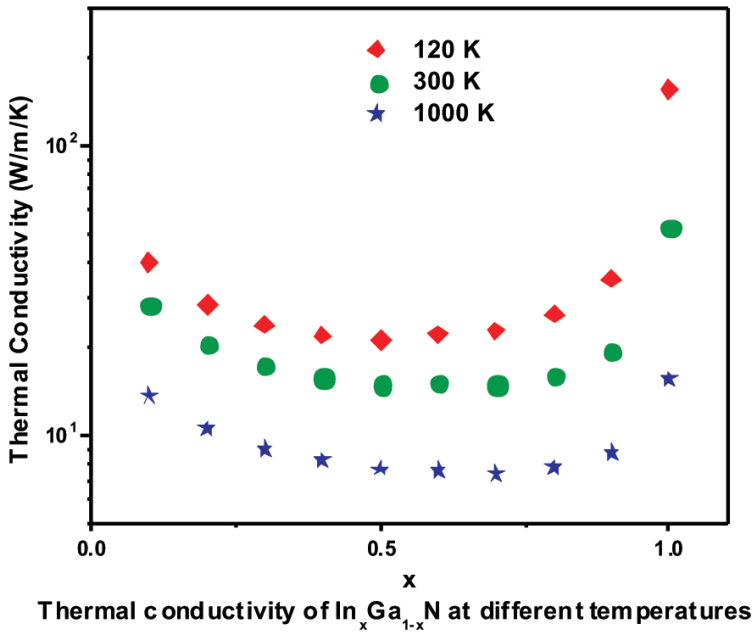
1. **S. Barman**, *Thermal Conduction in $In_xGa_{1-x}N$ Film*, Europhysics Letters, **107**, 56001 (2014).
2. B. K. Mahato, B. Rana, **S. Barman**, D. Kumar, S. Sugimoto, Y. Fukuma, Y. Otani and A. Barman, *Tunable Spin Wave Dynamics in Two-Dimensional $Ni_{80}Fe_{20}$ Nanodot Lattices by Varying Dot Shape*, Appl. Phys. Lett., **105**, 012406 (2014).
3. S. Pal, **S. Barman**, O. Hellwig and A. Barman, *Effect of the Spin-Twist Structure on the Spin-Wave Dynamics in $Fe_{55}Pt_{45}/Ni_{80}Fe_{20}$ Exchange Coupled Bi-Layers with Varying $Ni_{80}Fe_{20}$ Thickness*, J. Appl. Phys., **115**, 17D105 (2014).
4. C. Banerjee, S. Saha, **S. Barman**, O. Rousseau, Y. Otani and A. Barman, *Width Dependent Transition of Quantized Spin-Wave Modes in $Ni_{80}Fe_{20}$ Square Nanorings*, J. Appl. Phys., **116**, 163912 (2014).

Other Publications

1. B. K. Mahato, S. Choudhury, S. Barman, R. Mandal, O. Rousseau, Y. Otani and A. Barman, Configurational Anisotropy in Two-Dimensional Ferromagnetic Nanodot Lattices with Varying Dot Shapes, 59th. Annual Magnetism and Magnetic Materials Conference, Honolulu, Hawaii, 3-7 Nov., 2014.
2. A. Barman, R. Mandal, S. Barman, O. Rousseau and Y. Otani,

Broadband Ferromagnetic Resonance Study of Tunable Magnonic Spectra in $Ni_{80}Fe_{20}$ Antidot Lattices by Varying Lattice Symmetry, 59th. Annual Magnetism and Magnetic Materials Conference, Honolulu, Hawaii, 3-7 Nov., 2014.

3. S. Saha, S. Barman, S. Sugimoto, Y. Otani and A. Barman, Configurational anisotropy in two-dimensional magnonic crystals with varying lattice symmetry, International Magnetics Conference (INTERMAG 2014), Dresden, Germany, May 4-8, 2014.



Thermal conductivity of $In_xGa_{1-x}N$ at different temperatures

Soumendu Datta

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Dr. Soumendu Datta is presently a INSPIRE faculty of 3rd year in the department of Condensed Matter Physics and Material Sciences. His present research focuses on using first principles electronic structure calculations to study properties of nano materials for energy applications as the development of sustainable energy technology is one of the most important problems of today.

- My broad area of research is material science where I use mainly first principles density functional theory based electronic structure calculations to study properties of bulk as wess as nano materials. I have extensively studied the structure, electronic and magnetic properties of elemental as well as alloyed nano clusters of transition metal elements and semiconducting nano particles of various shapes and sizes. My current research interest focuses mainly on the materials for photocatalytic water-splitting process for hydrogen production with particular emphasis on engineering the properties of semiconducting nano systems for enhancing their opto-electronic properties

The following two works have been completed during this period:

1. **Enhanced magnetism of Cu_n clusters capped with nitrogen and endohedrally doped with Cr:** Possibility of producing high magnetic moments in Cu-nanoclusters, using N-capping as well as endohedral Cr-doping, has been demonstrated first time. We showed that the effects of N-capping are remarkable with respect to magnetic applications of the capped systems as the N-capping induces giant magnetic moments to the capped Cu_n clusters, such as 8 μ_B, 10 μ_B, 12 μ_B and 14 μ_B for the CunNn clusters with n = 3-6. We find that the enhanced magnetic moments of the capped systems result from the ferromagnetic coupling among all the Natoms as well as Cu-atoms centered magnetic moments. The N-capping is also accompanied by a substantial enhancement in their stability. The spin density surface plot for the ground state structures of the capped clusters, as shown in the Fig.1, indicates the ferromagnetic coupling of the constituent atom-centered moments for the capped systems. We suggest that these giant magnetic moments of the capped Cun clusters have relevance to the observed room temperature ferromagnetism of Cu doped GaN. For cage-like hollow Cu-clusters, an endohedral Cr-doping together with the N-capping appears as the most promising means to produce stable giant magnetic moments in the copper clusters. Fig1: Plot of spin density surface of the capped systems, CunNn in their ground state with n = 3-6.

2. **Study of morphology effects on magnetic interactions and bandgap variations for 3d late transition metal-doped ZnO nanostructures :** In an another work using first principles electronic structure calculations, the effects of morphology of semiconducting nano structure on the magnetic interaction between two magnetic dopant atoms as well as a possibility of tuning the band gaps have been studied in case of the bi-doped $(ZnO)_{24}$ nano structures with the impurity dopant atoms of 3d late transition metal – Mn, Fe, Co, Ni and Cu. To explore the morphology effect, three different structures of the host $(ZnO)_{24}$ nano-system having different degrees of spatial confinement, have been considered - a two dimensional (2D) nanosheet, another one dimensional (1D) nanotube and a finite cage-shaped nanocluster. It is shown here that the magnetic coupling between the two dopant atoms, remains mostly anti-ferromagnetic in course of changing the morphology from the sheet geometry to the cage-shaped geometry of the host systems, except for the case of energetically most stable bi-Mn doping, which shows a transition from ferromagnetic to anti ferromagnetic coupling with the decreasing aspect ratio of the host system. The anti-ferromagnetic magnetic interactions between the dopant atoms has been attributed to the super-exchange

interactions. Separation between the two dopant atoms for the most preferred substitution, is found to be sensitive to the morphology of the host systems – the anti-ferromagnetic couplings between the two dopants in the sheet structure, favor short-ranged interaction, while the anti-ferromagnetic couplings are long ranged in case of the bi-dopings in the cage-shaped structure.The effect of the shape change, however, has a significant effect on the overall band gap variations of both the pristine as well as all the bi-doped systems irrespective of the nature of the dopant atoms and provides means for easy tunability of their optoelectronic properties.

Future Plan

Sunlight is the enormous source of energy which has promises to meet our increasing energy demand. It is seen that more energy from the sunlight strikes the earth surface in one hour than the energy consumed on the planet in a year. In fact, we can use only a small fraction of the incident solar light. So, there is a huge gap between the present use of solar energy and its potentials which is the grand challenge in present energy research worldwide. In this respect, two promising technologies for the efficient utilization of solar energy, are : (1) Photo electrochemical (PEC) water splitting for the production of hydrogen fuel from water using sunlight, (2) Dye-sensitized solar cell (DSSC) for solar to electricity conversion. Both the technologies face crucial material challenges as mentioned below. Presently, I am working on the two classes of materials – metal-nonmetal codoped perovskite oxides for finding suitable PEC photocatalyst, and organic-inorganic hybrid perovskite oxides as suitable light harvester in DSSC. My research for the next one year will also evolve around them.

Publication in Journal

1. **S. Datta**, R. Banerjee and A. Mookerjee, *Enhanced magnetism of Cu_n clusters capped with N and endohedrally doped with Cr*, J. Chem. Phys., **142**, 024309 (2015).

Supervision of Student

Ph.D. Student: Sayan Baral

Lecture Delivered

1. Participated and presented a lecture at the National Conference on "Nanoscience and Nanotechnology", CRNN, Calcutta University, India during 8-9 September, 2014

Academic Visit

1. Visited Tezpur University to participate the "Networking-cum-Discussion Meet for INSPIRE Faculty Awardees" held during 20-21 March, 2015

Membership of Committees

Internal Committee: Included in an interview committee for selecting candidates for the admission'2015 to the IPhD/PhD programme of the institute

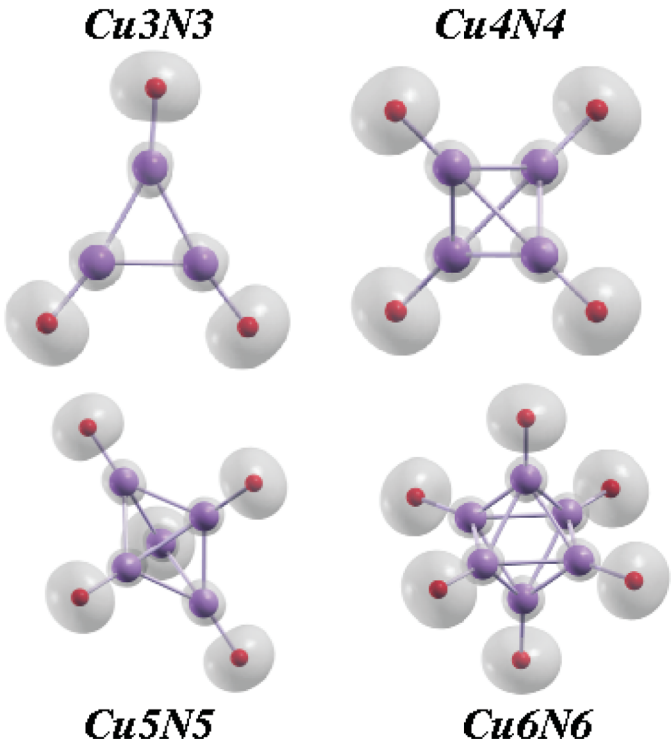

Fig1: Plot of spin density surface of the capped systems, CunNn in their ground state with n = 3-6.

Sugata Mukherjee

Associate Professor (Visiting)
sugata@boson.res.in

Sugata Mukherjee is Associate Professor (Visiting) in the Department of Condensed Matter and Materials Science.

- Current Research interests include:

(1) Electronic properties of two-dimensional Nanomaterials.

(2) Calculation of electrical and thermal transport properties of Nanomaterials.

We have carried out extensive first-principles calculations based on Density Functional Theory (DFT), using Generalized Gradient approximation (GGA) and van der Waals corrections, to investigate electronic structure of two-dimensional nanomaterials. The electrical and thermal transport properties were studied using Boltzmann transport theory applied to the band electrons.

We have studied electronic and phase stability of Cx(BN)1-x and strain-dependent bandstructure of ZrX2 (X=S,Se,Te) dichalcogenide two-dimensional nanomaterials. Recently, we have used Boltzmann transport theory based computational methods applied to the bandstructure, calculated from the DFT based first-principles methods, to obtain transport properties, e.g. electrical conductivity, Seebeck coefficient etc for graphene, graphene and hBN heterostructures. The thermal transport was studied using large-scale simulation of non-equilibrium heat equation using Tersoff-type force field for C-BN-C heterostructures and also for hBN multilayers. Our calculated thermal conductance was found to agree well with recent experimental measurements on those materials. The calculated electrical conductivity and the Seebeck coefficient for monolayer Graphene show very good agreement with measurements by Kim et al.

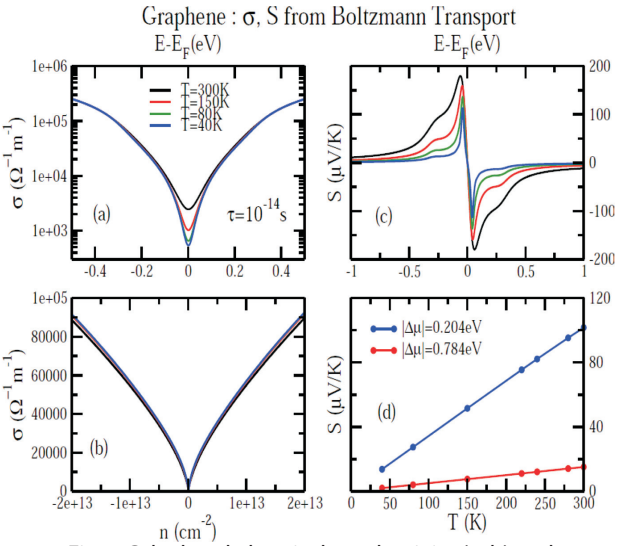

Fig 1: Calculated electrical conductivity (a, b) and Seebeck coefficient (c,d) for Graphene.

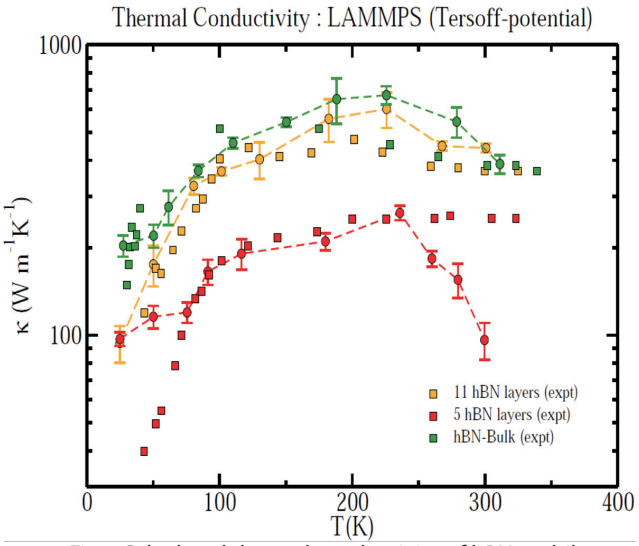

Fig2: Calculated thermal conductivity of hBN multilayers (circle) vs T, compared with experimental data (square).

Future Plan

We would like to extend our calculations of thermal transport within the framework of DFT based technique to obtain the Figure-of-merit (ZT) of the nanomaterials. This is an extremely important area of current research which can contribute to finding novel materials for the energy research.

Publications in Journals

1. Sohail Ahmad and **Sugata Mukherjee**, *A comparative study of electronic properties of bulk MoS_2 and its monolayer using DFT technique: Application of mechanical strain on MoS_2 monolayer*, Graphene, **3**, pp 53-59 (2014) (http://dx.doi.org/10.4236/graphene.2014.34008)
2. Ransell D'Souza and **Sugata Mukherjee**, *Electronic structure, phase stability and resistivity of hybrid hexagonal $C_x(BN)_{1-x}$ two-dimensional nanomaterial : A first-principles study*, Physica E, **69**, pp 138-144 (2015) (http://dx.doi.org/10.1016/j.physe.2015.01.026)

Other Publications

1. First-principles study of electronic structure, phase stability and thermoelectric property of $C_x(BN)_{1-x}$ two-dimesional nanomaterial, by S. Mukherjee and R. D' Souza, Proc of 9th International Cenference of Computational Physics, Singapore, (Jan 2015)
2. Electronic structure of graphene and related two-dimensional Nanomaterials: A first-principles study, by S. Mukherjee, Physics of Low Dimensional Structures, Vidyasagar University (2015)

Supervision of Students

Ph.D. Students: Ransell D'Souza (Project: Electronic structure, phase stability, transport properties and MC simulations of hybrid hexagonal $C_x(BN)_{1-x}$ nanomaterial)

Project Students: Debmalya Halder (ISM, Dhanbad) Summer project student. Project on "Tight-binding study of Carbon Nanoribbons and Nanotubes". (May-July 2014)

Lectures Delivered

1. *Electronic structure of Graphene and related two-dimensional nanomaterials*, Seminar talk by S. Mukherjee delivered at IIT Guwahati, Oct 2014.
2. *First-principles calculations of electronic properties of Graphene and related two-dimesional nanomaterials*, Invited talk by S. Mukherjee delivered at the International Conference on Advanced materials and Energy Technology (ICAMET-2014), IIEST, Shibpur, December 2014.
3. *First-principles study of the electronic structure, phase stability and thermoelectric properties of $C_x(BN)_{1-x}$ two-dimensional nanomaterial*. Invited talk by S. Mukherjee delivered at 9th International Conference on Computational Physics, National University of Singapore, Singapore, 7-11 Jan 2015.
4. *Electronic structure of Graphene and related two-dimensional nanomaterials*. Invited talk by S. Mukherjee delivered at Vidyasagar-SNBose national Workshop on Physics of Low-dimensional Structures, Vidyasagr University, Medinipur, 25-27 March 2015.
5. *Electronic structure, phase stability, resistivity and Monte-Carlo simulation of hybrid hexagonal Cx(BN)1-x two-dimensional nanomaterial*. Poster presented by R. D'Souza at NANODAYS 2015, SNBNCBS, Kolkata, 16-18 Feb 2015.
6. *Electronic structure, phase stability, resistivity and Monte-Carlo simulation of hybrid hexagonal Cx(BN)1-x two-dimensional nanomaterial*. Poster presented by R. D'Souza at BOSE-FEST 2015, SNBNCBS, Kolkata, 2-4 March 2015.

Academic Visit

1. Visited IIT Guwahati in Oct 2014 under TPSC programme

Course Taught

1. Taught the courses PHY 412 and PHY 602 "Physics of Materials"

Membership of Committees

External Committee: Ph.D. Oral examiner of Jadavpur University (Nov 2014)

Internal Committee: Vigilance officer (till Nov 2014); TPSC Convener (till Nov 2014)

Tanusri Saha Dasgupta

Professor
tanusri@bose.res.in

Tanusri Saha Dasgupta is a Computational Condensed Matter Physicist interested in novel materials properties both in bulk and in nanoscale.

- Electronic Structure of Complex Materials
- Strongly Correlated Electron Materials
- Nanomaterials
- Functional Metalorganics

Cooperativity in Spin-Crossover Transition in Metalorganic Complexes:

It is of significant technological interest to have understanding of cooperativity in spin-crossover phenomena observed in metalorganic polymeric complexes. Through Monte Carlo simulation of the model Hamiltonian we show the super-exchange interactions between localized magnetic moments at spin-crossover sites can play crucial role in cooperativity, depending on the nature of the elastic interactions. Considering the example of a real material, namely Fe-triazole, employing the material-specic density functional theory (DFT) calculation, we show this to be true for these systems. [Physical Rev B 90, 174433 (2014)]

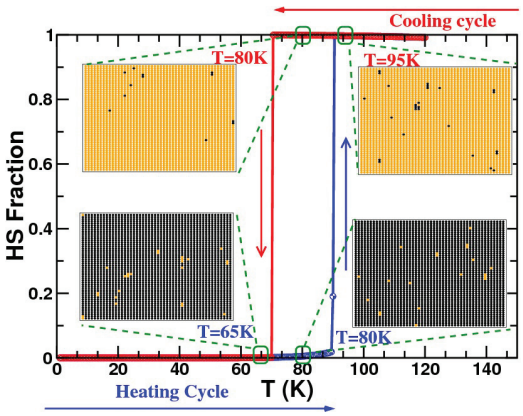

Fig1: High spin fraction plotted as a function of increasing and decreasing temperature calculated with DFT derived elastic and magnetic interactions corresponding to that of Fe-triazole. The insets show the snap-shots of pseudo-spin congurations at two dierent temperatures (80 K and 95 K) in cooling cycle, and two dierent temperatures (65 K and 80 K) in heating cycle.

Competition between heavy-fermion and Kondo interaction in isoelectronic A-site ordered perovskites:

We carry out first-principles calculations on A-site ordered perovskites with Cu in the A-site and B-sites descending along the 9th group of the periodic table to elucidate the emerging electronic and magnetic properties as d-orbitals change from the partially filled 3d, 4d, to 5d.The results show when descending from Co to Ir the charge transfers from the cuprate like Zhang-Rice state on Cu to the t2g orbital of the B site. As the Cu d-orbital occupation approaches the localized Cu2+ limit, a new mixed-valence ground state in CaCu3Rh4O12 and heavy fermion state in CaCu3Ir4O12 are obtained. [Nature Commun, 5, 5818 (2014)]

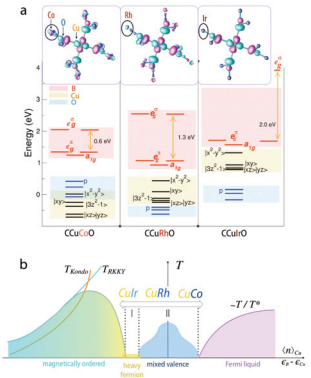

Fig2: a) Top panels: Plots of effective Wannier functions for O p, Cu dx2-y2 orbitals for CCCoO, CCRhO and CCIrO. Plotted are the constant value surfaces with lobes of different signs colored as cyan and magenta. The Cu, B- and O sites are shown as green, red and blue colored balls. Bottom panels: Energy level positions of Cu d, B d and O p states for CCCoO, CCRhO and CCIrO. b) Doniach phase diagram showing the dependency on the Cu occupation.

Future Plan

i) Oxide heterostructures

ii) Study of MAX and Maxene phases

iii) Study of graphene-oxide interface

iv) Osmate and Iridate Double perovskites

Publications in Journals

1. Tapan Chatterji, Antonio M dos Santos, Jamie J Molaison, Thomas C Hansen, Stefan Klotz, Mathew Tucker, Kartik Samanta, **Tanusri Saha-Dasgupta**, *Anomalous breakdown of Bloch's rule in the Mott-Hubbard insulator $MnTe_2$*, Physical Review B, **91**, 104412 (2015).

2. AN Vasiliev, OS Volkova, EA Zvereva, AV Koshelev, VS Urusov, DA Chareev, VI Petkov, MV Sukhanov, B Rahaman, **T Saha-Dasgupta,** *Valence-bond solid as the quantum ground state in honeycomb layered urusovite $CuAl(AsO_4)O$*, Physical Review B, **91** (14), 144406 (2015).

3. Santu Baidya, **T Saha-Dasgupta**, *Covalency driven low-temperature structural distortion and its effect on electronic structure of $Hg_2Ru_2O_7$*, Physical Review, B **91**, 075123 (2015).

4. Tilak Das, **Tanusri Saha-Dasgupta**, *Spin-state transition in unstrained & strained ultra-thin $BiCoO_3$ films*, Dalton Trans., **44**, 10882 (2015).

5. Man-Rong Li, Maria Retuerto, Zheng Deng, Tapati Sarkar, Javier Sanchez-Benitez, Mark C Croft, **Tanusri Saha Dasgupta**, Tilak Das, Trevor A Tyson, David Walker, Martha Greenblatt, *Strong Electron Hybridization and Fermi-to-Non-Fermi Liquid Transition in $LaCu_3Ir_4O_{12}$*, Chemistry of Materials **27**(1), 211 (2015).

6. Tanushree Chakraborty, S Baidya, Carlo Meneghini, **Tanusri Saha-Dasgupta**, Giulia Veronesi, Marco Merlini, Hiroko Yokota, Mitsuru Itoh, S Majumdar, Sugata Ray, *Covalency-driven structural instability and spin-phonon coupling in barium cobalt oxychloride,* Physical Review B, **90**, 235147 (2014).

7. Derek Meyers, S Middey, J-G Cheng, Swarnakamal Mukherjee, BA Gray, Yanwei Cao, J-S Zhou, JB Goodenough, Yongseong Choi, D Haskel, JW Freeland, **T Saha-Dasgupta**, J Chakhalian, *Competition between heavy fermion and Kondo interaction in isoelectronic A-site-ordered perovskites*, Nature Commun, **5**, 5818 (2014).

8. Hrishit Banerjee, Manoranjan Kumar, **Tanusri Saha-Dasgupta,** *Cooperativity in spin-crossover transition in metalorganic complexes: Interplay of magnetic and elastic interactions*, Physical Review B, **90**, 174433 (2014).

9. U Tutsch, B Wolf, S Wessel, L Postulka, Y Tsui, HO Jeschke, I Opahle, **T Saha-Dasgupta**, R Valentí, A Brühl, K Removiæ-Langer, T Kretz, H-W Lerner, M Wagner, M Lang, *Evidence of a field-induced Berezinskii–Kosterlitz–Thouless scenario in a two-dimensional spin–dimer system*, Nature Commun, **5**, 5169 (2014).

10. ajeev Chacko, Dhani Nafday, DG Kanhere, **T Saha-Dasgupta**, *Exact diagonalization study for nanographene: Modulation of charge and spin, magnetic phase diagram, and thermodynamics*, Physical Review B, **90,** 155433 (2014).

11. Man-Rong Li, Maria Retuerto, David Walker, Tapati Sarkar, Peter W Stephens, Swarnakamal Mukherjee, **Tanusri Saha Dasgupta**, Jason P Hodges, Mark Croft, Christoph P Grams, Joachim Hemberger, Javier Sánchez-Benítez, Ashfia Huq, Felix O Saouma, Joon I Jang, Martha Greenblatt, *Magnetic-Structure-Stabilized Polarization in an Above-Room-Temperature Ferrimagnet*, Angewandte Chemie International Edition, **53**, 10774 (2014).

12. Kartik Samanta, **T Saha-Dasgupta**, *Spin state of Mn2+ and magnetism in vanadate-carbonate compound, K2Mn3(VO4)2CO3,* Phys. Rev. B, **90**, 064420 (2014).

13. Mukul Kabir, **T Saha-Dasgupta**, *Manipulation of edge magnetism in hexagonal graphene nanoflakes*, Phys. Rev. B, **90**, 035403 (2014).

14. **Tanusri Saha-Dasgupta**, Peter M Oppeneer, *Computational design of magnetic metal-organic complexes and coordination polymers with spin-switchable functionalities*, MRS bulletin **39**(7), 614 (2014).

15. Amlan Dutta, Swastika Chatterjee, AK Raychaudhuri, Amitava Moitra, **T Saha-Dasgupta**, *In-silico investigation of Rayleigh instability in ultra-thin copper nanowire in premelting regime*, Journal of Applied Physics, **115**, 244303 (2014).

Other Publication

1. **T Saha-Dasgupta**, M Kabir, Edge Magnetism in Graphene Nanoflakes, Bulletin of the American Physical Society (2015).

Supervision of Students

Ph.D. Students: Dhani Nafday (SRF, externally funded); Hrishit Banerjee (SRF); Kartick Samanta (SRF); Ransell D'souza (SRF); Paulomi Chakraborty (SRF); Pallavi Paul (JRF); Soumi Bhuin (JRF, externally funded); Tuhin Maji (JRF); Swarnakamal Mukherjee (PhD to be submitted in 2015)

Project Students: Vishnu P.K., IISER Mohali (supported by Academy)

Post Doctoral Research Scientist: Tilak Das

Lectures Delivered

1. Magnetism in and on graphene, University of Groningen, March 2015

2. Electronic Structure of silicate minerals: Moscow State University, March 2015

3. Cooperativity in spin-crossover compounds, RAK-CAM, Feb 2015.
4. Magnetism in and on graphene, APCTP conference, Seoul National University, Dec 2014
5. Spin-orbit physics in 3d compounds, University of Santiago de Compostela, Spain, Nov 2014
6. First-principles study of low-dimensional systems, MISM2014, Russia, July, 2014
7. Double perovskites, CIMTEC2014, Italy June 2014
8. Role of A site cations, Materials Meeting, Manali, India, May 2014
9. Colloquium: Realistic theory of strongly correlated electron systems, IISER Pune, India, May 2014

Academic Visits

1. Indo-Russian project, Moscow State University, March 2015
2. Indo-Netherland project, University of Gottingen, March 2015
3. Indo-Russian project, Moscow State University, July 2014

Course Taught

1. PHY 602, Advanced Condensed Matter Physics: Electronic Structure & Physics of Materials, Spring 2014

Membership of Committees

External Committee: Member of Editorial Board, Pramana (2012 – till date)

Internal Committee: APMP committee; CAC committee; CSC-WG committee; CSC-AC

Award / Recognition

1. DAE Raja Ramanna prize

Sponsored Projects

1. Thematic Unit of Excellence of Computational Materials Science (funded by Nano-mission)
2. Magnetism in low dimensional quantum spin systems (DST-RFBR)
3. Graphene Spintronics with Complex Oxides (DST-NWO)
4. Physical properties of elemental solids, their compounds and oxides, and mineral phases at extreme conditions of pressure and temperature: an experimental and theoretical study (funded by Ministry of Earth Sciences)
5. Electronic Structure of MAX and MAXene phases (DST-BMW)
6. Development and Validation of a Modified Embedded Atom Method (funded by BRNS)

$$2$$

$$= \varphi(\sqrt{\sigma_1^2+\sigma_2^2}\,t) \qquad \sum_{k=1}^{r} \int_{b_k v}^{x+b_k v} \left(\int_0^t \psi_k^*(\tau)\,d\tau \right) dt - x \int_0^{b_k v} \psi_k^*(\tau)\,d\tau = \frac{x^2}{2} B(v) +$$

$$c_{ik}\sigma_k^2 = \lambda_i c_{ik} \qquad \eta_1 = \sum_{k=1}^{n} a_k \xi_k \qquad \log \varphi(u) = -\frac{\sigma^2 u^2}{2}$$

$$y = \phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-\frac{t^2}{2}}\,dt \qquad S(\alpha,\bar{T}) = \frac{2}{\pi} \int_0^{\pi} \frac{\sin \alpha t}{t}\,dt \qquad P(\eta$$

$$= \binom{n}{k} p^k (1-p)^{n-k} \qquad P(\eta < y \mid \xi = x) = \sup_{y' < y,\, y' \in \mathbb{R}} P(\eta < y' \mid \xi = x)$$

$$\log_2 \frac{1}{f(x)}\,dx \Big| < \varepsilon \qquad g^{-1} \cdot g = e \qquad \varsigma = \sqrt{\frac{\lambda_n}{\nu_n}} \left(\frac{\eta_{\lambda_n}}{\sqrt{\lambda_n}} + \frac{\eta_{\nu_n} - \eta_{\lambda_n}}{\sqrt{\lambda_n}} \right)$$

$$e^{-\frac{k^2\pi^2}{\lambda^2}} = H(k) \qquad \prod_{k \le b}; \qquad \bigcup_{i=1}^{n-1} M_i; \qquad \bigcap_{n=0}^{\infty} X_n \qquad f_n(t) = \frac{\lambda^n t^{n-1} e^{-\lambda t}}{(n-1)!}$$

$$-\infty$$

$$(t-u)\,du = \frac{\lambda^{n+1} t^n e^{-\lambda t}}{n!} \qquad \lim_{t \to 0} (\varepsilon t) = 0 \qquad \operatorname{limst}_{n \to +\infty} \frac{\zeta(n)}{n} =$$

$$|t|^{\alpha} \left[1 + i\beta \frac{t}{|t|} \omega(t,u) \right] \qquad B(v) = \sum_{k=1}^{r} \psi^*(b_k v) \qquad c_{iv} = \sum_{j=1}^{n} a_{ij} b_{jv}$$

$$\left(\frac{1}{2\pi} \right)^{-1} \qquad |\psi_\xi(t)| = \left| \int_{-\infty}^{\infty} e^{itx}\,dF(x) \right| \le \int_{-\infty}^{\infty} e^{-vx}\,dF(x) = \varphi_\xi(iv) \qquad \lim_{n \to \infty} P\left(\frac{\xi_{n+1} - k(n) - \log \frac{1}{q}}{\sqrt{\frac{1-q}{q}}} \right)$$

$$r$$

$$g^{-1} N g = \{ g^{-1} n g \mid$$

$$|-|X \cap \Psi| \qquad \lim_{n \to \infty} \frac{1}{\Gamma n} h_n\left(\frac{x}{\sqrt{n}} \right) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \qquad P_n(k) = P_{jk}^{(n)} \qquad P(\lim_{n \to \infty}$$

$$X \cap W$$

$$) = -\log 2 \left(\frac{\sum_{k=1}^{r} p_k^{\alpha} \log_2^2 \frac{1}{p_k}}{\sum_{k=1}^{r} p_k^{\alpha}} - \left(\frac{\sum_{k=1}^{r} p_k^{\alpha} \log_2 \frac{1}{p_k}}{\sum_{k=1}^{r} p_k^{\alpha}} \right)^2 \right) \qquad fg(u_i) = f\left(\sum_{j=1}^{\dim V_2} \right.$$

$$\sqrt{\frac{q(1-q)}{n}} + \alpha\left(\frac{1}{n}\right) \qquad P_{jk}^{(m)} = \sum_{l=0}^{\infty} P_{jl}^{(r)} P_{lk}^{(m-}$$

$$\prod_{k=1}^{r} \left[g_k\left(\frac{t}{\sqrt{N_0}} \right) \right]^{N_0 \alpha_k} = e^{-\frac{t^2}{2}}$$

$$\lim_{N \to \infty} \int_{-1}^{+4} f_N(x) \log_2 \frac{1}{f_N}$$

$$dx \ge \int_{-\infty}^{+\infty} f(x)^{\alpha}\,dx \qquad M(|\delta_j - 1|^s) = \int_0^{\infty} |x-1|^s e^{-x}\,dx$$

$$\left(\frac{1}{k} \sum_{k=1}^{n} R(k) \right)$$

$$\det(M') = \det(M) + \det(M^*) = \det(M) \qquad u(x,y) =$$

Department of

Department of Theoretical Sciences

Department of Department of Theoretical Sciences

Manu Mathur
Head of the Department

Department profile indicators:

Table A: Manpower and resources

Number of faculties	11 (permanent)
Number of Post–doctoral research associate (centre+project)	3
Number of Ph.D students	30
Number of other project staff	1
Number of summer students	4
Projects (ongoing)	0 (External Fund) + 1 (INSPIRE)

Table B: Research Activities indicators

Number of research papers in Journals	27
Number of Book-chapters/books	1
Number of other publications	2
Number of Ph.D students graduated (submitted+degree awarded)	16
Number of M.Tech/M.Sc projects	0

Table C: Academic activities and likeage

Number of courses taught by faculties	9	
Number of Visitors (non–associates)	2	
Number of associates	2	
Number of Seminars organized	12	
Number of Conference/Symposia/ Advanced Schools organized	3	
Number of talks delivered by members of department in conferences/Symposia	National	20
	International	12

Most important research highlights

- Gauging of Galilean symmetry, non-relativistic diffeomorphism invariance and its applications in fractional quantum Hall effect, Horava-Lifshitz geometry etc.
- Computation of the Connes distance function on the fuzzy sphere in non-commutative quantum mechanics to study the relationship between geometry and statistics
- Study of topological excitations in low dimensional spin systems
- Calculation of quantum corrections to the gluon propagator in a theory with topologically massive gluons

- Study of Lienad and quantum Lienard types of systems
- A realization of SU(2) lattice gauge theory in terms of Hydrogen atoms
- Formulation of a mean-field model of interacting synapses on a directed neural network
- Study of non-equilibrium steady-state systems in contact with each other
- Study strong phase separation in a one-dimensional periodic system forming pure domains at all temperatures
- Study of the density field in an active nematic
- Study of the fiber bundle model using equal load sharing dynamics
- Study of X-ray scattering by interstellar dust grains
- A study non-Gaussianity of two-mode resource states on teleportation

Summary of research activities

A new algorithmic approach towards the formulation of nonrelativistic diffeomorphism invariance is developed and applied to the problem of a two dimensional electron moving under the influence of an external field and also under the Chern-Simons dynamics.

The constitutive relations in two dimensional hydrodynamics in the presence of gauge and gravitational anomalies are presented. The relations between the response parameters and anomaly coefficients were found by exploiting the role of the Israel-Hawking-Hartle condition.

The Connes distance for the fuzzy sphere is computed in a simple way. A deep connection between geometry and statistics is revealed between mixed states in the context of quantum Hilbert space by this computation.

The quantum corrections to the gluon propagator in a theory with topologically massive gluons is computed. The b-function was found to be negative, and more negative than for usual massless SU(N) gauge theory. This also indicates that the theory is both short-range and asymptotically free.

A modification of general relativity due to Eddington, and Born and Infeld, regulates singularities and naturally gives rise to a cosmological constant, but its coupling to matter is not very obvious. Using a method due to Kaluza, we write the theory in five dimensions and compatified it on a circle down to four dimensions. This produced a natural nonlinear coupling of Eddington-inspired Born-Infeld gravity to electromagnetism, previously unknown. We also discovered charged black hole solutions of the resulting theory.

The analytical structure of the nonlinear Lienard oscillator is analyzed to show that it is a bi-Hamiltonian system depending upon the choice of the coupling parameters. While one has been recently studied in the context of a quantized momentum-dependent mass system, the other Hamiltonian also reflects a similar feature in the mass function and also depicts an isotonic character. We solve for such a Hamiltonian and give the complete solution in terms of a confluent hypergeometric function.

A geometrical description of the virial theorem of statistical mechanics was determined for second-order differential equations of the Liénard type. The explicit dependence of the virial function and the Jacobi last multiplier is illustrated.

Recent analytical methods are employed to investigate the possible classes of traveling wave solutions of some members of a family of short-pulse equations (SPE).

An exact connection between physical loop Hilbert space of SU(2) lattice gauge theories and Hilbert space of hydrogen atoms is found after making a series of iterative canonical transformations. The SU(2) loop dynamics obtained this way is shown is given in terms of the generators of the dynamical symmetry group SO(4,2) of hydrogen atoms. In the weak coupling continuum limit the SU(N) loop Hamiltonian in two space dimension reduces to generalized SU(N) spin model with nearest neighbor interactions.

It is shown that the contribution of magnons in the formation of vorticex/anti-vortex type topological excitations in Quantum spin 1\2 Heisenberg ferromagnets in the strong anisotropic limit below T_BKT is stable.

A semi-classical analysis of the neutron scattering results for spin ½ anti-ferromagnet La_2CuO_4 is performed. On the basis of an ideal gas of mobile vortices/anti-vortices the analysis results into negative values of integrated intensities when convoluted with commonly used resolution functions.

A study of the fiber bundle model using equal load sharing dynamics where the breaking thresholds of the fibers are drawn randomly from a power law distribution of the form $p(b)\sim b^{-1}$ in the range $10^{-\beta}$ to 10^{β} is presented.

Three different earthquake seismic data sets are used to construct the earthquake networks following the prescriptions of Abe and Suzuki. It has been observed that different links of this network appear with highly different strengths. This prompted us to extend the study of earthquake networks by considering it as the weighted network. Different properties of such weighted network have been found to be quite different from those of their un-weighted counterparts.

A mean-field model of interacting synapses on a directed neural network is formulated, focusing on the slow adaptive dynamics of synapses, driven by the fast dynamics of the neurons they connect.

The validity of the zeroth law of thermodynamics in the context

of non-equilibrium steady-state systems is studied. Remarkably, the answer is affirmative for a class of mass exchange rates satisfying a coarse-grained detailed balance condition.

Power laws are ubiquitous in nature and arise in widely unrelated systems. However, the question still remains if there is any broad underlying principle which generates them. It is argued that an equilibrium-like additivity property is the key, which explains the origin of power laws in a wide class of systems far away from equilibrium.

Chemotaxis of a single E. coli are studied in a medium where the nutrient chemical is also undergoing diffusion and its concentration has the form of a Gaussian whose width increases with time.

Strong phase separation (SPS) in a one-dimensional periodic system that forms pure domains at all temperatures are studied. Starting from a disordered state, the system shows algebraic coarsening, and in the long time limit, part of the system develops compact phases with sharp boundaries. The remaining part behaves like a nonequilibrium open system whose ends are connected to those pure phases. The domain boundaries show rich steady state dynamics. The results are qualitatively different from earlier widely studied systems like ABC model or Lahiri-Ramaswamy model that showed SPS.

Active nematics are conceptually the simplest orientationally ordered phase of self-driven particles, but have proved to be a perennial source of surprises. It is shown that transition from active nematic phase to the isotropic phase is necessarily accompanied by a clumping of the density which grows faster than governed by a conservation law.

Antibody solutions are typically much more viscous than solutions of globular proteins at equivalent volume fraction. It is proposed that this is due to molecular entanglements that are caused by the elongated shape and intrinsic flexibility of antibody molecules.

Self-propelled nature of particle produces density fluctuations in active systems much bigger than equilibrium systesm. Self-propelled mechanism in general arise from the asymmetric nature of the particle. We change the shape of the particle from sphere to long rods and calculate the large density fluctuation in active systems with respect to symmetry of the particle.

Scattering and absorption data of electromagnetic radiation by interstellar dust particles was used to propose a simple modification in Rayleigh-Gans-Debye approximation (RGDA). The results yield good agreement with Mie computations at all X- ray energies. A comprehensive review article on analytic phase functions in light scattering was published.

Manu Mathur
Head, Department of Theoretical Sciences

Amitabha Lahiri

Professor
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Prof. Amitabha Lahiri did his PhD from Syracuse University. He held Post-Doctoral Fellowships at Los Alamos National Laboratory and University of Sussex. He joined Satyendra Nath Bose National Centre for Basic Sciences in 1996. He is a theoretical physicist working in mathematical physics, general relativity, quantum field theory and particle physics.

- Mathematical physics, Application of category theory in physics; Differential geometry of path spaces; Principal fiber bundles and connections on path spaces; Topological mass mechanism for gluons; Modified theories of gravity; de Sitter type black hole solutions

We calculated quantum corrections to the gluon propagator in a theory with topologically massive gluons, in which the gluons get their mass from a derivative interaction with an antisymmetric tensor gauge field. The β-function, which measures the change of the coupling constant a with energy, was found to be negative, and more negative than for usual massless SU(N) gauge theory. This is opposite to what happens when gluons couple to scalars or fermions, which makes this a new and surprising result. This also indicates that the theory is both short-range and asymptotically free.

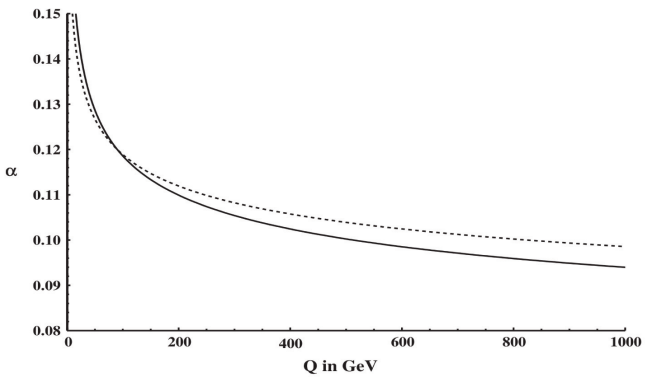

Fig. The flow of a with energy for ordinary (dotted) and topologically massive (solid) SU(3) Yang-Mills theory

Category theory formalizes mathematical structures in terms of objects and relations between them, which can be represented by arrows. The arrows generalize the notions of associativity and identity of group theory. We extended the concept of a semi-direct product of groups to categories, thus creating a new concept of semi-direct product of arrows. We then used this to construct a notion of action of a category, analogous to the action of groups on spaces. When these spaces are vector spaces or analogous categorical spaces, we get something like a representation, for which an analog of Schur's lemma was proven.

A modification of general relativity due to Eddington, and Born and Infeld, regulates singularities and naturally gives rise to a cosmological constant, but its coupling to matter is not very obvious. Using a method due to Kaluza, we wrote the theory in five dimensions and compatified it on a circle down to four dimensions. This produced a natural nonlinear coupling of Eddington-inspired Born-Infeld gravity to electromagnetism, previously unknown. We also discovered charged black hole solutions of the resulting theory.

Future Plan

The topological mass generation mechanism for remains interesting as it provides a gauge-invariant mass for vector bosons. Effects of such a mass on the quantum behaviour of gluons will be considered, in particular on the anomalous chromomagnetic dipole moments of quarks. The Linear Hadron Collider (LHC) may be able to put limits on gluon masses using these results. The mechanism will also be applied to photons, as an alternative approach to superconductivity. Possible origins of this mechanism from electron-electron interactions will be explored.

In other work relevant to the LHC, models which extend the symmetry breaking sector of the Standard Model, specifically various 2-Higgs doublet models, will be explored. These have

additional charged and neutral scalar particles – bounds on their masses will be calculated using known theoretical and experimental constraints.

In work related to gravity, gauge theoretic descriptions of gravity will be studied, in particular perturbations and matter couplings in the tetrad formulation of gravity. Field theory in curved spacetime will be studied as well.

Publications in Journals

1. Saikat Chatterjee, **Amitabha Lahiri** and Ambar N. Sengupta, *Twisted actions of categorical groups*, Theory and Applications of Categories**, 29**, 215 (2014).
2. Debmalya Mukhopadhyay and **Amitabha Lahiri**, β-*function for topologically massive gluons,* Phys. Rev. D,**90**, 025015 (2014).
3. Karan Fernandes and **Amitabha Lahiri**, *Kaluza ansatz applied to Eddington inspired Born-Infeld gravity,* Phys.Rev. D, **91**, 044014 (2015).

Other Publication

1. Saikat Chatterjee, **Amitabha Lahiri** and Ambar N. Sengupta, *Double Category Related to Path Space Parallel Transport and Representations of Lie 2 Groups,* Springer Proc.Math.Stat. 85 (2014) 379.

Supervision of Students

Ph.D. Students: Debmalya Mukhopadhyay, Subhasish Chakrabarty, Ishita Dutta Choudhury, Ambalika Biswas, Karan Fernandes

Project Student: Debalina Banerjee (IphD, SNBNCBS)

Post Doctoral Research Scientists: Suman Ghosh, Rohit Kumar

Independent Publication of Student

1. Rohit Kumar, *Off-shell nilpotent (anti-)BRST symmetries for a free particle system on a toric geometry: superfield formalism*, Europhys. Lett., **106**, 51001 (2014).

Lectures Delivered

1. Kaluza Reduction of Eddington-inspired Born-Infeld action, Invited talk at the International Conference on Gravity and Matters of the Universe, Jamia Millia Islamia, October 2014.
2. Naturalness and scalar masses in 2 Higgs-doublet models, Invited talk at Advances in High Energy Physics, Hyderabad University, February 2015.

Course Taught

1. PHY 102 Mathematical Methods Autumn 2014

Membership of Committees

Internal Committee: Consultative Advisory Committee, Students' Curriculum and Research Evaluation Committee, Students Advisory Committee, Complaints Committee, Computer Services Cell (Working Group & Advisory Committee), Conferences, Workshops and Extension Programmes Committee

Anita Mehta

Senior Professor
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Professor Anita Mehta works on complexity in natural and intelligent systems. Current research areas include synaptic metaplasticity and memory, agent-based models of competitive learning, universality in predator-prey survivor distributions, citation network dynamics, encodings of NP complete problems and investigations of stochasticity in the visual system of the fruitfly. Her current collaborations include her group at the SN Bose Centre as well as scientists based at New York University, the Institut de Physique Theorique, Saclay and the University of Leipzig.

- Synaptic plasticity: agent-based models of competitive and cooperative dynamics: simulations of predator-prey dynamics on preferentially attached networks: citation network dynamics: analytical theories of survivor distributions in dissipative models: stochasticity in the fly retina

1. A mean-field model of interacting synapses on a directed neural network was formulated, focusing on the slow adaptive dynamics of synapses, driven by the fast dynamics of the neurons they connect. Cooperation was modeled from the usual Hebbian perspective, while competition was modeled by an original polarity-driven rule. The emergence of a critical manifold culminating in a tricritical point was shown to be crucially dependent on the presence of synaptic competition. A universal 1/t power-law relaxation of the mean synaptic strength along the critical manifold and an equally universal $1/\sqrt{t}$ relaxation at the tricritical point are the surprising deviations from the otherwise generic exponential relaxation. This leads to the natural emergence of long- and short-term memory from different parts of parameter space in a synaptic network, which is the most original and important result of our present investigations. (Published in Phys Rev E 90, 032709 (2014))

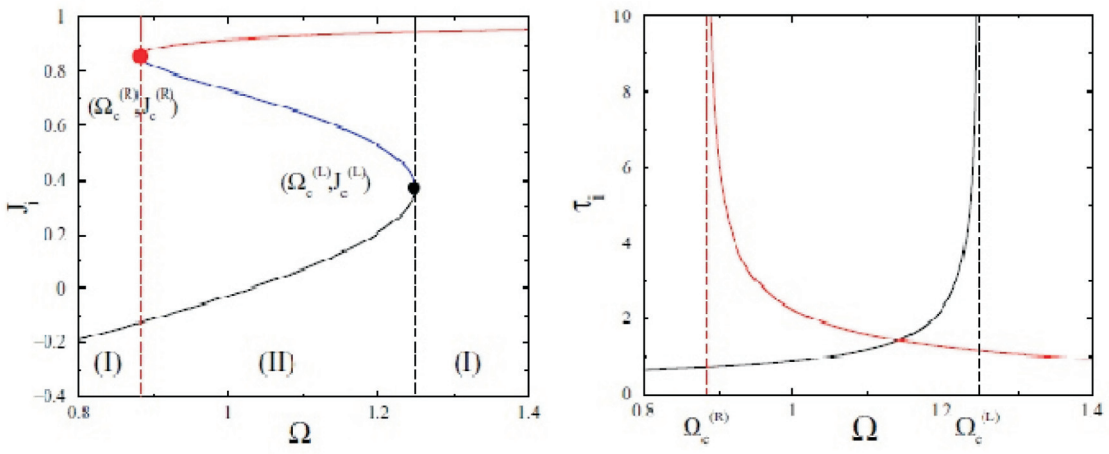

Fig: Top: Fixed points J_i against potentiating rate Ω in reduced units, for the extremal model with ω=0.03. Bottom (black) and top (red) curves: attractive fixed points. Intermediate (blue) curve: repulsive fixed point. Right (black) and left (red) filled symbols have respective coordinates $(\Omega_{(L)c} \approx 1.24768, J_{(L)c} \approx 0.37013)$ and $(\Omega_{(R)c} \approx 0.88270, J_{(R)c} \approx 0.85650)$. Bottom: relaxation times associated with the attractive fixed points. Vertical lines at $\Omega = \Omega_{(L)c}$ and $\Omega = \Omega_{(R)c}$ demarcate regimes I and II and locate the divergences (37), (38).

2. The effects of preferential attachment on a model of competing clusters were examined. In this model, cluster masses grow at the expense of their neighbours; on a lattice, this is known to result in the asymptotic survival and indefinite growth of clusters which are isolated from each other. The presence of preferential attachment results in an inhomogeneous topology, where hubs monopolise the connections, while most other nodes are sparsely connected. Interestingly, this results in the protection of the less massive clusters from annihilation, to which the hubs are doomed. (Published in Eur. Phys. J. Special Topics 223, 2745–2758 (2014))

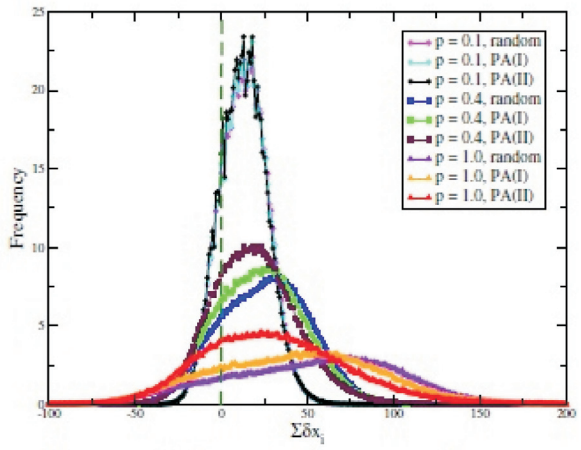

Fig: The cumulative mass difference distributions for the eventual survivors in three wiring processes. The area under the negative portion of the curve at any *p* is less than that under the positive portion implying a larger surviving possibility for the massive clusters. The curve for a given *p* has the highest peak for PA(II) and the lowest peak value for the random case. The plots are obtained numerically from the same 50×50 lattice of Fig.9 under the 10-cycle scheme due to all scenarios of additional wiring (S(1)=0.85).

Future Plan

I am continuing my work on stochasticity in the colour vision rhodopsins of two different species of fruitfly. We have provided a unifying description of two different manifestations of stochasticity, resulting in different ordering patterns as well as different error correction mechanisms for each species. The ultimate objective is to construct a phase diagram of possible patterns in terms of their correlations, and to compare with experimental results. This work is being done in collaboration with quantitative biologists in Leipzig and experimental biologists in New York.

In collaboration with a colleague in France, I am constructing an analytical theory for the fraction of survivors in a generalized network with predator-prey dynamics. The exact equations are non-integrable, so that renormalization schemes have been constructed on a variety of embeddings to evaluate the survivor fraction. We are also looking analytically at the dynamics of citation networks.

Finally, in collaboration with colleagues in Leipzig, I am looking at mathematical properties of good encodings for NP-complete problems, with a view to establishing an analogy with the renormalization group.

Publications in Journals

1. J M Luck and **Anita Mehta**, *Slow synaptic dynamics in a network: From exponential to power-law forgetting*, Physical Review E, **90**, 032709 (2014).
2. S Aich and **Anita Mehta**, *The clash of the Titans: how preferential attachment helps the survival of the smallest*, Eur. Phys. J. Special Topics, **223**, 2745-2758 (2014).

Other Publication

1. **Anita Mehta**, translated into Spanish by Julia Taguena and Sue Berlanga, "Ciencia y sociedad: La perspective de una mujer cientifica de la India", (2014) Ciencia y Desarrollo, May-June, 46-49.

Supervision of Students

Ph.D. Students: D P Shinde (awarded Ph D in 2015); S Aich

Project Students: Bapun Giri (IISER Kolkata); Haleh Ebadi (University of Leipzig)

Lectures Delivered

Seminars and Colloquia

1. Colloquium, 'Perceiving, learning and forgetting – a physicist's take', Physics Department, Istanbul Technical University, Istanbul, May (2014)
2. Colloquium, 'The dynamics of sand', Max Planck Institute for Dynamics and Self-Organization, Goettingen, June (2014)
3. Seminar, 'Perceiving, learning and forgetting – a physicist's take', Department of Physics, University of Barcelona, Barcelona, June (2014)

Conference invited talks

1. Invited speaker at Physics and Neuroscience at the International Institute of Physics, Natal, Brazil, August 2014.
2. Invited discussant at Stochastic physics in Biology, Gordon Conference, Ventura, California, January 2015.

Academic Visits

1. Visiting Professor at Department of Bioinformatics, University of Leipzig (May-June 2014)
2. Visiting Senior scientist at Service de Physique Theorique, Saclay, France (June 2014)
3. Visiting Professor at the International Institute of Physics, Natal, Brazil (August 2014)

Membership of Committees

External Committee: Member and Mentor of National Network for Mathematical and Computational Biology, Science and Engineering Research Board, India (2014 -); Member of Working Group for Women in Physics, Asia-Pacific Physics Conferences (2010-); On Editorial Board of Granular Matter and CHAOS; Member of Scientific Committee of 'Association pour l'Etude de la Micromécanique des Milieux Granulaires' since its inception

Award / Recognition

Fellow of the American Physical Society

Biswajit Chakraborty

Professor
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Prof. Biswajit Chakraborty did his PhD from IMSc, Chennai (Madras University) in 1992. Then after a brief period of Post-Doctoral position in IIT, Kanpur he was a visiting fellow for a couple of years in HRI, Allahabad. Eventually, he joined SNBNCBS in 1994 - initially as a PDF and got absorbed in the faculty in 1997. Currently, he is a Professor in the department of Theoretical Sciences in SNBNCBS.

- I continued working on non-commutative quantum theories during this period. Particularly, we tried to compute the Connes distance function on the fuzzy sphere both in the classical and quantum Hilbert spaces in the Hilbert-Schmidt operator formalism of non-commutative quantum mechanics and studied the relationship between geometry and statistics.
- Besides, we also initiated the computation of Connes distance for the double Moyal plane.

(1) We have shown the computation of Connes distance can be done in a simpler way using our earlier developed algorithm, even for the fuzzy sphere. Using this algorithm, by constructing appropriate spectral triples for both classical configuration space and quantum Hilbert space, we were able to compute the infinitesimal distance using both the integer and Perelomov coherent state basis in the classical configuration space. Subsequently, we also demonstrate that a deep connection between geometry and statistics can be revealed by the computation of Connes distance between mixed states in the context of quantum Hilbert space.

(2) Apart from the Connes prescription to compute the spectral distance another proposal was put forward by Doplicher *et. al.*- referred to as quantum length. We have initiated a study to compare the distance functions computed through either of this. One remarkable difference between these two prescriptions is that Connes spectral distance vanishes between the state and itself in contrast to the prescription of Doplicher *et. al.*. To circumvent this problem the modified quantum length was introduced by Martinetti *et. al.*. We have shown, again using our Hilbert Schmidt operatorial formulation that the modified quantum length merges with that of Connes distance asymptotically, if the so-called `harmonic oscillator basis' is considered. On the other hand, in the coherent state basis both these distances differ only by a numerical factor. We further showed that, no modification in the distance can be obtained in the context of quantum Hilbert space if the Doplicher *et. al.*'s definition is of quantum length is employed. This is in contrast to Connes definition of spectral distance which is sensitive to the presence of additional degrees of freedom involved in a generic mixed state, and can therefore be regarded as a superior one.

Future Plan

1. In another approach, compatibility between these two definitions of distance functions was attempted by Martinetti *et. al.* by considering a double Moyal plane so that any generic state will be of a tensor product form where the first slot is reserved for the usual state of C*-algebra occurring in the spectral triple of a single Moyal plane and the second slot is reserved for the state of the spectral triple describing just a two-point space. In their approach, they also proved Pythagoras equality by considering the distances between a pair of points, each belonging to different Moyal planes. We are currently involved in the computation of these distances using the above-mentioned algorithm.
2. We are also investigating the possibility of introducing a fluctuated Dirac operator, by incorporating suitable gauge fields and study its impact on metric/geometry.

Publication in Journal

1. Y. Chaoba Devi, S. Prajapat, A. K. Mukhopadhyay,

B. Chakraborty, F. G. Scholtz, *Connes distance function on fuzzy sphere and the connection between geometry and statistics*, Journal of Mathematical Physics, **56**, 041707 (2015).

Supervision of Students

Ph.D. Students: Yendrembam Chaoba Devi, Aritra Narayan Bose, Debabrata Ghorai (tentatively under INSPIRE fellowship)

Lecture Delivered

1. A talk on 'Entropy and Geometry in Non-Commutative Spaces: Moyal Plane and Fuzzy Sphere' was given at National Institute for Theoretical Physics (NITheP), Stellenbosch, South Africa in the 'Workshop on Quantum Physics: Foundations and Applications' held during 3rd – 13th February, 2015.

Academic Visit

1. Visited National Institute for Theoretical Physics (NITheP), Stellenbosch, South Africa during 2nd – 20th February, 2015 to attend the above mentioned mini-workshop and for carrying out collaborative work with Prof. F. G. Scholtz.

Course Taught

1. Taught a one semester course on 'Advanced Quantum Mechanics' (PHY 303) for the 3rd semester I.PhD students during August-November, 2014

Membership of Committees

External Committee: I have been chosen as a member of the Board of Research Studies (BRS) in physics in the dept. of West Bengal State University, Barasat.

Internal Committee: Admission Committee, CWEP-EVLP

Makhtedar Sanjay Kumar

Associate Professor
sanjay@bose.res.in

M. Sanjay Kumar received his M. Sc. (1984) and Ph. D. (1989) in Physics from University of Hyderabad. He had been a post-doctoral fellow at University of Rochester, Institute of Mathematical Sciences, Chennai and Raman Research Institute, Bangalore. He joined the Satyendra Nath Bose National Centre for Basic Sciences as faculty in 1999.

- Quantum Optics and Quantum Information

A comparative study non-Gaussianity of two-mode resource states on teleportation has been undertaken using two different measures of non-Gaussianity namely one based on Hilbert-Schmidt distance and another based on Wehrl entropy.

A preliminary understanding of the question of which two-mode resource states are suitable for quantum teleportation has been achieved. The question is being investigated further.

Future Plan

Continue work on the above-mentioned problems.

Supervision of Student

Ph.D. Student: Soumyakanti Bose

Courses Taught

1. "Quantum Mechanics I" IPhD course (August-November 2014)
2. "Quantum Mechanics II" IPhD course (January-April 2015)

Membership of Committees

Internal Committee: Member, Admissions Committee; Admissions Coordinator; Member, EVLP (VASP) Committee

Manu Mathur

Professor
manu@bose.res.in

Prof. Manu Mathur is interested in Lattice Gauge Theories, Loop Formulation of Gauge Theories, Mathematical Physics.

- Lattice Gauge Theories, Loop Formulation of Gauge Theories, Mathematical Physics

From Lattice Gauge Theories to Hydrogen Atoms

We found a connection between physical (loop) Hilbert space of SU(2) lattice gauge theories and Hilbert space of hydrogen atoms. A series of canonical transformations on the the Kogut-Susskind link operators transform them into physical loop and unphysical string operators. The strings, being associated with spurious gauge degrees of freedom, decouple from the physical Hilbert space. On the other hand, the physical loop operators are shown to create a Physical Hilbert space which can be exactly identified with the Hilbert space of Wigner coupled Hydrogen atoms. Further, the loop Hamiltonian obtained this way is shown to be made up of the 15 generators of the dynamical symmetry group SO(4,2) of hydrogen atoms. The possibility of using these ideas in cold atom experiments to realize non-abelian gauge theories is briefly discussed. This gauge invariant ``hydrogen atom'" approach, without non-abelian Gauss law constraints, may be useful in cold atom experiments to realize non-abelian gauge theories.

The canonical transformations, leading to a gauge invariant loop formulation, are also valid for SU(N), N = 3. As expected, the SU(N) loop Hamiltonian is non-local. However, we show that in the weak coupling continuum limit, all non-local terms are of higher order in coupling. Therefore, they can be treated in perturbation theory.

Our loop approach through canonical transformations also solves the highly non-trivial and non-local SU(N) Mandestam constraints associated with loop formulations. Solutions of these constraints for N = 3 were not known.

The canonical transformations discussed also avoid the problem of Bianchi identity constraints associated with loop formulation of SU(N) lattice gauge theories in three space dimension.

Future Plan

1) Explore the spectrum of SU(N) lattice gauge by developing a weak coupling loop perturbation theory near the coninuum limit.
2) Use Variational ansatz, coupled cluster method within the above loop formulation to study the spectrum.
3) Using Tensor networks in the above hydrogen atom basis to explore the gauge theory spectrum.

Supervision of Student

Ph.D. Student: T. P. Sreeraj

Lecture Delivered

1. Lattice Gauge Theories and Hydrogen atoms, Physics Department, University of Hyderabad

Course Taught

1. Taught a course on Elecromagnetic theory with Professor S K Sharma

Partha Guha

Professor
partha@bose.res.in

Research interests of Prof. Partha Guha are centered around nonlinear dynamics, integrable systems and geometrical mechanics.

- Nonlinear dynamics, geometrical mechanics and nonholonomic dynamics

LIENARD and QUANTUM LIENARD TYPE SYSTEMs: We have examined the analytical structure of the nonlinear Lienard oscillator and show that it is a bi-Hamiltonian system depending upon the choice of the coupling parameters. While one has been recently studied in the context of a quantized momentum-dependent mass system, the other Hamiltonian also reflects a similar feature in the mass function and also depicts an isotonic character. We solve for such a Hamiltonian and give the complete solution in terms of a confluent hypergeometric function.

In a different project a geometrical description of the virial theorem of statistical mechanics was determined for second-order differential equations of the Liénard type. The explicit dependence of the virial function and the Jacobi last multiplier was illustrated.

PATTERN FORMATION and SOLITON: In a joint work with Gambino et al. we employ three recent analytical methods to investigate the possible classes of traveling wave solutions of some members of a family of so-called short-pulse equations (SPE). A recent, novel application of phase-plane analysis is first employed to show the existence of breaking kink wave solutions in certain parameter regimes. Secondly, smooth traveling waves are derived using a recent technique to derive convergent multi-infinite series solutions for the homoclinic (heteroclinic) orbits of the traveling-wave equations for the SPE equation, as well as for its generalized version with arbitrary coefficients. These correspond to pulse (kink or shock) solutions respectively of the original PDEs. Finally, variational methods are employed to generate families of both regular and embedded solitary wave solutions for the SPE PDE.

Future Plan

This year I am focusing on locally conformal symplectic geometry, cosymplectic geometry and their application to dynamical systems. I will continue my work on (super) integrable geodesic flows on infinite-dimensional groups and their nonholonomic extension.

Publications in Journals

1. B. Bagchi, A. Ghose Choudhury and **Partha Guha**, *On quantized Liénard oscillator and momentum dependent mass*, J. Math. Phys., **56**, 012105 (2015).
2. **Partha Guha** and A. Ghose Choudhury, *Folding transformations of equations from the Gambier family*. , **22**, no. 1-3, 1028–1035 (2015).
3. G. Gambino, U. Tanriver, **P. Guha**, A. Ghose, Choudhury, S. Roy Choudhury, *Regular and singular pulse and front solutions and possible isochronous behavior in the short-pulse equation: phase-plane, multi-infinite series and variational approaches*, **20**, no. 2, 375–388 (2015).
4. J. F. Carinena, A. Ghose Choudhury and **Partha Guha**, *Generalized virial theorem for the Liénard-type systems*, Pramana, **84**, 373-385 (2015).
5. **Partha Guha**, E. Harikumar, E. N.S. Zuhair, *MICZ-Kepler systems in noncommutative space and duality of force laws*, **29**, no. 32, 1450187 (2014).

Supervision of Students

Ph.D. Student: Sumanto Chanda

Project Student: Ankan Pandey

Lecture Delivered

1. Integrable ODEs in and out from the Virasoro orbit, EPFL Laussane, 17 October 2014

Academic Visits

1. Visited Harishchandra Research Institute, 30 August to 3rd September, 2014
2. Visited Professor Tudor Ratiu, Chair, Applied Analysis, EPFL, Laussane, October-December 2014
3. Visited Professor Jose Carinena at University of Zaragoza, 30 November to 6th December, 2014

Punyabrata Pradhan

Assistant Professor
punyabrata.pradhan@bose.res.in

Dr. Punyabrata Pradhan obtained B. Sc. (in 1998) and M.Sc. (in 2000) degree from University of Calcutta, India and Ph. D. degree (in 2006) from Tata Institute of Fundamental Research, Mumbai, India. After doing his postdoctoral research in Technion, Israel and University of Stuttgart, Germany, he joined the S. N. Bose National Centre for Basic Sciences, Kolkata in 2011.

- Nonequilibrium steady state (NESS), Fluctuation-response relations, thermodynamic characterization of NESS, phase coexistence in NESS, traveling wave in driven diffusive systems

1. We explore what happens when two non-equilibrium steady-state systems are kept in contact and allowed to exchange a conserved quantity, e.g., mass. Upon contact, the combined system eventually settles in a new stationary state. However, an intriguing question whether one could describe such a scenario in terms of zeroth law of thermodynamics still remains unsettled. Remarkably, for a class of mass exchange rates satisfying a coarse-grained detailed balance condition, we find an affirmative answer to the question, which can lead to an interesting thermodynamic structure encompassing a vast class of systems having a non-equilibrium steady state.
2. Power laws are ubiquitous in nature and arise in widely unrelated systems. However, the question still remains if there is any broad underlying principle which generates them. We argue that an equilibrium-like additivity property is the key, which explains the origin of power laws in a wide class of systems far away from equilibrium. The principle of additivity not only provides a unique thermodynamic interpretation to the emergence of power laws in these non-equilibrium systems, but also can be used to calculate the full scaling form of the distribution functions. From a general perspective, the analysis could help in addressing the question of how to characterize phase coexistence in driven systems - a long-standing issue in non-equilibrium statistical physics.
3. We introduce and study a lattice model where particle hop rate not only depends on occupation of the departure site but also on the occupation of all of its neighbours within a range R; we refer to this process as finite range process (FRP). We show that, in finite range process in one dimension, one can have a cluster-wise factorized steady state (CFSS) for specific choice of hop rates. We provide a transfer-matrix formulation to calculate the spatial correlation functions, of all orders, in a class of CFSS. Moreover, we formulate a criterion for hop rates that give rise to condensation in FRP.

Future Plan

1. Characterization of phase transition in driven systems in general.
2. Transport properties in systems periodically driven by an external potential.

Supervision of Students

Ph.D. Students: Sayani Chatterjee, Arghya Das and Subhadip Chakraborti

Project Student: Amal Garai

Lectures Delivered

1. Additivity principle and emergence of power laws; Indian Institute of Science; Bangalore; February; 2015
2. Additivity principle and thermodynamic characterization of mass transport processes; Indian Institute of Technology; Kanpur; October; 2014

Meeting Organized

Statphys – Kolkata VIII; December 1 – 5 (2014); S. N. Bose National Centre for Basic Sciences, Kolkata

Rabin Banerjee

Senior Professor
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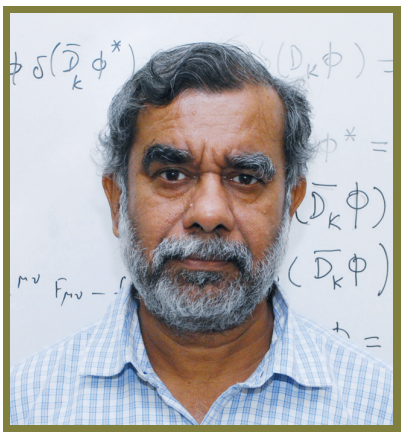

Dr. Rabin Banerjee received his M.Sc. from IIT Kharagpur and P.hD. from Calcutta University (SINP). He was a Humboldt fellow at Heidelberg, Munich and Cologne, a CNPq fellow at Rio de Janerio, a BK-21 fellow at Seoul and JSPS fellow at KEK, Tsukuba. He joined the centre in 1989.

- Gauging the Galilean symmetry and non-relativistic diffeomorphism invariance, Its applications in fractional quantum Hall effect, Horava-Lifshitz geometry etc., Hamiltonian formulation of fluids, Entropy current in two dimensional anomalous fluids, PT-symmetry in theoretical and experimental quantum mechanics

We have continued our work on fluid dynamics. Specifically, ideal fluid dynamics is studied as a relativistic field theory with particular stress on its Hamiltonian structure. We also consider the Hamiltonian formulation of fluids interacting with an external gauge field. The complementary roles of the canonical (Noether) and symmetric stress tensors are discussed. Interestingly it is found that the Schwinger condition holds in this context. This is a new finding in the realm of fluid dynamics.

We present a new approach to analyse constitutive relations in two dimensional hydrodynamics in the presence of gauge and gravitational anomalies. For the chiral theory, these relations may be put in the ideal (chiral) fluid form but this feature does not exist in the nonchiral case.The relations between the response parameters and anomaly coefficients were found by exploiting the role of the Israel-Hawking-Hartle condition.

A new algorithmic approach towards the formulation of nonrelativistic diffeomorphism invariance has been developed which involves both matter and gauge fields. A systematic procedure has been provided, based on the gauging of the Galilean symmetry of nonrelativistic matter field theories that can also accommodate all types of abelian gauge interactions. This algorithm is applied to the problem of a two dimensional electron moving under the influence of an external field and also under the Chern-Simons dynamics. Our approach has led to several new insights and new results in the context of abstracting spatial diffeomorphism invariance and its role in understanding fractional quantum Hall effect.

The above approach has also led to important mathematical advances. It may be recalled that Newtonian gravity was formulated as a geometrodynamic theory way back in 1930s by Elie Cartan, in what is named aptly as Newton-Cartan space time. Though there are several approaches of realizing the algebraic structure of the Newton-Cartan geometry from a contraction of the relativistic results, a dynamical (field theoretic) realization is absent. We have presented such a realization following our approach of gauging the Galilean symmetry.

Recently the role of PT-symmetry has been explored in various experimental settings. Of particular significance is the experiment labeled as whispering gallery microresonators. Its importance lies in the fact that it implements a classical analogue of quantum systems described by non-hermitian PT-symmetric Hamiltonians. Also, a phase transition from Pt-symmetry breaking phase to PT-symmetric phase was noted. We have provided analytical techniques to reproduce the results found experimentally or by numerical techniques. It is based on our analysis of two coupled chiral oscillators that simulate the experimental resonators with loss and gain.

Future Plan

We wish to pursue our investigations on the gauging of the Galilean symmetry outlined earlier. Indeed there are several applications that could be attempted. It is possible to provide a deeper study into the understanding of the fractional quantum Hall effect. Particularly, we feel, that the geometry of this effect could be elaborated by our techniques. The obtention of the Hall viscosity and the Wen-Zee term which

are topological responses of fractional quantum Hall fluids to the geometric shear deformation and curvature, could be attempted.

Another possible application would be to study the projectable version of the Horava Lifshitz gravity which, though an example of nonrelativistic gravity, is different from the usual Newtonian gravity. We should be able to give a dynamical construction of the metric that reproduces the transformation of the physical variables- lapse, shift and spatial component of the metric.

We may continue our investigations into the theoretical aspects of PT-symmetry that would further clarify the experimental results with microresonators.

Publications in Journals

1. **R. Banerjee**, S. Ghosh and A. K. Mitra, *Hamiltonian analysis of interacting fluids*, Eur. Phys. J. C, **75** (5), 207 (2015).
2. **R. Banerjee**, A. Mitra and P. Mukherjee, *General algorithm for nonrelativistic diffeomorphism invariance*, Phys. Rev. D, **91** (8), 084021 (2015).
3. **R. Banerjee**, A. Mitra and P. Mukherjee, *Localization of the Galilean symmetry and dynamical realization of Newton-Cartan geometry*, Class.Quant.Grav., **32** (4), 045010 (2015).
4. **R. Banerjee**, A. Mitra and P. Mukherjee, *A new formulation of non-relativistic diffeomorphism invariance*, Phys.Lett. B, **737**, 369-373 (2014).
5. **R. Banerjee** and S. Dey. *Constitutive relations and response parameters in two-dimensional hydrodynamics with gauge and gravitational anomalies*. Phys.Lett. B, **733**, pp. 198–201 (2014).
6. **R. Banerjee** and S. Upadhyay. *Generalized supersymmetry and sigma models*, Phys.Lett. B, **734**, pp. 369–376 (2014).
7. **R. Banerjee**, S. Dey, B. R. Majhi, and A. K. Mitra, *Two dimensional hydrodynamics with gauge and gravitational anomalies*, Phys.Rev. D, **89**, p. 104013 (2014).

Supervision of Students

Ph.D. Students: Biswajit Paul (Degree awarded), Arindam Lala, Shirsendu De, Arpan Krishna Mitra, Arpita Mitra, Subhadip Basu

Independent Publication of Students

1. Arindam Lala, *Magnetic response of holographic Lifshitz superconductors: Vortex and Droplet solutions*, Phys Lett B, **735**, 396-401 (2014).
2. Shirsendu Dey, Arindam Lala, *Holographic s-wave condensation and Meissner-like effect in Gauss–Bonnet gravity with various non-linear corrections*, Annals of Phys, **354**, 165-182 (2015).

Lecture Delivered

1. Gauge and gravitational anomalies, Punjab University, Chandigarh, 13- 15 May, 2014 at International Workshop on Unification and Cosmology after Higgs Discovery.

Membership of Committees

Internal Committee: Various committees, either as Chairperson in my capacity as Dean (Faculty) or as a member

Award / Recognition

1. Distinguished Referee of European Physical Journal C (EPJC)

Sakuntala Chatterjee

Assistant Professor
sakuntala.chatterjee@bose.res.in

Sakuntala Chatterjee finished her PhD in 2007 from Department of Theoretical Physics in Tata Institute of Fundamental Research, Mumbai. From 2007 to 2009 she did a postdoc in Research Centre Juelich, Germany. From 2009 to 2011 she did another postdoc in Technion, Israel. In 2011 she has joined S.N. Bose Centre as an Assistant Professor.

- Nonequilibrium Statistical Physics: Phase separation in interacting particle systems, Nonequilibrium
- Steady state with time-periodic drive, Boundary induced phase-transition
- Biological Physics: Chemotaxis of E.coli bacteria, Actin-based cell motility, Ion-channel transport

Optimal search in E.coli chemotaxis: We study chemotaxis of a single *E. coli* in a medium where the nutrient chemical is also undergoing diffusion and its concentration has the form of a Gaussian whose width increases with time. We measure the average first passage time of the bacterium at a region of high nutrient concentration. In the limit of very slow nutrient diffusion, the bacterium effectively experiences a Gaussian concentration profile of fixed width. In this case we find that there exists an optimum width of the Gaussian when the average first passage time is minimum, i.e. the search process is most efficient. Our numerical simulation in a model of a non-Markovian random walker agrees well with our analytical calculations in a related coarse-grained model. We also present our simulation results for the case when the nutrient diffusion and bacterial motion occur over comparable time-scales and the bacterium senses a time-varying concentration field.

Fast relaxation to strong phase separation: We study strong phase separation (SPS) in a one-dimensional periodic system that forms pure domains at all temperatures. Starting from a disordered state, the system shows algebraic coarsening, and in the long time limit, part of the system develops compact phases with sharp boundaries. The remaining part behaves like a nonequilibrium open system whose ends are connected to those pure phases. The domain boundaries show rich steady state dynamics. Our results are qualitatively different from earlier widely studied systems like ABC model or Lahiri-Ramaswamy model that showed SPS.

Future Plan

1. Modeling actin-based cell motility
2. Interacting particle system driven by time-periodic potential: study of extended defect, multiple defects and interacting defects

Publication in Journal

1. Mithun K Mitra and **Sakuntala Chatterjee**, *Boundary induced phase transition with stochastic entrance and exit*, Journal of Statistical Mechanics, **2014**, P10019 (2014).

Supervision of Students

Ph.D. Students: Subrata Dev, Rajkumar Sadhu, Shauri Chakraborty

Post Doctoral Research Scientist: Sanchari Goswami

Lectures Delivered

1. Boundary induced phase transition with stochastic entrance and exit, IISER-Kolkata, Departmental seminar at Physics Department, Mohanpur, March 2015
2. Boundary induced phase transition with stochastic entrance and exit, Indian Statistical Physics Community Meeting, ICTS, Bangalore, February 2015

Course Taught

1. PHY 201, Statistical Mechanics, Spring semester 2015

Membership of Committees

Internal Committee: Creche committee, Medical committee, Project cell

Meeting Organized

1. StatPhys Kolkata VIII, December 1-5, 2014, SNBNCBS

Samir Kumar Paul

Associate Professor
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Samir Kumar Paul is a Mathematical physicist who worked in Theoretical Particle Physics and some aspects String theory and Conformal Field Theory. Presently he has been working in Topological Excitations in Low dimensional Spin systems and also in the role of algebraic functions in various algebras on Riemann surfaces.

- We have worked in the mainly on two aspects of topological excitations in low dimensional spin systems. One is on the connection between topological vortex-like excitations and conventional excitations in quantum ferromagnetic spin systems on a two dimensional square lattice. The other is a thorough theoretical analysis of the neutron scattering results for spin ½ anti-ferromagnet La_2CuO_4
- Another research area is on scale and conformal invariance in a particular sector of the solution space of a Yang-Mills-Higgs system

We have been able to point out contribution of frgale magnons in the formation of vorticex/anti-vortex type topological excitations in Quantum spin 1\2 Heisenberg ferromagnets in the strong anisotropic limit below T_BKT is stable. For a single charge-1 vortex (infinitely dilute limit) the length scale of the system is of the order of 10^{-5} cm considering a typical value of 3A for lattice spacing. The length scale falls into the mesoscopic length scale. In the case of finite density charge 1 vortices the length scale of the system becomes of the order of 10^{-4} cm which is again in the mesoscopic regime. (Subhajit Sarkar, Ranjan Chaudhury and Samir K. Paul; arXiv : 1410.5921v2[cond-mat.str-el]).

We have performed a semi-classical analysis (full quantum theoretic formulation of topological excitations not yet being known) of the neutron scattering results for spin ½ anti-ferromagnet La_2CuO_4. On the basis of an ideal gas of mobile vortices/anti-vortices (studieed so far in the literature) our analysis results into negative values of integrated intensities when convoluted with commonly used spectral window functions along with the resolution width specified in the experiment. resolution functions. Vigorous oscillations in the theoretically obtained integrated intensities are reduced substantially by modifying the window functions. However the oscillations resulting from convolutions vanish completely at a temperature regime which falls just outside the regime of applicability of vortex/meron gas phenomenology. All this necessitates a full quantum theory to be built up. (Subhajit Sarkar, Ranjan Chaudhury and Samir K. Paul, manuscript under preparation).

The significant result in studying the scale dilatation and conformal invariance of a SU(2) Yang-Mills-Higgs system of Georgi-Glashaw type Lagrangian is that it is only at D=4 in the vanishing limit of the dimensionless parameter indicating absence of the Higgs potential that there is formal dilatation invariance in the theory and no conformal invariance. This is owing to the fact that boundary conditions dictated in presence of Higgs potential persists, indicating that scale invariance can hold for the Bogomolny-Prasad-Sommerfield monopole solutions. Similar analysis on Nielsen-Olesen vortex model (U(1) analogue of the above model) reveals that relativistic generalisation of Gingzburg-Landau phenomenological field theory of superconductivity does not respect scale invariance since the vortex core radius diverges under imposition of dilatation invariance (Subhajit Sarkar, Ranjan Chaudhury and Samir K. Paul, manuscript under preparation).

Future Plan

We have established that semiclassical formulations fail to describe mobile vortices. Also we have established there can be a path integral formulation for static quantum vortices in an extremely anisotropic quantum Heisenberg ferromagnetic and anti-ferromagnetic model (arXiv: 1410.5921v2 [cond-mat.Str-el], 22p). Now we propose to apply build up a finite temperature field theoretic approach for calculating dynamical

spin-spin correlation functions.

Supervision of Student

Ph.D. Student: Subhajit Sarkar (CMPMS, Jointly with Ranjan Chaudhury)

Courses Taught

1. PHY 406, Advanced Mathematical Methods, IPHD 4th semester
2. PHY 507 Mathematical Methods, Post M Sc Ph D students (as a part of UGC requirement)

Membership of Committees

Internal Committee: SCREC, Security Monitoring Committee

Shradha Mishra

DST-INSPIRE Faculty
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Dr. Shradha Mishra did her Ph.D from IISc Bangalore between 2003-2008. Her Ph.D work is on Dynamics, order and fluctuations in active nematic. Equilibrium and nonequilibrium statistical mechanics is major area of her research interest. In particular she is interested in collective behaviour of self propelled active particles, Self organised pattern formation in biological, granular systems, driven diffusive systems and theoretical understanding of protein aggregation.

- Equilibrium and nonequilibrium statistical mechanics is major area of my research interest. In particular I am interested in collective behaviour of self-propelled active particles, Self organised pattern formation in biological, granular systems, driven diffusive systems and theoretical understanding of protein aggregation

1. Mesoscopic theory for fluctuating active nematics: The term active nematics designates systems in which apolar elongated particles spend energy to move randomly along their axis and interact by inelastic collisions in the presence of noise. Starting from a simple Vicsek-style model for active nematics, we derive a mesoscopic theory, complete with effective multiplicative noise terms, using a combination of kinetic theory and Itô calculus approaches. The stochastic partial differential equations thus obtained are shown to recover the key terms argued in Ramaswamy et al (2003 Europhys. Lett. 62 196) to be at the origin of anomalous number fluctuations and long-range correlations. Their deterministic part is studied analytically, and is shown to give rise to the long-wavelength instability at onset of nematic order (see Shi X and Ma Y 2010 arXiv:1011.5408). The corresponding nonlinear densitysegregated band solution is given in a closed form.

2. Aspects of the density field in an active nematic: Active nematics are conceptually the simplest orientationally ordered phase of self-driven particles, but have proved to be a perennial source of surprises. We show here through numerical solution of coarse-grained equations for the order parameter and density that the growth of the active nematic phase from the isotropic phase is necessarily accompanied by a clumping of the density. The growth kinetics of the density domains is shown to be faster than the Embedded Image law expected for variables governed by a conservation law. Other results presented include the suppression of density fluctuations in the stationary ordered nematic by the imposition of an orienting field. We close by posing some open questions.

3. Entanglement model of antibody viscosity: Antibody solutions are typically much more viscous than solutions of globular proteins at equivalent volume fraction. Here we propose that this is due to molecular entanglements that are caused by the elongated shape and intrinsic flexibility of antibody molecules. We present a simple theory in which the antibodies are modeled as linear polymers that can grow via reversible bonds between the antigen binding domains. This mechanism explains the observation that relatively subtle changes to the interparticle interaction can lead to large changes in the viscosity. The theory explains the presence of distinct power law regimes in the concentration dependence of the viscosity as well as the correlation between the viscosity and the charge on the variable domain in our antistreptavidin IgG1 model system.

4. Giant Number fluctuation in the collection of active apolar particles from spheres to long rods: We study a collection of self-propelled apolar particles of different asymmetry on a two dimensional substrate. Particle asymmetry is defined by different hopping probabilities along the long and short axes of the particle. Hopping probabilities p or s = 2p - 1 are introduced in such a way that p = 1/2 or s = 0.0 are spherically symmetric particles and p = 1 or s = 1.0 are elongated rod type particles. Number fluctuation for different hopping probabilities p is calculated analytically. Number fluctuation changes with the equilibrium limit \Delta N \sqrt(N) for s = 0.0 to far from the equilibrium limit

ΔN ~ N^a, a > 0.5 for non zero s. We calculate the density structure factor and number fluctuation numerically by solving nonlinear partial differential equations of motion for density and nematic order parameters. For small wave vector q, the structure factor diverges as 1/q^2 and the corresponding number fluctuation.

Future Plan

1. Effect of disorder on the growth law in the collection of active particle systems: In our recent study of active nematic we found that although the system is not in equilibrium and have density fluctuations very different from normal, but growth law for nonconserved order parameter is same in the equilibrium, predicted before in usual phase ordering kinetics. But growth laws are very different in quenched disorder systems. We what to understand the effect of quenched disorder on the growth law in the collection of active particle systems.

2. Topological Distance Dependent Transition in a Binary Flock: In a binary flock, the velocity of an agent is updated depending only on the velocity of another agent and that of itself. Here, the other agent is selected as the n-th nearest neighbor; the specific value of n is kept fixed and it acts as a parameter of the problem. Only the angular noise has been considered in this study. Using extensive numerical calculations we argued that for n = 1 and 2, the transition is discontinuous, where as for n = 5, a continuous transition has been observed.

3. Deterministic flipping scatterers on square and triangular lattices: In the past, there have been a number of ways in which the Lorentz lattice gas (LLG), have been used to model different phenomena. The original one isbiological and goes back to something called "Langton's Ant". Later in the paper with Meng [1] (Growth, self-randomization, and propagation in a Lorentz lattice gas) the idea was that an organized configuration corresponded to a "solid" material state whereas a disordered configuration corresponded to a "liquid" state. We consider the model of periodic block configurations of scatterers on square lattice, there may be a way of similarly relating what we observe to some physical or biological process. For instance, the lattice sites which are vacant, could correspond to "defects" in a material/landscape/media. Alternatively, in the biological sense we could refer to these vacancies as "mutations" if there is some way in which these vacancies "mutate" the dynamics of the particle.

Publications in Journals

1. Jeremy Schmit, Feng He, **Shradha Mishra**, Randal R. Ketchmem, Christofer E. Woods and Bruce Kerwin, *Entanglement model of antibody viscosity*, J. Phys. Chem. B, **118** (19), pp 5044-5049 (2014).

2. **Shradha Mishra**, *Giant Number fluctuation in the collection of active apolar particles: from spheres to long rods*, J. Stat. Mech., **2014**, P07013 (2014).

3. **Shradha Mishra**, Sanjay Puri and Sriram Ramaswamy, *Aspects of the density field in an active nematic*, Phil. Trans. R. Soc. A, **372**, 20130364 (2014).

Supervision of Students

Ph.D. Student: Sudipta Pattanayak (Joined in Aug 2014)

Project Students: Mamta Gautum (Project Assistant), Sanchari Bhattacharya (Short term Project Assistant)

Lectures Delivered

1. Talk at Bangalore Statistical Physics Meeting (Feb 13-15 2015). Title: Role of density fluctuations on the nature of phase transition in active self-propelled particles.

2. Invited Talk in Statphys Kolkata VIII (Dec 1 – 5 2014) Title: Aspect of density field in an active nematic.

3. Seminar at IIT Hyderabad (Department of Physics) (Nov 2014) Title: Coupling of density and orientation field in active systems.

4. Seminar at Presidency University (Department of Physics) (Sept 2014) Title: Fluctuating Hydrodynamics of active nematic.

5. Invited TPSC seminar at Department of Physics Banaras Hindu University Varanasi (August 2014): Title: Role of density field in an active nematic.

Course Taught

1. PHY 603 Advance Statistical Physics (Jan – May 2015)

Subhrangshu Sekhar Manna

Senior Professor
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Dr. S. S. Manna worked in Saha Institute of Nuclear Physics, Calcutta for Ph. D. program and received the degree from the University of Calcutta in 1987. He did his Post doctoral researches at Melbourne University, Australia; Forschungzentrum, Germany; St. Francis Xavier University, Canada and Yale University, USA. He joined the Physics Department at I. I. T. Bombay in June, 1992 and later moved to Satyendra Nath Bose National Centre for Basic Sciences, Calcutta in January, 1998.

- Statistical Physics of Critical Phenomena: Especially (I) Self-organized criticality (ii) Percolation Models (iii) Breakdown Phenomena in materials (iv) Collective Behavior

[A] We present a study of the fiber bundle model using equal load sharing dynamics where the breaking thresholds of the fibers are drawn randomly from a power law distribution of the form $p(b)\sim b^{-1}$ in the range $10^{-\beta}$ to 10^{β}. Tuning the value of β continuously over a wide range, the critical behavior of the fiber bundle has been studied both analytically as well as numerically. Our results are:

(i) The critical load $\sigma_c(\beta,N)$ for the bundle of size N approaches its asymptotic value $\sigma_c(\beta)$ as $\sigma_c(\beta,N) = \sigma_c(\beta)+AN^{-1/\nu(\beta)}$ where $\sigma_c(\beta)$ has been obtained analytically as $\sigma_c(\beta) = 10^\beta/(2\beta e\ln10)$ for $\beta \geq \beta_u = 1/(2\ln10)$, and for $\beta<\beta_u$ the weakest fiber failure leads to the catastrophic breakdown of the entire fiber bundle, similar to brittle materials, leading to $\sigma_c(\beta) = 10^{-\beta}$;

(ii) the fraction of broken fibers right before the complete breakdown of the bundle has the form $1-1/(2\beta \ln10)$;

(iii) the distribution $D(\Delta)$ of the avalanches of size Δ follows a power law $D(\Delta)\sim \Delta^{-\xi}$ with $\xi = 5/2$ for $\Delta \gg \Delta_c(\beta)$ and $\xi = 3/2$ for $\Delta \ll \Delta_c(\beta)$, where the crossover avalanche size $\Delta_c(\beta) = 2/(1-e10^{-2\beta})^2$.

[B] Three different earthquake seismic data sets are used to construct the earthquake networks following the prescriptions of Abe and Suzuki [Euro. Phys. Lett. {\bf 65}, 581 (2004)]. It has been observed that different links of this network appear with highly different strengths. This prompted us to extend the study of earthquake networks by considering it as the weighted network. Different properties of such weighted network have been found to be quite different from those of their un-weighted counterparts.

Future Plan

(i) New model of Percolation

(ii) Two dimensional democratic model of fiber bundle model

(iii) Phase transition in Prisoner's Dilemma problem

(iv) Topological distance dependent transition in binary flocks of Collective behavior.

Publications in Journals

1. Abhijit Chakraborty, G. Mukherjee and **S. S. Manna**, *Weighted network analysis of earthquake seismic data,* Physica A, **433**, 336 (2015).
2. Chandreyee Roy, Sumanta Kundu, **S. S. Manna**, *Fiber Bundle model with Highly Disordered Breaking Thresolds*, Physical Rev. E., **91**, 032103 (2015).

Supervision of Students

Ph.D. Students: Biplab Bhattacharya, Sumanta Kundu, Chandreyee Roy, Monalisa Singh Roy

Lecture Delivered

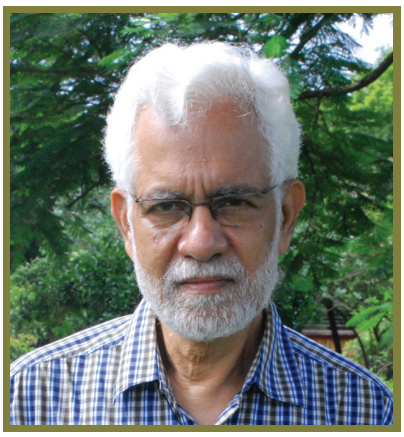
1. Delivered a lecture on "Retarded Percolation with Continuously Tunable Critical Threshold" in a conference in IMSc Chennai, in the conference titled: "Fracture: from micro-scale processes to macro-scale response", January 6-10 2015.

Course Taught

1. PHY 104, Computational Methods in Physics – I, Fall 2014

Subodh Kumar Sharma

Emeritus Professor
sharma@bose.res.in



Dr. Sharma obtained his Ph. D. from Calcutta University in 1977, working at Saha Institute of Nuclear Physics. He has worked at BITS Pilani, SINP Kolkata, Institute of Wetland Management and Ecological Design, Kolkata, UWCC Cardiff (UK), Imperial College, London and the S N Bose National Centre for Basic Sciences. He has published about 75 peer reviewed papers. He has co-authored a book (with Dr. D J Somerford, UWCC, Cardiff): "Light Scattering by optically soft particles: Theory and applications." published by Springer-Praxis in 2006.

- Development of analytic formulas for extinction contribution of major dust components of interstellar dust
- Approximate formulas for small angle scattering of X-rays by interstellar dust grains

1. The solution of problems involving scattering of electromagnetic waves is quite complex even for the simplest case of scattering by a single particle. Consequently, approximate solutions are extensively employed. At X-ray energies the refractive index of the interstellar dust particles is close to that of the surrounding medium. A widely used approximation for particles with such refractive indices is the well known Rayleigh-Gans-Debye approximation (RGDA). Numerical tests of validity of this approximation for the small angle scattering of X-rays scattered by an interstellar dust grain however reveal that the validity of this approximation is limited only to X-rays of energies greater than about 1 keV. At lower energies the RGDA overestimates the exact results. We have proposed a simple modification of this approximation. The resulting approximation has been shown to retain the simpicity of the RGDA but yields good agreement with Mie computations at all X-ray energies.
2. Scattering phase function is an important quantity and is required as input for solving the multiple scattering problems. But, in practice, the exact analytic form of the phase function is rarely known. Thus, the problems are solved either numerically or by employing approximate phase functions. This has led to the development of a number of approximate phase functions in diverse contexts in which multiple scattering problems are of interest. We performed a critical study of these phase functions in the form of a review and have published the study in the journal "Light Scattering Reviews."

Future Plan

1. Work on the development of formulas for the scattering of X-rays by a single interstellar dust particles will continue. In addition, we also intend to extend the study to a collection of particles with the aim of reproducing halo formation around a X-ray emitting star. The approximation methods will be studied and evaluated from the point of view of deciphering dust properties from the halo intensity.
2. As mentioned above we have developed a modified Rayleigh-Gans-Debye formula for the analysis of angular scattering of a particle whose refractive index is close to that of the surrounding medium. The situation regarding refractive index iis similar in the case of scattering of light by a soft biomedical tissue. The modified formula should therfore be applicable to scattering by such tissues too. We intend to examine this possibility as well.

Publication in Journal

1. **S. K. Sharma**, *A modified Rayleigh-Gans-Debye formula for small angle X-ray scattering by interstellar dust grains*, Astrophys Space Sci., **357**, 80 (2015).

Book Published

1. **S. K. Sharma**, In book: Light Scattering Reviews Vol. 9, Chapter: A review of approximate analytic light scattering phase functions, Publisher: Springer-Praxis, Editors: A Kokhanovsky, pp.53-100.

Lectures Delivered

1. A modified Rayleigh-Gans-Debye approximation for the small angle X-ray scattering by interstellar dust particles, Tezpur University, Tezpur, December, 2014
2. A discussion on some light scattering methods for biomedical tissue characterization, IISER, Kolkata, August, 2014

Academic Visit

1. Collaboration with Dr. Ranjan Gupta, IUCAA, Pune, November-December, 2014

Course Taught

1. PHY 203, Electromagnetic Theory, 2nd semester.

Membership of Committees

External Committee: Member, committee constituted by VIT, Vellore for selection of Best colleges in Engineering, Science, Arts and Commerce disciplines; Member, committee for evaluation of progress of SRFs at IISER, Kolkata

Internal Committee: Member, committee for evaluation of entries of Hindi Essay Competition

Bhushan Omprakash Awasarmol

Scientist D

Bhushan Omprakash Awasarmol graduated in Bachelor of Engineering in Information Technology and 7 years of Experience in the System Administration and High Performance Computing Cluster Management. Previously he worked in various Government and private organizations like IIT Indore, IITM Pune, IUAC New Delhi, Acer and HCL.

Meetings Organized

1. TUECMS Seminar, 23/06/2015, Fermion
2. TUECMS Seminar, 15/05/2015, Fermion
3. TUECMS Seminar, 07/04/2015, Fermion
4. TUECMS Seminar, 10/03/2015, Fermion

Work Details

1. Development of Unique Cray Monitoring Portal
2. Cray Environment (Temperature) Problem Resolution
3. Technical difficulties of Users
4. Software Installation and upgradation
5. Queuing policy implementation
6. Software program generation for automation of various activities of cray
7. Contribution to TUECMS Seminar
8. Regular tracking of hardware failure
9. Co-ordination with vendors (Cray & Emerson) for regular and emergency activities
10. Other regular maintenance activities, making system up when power failure
11. Cray Usage Report Generations
12. Implementation of various servers required for cray

Library

About Library

Library of the Centre is the hub of learning and research activities. Since inception of the Centre in 1986, library has been playing an important role in providing information and various academic services to its users. The library also provides service to outside students, researchers and professionals working throughout the country and abroad in all possible ways.

Resources

The Library has a good and useful collection of documents. Presently library possesses more than 14115 books and 8000 bound volume journals. The Library subscribes many useful journals published by reputed publishers mostly in electronic version. In addition, being a member of National Knowledge Resource Consortium (NKRC), library gets access to a wide range of online journals. The library is also equipped with databases like Web of Science, SciFinder Scholar, Mathscinet, ICSD (Inorganic Crystal Structure Database) etc. Library has a Fiction Section with popular books on English, Hindi and Bengali literature. It includes novels, short stories, biographies, dramas, and books on general interests aiming to satisfy all type of readers. Library has a good collection of audio-visual materials. In the magazine and newspaper reading section, 17 popular magazines and 13 daily newspapers in different languages are subscribed regularly. The library is enriched with a valuable archive of S N Bose. This archive includes some personal belongings of S N Bose and some of his personal book collections.

Library Hours

The Library is open from morning 9.00 AM to Night 12.00 at night. During examination Library is open for whole night. Saturday 9.00 AM to 8.00 PM. However, circulation counter is open from 9:00 AM to 5:30 PM. Library is closed on Sundays and national holidays.

Library Users

On an average 50 users visit the library per day. Online journals and databases are accessible within the campus through campus LAN and outside the campus through VPAN. Therefore users may use those online resources from their convenient places.

Services

1 **Reading Facility:** Library provides reading facility to its members as well as outside visitors. All the books including reference collections are classified and are open-accessed.

2 **Document Lending Service:** Each member is entitled to issue 6 books and 2 bound volumes of journals at a time.

3 **Reference Service:** Reference service is provided via e-mail, telephone or personal interaction with the help of different reference tools like encyclopedias, directories, dictionaries, yearbooks, web of science, annual report etc.

4 **OPAC:** Library offers Online Public Access Catalogue (OPAC) which allows user to browse library collection by author, title, subject, classification number, etc. through web OPAC.

5 **E-resources and Internet Facility:** Library is well equipped with sufficient number of computers with internet connectivity through cable LAN and wireless networking facility for laptop users. Library is having access to plenty of electronic journals, databases, archives and consortium resources. Users are having full access to the subscribed e-resources.

6 **Reprographic Services:** Library has printer cum copier, good colour printer, photocopy machine and poster printer for providing extensive reprographic service.

7 **Audio-visual Room:** Library has a separate Audio-visual Room for showing multimedia presentations, video lectures, documentaries etc. The room is equipped with projector, screen, white board and sitting arrangements. The room is used as a discussion room for teachers and students.

8 **Bibliometric Services:** Library helps to prepare various bibliometric reports specially usage statistics, citation analysis, h-index, Impact factor of Journals etc. as per users' requirements.

9 **Library Resource Sharing Activities:** The library shares its resources with all important academic/research institutions in India. As a member of National Knowledge Resource Consortium (NKRC), the library keeps close contacts with libraries under DST and CSIR. SNB library has institutional membership in the British Council Library (BCL), Kolkata.

10 **Library is for Leisure:** Library has a separate section for Bengali, Hindi, and English literature, fiction, classic literature, novel, history, and books on general interest.

11 **Map Section:** Library created a map section containing 5 large wall fixed maps. i.e. map of World, India, West Bengal, North 24 Parganas and Salt Lake City.

12 **Documentation Service:** Library has been compiling the Annual Report, Annual Research Profile, Diary, and Calendar of the Centre and coordinating the process of printing. Printing and designing of different documents of the Centre like poster, conference brochure etc.

13 **New arrival Section:** Library has this section where newly processed books are displayed for the user in every month. Same list is uploaded in the website on the first week of every month.

14 **Research publication status and citation received:** Every month Library has been preparing pictorial research publication status of the Centre and citation received by those publications. It is uploaded in the website on regular basis.

15 **Institutional Repository:** Library has an institutional digital repository with search engine facility. It is enriched with pre-published version of the published research papers of the S.N. Bose Centre. Library has also developed the S.N. Bose Archive containing photographs and scanned documents related to S. N. Bose. The archive is linked to the Centre's website. Library has repository of Ph.D. thesis of the Centre.

Resources and Services Added in the F.Y. 2014-15

1 Approximately 430 new books and some new journals have been added in the library collection during the last financial year.

2 Library has developed an institutional digital repository with multiple way search facility. It is enriched with pre-published version of the published research papers of the S.N. Bose Centre. In this financial year retrospective papers for he years 2013 and 2007 have been uploaded in the repository.

3. In the Financial Year 2014-15, the special Fiction Section has been enriched by procuring 258 books of classic literature, novel, short story, biography and books of general interests.

4. Library discussion room has been upgraded with presentation facilities and internet. It can be booked online for any seminar/talk with 25 sitting capacity.

5. To reduce the dependency of paid proprietary Library Management Software Libsys, Library has customized open source software KOHA. KOHA has been upgraded with all bibliographical records. And it is ready to work in parallel with Libsys software.

Saumen Adhikari
Librarian–cum–Information Officer

Engineering Section

1. Report on Engineering Section (Infrastructure Development, Maintenance & Housekeeping and Support Services):

A. Civil

(a) Construction of Integrated Hostel Building and Transit Quarters Complex (IHB&TQC) G+3 Phase-I:

The construction activities were started on 16th February, 2015. This is a deposit work awarded to M/s. Bridge and Roof Co. (India) Ltd. after observing GFR Rule. M/s. Ghosh, Bose & Associates was selected through competition as Consultant Architect of this Project. M/s. Bridge and Roof Co. (India) Ltd. was selected as Project Management Consultant (PMC) of this project Within this period approximately more than 100 no.s Bored cast-in-situ piles of diameter 600 mm. and 400 mm. have been driven.

(b) Renovation of Corridors, Face Lifting to Rear Portion and Painting to few Rooms of A and B Wings of Bhagirathi Guest House:

Corridors of Wing A and Wing B along with few rooms at both the wings of Bhagirathi Guest House were renovated. Backside of same wings were painted, keeping parity with newly renovated Central Portion of the Guest House.

(c) Construction of Peripheral Pathway along the Boundary Wall:

A peripheral pathway, of average width 1200 mm. made up of cement concrete paver block and supported by kerb stone at both sides where possible, was constructed along the boundary wall of the campus to facilitate security monitoring and morning walking of campus residents.

(d) Repairing and Renovation of Bhagirathi Guest House (Central Portion):

Within this period a room with attached toilet, specially made for differently abled persons was completed. A special type of roof treatment for this Bhagirathi Guest House comprising of Atactic Polypropylene Polymer Sheet followed by a layer of heat resistance roof tiles were laid.

(e) Construction of Sub-Station Building for S. N. Bose National Centre for Basic Sciences:

In view of meeting the power demand to cater for the upcoming laboratories, hostel buildings and new facilities, a new electrical substation has been constructed for installation of 11 kV HV switch gears, transformers and MV distribution panel.

To make those instruments in-house position carefully this building was designed and constructed by providing cable channels inside of the rooms and also constructed ramps for dragging the equipments inside of the room. Moreover, to make it waterproof of the roof a special treatment has been adopted so that machines inside of the room to be safe from water leaking from rooftop.

(f) Creation of Special Room for installation of Supercomputing Facility:

This is a special type of work. To keep the heavily loaded supercomputing equipments a false floor has been constructed methodically so that there should not be any concentrated load in the mother floor. Specially made thermal insulated fire resistant board for false ceiling has been provided. Further, wall has been improvised by thermal insulator for resisting moisture.

(g) Furnishing Offices, Hostels, Staff Quarters and Laboratories:

According to the demand of different faculties and other officials, different types of cubicles in modular shape are constructed for their office spaces.

(h) Construction of 2 Nos. Laboratory Buildings at SNBNCBS:

To increase the laboratory spaces for providing the facility for research work to the scientists, two bigger size laboratories at two different places are being constructed. For laboratory-1 which is near to Pump House and laboratory-2 near to clean Room Building and VSM laboratory attached to main building are being constructed. Foundations of those laboratory buildings have been completed.

(i) Apart from above mentioned construction works, the Engineering Section has to perform annual maintenance for Cleaning Service of Main Buildings, Cleaning Service of Hostel Buildings, Horticulture & Landscaping, Sanitary and Plumbing works and maintenance of several lifts at Krishnachura Hostel and Main Building,

B. Electrical Work:

(a) Procurement and Erection, testing and commissioning of 11KV/433V new Electrical Sub-Station.:

With the infrastructure development, the energy demands for Centre are also growing higher. To meet up the demand, a new electrical substation was proposed with 2 Nos 630 KVA ONAN type transformer and its corresponding HT & LT distribution panels. After tendering (technical scrutiny & evaluation of price bid), the order is already placed and the entire substation building will start working from the next financial year.

(b) Supply, Installation and Commissioning of 50 watt LED based (AC) solar street lighting system (Retrofit) on the existing street light pole of S N Bose National centre for Basic Sciences:

With the increasing demand, the energy saving and use of renewable energy is also a great aspect in today's scenario. To meet up this, an initiative has been taken up and 150 W conventional HPSV lamps are replaced by 50 Watt LED based solar lamp.

(c) Supply, Installation and Testing Commissioning of Variable Refrigerant Flow type AC system at Library area of SNBNCBS:

To achieve Maximum efficiency & accustom with newer refrigeration technology, Variable Refrigerant Flow type AC system (VRF) is introduced at the library of the Centre.

(d) Electrical power supply work at Computer Centre of SNBNCBS for CRAY supercomputing facility:

The entire electrical power supply work for the CRAY Super computing facility has been done satisfactorily.

(e) Renovation of electrical arrangement of Bhagirathi Guest House:

The new electrical arrangements has been done at Bhagirathi Guest House for more smooth operation of electrical system

(f) Additional electrical power supply arrangements for Computer Centre Server rooms:

To generate the trouble free electrical system with increasing number of high computing cluster and server system, the entire electrical power supply has been enhanced after taking care of all safety norms.

(g) Electrical installation work for new Helium Plant Building:

Electrical power supply work including cabling, panel and complete electrical installation work has been done for Centre's new Helium Plant Building

(h) New Electrical arrangements for 2nd floor Laboratories at Main Building, SNBNCBS:

To increase the laboratory spaces for providing the facility for research work to the scientists, the entire electrical arrangements for 5 Nos laboratories at 2nd floor of the Main Building, SNBNCBS has been completed satisfactorily.

(i) Automatic fire alarm system work at Library & few Ground floor Laboratories:

Automatic Fire alarm system (AFAS) work for the library & few Ground floor laboratories have been done for safety of the concerned users.

(j) Annual Maintenance, Preventive Maintenance and daily requirement of electrical support for every corner of SNBNCBS:

The electrical safety takes the maximum priority. To achieve this, electrical maintenance along with periodic preventive maintenance has been carried out throughout the year.

Any fault detected, was also rectified with priority. New small installation and any electrical requirements are also taken care by the concerned staff round the clock at the entire campus of SNBNCBS

Jnanada Ranjan Bhattacharya
Superintending Engineer

Computer Services Cell

Sanjoy Choudhury

Scientist – c

The nature of work has two distinct regions:

1. **Administrative nature**: Handling Central Computational facilities under Computer Services Cell as Scientist I/C of the Cell.
2. **Academic nature**: Research Activities individual and along with Collaborative research work under Dr. Soumen Mandal.

Academic Work-General research areas and problems worked on:

i) Fastest way to compute Massive Astronomical Data Processing and Analysis using data pipeline through Multiscale parallel Hybrid Programming and

ii) A hybrid-computing environment (data parallel with concurrent parallelization) for Burrows Wheeler alignment for massive amount of short read sequence data of Human Genome.

Publications: Gupta S, **Choudhury S** and Panda B: MUSIC: A hybrid-computing environment for Burrows-Wheeler alignment for massive amount of short read sequence data.MECBME (**2014**). doi: 10.1109/MECBME.2014.6783237, IEEE.

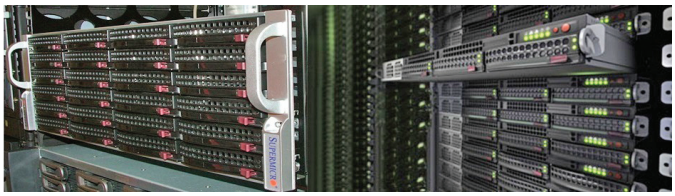
Teaching Activities: PHY 501 Research Methodology

The Computer Services Cell (CSC) enables to extend all computational facilities and computer related services of the centre. The **Computer Services Cell Advisory Committee (CSC-AC)** governs the cell and the **Computer Services Cell Working Group Committee (CSC-WG)** carries out required services. CSC In-charge (Mr. Sanjoy Choudhury), Jr. Computer Engineers (Mr. Abhijit Ghosh, Mr. Abhijit Roy, and Mr. Sagar S. De) and Jr. Assistant (Mr. Bijay Pramanik) had supported all kind of day-to-day activities associated to the cell.

At the end of the academic year 2014-15, there were more than 500 users including faculty members, administrative staffs, PDRAs, and students. The Centre is backboned with a fiber optic based internal network capable to support up to 1Gbps. Internet facility had been pulled up to support up to 1Gbps access supported by NKN and an 8Mbps line by Tata Communication Pvt. Ltd. as a backup. Web, Intranet server configuration had been extended. Wi-Fi support had been extended for better coverage. Desktops, Printers, UPSes, Xerox machines and other Network devices had been maintained regularly. Activities such as updation of website, tenders, jobs, web-based General Notice Board (where the Centre's general, official, academic, seminar and placement related notices are posted regularly) are followed regularly. CSC facilited Centre by developing new web applications, taking care of email facility, online admission. CSC also looks after other centre computational facilities including Serial Computing Clusters and Parallel Computing Clusters built by Super Micro. Project Clusters are also maintained by the cell. New super computer (CRAY) has been installed as a part of TUE-CMS project. As a part of the Centre's vision towards Academic/Scientific society, CSC allows external users (Academic/Research) to use center's computational facilities.

Summary of central computational facilities

Machine Name	Processor Core	Storage	User
Photon	84	NA	55
Phonon	84	NA	27
HPC	344	2.2 TB	72
UNANST (partial)	96	12 TB	--
AMRU1	360	6 TB	31
AMRU2	48	NA	27



CSC-AC Members: Prof. Tanusri Saha Dasgupta, Prof. Priya Mahadevan, Prof. Amitabha Lahiri, Prof. Ranjit Biswas, Dr. Soumen Mondal, Ms. Shohini Majumder, Mr. A. K. Sarkar, , Dr. Punyabrata Pradhan, Mr. Sanjoy Choudhury.

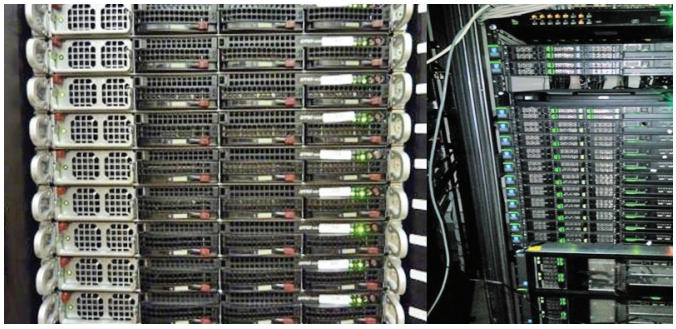
CSC-WG Members: Prof. Tanusri Saha Dasgupta, Prof. Amitabha Lahiri, Dr. Manoranjan Kumar, Mr. S. K. Singh, Mr. Soumen Adhikari, Mr. Sanjoy Choudhury, Mr. Abhijit Ghosh, Mr. Abhijit Roy, Mr. Sagar S. De.

Major achievements (2014-15)

- Upgrade primary internet lease line provided by National Knowledge Network from 100 Mbps to 1 Gbps for better access of internet around the clock.
- In the process of reducing dependencies from ISPs and to increase network reliability, CSC step forward towards Multi-homing. Therefore CSC has acquired a pool of 256 public IP addresses along with Autonomous System Number (ASN) from Indian Registry for Internet Name and Numbers (IRINN).
- Centre Website had been enabled for bilingual (English and Hindi) facility.
- For day-to-day use, new web applications had been developed and deployed - to work within intranet.
- New Faculty Search Committee blog had been developed as per the recommendations of Faculty Search Committee.
- Ticketing system for the Engineering and Estate Office Complaints had been introduced.
- Hall Booking application had been developed for reliable and sophisticated use with new feature.
- As a part of the centre's focus towards improvement of Academic/Scientific society, CSC made policy to allow external users (limited to Academic & Research) to use 10% of Centre's High Performance Computational Facility.

Summary of project sponsored computational facilities

Machine Name	Processor Core	Storage	User
ATHENA	320	NA	12
UNANST (partial)	480	12 TB	25
CRAY	7808	255	50



- Backup systems had been configured for any unusual accidental breakdown.
- Network racks had been rearranged for better arrangement and maintenance concern.
- CSC configured Linux based new personal firewall, gateway for the centre.
- VPN service had been revised and reconfigured in the dedicated gateway firewall supporting LAN as well as Journal access.
- Web applications such as Radhachura booking, Guesthouse Billing, Visitor pass, Asset Manager, Online Confreg had been developed and deployed in the intranet server.
- Admission application has been modified to fulfil 2015 admission criteria.
- BCRC blog has been created.
- Guesthouse Wi-Fi has been re-established after building repair. Entire guest house is now covered by enterprise class Wi-Fi equipment to provide internet facilities.
- Old CO_2 and Dry Powder based fire extinguishers had been replaced with safer clean agent based fire extinguishers in the cell.
- Comprehensive fire safety solution had been proposed for the entire computer centre which is in the due process of being implemented.

Sanjoy Choudhury
In-charge, Computer Services Cell

Project Cell

The project cell facility provides a smooth and streamlined procedure for regular housekeeping for the incumbent projects, channels itself to any new project grant application and finally is a storehouse for the past projects. The website, http://bose.res.in/~prjcell, for the project cell now has the relevant forms for use of the concerned people. Via the then director's order, the cell also now includes more members from different departments. The full composition can be found in the website.

The following table summarises the details of externally funded projects that were running for the last five years, ending with the concerned financial year.

Year	No. of Projects	Amount Received (Rs.)
2010-2011	40	4,83,19,968=00
2011-2012	41	7,13,74,645=00
2012-2013	36	5,94,78,715=00
2013-2014	31	10,10,54,463=00
2014-2015	32	4,72,26,394=00

The details of ongoing projects in 2014-2015 is listed below –

Project Title	PI / Co – PI	Funding Agency
"J.C. Bose Fellowship"	Prof. A.K. Raychaudhuri	DST SR/S2/JCB-17/2006
DST/KD/09-10/28 - "Investigation of the intrinsic conductivity of undoped single Si nanorod/nanowire grown by vapor transport and chemical method"	Dr. Kaustuv Das	DST (SERB SR/FTP/PS-60/2009
SRC/TSD/09-10/38 - "Magnetism in organic materials"	Dr. Tanusri Saha Dasgupta	Swedish Research Council (SRC)
DST/AKR/09-10/40 - "Unit on Nanoscience at SNBNCBS, Kolkata (UNANST – II)	Prof. A.K. Raychaudhuri	DST SR/NM/NS-53/2010
DST/PM/10-11/41 – "Electronic and structural properties of semiconductors at the nanoscale"	Dr. Priya Mahadevan	DST (Nano Mission) SR/NM/NS-91/2010(G)
DST/KA/10-11/43 – "The study of photo-desorption and photo -ionization of Complex Molecules in Star Forming Regions"	Dr. Kinsuk Acharyya	DST (SERC Fast Track) SR/FTP/PS-075/2010(G)
DST/BBB/11-12/61 – "Geoelectrical Methods: Theory and Application"	Prof. Bimalendu B. Bhattacharya	DST (SERB) HR/UR/09/2011dated 13-2-2012
DST(FT)/MG/11-12/62 – "Structural and functional characterization of small heat shock proteins from *Bradyrhizobium japonicum*"	Dr. Mahua Ghosh	SR/FT/LS-94/2011 dated 29-5-2012 (SERB)
DST/AKR/11-12/63 – "Thematic Unit for Excellence on Nanodevice Technology"	Prof. A.K. Raychaudhuri / Dr. Anjan Barman (Coordinator)	DST SR/NM/NS-09/2011

Project Title	PI / Co – PI	Funding Agency
CSIR/RKM/11-12/67 – "Water encapsulated in mixed reverse micelles: modulation of its structure, dynamics and activity"	Dr. Rajib Kumar Mitra	CSIR 01(2573)/132/EMR-II
"Thematic Unit of Excellence on Computational Materials Science at the SNBNCBS, Kolkata"	Prof. Tanusri Saha Dasgupta	DST SR/NM/NS-29/2011
DST/SKP/11-12/78 – "Spectroscopic Studies on Light Harvesting Hybrid Materials and Potential Application in Dye-sensitized Solar Cells"	Dr. Samir Kumar Pal	DST DST/TM/SERI/2k11/ 103
DBT(RGYI)/MP/11-12/80 – "Cavity Ring-down Spectroscopy for Real Time Breath Analysis: A Next Generation Diagnostics in Modern Medicine"	Dr. Manik Pradhan	DBT (RGYI) BT/PR6683/GBD/27/477/2012
DST/PM/11-12/82 – "Modeling multiferroic materials"	Dr. Priya Mahadevan	DST-DAAD (Indo-German) INT/FRG/DAAD/P-224/2012
MES/MP/11-12/85 – "Development of a mid-IR Cavity Ring-Down Spectrometer for High-Precision Real-Time Continuous Monitoring of Multiple Trace Gases and Stable Isotopic Species in the Atmosphere"	Dr. Manik Pradhan	MoES/16/26/12-RDEAS
DST/JC/12-13/91– "Microscopic calculations of metal ion binding to proteins"	Dr. Jaydeb Chakrabarti	DST (SERB) SR/S2/CMP-100/2012
DBT/AM/12-13/92 – "Development of nanomaterial based dual mode contrast agent and their surface mediated conjugation study from first principles"	Prof. Abhijit Mookerjee, Dr. Ranjit Biswas (From SNBNCBS)	Biotech Consortium India Ltd. (DBT) BCIL/NER-BPMC/2013-367
DST-NWO/TSD/12-13/98 – "Graphene Spintronics with Complex Oxides"	Prof. Tanusri Saha – Dasgupta (From SNBNCBS)	DST (India-Netherland) INT/NL/FM/P-001/2013
DST-UKIERI/AB/12-13/102 – "Nano-Engineered Magnetic Materials for Spintronic Applications"	Dr. Anjan Barman	DST-UKIERI INT/UK/UKIERI/P-44/2013
DST/SKP/12-13/105 –"Study on the role of biomolecular conformation and environmental dynamics in the process of molecular recognition with Time-resolved optical spectroscopy"	Dr. S. K. Pal	DST (SERB) SB/S1/PC-011/2013
DRDO/PKM/12-13/108 – "Development of synthetic body armour based on smart fluids"	Dr. P. K. Mukhopadhyay	(DRDO) PXE/TE/CARS PXE/CARS/01/2013
"Ramanujan Fellowship"	Dr. Manoranjan Kumar	DST SR/S2/RJN-69/2012
BRNS/SKP/13-14/111 – "Science and application of organic ligand-transition metal oxide hybrids as new functional materials"	Dr. S. K. Pal	DAE – BRNS 2013/37P/73/BRNS

Project Title	PI / Co – PI	Funding Agency
DST/ASM/13-14/112 – "Fundamental aspects of Quantum Theory and Quantum Information Science"	Prof. Archan S. Majumdar	SERB SB/S2/LOP-008/2013
DST/MM/13-14/113 – "Preparation of magnetic nanoparticles and proper biofunctionalization for their use in drug delivery and release"	Dr. Madhuri Mandal	DST SR/WOS-A/CS-15/2013 (G)
DAE(BRNS)/TSD/13-14/114 "Development and validation of a Modified Embedded Atom Method (MEAM) Potential for Aluminum Alloys"	Prof. Tanusri Saha - Dasgupta	BRNS(DAE) 37(3)/14/41/2014-BRNS 1466 dated 1-9-14
CSIR/RB/13-14/116 – "Jump Dynamics in Ionic Liquids and non-exponential Relaxation"	Prof. Ranjit Biswas	(CSIR) 01(2811)/14/EMR-II
DAE(BRNS)/PM/13-14/117 – "Functional transition metal oxides"	Dr. Priya Mahadevan	BRNS (DAE) 37(3)/14/22/2014-BRNS/554
DST/RKM/13-14/119 – "Real Time structure and solvation dynamics of proteins during folding/unfolding in crowded environment"	Dr. Rajib Kumar Mitra	DST(SERB) SB/S1/PC-056/2013
DST/TSD/13-14/124 – "Magnetism in low dimensional quantum spin systems"	Dr. Tanusri Saha - Dasgupta	(DST-RFBR) INT/RUS/RFBR/P-166
DST(SERB)/PMahata/14-15/134 – "Uses of metal-organic network compounds as precursors for the formation of nano-sized ceramic oxides: Spinel and perovskite"	Dr. Partha Mahata	SERB SB/FT/CS-114/2012
SERB (DST)/AD/14-15/154 "Microwave dielectric properties and collective vibrational modes of double perovskite oxides"	Dr. Alo Dutta	SERB (DST) SB/FTP/PS-175/2013

In addition to the generation of financial assets, the projects attracted a lot of human resources. There were 14 project students in this particular year, 20 PDF/RAs and 5 DST Inspire Faculties.

Pratip Kumar Mukhopadhyay
Convenor, Project Cell

Technical Cell

Technical Cell maintains all the central experimental facilities of our Centre. There are 22 no. equipments maintained by Technical Cell which are being used by our staffs and students at free of cost and are made available to the external users on payment basis.

Main job done under the Cell: Facility running, utilization through a transparent slot booking system (users: internal and external), maintenance, up-gradation, procurement and installation of equipments.

Major 14 no. equipments, chillers and UPS are maintained by AMC on non comprehensive basis.

The list of the major equipments falling under technical cell are given below:

- X-ray Diffractometer (XRD)
- Mini X-ray Diffractometer (Mini XRD)
- Environmental Scanning Electron Microscope (ESEM)
- Field Emission Scanning Electron Microscopy (FESEM)
- Energy Dispersive X-Ray Analysis (EDAX)
- High Resolution Transmission Electron Microscope (HRTEM)
- Atomic Force Microscopy (AFM)
- Vibrating Sample Magnetometer (VSM)
- Thermo Gravimetry/Differential Thermal Analyzer (TG/DTA)
- Dynamic Light Scattering (DLS)
- Spectroscopic Ellipsometer
- Pulsed Laser Deposition (PLD) Unit
- DSC / Modulated DSC

The details about the facility is available in the website
http://newweb.bose.res.in/facilities/TechnicalCell/

List of internal users in different major equipments:

Name of the instruments	Number of internal users
AFM	35
XRD (Mini)	42
XRD (X'pert Pro)	50
TG/DTA	20
DSC	16
HRTEM	52
FESEM	53
VSM	42

List of External Users:

1. Jadavpur University	11. M S University**	21. Delhi, IIT**
2. Burdwan University	12. IFTM University**	22. IISER Kolkata
3. Presidency University	13. Indian Statistical Institute	23. NIT, Durgapur
4. Kalyani University	14. Bose Institute	24. CIT, Assam**
5. Calcutta University (Sci. College)	15. Saha Institute of Nuclear Physics	25. Shree Devi Institute of Technology**
6. CU (Ballygunge Science College)	16. IACS, Kolkata	26. DIT**
7. Hyderabad University**	17. CMERI, Durgapur	27. Ashutosh College
8. Tezpur University**	18. VIT**	28. Sammilani College
9. Tribhuvan University/Nepal**	19. BESU, Shibpur	29. Reliance Industries Ltd.**
10. Vignan University**	20. WBUT	30. Botanical Survey of India

**** Outside state- 12 institutions/organization**

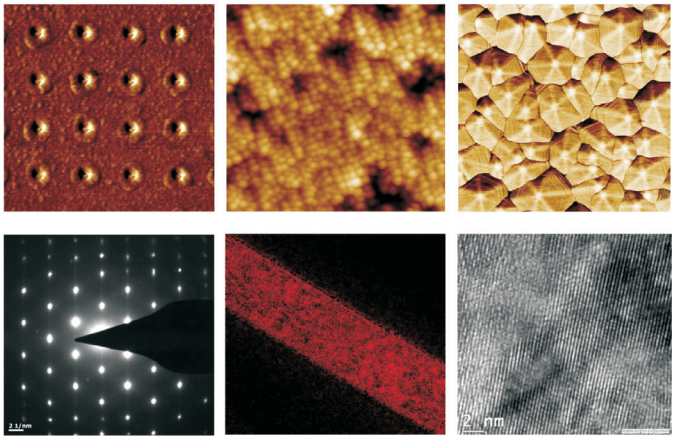
Total Equipment utilization time:

A brief monthly report stating up-time of facilities, status of any facility not working, hours utilized and users who utilized, which is being uploaded in the Centre's intranet every month.

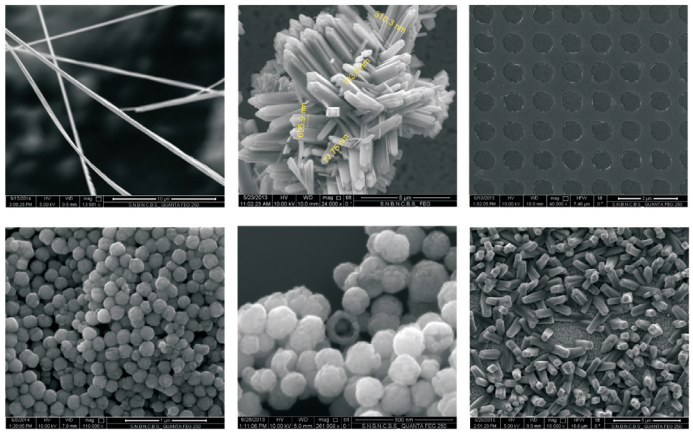
Item	Usage time (hr)	Up time (%)	Down time (%)
XRD & mini XRD	880	80%	20%
FESEM	480	90%	10%
VSM	1400	97%	3%
AFM	1374	95%	5%
PLD	899	95%	5%
TEM	860	80%	20%
TG/DTA	627	90%	10%

Note: Other equipments, not included in the table: users are less, but uptime is 95%.

Few images of Microscopic study of different samples done by different Faculty members:



Courtesy: *Prof. Anjan Barman, Prof. A.K. Raychaudhuri, Dr. Barnali Ghosh (Saha)*



Courtesy: Prof. Anjan Barman, Prof. A.K. Raychaudhuri, Prof. Kalyan Mandal, Dr. Barnali Ghosh (Saha)

Barnali Ghosh (Saha)

Barnali Ghosh (Saha)
Scientist in-charge, Technical Cell

Mechanical Workshop

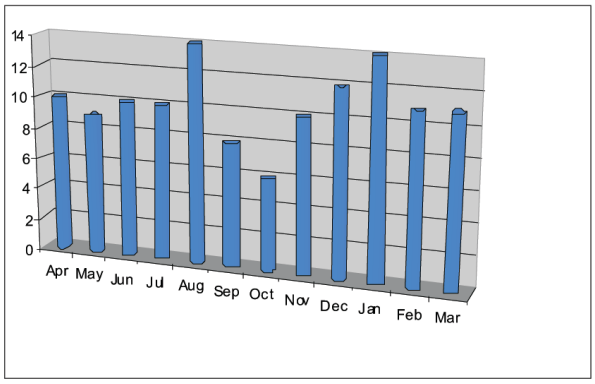
The glass blowing as well as the mechanical workshop sections were operational in this year and gave service to users from inside the centre and a few out of it. The glass blowing facility is used to construct various glass and quartz contraptions, and a major demand is for vacuum or argon flushed quartz ampouling for various atmosphere sensitive samples.

There were 27 outside works done for outside users, generating some revenue also in the process. The number of jobs from the centre is 69.

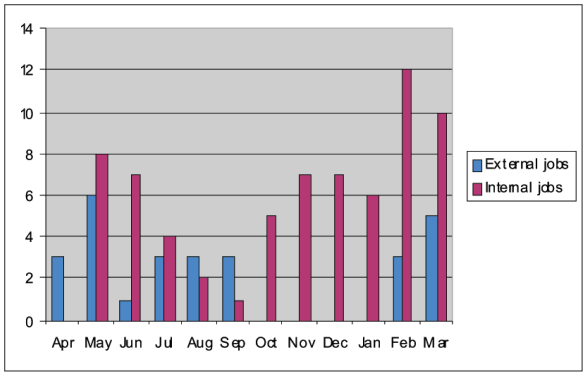
For the mechanical workshop, it has a small lathe machine, a milling machine, a drilling machine etc. for simple jobs. There were quite a few users from the labs and other departments. It finished 125 jobs in all.

The mechanical workshop remains open on all working days. The glass blowing section normally works on Tuesdays, but can be operated on other days if the need arises.

Pratip Kumar Mukhopadhyay
In-charge, Mechanical Workshop



Graph for work done by the mechanical workshop



Graph for work done by the glass blowing section

Guest House

Bhagirathi – The Guest House

The Centre has its own modern guest house named 'Bhagirathi' located within the premises. In the guest house there are five (5) fully air conditioned suites and three (3) fully air conditioned transit rooms each having attached bath and kitchenette. There are also eight (8) double-bedded rooms and forty six (46) single bedded rooms. All the double and single bedded rooms are also air-conditioned and are fully furnished and have attached baths. All rooms are provided with basic amenities like hot water, telephone, television with DTH connections, electric kettle etc. The Guest House is Wi-Fi enabled. The third floor of the guest house comprising twenty two (22) single bedded rooms and four (4) double bedded rooms are being presently used for accommodating students. There is a seminar room within the guest house building for hosting seminars, conferences, meetings etc. The doctor's chamber is also located at the guest house building. The Centre's modern cafeteria with a kitchen is also housed in the guest house building. Apart from serving regular meals to the staff members of the Centre and to the visitors, the cafeteria also serves as a venue for hosting lunches and high-tea on special occasions like seminars, conferences etc. of the Centre. The Central portion of the guest house has recently been renovated and entrance and lobby has got a new look. The guest house not only accommodates guests and visitors of the Centre, the Centre also extend the guest house facility to various government departments and organizations, research laboratories, universities etc.

Shohini Majumder

Shohini Majumder
Registrar

Crèche

'Kishlay' is a home away from home for the children of staff and students of S. N. Bose National Centre for Basic Sciences.

The purpose of 'Kishlay' is to meet, to the best of ability, the child's basic needs (social, intellectual, physical and emotional) with love, integrity, hard work and self-discipline. 'Kishlay' provides a nurtured environment where the child can build a foundation for continued learning. 'Kishlay' also provides a family – friendly workplace for its employees. At present, there are 3 children in 'Kishlay'.

Majumder

Shohini Majumder
Registrar

Recreational and Cultural Programmes

Throughout the year, the Centre organized number of cultural events involving participation of all staff and students of the Centre.

- On the occasions of the 66th Republic Day on 26th January 2015 and 68th Independence Day on 15th August 2014, the Director hoisted the national flag in the premises of the Centre. On both the occasions, national anthem was sung by students and staff present and parade was performed by the Centre's security personnel. Small replicas of national flags were distributed amongst the members present in the gathering and tea and snacks were served.
- The Visual Arts Group of 'Muktangan' celebrated the 90th Birthday of Satyajit Ray on 2nd May 2014 by screening three of his films (Kolkata trilogy) – Pratidwandi (1970), Seemabaddha (1971) and Jana Aranya (1976) at FERMION.
- The Sports Activity Group of 'Muktanagan' arranged an Intra-Institute Singles Table Tennis Tournament (open to all students, staff and faculties of the Centre) on 9th May 2014 and 10th May 2014. The winners i.e. 1st, 2nd and 3rd position holders were presented with trophies and all the participants were given consolation prizes.
- The Performing Arts Group of 'Muktanagan' presented a cultural programme titled " Ponchishey Boishakh"at Silver Jubilee Hall of the Centre on 9th May 2014 to observe the birthday of Kabiguru Rabindranath Tagore.

Like previous years, the Centre organised number of programmes in September 2014 to celebrate the Hindi Mahina. As a part of the programme, the following programme was undertaken:

- Signing of Attendance Register in Hindi.
- Everyday one new Hindi word with its English meaning displayed in the Reception area.
- Showing of Hindi Feature Film 'Khoobsurat' for the students of the Centre.
- In house Hindi Cultural Programme was staged by 'Muktangan'.
- Hindi Comedy play "Indra ka Gada" performed by 'Padatik' group.
- A quiz session for all in Hindi
- A Hindi Essay competition on Scientific matter was organised during the Hindi Mahina.
- The Centre organised Cleanliness Oath/Pledge [Swachh Shapath] on 2nd October 2014 at the Centre's premises as part of the Swachh Bharat Mission campaign introduced by Government of India. All the staff and students of the Centre were present on the said date to take the Cleanliness Oath.
- The Sports Activity Group of 'Muktangan' organised an

Intra-Institute Cricket Tournament on 4th November 2014 at the Centre. The winners were awarded with suitable prizes.

- The Visual Arts Group of 'Muktangan' arranged the presentation of a documentary film named "Story of Birds" from the photographic collection of Prof. Prosenjit Singha Deo on 18th December 2014 at FERMION.
- The Centre celebrated Satyendra Nath Bose's 121st birthday on 1st January 2015. The bust of Satyendra Nath Bose was garlanded by the Director and other senior faculties and high tea was arranged on the occasion.
- The Sports Activity Group of 'Muktangan' organised an Inter - Department Badminton Tournament (Singles, Doubles and Mixed Doubles) on 10th February 2015 and 11th February 2015 within the Centre's premises. The winners i.e. 1st, 2nd and 3rd position holders were presented with trophies and all the participants were given consolation prizes.
- On the occasion of 'BOSE FEST 2015' held during 2nd March 2015 – 4th March 2015, Family Day was celebrated on the evening of 3rd March 2015. On 3rd March 2015, the Performing Arts Group of 'Muktangan' organised an in-house programme comprising of individual and group performances of singing, recitation, Hindi Drama – on social issues, Nrityalekha – Dance Programme named 'Achhut'. The 'SciPiX' (Volume III, Issue I) an in-house magazine organised by the students, was also inaugurated under the aegis of 'Muktangan'. The programmes were attended by friends and family members of staff and students and were a huge success. "Photo Fest" – the photography exhibition cum competition among the staff and students participants of the Centre organised by the Visual arts Group of 'Muktanagan' also took place during this period. The In-house Bose Fest programme was followed by a gala dinner attended by friends and family members of the staff and students of the Centre. Just prior to the Bose Fest 2015, 'Muktangan' got it's official 'LOGO' selected through an in house logo competition.
- The Sports Activity Group of 'Muktangan' organised an Intra - Institute Table Tennis Tournament (Singles and Doubles) on 25th March 2015 and 26th March 2015 within the Centre's premises. The winners i.e. 1st, 2nd and 3rd position holders were presented with trophies and all the participants were given consolation prizes.

Majumder

Shohini Majumder
Registrar


Publications

Publications

Journal Publications

Department of Astrophysics & Cosmology

1. T. Pramanik, M. Kaplan and **A. S. Majumdar**, *Fine-grained Einstein-Podolsky-Rosen-steering inequalitites*, Phys. Rev. A, **90**, 050305 (R) (2014).
2. S. Adhikari, D. Home, **A. S. Majumdar**, A. K. Pan, A. Shenoy, R. Srikanth, *Toward secure communication using intra-particle entanglement*, Quant. Inf. Process., **14**, 1451 (2015).
3. M. Banik, S. Das, **A. S. Majumdar**, *Measurement incompatibility and channel steering*, Phys. Rev. A, **91**, 062124 (2015).
4. B. C. Paul and **A. S. Majumdar**, *Emergent universe with interacting fluids and the generalized second law of thermodynamics*, Class. Quant. Grav., **32**, 115001 (2015).
5. D. Saha, S. Mal, P. K. Panigrahi, D. Home, *Wigner's form of the Leggett-Garg inequality, the no-signaling-in-time condition, and unsharp measurements*, Phys. Rev. A, **91**, 032117 (2015).
6. **R. K. Das**, D. P. K. Banerjee, A. Nandi, N M Ashok, **S. Mondal**, *Near-infrared studies of V5558 Sgr: an unusually slow nova with multiple outbursts*, MNRAS, **447**, 806 (2015).
7. **R. K. Das** and A. Mondal, *Abundance analysis of the recurrent nova RS Ophiuchi (2006 outburst)*, New Astronomy, **39**, 19 (2015).
8. S. Palit, T. Basak, S. Pal, & **S. K. Chakrabarti**, *Theoretical study of lower ionospheric response to solar flares: sluggishness of D-region and peak time delay*, Astrophysics and Space Science, **356**, 19 (2015).
9. A. Das, L. Majumdar, **S. K. Chakrabarti**, and D. Sahu, *Deuterium enrichment of the interstellar medium*, New Astronomy, **35**, 53 (2015).
10. D. Debnath, S. Mondal and **S. K. Chakrabarti**, *Characterization of GX 339-4 outburst of 2010-11: analysis by XSPEC using two component advective flow model*, Mon. Not. R. Astron. Soc., **447**, 1984 (2015).
11. S. Pal, S. Chakraborty and **S. K. Chakrabarti**, *On the use of Very Low Frequency transmitter data for remote sensing of atmospheric gravity and planetary waves*, Advances Sp. Research, **55**, 1190 (2015).
12. S. Sasmal, S. Pal, & **S. K. Chakrabarti**, *Study of long path VLF signal propagation characteristics as observed from Indian Antarctic station, Maitri*, Advances Sp. Research, **54**, 1619 (2014).
13. D. Debnath, **S. K. Chakrabarti**, & S. Mondal, *Implementation of two-component advective flow solution in XSPEC*, Mon. Not. R. Astron. Soc., **440**, L121 (2014).
14. S. Mondal, D. Debnath, & **S. K. Chakrabarti**, *Inference on Accretion Flow Dynamics Using TCAF Solution from the Analysis of Spectral Evolution of H 1743-322 during the 2010 Outburst*, The Astrophysical Journal, **786**, 4 (2014).
15. **S. K. Chakrabarti**, D. Bhowmick, S. Chakraborty, S. Palit, S. K. Mondal, A. Bhattachiaryya, S. Middya, & S. Chakrabarti, *Study of properties of cosmic rays and solar X-ray flares by balloon borne experiments*, Ind. J. Phys., **88**, 333 (2014).
16. S. Mondal, D. Debnath, & **S. K. Chakrabarti**, *Spectral signatures of dissipative standing shocks and mass outflow in presence of Comptonization around a black hole*, Astrophys. & Sp. Sc., **353**, 223 (2014).
17. S. Mondal, **S. K. Chakrabarti**, & D. Debnath, *Is Compton Cooling Sufficient to Explain Evolution of Observed Quasi-periodic Oscillations in Outburst Sources?*, Astrophys. J., **798**, 57 (2015).
18. S. Sasmal, **S. K. Chakrabarti**, & S. Ray, *Unusual behavior of Very Low Frequency signal during the earthquake at Honshu/Japan on 11 March, 2011*, Ind. J. Physics, **88**. 1013 (2014).

Department of Chemical, Biological & Macro-Molecular Sciences

19. Surajit Sen, Tushar Kanti Dey, Mihir Ranjan Nath and **Gautam Gangopadhyay**, *Comparison of electromagnetically induced transparency in lambda, cascade and vee three-level systems*, Journal of Modern Optics, **62**, 166–174 (2015).
20. T. K. Dey, A. Gangopadhyay and **G. Gangopadhyay**, *A Noisy Nutrient Induced Instability in Phytoplankton Blooms*, Int. J. Curr. Res. Acad. Rev., **3**, 51-59 (2015).
21. Manas Mondal, Devapriya Choudhury, **Jaydeb Chakrabarti**, Dhananjay Bhattacharyya, *Role of indirect readout mechanism in TATA box binding protein-DNA interaction*, Journal of Computer-Aided Molecular Design **29**(3): 283-295 (2015).
22. **J. Chakrabarti** and Suman Dutta, *Analytical form of forces in hydrophobic collapse*, Chem Phys Lett, **620**, 109-113 (2015).
23. Samapan Sikdar, **J. Chakrabarti** and **Mahua Ghosh**, *A microscopic insight from conformational thermodynamics to functional ligand binding in proteins*, Molecular BioSystems, **10**, 3280-3289 (2014).

24. Atanu Ghosh, T. Pradeep and **Jaydeb Chakrabarti**, *Coalescence of atomically precise clusters on graphenic surfaces*, J. Phys. Chem. C, **118**(25) 13959–13964 (2014).

25. Samapan Sikdar, **Mahua Ghosh**, Molly De Raychaudhury and **J. Chakrabarti**, *Quantum chemical studies on the role of residues in calcium ion binding to Calmodulin*, Chem Phys Lett, **605-606**, 103-107(2014).

26. C. Ghosh, G. Banik, A. Maity, S. Som, A. Chakraborty, C. Selvan, S. Ghosh, S. Chowdhury and **M. Pradhan**, *Oxygen-18 isotope of breath CO_2 linking to erythrocytes carbonic anhydrase activity: a biomarker for pre-diabetes and type 2 diabetes"*, Scientific Reports (Nature Publishing Groups), **5**, 8137 (2015).

27. Suman Som, Abhijit Maity, Gourab Dutta Banik, Chiranjit Ghosh, Sujit Chaudhuri, Sunil Baran Daschakraborty, Shibendu Ghosh and **Manik Pradhan**, *Excretion kinetics of ^{13}C-urea breath test: influences of endogenous CO_2 production and dose recovery on the diagnostic accuracy of Helicobacter pylori infection*, Anal Bioanal Chem., **406**, 5405 (2014).

28. A. Maity, S. Som, C. Ghosh, G. Banik, S. Daschakraborty, S. Ghosh, S. Chaudhuri, and **M. Pradhan**, *Oxygen-18 stable isotope of exhaled breath carbon dioxide as a non-invasive marker of Helicobacter pylori infection*, J. Anal. At. Spectrom., **29**, 2251 (2014).

29. Gourab D. Banik, Abhijit Maity, Suman Som, Chiranjit Ghosh, Sunil B. Daschakraborty, Sujit Chaudhuri, Shibendu Ghosh and **Manik Pradhan**, *Diagnosis of small intestinal bacterial overgrowth in irritable bowel syndrome patients using high-precision stable $^{13}CO_2/^{12}CO_2$ isotope ratios in exhaled breath*, J. Anal. At. Spectrom. **29**, 1918 (2014).

30. N. Samanta, D. Das Mahanta, and **R. K. Mitra**, *Collective Hydration Dynamics of Guanidinium Chloride Solutions and its Possible Role in Protein Denaturation: A Terahertz Spectroscopic Study*, Phys. Chem. Chem. Phys., **16**, 23308-23315 (2014).

31. N. Samanta, D. Das Mahanta, and **R. K. Mitra**, *Does Urea Alter the Collective Hydrogen-Bond Dynamics in Water? A Dielectric Relaxation Study in the Terahertz-Frequency Region*, Chem. Asian J., **9**, 3457-3463 (2014).

32. N. Samanta, D. Das Mahanta, S. Hazra, G. S. Kumar and **R. K. Mitra**, *Short Chain Polyethylene Glycols Unusually Assist Thermal Unfolding of Human Serum Albumin*, Biochimie, **104**, 81-89 (2014).

33. A. Patra, T. Q. Luong, **R. K. Mitra**, and M. Havenith, *The Influence of Charge on the Structure and Dynamics of Water Encapsulated in Reverse Micelles*, Phys. Chem. Chem. Phys., **16**, 12875-12883 (2014).

34. A. Das, and **R. K. Mitra**, *Does the Optimum Hydrophilic Lipophilic Balance Condition Affect the Physical Properties of Mixed Reverse Micelles? A Spectroscopic Investigation*, J. Phys. Chem. B, **118**, 5488-5498 (2014).

35. Sandipa Indra and **Ranjit Biswas**, *Heterogeneity in (2-Butoxyethanol + Water) Mixtures: Hydrophobicity-Induced Aggregation or Criticality Driven Concentration Fluctuations?*, Journal of Chemical Physics, **142**, 204501/1-8 (2015).

36. Satya N. Tripathy, Zaneta Wojnarowska, Justyna Knapik, Hideaki Shirota, **Ranjit Biswas** and Marian Paulch, *Glass Transition Dynamics and Conductivity Scaling in Ionic Deep Eutectic Solvents: The Case of (Acetamide+Lithium Nitrate/Sodium Thiocynate) Melts*, Journal of Chemical Physics, **142**, 184504/1-10 (2015).

37. Anuradha Das, Suman Das, and **Ranjit Biswas**, *Density Relaxation and Particle Motion Characteristics in a non-Ionic Deep Eutectic Solvent (Acetamide + Urea): Time-Resolved Fluorescence Measurements and All-Atom Molecular Dynamics Simulations*, Journal of Chemical Physics, **142**, 034505/1-10 (2015).

38. Suman Das, **Ranjit Biswas**, and Biswaroop Mukherjee, *Reorientational Jump Dynamics and Its Connections to Hydrogen Bond Relaxation in Molten Acetamide: An All-Atom Molecular Dynamics Simulation Study*, Journal of Physical Chemistry B, **119**, 274-283 (2015).

39. Das, **Ranjit Biswas**, Anuradha and Hideaki Shirota, *Low-Frequency Collective Dynamics in Deep Eutectic Solvents of Acetamide and Electrolytes: A Femtosecond Raman-Induced Kerr Effect Spectroscopic Study*, Journal of Chemical Physics, **141**, 134506/1-11 (2014).

40. Harun Al Rasid Gazi, Hemant K Kashyap and **Ranjit Biswas**, *Solvent Sorting in (Mixed Solvent + Electrolyte) Systems: Time-Resolved Fluorescence Measurements and Theory*, Journal of Chemical Sciences, **127**, 61-70 (2015).

41. Tamisra Pal and **Ranjit Biswas**, *Stokes Shift Dynamics in (Non-Dipolar Ionic Liquid + Dipolar Solvent) Binary Mixtures: A Semi-molecular Theory*, Journal of Chemical Physics, **141**, 164502/1-10 (2014).

42. Sandipa Indra and **Ranjit Biswas**, *Hydrogen Bond Dynamics of Water in Presence of an Amphiphile, Tetramethylurea: Signature of Confinement-Induced Effects*, Molecular Simulation, **41**, 471- 482 (2015).

43. Tamisra Pal and **Ranjit Biswas**, *Slow Solvation in Ionic Liquids: Connections to Non-Gaussian Moves and Multi-Point Correlations*, Journal of Chemical Physics, **141**, 104501/1-12 (2014).

44. N. Polley, S. Saha, S. Singh, A. Adhikari, S. Das, B. Roy Choudhury and **S. K. Pal**, *Development and Optimization of a Non-contact Optical Device for Online Monitoring of Jaundice in Human Subjects*, J. Biomed. Optics, **20**, 067001 (2015).

45. S. Chaudhuri, S. Sardar, D. Bagchi, S. Singha, P. Lemmens

and **S. K. Pal**, *Sensitization of an Endogenous Photosensitizer: Electronic Spectroscopy of Riboflavin in the Proximity of Semiconductor, Insulator and Metal Nanoparticles*, J. Phys. Chem. A, **119**, 4162 (2015).

46. N. Polley, S. Singh, A. Giri, P. K. Mondal, P. Lemmens and **S. K. Pal**, *Ultrafast FRET at Fiber Tips: Potential Applications in Sensitive Remote Sensing of Molecular Interaction*, Sensors and Actuators B: Chemical, **210**, 381 (2015).
47. S. Sardar, P. Kar, S. Sarkar, P. Lemmens and **S. K. Pal**, *Interfacial Carrier Dynamics in PbS-ZnO Light Harvesting Assemblies and their Potential Implication in Photovoltaic/ Photocatalysis Application*, Solar Energy Materials and Solar Cells, **134**, 400 (2015).
48. S. Sardar, S. Chaudhuri, P. Kar, S. Sarkar, P. Lemmens and **S. K. Pal**, *Direct Observation of Key Photoinduced Dynamics in a Potential Nano-delivery Vehicle of Cancer Drugs*, Phys. Chem. Chem. Phys., **17**, 166 (2015).
49. S. Singh, N. Polley, A. Mitra and **S. K. Pal**, *Spark Spectrometry of Toxic Smokes: Towards a Portable, Inexpensive and High-resolution Environment Monitoring Instrument*, Clean Technologies and Environmental Policy, **16**, 1703 (2014).
50. N. Goswami, S. Chaudhuri, A. Giri, P. Lemmens and **S. K. Pal**, *Surface Engineering for Controlled Nanocatalysis: Key Dynamical Events from Ultrafast Electronic Spectroscopy*, J. Phys. Chem. C, **118**, 23434 (2014).
51. S. Sardar, P. Kar and **S. K. Pal**, *The Impact of Central Metal Ions in Porphyrin Functionalized ZnO/TiO_2 for Enhanced Solar Energy Conversion*, J. Mat. NanoSci., **1**, 12 (2014).
52. P. Kar, S. Sardar, E. Alarousu, J. Sun, Z. S. Seddigi, S. A. Ahmed, E. Y. Danish, O. F. Mohammed and **S. K. Pal**, *The impact of the metal ions in the porphyrin-based applied materials for visible-light photocatalysis: Key information from ultrafast electronic spectroscopy*,

    Chemistry: A European Journal, **20**, 10475 (2014).
53. S. Banerjee, S. Chaudhuri, A. K. Maity, P. Saha and **S. K. Pal**, *Role of Caffeine in DNA Recognition of a Potential Food-Carcinogen Benzo[a]pyrene and UVA induced DNA damage*, J. Mol. Recog., **27**, 510 (2014).
54. S. Chaudhuri, S. Batabyal, N. Polley and **S. K. Pal**, *Vitamin B_2 in Nanoscopic Environments under Visible Light: Photosensitized Antioxidant or Phototoxic Drug?*, J. Phys. Chem. A, **118**, 3934 (2014).
55. Prasenjit Kar, Samim Sardar, **Srabanti Ghosh**, Bo Liu, Peter Lemmens, Omar F. Mohammed and Samir Kumar Pal, *Nano Surface Engineering of Mn_2O_3 for Potential Light-harvesting Application*, Journal of Materials Chemistry C (2015) DOI: 10.1039/C5TC01475A.
56. **Srabanti Ghosh**, Hynd Remita, Prasenjit Kar, Susobhan Choudhury, Samim Sardar, Patricia Beaunier, Partha Sarathi Roy, Swapan Kumar Bhattacharya and **Samir Kumar Pal**, *Facile synthesis of Pd nanostructures in hexagonal mesophases as a promising electrocatalyst for ethanol oxidation*, Journal of Materials Chemistry A, **3**, 9517–9527 (2015).
57. **S. Jana**, S. Das, C. Ghosh, A. Maity, **M. Pradhan**, *Halloysite Nanotubes Capturing Isotope Selective Atmospheric CO_2*, Sci. Rep. (Nature Publishing Group), **5**, 8711 (2015).
58. S. Das and **S. Jana**, *A Facile Approach to Fabricate Halloysite/ Metal Nanocomposites with Preformed and In-situ Synthesized Metal Nanoparticles: A Comparative Study of Their Enhanced Catalytic Activity*, Dalton Trans. (Royal Society of Chemistry), **44**, 8906 – 8916 (2015).
59. **S. Jana** and S. Das, *Development of Novel Inorganic-Organic Hybrid Nanocomposites as a Recyclable Adsorbent and Catalyst*, RSC Adv. (Royal Society of Chemistry), **4**, 34435-34442 (2014).

Department of Condensed Matter Physics and Material Sciences

60. Priyadarshini Parida, Biplab Ganguli and **Abhijit Mookerjee**, *Electronic and magnetic properties at rough and sharp transition metal–metal interfaces: an augmented space approach*, J. Magn. Magn. Mat., **381**, 422 (2015).
61. Tanmoy Ghosh, Ambika Prasad Jena and **Abhijit Mookerjee**, *Effects of chemical ordering and composition on the magnetic properties of disordered FeAl alloys*, J. of Alloys and Compounds, **639**, 583-587 (2015).
62. **A. Dutta**, M. Bhattacharya, and P. Barat, *Statistics of dislocation pinning at localized obstacles*, J. App. Phys., **116**, 143510 (2014).
63. **A. Dutta**, Swastika Chatterjee, **A. K. Raychaudhuri**, Amitava Moitra, and **T. Saha-Dasgupta**, *In-silico investigation of Rayleigh instability in ultra-thin copper nanowire in premelting regime*, J. App. Phys., **115**, 244303 (2014).
64. **A. Dutta**, *Kinetics of neck formation during nanoparticle sintering: approach of dimensionality reduction*, Rev. Adv. Mat. Sci., **39**, 25 (2014).
65. S. Pal, J. W. Klos, K. Das, O. Hellwig, P. Gruszecki, M. Krawczyk, and **A. Barman**, *Optically Induced Spin wave Dynamics in $[Co/Pd]_8$ Antidot Lattices with Perpendicular Magnetic Anisotropy*, Appl. Phys. Lett., **105**, 162408 (2014).
66. Sinha, A. T. Hindmarch, D. A. Atkinson, **A. Barman**, *Time-Domain Detection of Current Controlled Magnetization Damping in $Pt/Ni_{81}Fe_{19}$ Bilayer and Determination of Pt Spin Hall Angle*, Appl. Phys. Lett., **105**, 112409 (2014).
68. **A. Barman** and A. Haldar, *Time-domain study of magnetization dynamics in magnetic thin films and micro- and nanostructures*, Solid State Physics, **65**, pp. 1-108 (2014).

69. A. Haldar, C. Banerjee, P. Laha, and **A. Barman**, *Brillouin light scattering study of spin waves in NiFe/Co exchange spring bilayer films*, J. Appl. Phys., **115**, 133901 (2014).

70. J. S. Roy, T. P. Majumder, R. Dabrowski, B. K. Mahato and **A. Barman**, *Optical behaviour of CdS nanorods dispersed in liquid crystal*, Adv. Mater. Lett., **6**, 47 (2015).

71. R. K. Upadhyay, N. Soin, S. Saha, **A. Barman** and S. S. Roy, *Fast and facile preparation of CTAB based gels and their applications in Au and Ag nanoparticles synthesis*, Materials Chemistry and Physics, **156**, 105 (2015).

72. G. Dwivedi, M. Kumar, P. Shahi, **A. Barman**, S. Chatterjee, and A. Ghosh, *Low Temperature Magnetic and Transport Properties of LSMO-PZT Nanocomposites*, RSC Advances, **5**, 30748 (2015).

73. S. Saha, S. Barman, S. Sugimoto, Y. Otani, and **A. Barman**, *Tunable Picosecond Spin Dynamics in Two Dimensional Ferromagnetic Nanodot Arrays with Varying Lattice Symmetry*, RSC Advances, **5**, 34027 (2015).

74. K. Das, S. Samanta, Prashant Kumar, K.S. Narayan and **A. K. Raychaudhuri**, *Fabrication of Single Si Nanowire Metal-Semiconductor-Metal Device for Photodetection*, IEEE Transactions on Electron Devices, **61**, 1444 (2014).

75. Rajib Nath, **A. K. Raychaudhuri**, Ya M Mukovskii, N. Andreev, Vladimir Chichkov, *Room temperature resistive state switching with hysteresis in $GdMnO_3$ thin film with low threshold voltage*, Applied Physics Letters, **104**, 183508 (2014).

76. K. Das, S. Mukherjee, S. Manna, S. K. Ray and **A. K. Raychaudhuri**, *Single Si nanowire (diameter = 100 nm) based polarization sensitive near-infrared photodetector with ultra-high responsivity*, Nanoscale, **6**, 11232 (2014).

77. L. Pagliari, M. Dapiaggi,F. Maglia,T. Sarkar, **A. K. Raychaudhuri**, T. Chatterji, M. Carpenter, *Strain heterogeneity and magnetoelastic behaviour of nanocrystalline half-doped La, Ca manganite, $La_{0.5}Ca_{0.5}MnO_3$*, J.Phys.: Condensed Matter, **26**, 435303 (2014).

78. Manotosh Chakravorty and **A. K. Raychaudhuri**, *Magnetoresistance of polycrystalline Gadolinium with varying grain size*, Journal of Applied Physics, **117**, 034301 (2015).

79. Shahnewaz Mondal, Rishi Ram Ghimire and **A. K. Raychaudhuri**, *Mobility enhancement in Electric Double Layer gated n-ZnO ultraviolet photodetector by synergy of gate and illumination: A photo Hall study*, Appl. Phys.Letts, **106**, 041102 (2015).

80. Rishi Ram Ghimire, Shahnewaz Mondal and **A. K. Raychaudhuri**, *Synergistic ultraviolet photoresponse of a nanostructured ZnO film with gate bias and ultraviolet illumination*, Journal of Applied Physics, **117**, 105705 (2015).

81. Subarna Datta, Sudeshna Samanta, **Barnali Ghosh**, and **A. K. Raychaudhuri**, *Low-frequency resistance fluctuations in a single nanowire (diameter »45nm) of a complex oxide and its relation to magnetic transitions and phase separation*, Applied Physics Letters, **105**, 073117, (2014).

82. Samik Roy Moulik, Sudeshna Samanta, and **Barnali Ghosh**, *Photoresponse in thin films of WO_3 grown by pulsed laser deposition*, Applied Physics Letters, **104**, 232107 (2014).

83. Nilotpal Ghosh, Subarna Datta and **Barnali Ghosh,** *Size dependence in magnetic memory, relaxation and interaction of $La_{0.67}Sr_{0.33}MnO_3$*, Journal of Magnetism and Magnetic Materials, **382**, 277–282 (2015).

84. Nilotpal Ghosh, Sudeshna Samanta, **Barnali Ghosh**, *Observation of ZBCP Above T_c at $Au/Y_1Ba_2Cu_3O_{7-5}$ Heterostructure with a Nano Hole: A Possible Evidence for the Cooper Pairs above T_c*, Jl. Superconductivity and Novel Magnetism, **27**, 1245-1248, (2014).

85. A. Ghosh and **K. Mandal**, *Effect of structural disorder on the magnetocaloric properties of Ni-Mn-Sn alloy*, Applied Physics Letters, **104**, 031905 (2014).

86. A. Chaudhuri and **K. Mandal**, *Study of structural, ferromagnetic and ferroelectric properties of nanostructured barium doped Bismuth Ferrite*, Journal of Magnetism and Magnetic Materials, **353**, 57 (2014).

87. A. K. Singh, B. Das, P. Sen, S. K. Bandyopadhyay and **K. Mandal**, *Effect of alpha-Particle Irradiation on the Magnetic Properties of Ni Nanowires*, IEEE Transaction on Magnetics, **50**, 2302104 (2014).

88. S. Ghosh, G. G. Khan, **K. Mandal**, S. Thapa, P.M.G. Nambissan, *Positron annihilation studies of vacancy-type defects and room temperature ferromagnetism in chemically synthesized Li-doped ZnO nanocrystals*, Journal of Alloys and Compounds, **590**, 396 (2014).

89. D. Pal, A. Ghosh and **K. Mandal**, *Large inverse magnetocaloric effect and magnetoresistance in nickel rich $Ni_{52}Mn_{34}Sn_{14}$ Heusler alloy*, Journal of Magnetism and Magnetic Materials, **360**, 183 (2014).

90. A. K. Singh and **K. Mandal**, *Effect of Aspect Ratio and Temperature on Magnetic Properties of Permalloy Nanowires*, Journal of Nanoscience and Nanotechnology, **14,** 5036 (2014).

91. A. K. Singh, D. Sarkar, G. G. Khan and **K. Mandal**, *Hydrogenated NiO nanoblock architecture for high performance pseudocapacitor*, ACS Applied Materials & Interfaces, **6**, 4684 (2014).

92. A. K. Singh, D. Sarkar, G. G. Khan and **K. Mandal**, *Designing one dimensional Co-Ni/Co_3O_4-NiO core/shell nano-heterostructure electrodes for high-performance pseudocapacitor*, Applied Physics Letters, **104**, 133904 (2014).

93. M. Pal, R. Rakshit and **K. Mandal**, *Surface modification of $MnFe_2O_4$ nanoparticles to impart intrinsic multiple fluorescence and novel photocatalytic properties*, ACS Applied Materials & Interfaces, **6**, 4903 (2014).

94. S. Ghosh, P.M.G. Nambissan, S. Thapa, and **K. Mandal**, *Defect dynamics in Li substituted nanocrystalline ZnO: A spectroscopic analysis*, Physica B: Condensed Matter, **454**, 102 (2014).

95. M. Pal, R. Rakshit and **K. Mandal**, *Facile functionalization of Fe_2O_3 nanoparticles to induce inherent photoluminescence and excellent photocatalytic acivity*, Applied Physics Letters, **104**, 233110 (2014).

96. D. Sarkar, A. K. Singh, G. G. Khan and **K. Mandal**, *TiO_2/ZnO core/shell nano-heterostructure arrays as photo-electrodes with enhanced visible light photoelectrochemical performance*, RSC ADVANCES, **4**,55629 (2014).

97. A. Ghosh and **K. Mandal**, *A Comparative Study of Magnetocaloric Properties Between Ni-rich and Mn-rich Ni-Mn-Sn Alloys*, IEEE Transaction on Magnetics, **50**, 2504304 (2014).

98. Ankita Ghatak, Gouranga H. Debnath, **Madhuri Mandal** and Prasun Mukherjee, *Lanthanide cation-induced tuning of surface capping properties in zinc sulfide nanoparticles: an infrared absorption study*, RSC Adv., **5**, 32920 (2015).

.99. Monalisa Pal, Rupali Rakshit, **Madhuri Mandal**, and **Kalyan Mandal**, *Surface Modification of a-Fe_2O_3 Nanoparticles to Develop as Intrinsic Photoluminescent Probe and Unprecedented Photocatalyst*, IEEE Transactions on Magnetics, **50**, 5200404 (2014).

100. H Banerjee, **Manoranjan Kumar** and T Saha-Dasgupta, *Cooperativity in spin-crossover transition in metalorganic complexes: Interplay of magnetic and elastic interactions*, Physical Review B, **90** (17), 174433 (2014).

101. Debal Kanti Singha, Saurav Bhattacharya, Prakash Majee, Sudip Kumar Mondal, **Manoranjan Kumar** and Partha Mahata, *Optical detection of submicromolar levels of nitro explosives by a submicron sized metal–organic phosphor material*, J. Mater. Chem. A, **2**, 20908 (2014).

102. Sandeep Agarwal and **P. K. Mukhopadhyay**, *The effect of Al replacement and heat treatment on magnetocaloric properties of Ni_2Mn-Sn ferromagnetic shape memory alloys*, J. Alloy. Compd, **608**, 329 (2014).

103. Sanjay Singh, S. W. D'Souza, K. Mukherjee, P. Kushwaha, S. R. Barman, Sandeep Agarwal, **P. K. Mukhopadhyay**, Aparna Chakrabarti, and E. V. Sampathkumaran, *Magnetic properties and magnetocaloric effect in Pt doped Ni-Mn-Ga*, Appl. Phys. Lett, **104**, 231909 (2014).

104. Sandeep Agarwal, Enric Stern-Taulats, Lluís Mañosa, **P.K. Mukhopadhyay**, *Effect of low temperature annealing on magneto-caloric effect of Ni–Mn–Sn–Al ferromagnetic shape memory alloy*, Journal of Alloys and Compounds, **641**, 244–248 (2015).

105. Mayukh K. Ray, K. Bagani, **P. K. Mukhopadhyay** and S. Banerjee, *Origin of cluster spin glass and nuclear Schottky anomaly in $Mn_{50}Ni_{38.5}Sn_{11.5}$ alloy*, EPL, **109**, 47006 (2015).

106. Kapil Gupta, Basudeb Mandal and **Priya Mahadevan**, *Strain-induced metal-insulator transition in ultrathin films of $SrRuO_3$*, Phys. Rev. B, **90**, 125109 (2014).

107. T. Basu, V.V. Ravi Kishore, S. Gohil, K. Singh, N. Mohapatra, S. Bhattacharjee, B. Gonde, N.P. Lalla, **Priya Mahadevan**, S. Ghosh and E.V. Sampathkumaran, *Displacive-type ferroelectricity from magnetic correlations within spin-chain*, Sci. Rep., **4**, 5636 (2014).

108. Soumi Roy Chowdhury and **Ranjan Chaudhury**, *Investigation of fermionic pairing on tight binding lattice for low dimensional systems – Fermi liquid vs. Luttinger-Tomonaga liquid*, Physica B, **465**, 60 (2015).

109. **Ranjan Chaudhury**, *Tautomeric mutation in DNA. A theoretical comparative study and synthesis between various proposed quantum models*, Nanostructures, Mathematical Physics and Modelling, **12**(1), 85 (2015).

110. **S. Barman**, *Thermal Conduction in $In_xGa_{1-x}N$ Film*, Europhysics Letters, **107**, 56001 (2014).

111. B. K. Mahato, B. Rana, **S. Barman**, D. Kumar, S. Sugimoto, Y. Fukuma, Y. Otani and **A. Barman**, *Tunable Spin Wave Dynamics in Two-Dimensional $Ni_{80}Fe_{20}$ Nanodot Lattices by Varying Dot Shape*, Appl. Phys. Lett., **105**, 012406 (2014).

112. S. Pal, **S. Barman**, O. Hellwig and **A. Barman**, *Effect of the Spin-Twist Structure on the Spin-Wave Dynamics in $Fe_{55}Pt_{45}/Ni_{80}Fe_{20}$ Exchange Coupled Bi-Layers with Varying $Ni_{80}Fe_{20}$ Thickness*, J. Appl. Phys., **115**, 17D105 (2014).

113. C. Banerjee, S. Saha, **S. Barman**, O. Rousseau,Y. Otani and A. Barman, *Width Dependent Transition of Quantized Spin-Wave Modes in Ni80Fe20 Square Nanorings*, J. Appl. Phys., **116**, 163912 (2014).

114. **S. Datta**, R. Banerjee and **A. Mookerjee**, *Enhanced magnetism of Cu_n clusters capped with N and endohedrally doped with Cr*, J. Chem. Phys., **142**, 024309 (2015).

115. Sohail Ahmad and **Sugata Mukherjee**, *A comparative study of electronic properties of bulk MoS_2 and its monolayer using DFT technique: Application of mechanical strain on MoS_2 monolayer*, Graphene, **3**, pp 53-59 (2014) (http://dx.doi.org/ 0.4236/graphene.2014.34008)

116. Ransell D'Souza and **Sugata Mukherjee**, *Electronic structure, phase stability and resistivity of hybrid hexagonal $C_x(BN)_{1-x}$ two-dimensional nanomaterial : A first-principles study*, Physica E, **69**, pp 138-144 (2015) (http://dx.doi.org/10.1016/j.physe.2015.01.026)

117. Tapan Chatterji, Antonio M dos Santos, Jamie J Molaison, Thomas C Hansen, Stefan Klotz, Mathew Tucker, Kartik Samanta, **Tanusri Saha-Dasgupta**, *Anomalous breakdown of Bloch's rule in the Mott-Hubbard insulator $MnTe_2$*, Physical Review B, **91**, 104412 (2015).

118. AN Vasiliev, OS Volkova, EA Zvereva, AV Koshelev, VS Urusov, DA Chareev, VI Petkov, MV Sukhanov, B Rahaman, **T Saha-Dasgupta,** *Valence-bond solid as the quantum ground state in honeycomb layered urusovite CuAl(AsO$_4$)O*, Physical Review B, **91** (14), 144406 (2015).

119. Santu Baidya, **T Saha-Dasgupta**, *Covalency driven low-temperature structural distortion and its effect on electronic structure of $Hg_2Ru_2O_7$*, Physical Review, B **91**, 075123 (2015).

120. Tilak Das, **Tanusri Saha-Dasgupta**, *Spin-state transition in unstrained & strained ultra-thin $BiCoO_3$ films*, Dalton Trans., **44**, 10882 (2015).

121. Man-Rong Li, Maria Retuerto, Zheng Deng, Tapati Sarkar, Javier Sanchez-Benitez, Mark C Croft, **Tanusri Saha Dasgupta**, Tilak Das, Trevor A Tyson, David Walker, Martha Greenblatt, *Strong Electron Hybridization and Fermi-to-Non-Fermi Liquid Transition in $LaCu_3Ir_4O_{12}$*, Chemistry of Materials **27**(1), 211 (2015).

122. Tanushree Chakraborty, S Baidya, Carlo Meneghini, **Tanusri Saha-Dasgupta**, Giulia Veronesi, Marco Merlini, Hiroko Yokota, Mitsuru Itoh, S Majumdar, Sugata Ray, *Covalency-driven structural instability and spin-phonon coupling in barium cobalt oxychloride,* Physical Review B, **90**, 235147 (2014).

123. Derek Meyers, S Middey, J-G Cheng, Swarnakamal Mukherjee, BA Gray, Yanwei Cao, J-S Zhou, JB Goodenough, Yongseong Choi, D Haskel, JW Freeland, **T Saha-Dasgupta**, J Chakhalian, *Competition between heavy fermion and Kondo interaction in isoelectronic A-site-ordered perovskites*, Nature Commun, **5**, 5818 (2014).

124. U Tutsch, B Wolf, S Wessel, L Postulka, Y Tsui, HO Jeschke, I Opahle, **T Saha-Dasgupta**, R Valentí, A Brühl, K Removiæ-Langer, T Kretz, H-W Lerner, M Wagner, M Lang, *Evidence of a field-induced Berezinskii–Kosterlitz–Thouless scenario in a two-dimensional spin–dimer system*, Nature Commun, **5**, 5169 (2014).

125. Sajeev Chacko, Dhani Nafday, DG Kanhere, **T Saha-Dasgupta**, *Exact diagonalization study for nanographene: Modulation of charge and spin, magnetic phase diagram, and thermodynamics*, Physical Review B, **90,** 155433 (2014).

126. Man-Rong Li, Maria Retuerto, David Walker, Tapati Sarkar, Peter W Stephens, Swarnakamal Mukherjee, **Tanusri Saha Dasgupta**, Jason P Hodges, Mark Croft, Christoph P Grams, Joachim Hemberger, Javier Sánchez-Benítez, Ashfia Huq, Felix O Saouma, Joon I Jang, Martha Greenblatt, *Magnetic-Structure-Stabilized Polarization in an Above-Room-Temperature Ferrimagnet*, Angewandte Chemie International Edition, **53**, 10774 (2014).

127. Kartik Samanta, **T Saha-Dasgupta**, *Spin state of Mn2+ and magnetism in vanadate-carbonate compound, K2Mn3(VO4)2CO3,* Phys. Rev. B, **90**, 064420 (2014).

128. Mukul Kabir, **T Saha-Dasgupta**, *Manipulation of edge magnetism in hexagonal graphene nanoflakes*, Phys. Rev. B, **90**, 035403 (2014).

129. **Tanusri Saha-Dasgupta**, Peter M Oppeneer, *Computational design of magnetic metal-organic complexes and coordination polymers with spin-switchable functionalities*, MRS bulletin **39**(7), 614 (2014).

Department of Theoretical Sciences

130. Saikat Chatterjee, **Amitabha Lahiri** and Ambar N. Sengupta, *Twisted actions of categorical groups*, Theory and Applications of Categories**, 29**, 215 (2014).

131. Debmalya Mukhopadhyay and **Amitabha Lahiri**, b-*function for topologically massive gluons,* Phys. Rev. D,**90**, 025015 (2014).

132. Karan Fernandes and **Amitabha Lahiri**, *Kaluza ansatz applied to Eddington inspired Born-Infeld gravity,* Phys.Rev. D, **91**, 044014 (2015).

133. Rohit Kumar, *Off-shell nilpotent (anti-)BRST symmetries for a free particle system on a toric geometry: superfield formalism*, Europhys.Lett., **106**, 51001 (2014).

134. J M Luck and **Anita Mehta**, *Slow synaptic dynamics in a network: From exponential to power-law forgetting*, Physical Review E, **90**, 032709 (2014).

135. S Aich and **Anita Mehta**, *The clash of the Titans: how preferential attachment helps the survival of the smallest*, Eur. Phys. J. Special Topics, **223**, 2745-2758 (2014).

136. Y. Chaoba Devi, S. Prajapat, A. K. Mukhopadhyay, **B. Chakraborty**, F. G. Scholtz, *Connes distance function on fuzzy sphere and the connection between geometry and statistics*, Journal of Mathematical Physics, **56**, 041707 (2015).

137. B. Bagchi, A. Ghose Choudhury and **Partha Guha**, *On quantized Liénard oscillator and momentum dependent mass*, J. Math. Phys., **56**, 012105 (2015).

138. **Partha Guha** and A. Ghose Choudhury, *Folding transformations of equations from the Gambier family.* , **22**, no. 1-3, 1028–1035 (2015).

139. G. Gambino, U. Tanriver, **P. Guha**, A. Ghose, Choudhury, S. Roy Choudhury, *Regular and singular pulse and front solutions and possible isochronous behavior in the short-pulse equation: phase-plane, multi-infinite series and variational approaches*, , **20**, no. 2, 375–388 (2015).

140. J. F. Carinena, A. Ghose Choudhury and **Partha Guha**, *Generalized virial theorem for the Liénard-type systems*, Pramana, **84**, 373-385 (2015).

141. **Partha Guha**, E. Harikumar, E. N.S. Zuhair, *MICZ-Kepler systems in noncommutative space and duality of force laws*, , **29**, no. 32, 1450187 (2014).

142. **R. Banerjee**, S. Ghosh and A. K. Mitra, *Hamiltonian analysis of interacting fluids*, Eur. Phys. J. C, **75** (5), 207 (2015).

143. **R. Banerjee**, A. Mitra and P. Mukherjee, *General algorithm for nonrelativistic diffeomorphism invariance*, Phys. Rev. D, **91** (8), 084021 (2015).

144. **R. Banerjee**, A. Mitra and P. Mukherjee, *Localization of the Galilean symmetry and dynamical realization of Newton-Cartan geometry*, Class.Quant.Grav., **32** (4), 045010 (2015).

145. **R. Banerjee**, A. Mitra and P. Mukherjee, *A new formulation of non-relativistic diffeomorphism invariance*, Phys.Lett. B, **737**, 369-373 (2014).

146. **R. Banerjee** and S. Dey. *Constitutive relations and response parameters in two-dimensional hydrodynamics with gauge and gravitational anomalies*. Phys.Lett. B, **733**, pp. 198–201 (2014).

147. **R. Banerjee** and S. Upadhyay. *Generalized supersymmetry and sigma models*, Phys.Lett. B, **734**, pp. 369–376 (2014).

148. **R. Banerjee**, S. Dey, B. R. Majhi, and A. K. Mitra, *Two dimensional hydrodynamics with gauge and gravitational anomalies*, Phys.Rev. D, **89**, p. 104013 (2014).

149. Arindam Lala, *Magnetic response of holographic Lifshitz superconductors: Vortex and Droplet solutions*, Phys Lett B, **735**, 396-401 (2014).

150. Shirsendu Dey, Arindam Lala, *Holographic s-wave condensation and Meissner-like effect in Gauss–Bonnet gravity with various non-linear corrections*, Annals of Phys, **354**, 165-182 (2015).

151. Jeremy Schmit, Feng He, **Shradha Mishra**, Randal R. Ketchmem, Christofer E. Woods and Bruce Kerwin, *Entanglement model of antibody viscosity*, J. Phys. Chem. B, **118** (19), pp 5044-5049 (2014).

152. **Shradha Mishra**, *Giant Number fluctuation in the collection of active apolar particles: from spheres to long rods*, J. Stat. Mech., **2014**, P07013 (2014).

153. **Shradha Mishra**, Sanjay Puri and Sriram Ramaswamy, *Aspects of the density field in an active nematic*, Phil. Trans. R. Soc. A, **372**, 20130364 (2014).

154. Abhijit Chakraborty, G. Mukherjee and **S. S. Manna**, *Weighted network analysis of earthquake seismic data,* Physica A, **433**, 336 (2015).

155. Chandreyee Roy, Sumanta Kundu, **S. S. Manna**, *Fiber Bundle model with Highly Disordered Breaking Thresolds*, Physical Rev. E., **91**, 032103 (2015).

156. **S. K. Sharma**, *A modified Rayleigh-Gans-Debye formula for small angle X-ray scattering by interstellar dust grains*, Astrophys Space Sci., **357**, 80 (2015).

Inter-departmental Publications

157. D. Polley, **A. Barman**, and **R. K. Mitra**, *Controllable Terahertz Conductivity in Single Walled Carbon Nanotube/Polymer Composites*, J. Appl. Phys., **117**, 023115 (2015).

158. Kallol Mukherjee, Anuradha Das, Samiran Choudhury, **Anjan Barman** and **Ranjit Biswas**, *Dielectric Relaxations of (Acetamide + Electrolyte) Deep Eutectic Solvents in the Frequency Window, 0.2: Anion and Cation Dependence*, Journal of Physical Chemistry B, **119**, 8063-8071 (2015).

159. C. Ghosh, A. Maity, G. Banik, S. Som, A. Chakraborty, C. Selvan, S. Ghosh, **B. Ghosh**, S. Chowdhury and **M. Pradhan**, *Non-invasive ^{13}C-glucose breath test using residual gas analyzer-mass spectrometry: a novel tool for screening individuals with pre-diabetes and type 2 diabetes*, J. Breath. Res., **8**, 036001 (2014).

Other Publications

Department of Astrophysics & Cosmology

1. D. Debnath, & **S. K. Chakrabarti**, Properties of the Propagating Oscillatory Shock Wave in the Accretion Flows around Few Transient Black Hole Candidates during Their Outbursts, 2015, Proceedings of 13th marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2423

2. D. Dipak, **S. K. Chakrabarti**, & A. Nandi, A Comparative Study of the Timing and the Spectral Properties during Two Recent Outbursts (2010 and 2011) of H 1743-322, 2015, Proceedings of 13th marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2410

3. S. K. Garain, H. Ghosh, & **S. K. Chakrabarti**, Effects of Compton Cooling on Outflows in a Two Component Accretion Flow around a Black Hole: Results of a Coupled Monte Carlo-TVD Simulation, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2404

4. K. Giri, & **S. K. Chakrabarti**, Numerical Simulations of a Two Component Advective Flow for the Study of the Spectral and Timing Properties of Black Holes, 2015, Proceedings of 13th Marcel Grossman meeting, Eds. R. Ruffini et al., World Scientific: Singapore, p. 2401

Department of Chemical, Biological & Macro-Molecular Sciences

5. C. Ghosh, S. Chowdhury, S. Ghosh, and **M. Pradhan**, Breath analysis by residual gas analyzer-mass spectrometry: a non-invasive method for screening individuals with pre-diabetes and type 2 diabetes, In. J. Clin. Biochem., 29, 1, 97 (2014)

6. A. Maity, S. Daschakraborty, S. Chaudhuri and **M. Pradhan**, ^{18}O-isotope of Breath CO_2: a potential non-invasive marker of H. pylori infection, In. J. Clin. Biochem., 29, 1, 62-63 (2014)

Department of Condensed Matter Physics and Material Sciences

7. M. Bhattacharya, **A. Dutta**, and P. Barat, Stick slip response of dislocation core, TMS 2014 Annual Meeting Supplemental Proceedings, 257 (2014).
8. **A. Dutta**, M. Bhattacharya, and P. Barat, Statistical estimation of dislocation pinning at precipitates, voids and bubbles, EPD Congress 457 (2014).
9. N. Porwal, D. Polley, S. Pal, P. Laha, **A. Barman**, P. K. Datta, Fabrication and Characterization of 2-D Magnetic Antidot Arrays for Application in Magnonic Crystals, International Conference on Fibre Optics and Photonics, M4A. 71, 2014. (http://dx.doi.org/10.1364/PHOTONICS.2014.M4A.71)
10. **A. Barman**, R. Mandal, **S. Barman**, O. Rousseau and Y. Otani, Broadband Ferromagnetic Resonance Study of Tunable Magnonic Spectra in $Ni_{80}Fe_{20}$ Antidot Lattices by Varying Lattice Symmetry, 59th. Annual Magnetism and Magnetic Materials Conference, Honolulu, Hawaii, 3-7 Nov., 2014.
11. A. K. Singh and **K. Mandal**, High performance supercapacitor electrodes based on metal/metal oxide core/shell nano-heterostructures, DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, 1665, 050003.
12. R. Rakshit, M. Pal and **K. Mandal**, Terahertz conductivity study of magnetite nanostructures, DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, 1665, 050007.
13. A.K. Singh, G.G. Khan, B. Das, **K. Mandal**, Growth and Magnetic characterization of 1D Permalloy Nanowires using self developed AAO Templates, International Conference on Materials Science and Technology (ICMST 2012), IOP Publishing IOP Conf. Series: Materials Science and Engineering, 2015, 73, 012125.
14. A. Ghosh and **K. Mandal**, Magnetocaloric effect in Mn-rich Mn-Fe-Ni-Sn alloys, DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, 1665, 030015.
15. A. Chaudhury and **K. Mandal**, Enhancement of ferromagnetic and dielectric properties of nanostructured barium doped bismuth fabricated by facile hydrothermal route, DAE Solid State Physics Symposium-2014, AIP Conference Proceedings, 2015, 1665, 050022.
16. B. K. Mahato, S. Choudhury, **S. Barman**, R. Mandal, O. Rousseau, Y. Otani and **A. Barman**, Configurational Anisotropy in Two-Dimensional Ferromagnetic Nanodot Lattices with Varying Dot Shapes, 59th. Annual Magnetism and Magnetic Materials Conference, Honolulu, Hawaii, 3-7 Nov., 2014.
17. S. Saha, **S. Barman**, S. Sugimoto, Y. Otani and **A. Barman**, Configurational anisotropy in two-dimensional magnonic crystals with varying lattice symmetry, International Magnetics Conference (INTERMAG 2014), Dresden, Germany, May 4-8, 2014.
18. **S. Mukherjee** and R. D' Souza, First-principles study of electronic structure, phase stability and thermoelectric property of $C_x(BN)_{1-x}$ two-dimesional nanomaterial, Proc of 9th International Cenference of Computational Physics, Singapore, (Jan 2015)
19. **S. Mukherjee**, Electronic structure of graphene and related two-dimensional Nanomaterials: A first-principles study, Physics of Low Dimensional Structures, Vidyasagar University (2015)
20. **T Saha-Dasgupta**, M Kabir, Edge Magnetism in Graphene Nanoflakes, Bulletin of the American Physical Society (2015).

Department of Theoretical Sciences

21. Saikat Chatterjee, **Amitabha Lahiri** and Ambar N. Sengupta, Double Category Related to Path Space Parallel Transport and Representations of Lie 2 Groups, Springer Proc.Math.Stat. 85 (2014) 379.
22. **Anita Mehta**, translated into Spanish by Julia Taguena and Sue Berlanga, Ciencia y sociedad: La perspective de una mujer cientifica de la India, Ciencia y Desarrollo, May-June, 46-49 (2014).

Inter-departmental Publications

23. D. Polley, A. Patra, **A. Barman**, and **R. K. Mitra**, Modulating Conductivity of Au/CNT Composites in THz Frequency Range: A THz Resistor, Conference Proceedings, 39th International Conference on Infrared, Millimeter and THz Waves, The University of Arizona, Tucson, USA, September 14-19, 2014.
24. **Dipankar Mukhopadhyay**, Post-independence science policy and science funding in India, Current Science, v.107, no.12, 1983 (2014).
25. **Dipankar Mukhopadhyay**, Science, Technology and Innovation Policy, 2013- Outline of a Coherent Strategy for Translating It into Action, Current Science, v.109, no.5, 10 September 2015.

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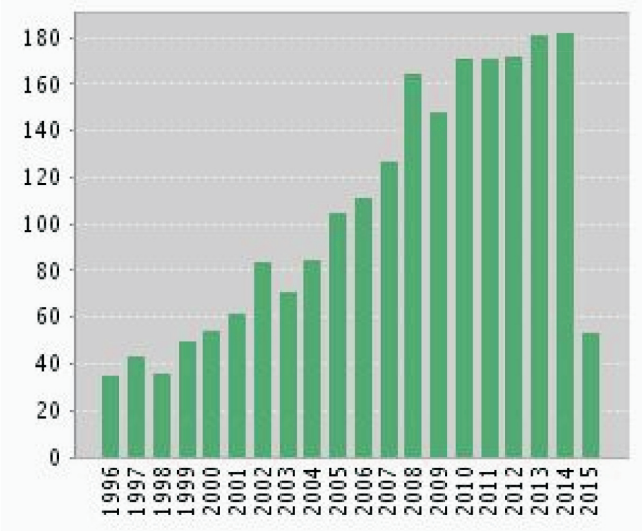

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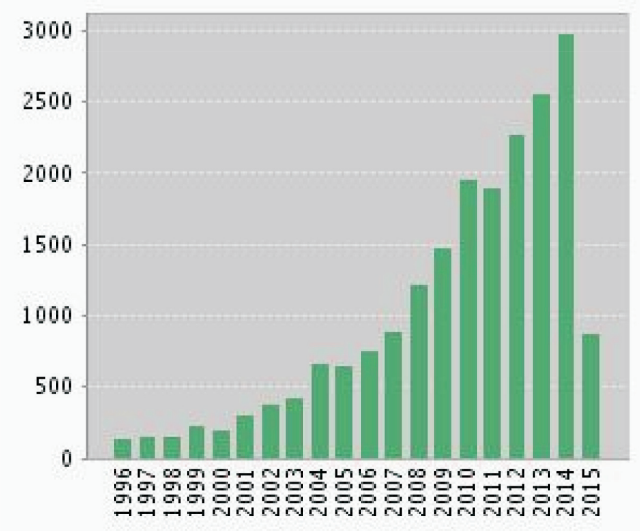

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5	Angewandte Chemie International Edition	13.734	1	13.734
6	Annals of Physics	3.065	1	3.065
7	Applied Physics Letters	3.794	12	45.528
8	Astrophysical Journal	6.733	2	13.466
9	Astrophysics and Space Science	2.064	3	6.192
10	Biochimie	3.142	1	3.142
11	Chemical Physics Letters	2.145	2	4.29
12	Chemistry: A European Journal	5.696	1	5.696
13	Chemistry: An Asian Journal	4.572	1	4.572
14	Chemistry of Materials	8.354	1	8.354
15	Classical and Quantum Gravity	3.168	2	6.336
16	Clean Technologies and Environmental Policy	1.671	1	1.671
17	Communications in Nonlinear Science and Numerical Simulation	2.866	2	5.732
18	Dalton Transactions	4.197	2	8.394
19	European Physical Journal C	5.084	1	5.084
20	European Physical Journal Special Topics	1.399	1	1.399
21	Europhysics Letters	2.26	3	6.78
22	Graphene	2.09	1	2.09
23	IEEE Transactions on Electron Devices	2.358	1	2.358
24	IEEE Transaction on Magnetics	1.213	3	3.639
25	Indian Journal of Physics	1.785	2	3.57
26	International Journal of Current Research and Academic Review	1.215	1	1.215
27	International Journal of Modern Physics A	1.086	1	1.086
28	Journal of Alloys and Compounds	2.39	4	9.56
29	Journal of Analytical Atomic Spectrometry	3.396	2	6.792
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31	Journal of Biomedical Optics	2.859	1	2.859
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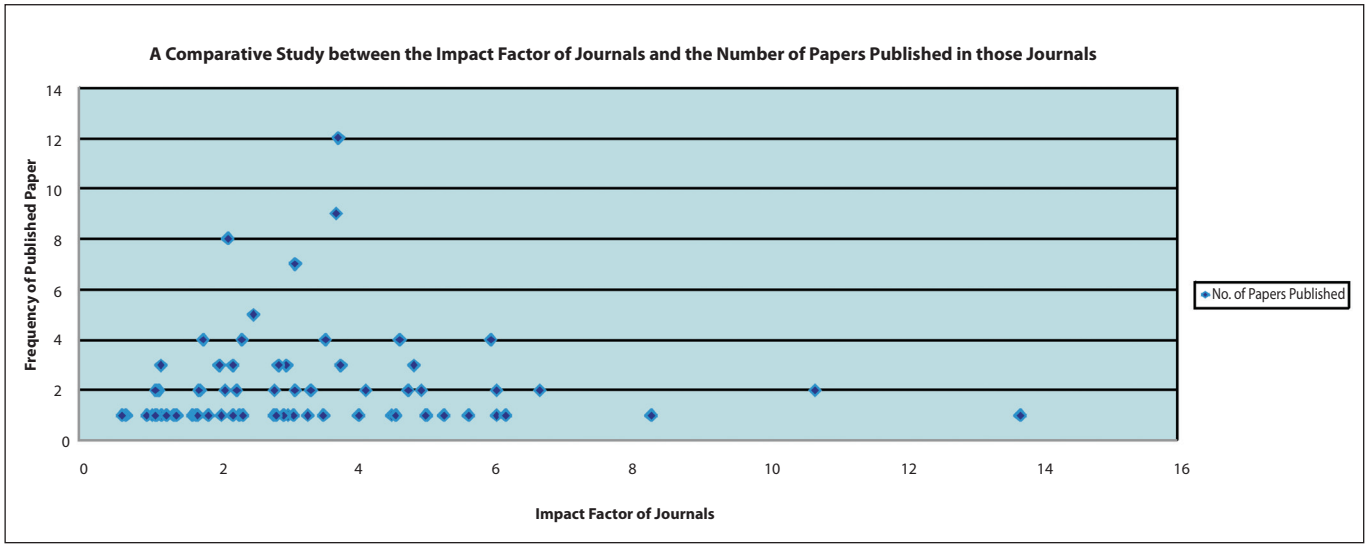
34	Journal of Chemical Sciences	1.298	1	1.298
35	Journal of Computer-Aided Molecular Design	2.99	1	2.99
36	Journal of Magnetism and Magnetic Materials	1.826	4	7.304
37	Journal of Materials Chemistry A	6.101	2	12.202
38	Journal of Materials Chemistry C	6.101	1	6.101
39	Journal of Materials NanoScience	New Journal	1	New Journal
40	Journal of Mathematical Physics	1.176	2	2.352
41	Journal of Modern Optics	1.008	1	1.008
42	Journal of Molecular Recognition	3.006	1	3.006
43	Journal of Nanoscience and Nanotechnology	1.149	1	1.149
44	Journal of Physical Chemistry A	1.766	2	3.532
45	Journal of Physical Chemistry B	3.607	4	14.428
46	Journal of Physical Chemistry C	4.814	2	9.628
47	Journal of Physics: Condensed Matter	2.355	1	2.355
48	Journal of Statistical Mechanics	2.404	1	2.404
49	Journal of Superconductivity and Novel Magnetism	0.702	1	0.702
50	Materials Chemistry and Physics	2.259	1	2.259
51	Molecular BioSystems	3.35	1	3.35
52	Molecular Simulation	1.133	1	1.133
53	Monthly Notices of the Royal Astronomical Society	4.9	3	14.7
54	MRS bulletin	5.069	1	5.069
55	Nanoscale	6.233	1	6.233
56	Nanostructures, Mathematical Physics and Modelling	New Journal	1	New Journal
57	Nature Communications	10.742	2	21.484
58	New Astronomy	1.146	2	2.292
59	Philosophical Transactions of the Royal Society A	2.891	1	2.891
60	Physica A	1.722	1	1.722
61	Physica B: Condensed Matter	1.133	2	2.266
62	Physica E	1.436	1	1.436
63	Physical Chemistry Chemical Physics	3.829	3	11.487

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
64	Physical Review A	3.042	3	9.126
65	Physical Review B	3.767	9	33.903
66	Physical Review D	4.691	4	18.764
67	Physical Review E	2.313	2	4.626
68	Physics Letters B	6.019	4	24.076
69	Pramana	0.649	1	0.649
70	Quantum Information Processing	1.748	1	1.748
71	Reviews on advanced materials science	1.287	1	1.287
72	RSC Advances	2.562	5	12.81
73	Scientific Reports (Nature Publishing Group)	2.927	3	8.781
74	Sensors and Actuators B: Chemical	4.097	1	4.097
75	Solar Energy Materials and Solar Cells	5.337	1	5.337
76	Solid State Physics	1.883	1	1.883
77	Theory and Applications of Categories	0.254	1	0.254
	Total	240.708	159	510.716

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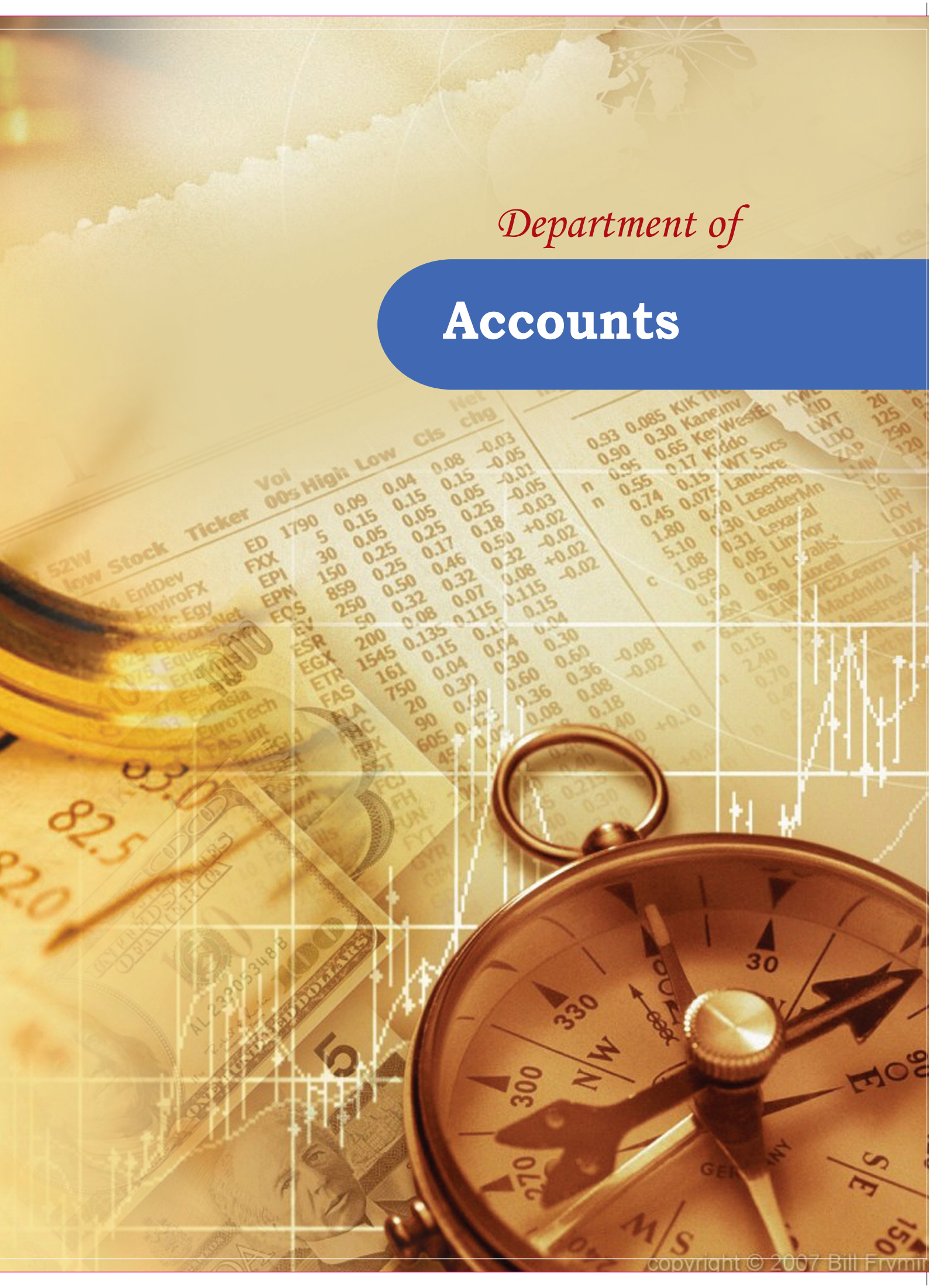
Department of
Accounts

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 098

BUDGET SUMMARY 2014-2015

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the year 2014-2015.

Figure in Lakhs (₹.)

	Actuals 2013-2014	Budget Estimate 2014-2015	Revised Estimate 2014-2015
Non-Plan	12.38	20.78	12.30*
Plan	3084.97	3467.19	3291.17*
TOTAL	3097.35	3487.97	3303.47

* Sanctioned by DST Plan ₹. 2737.51 lakhs, Non-Plan ₹. 11.48 lakhs and released as under:

Non-Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/NP/003/2014/1	05.05.14	₹. 4.25 lakhs
2	AI/SNB/NP/003/2014/2	01.09.14	₹. 5.10 lakhs
3	AI/SNB/NP/003/2014/3	17.02.15	₹. 2.13 lakhs
	TOTAL		₹. 11.48 lakhs

Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/GEN/003/2014/1	05.05.14	₹. 493.75 lakhs
2	AI/SNB/SC/003/2014/1	05.05.14	₹. 11.00 lakhs
3	AI/SNB/SAL /003/2014/1	02.05.14	₹. 226.00 lakhs
4	AI/SNB/CAP/003/2014/1	05.05.14	₹. 431.67 lakhs
5	AI/SNB/GEN/003/2014/2	01.09.14	₹. 504.00 lakhs
6	AI/SNB/CAP/003/2014/2	01.09.14	₹. 390.00 lakhs
7	AI/SNB/SC/003/2014/2	01.09.14	₹. 23.63 lakhs
8	AI/SNB/SAL/003/2014/2	25.04.14	₹. 350.00 lakhs
9	AI/SNB/SC/003/2014/3	21.01.15	₹. 12.62 lakhs
10	AI/SNB/SAL/003/2014/3	21.01.15	₹. 154.84 lakhs
11	AI/SNB/GEN/003/2014/3	21.01.15	₹. 140.00 lakhs
	TOTAL		₹. **2737.51 lakhs**
	TOTAL		₹. **2748.99 lakhs**

INDEPENDENT AUDITORS' REPORT

To the Governing Body of Satyendra Nath Bose National Centre for Basic Sciences

1. Report on the Financial Statements

We have audited the accompanying financial statements of **SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES** ("the Centre") which comprise the Balance Sheet as at March 31, 2015, the Income and Expenditure Account and the Receipts and Payments Account for the year then ended, and a summary of Significant Accounting Policies and Notes on Accounts.

2. Management's Responsibility for the Financial Statements

Management of the Centre is responsible for the preparation of these financial statements that give a true and fair view of the financial position, financial performance. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

3. Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Company's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

4. Opinion

In our opinion and to the best of our information and according to the explanations given to us, the financial statements give a true and fair view in conformity with the accounting principles generally accepted in India:

(a) in the case of the Balance Sheet, of the state of affairs of the Centre as at March 31, 2015.

(b) in the case of the Income & Expenditure Account, of the surplus for the year ended on that date; and

(c) in the case of the Receipts & Payments Account, of the Receipts & Payments for the year ended on that date.

5. Emphasis of matters

Without qualifying our opinion we draw attention for the following matters:

(a) Note No. 2.2.1 of the Schedule 25 regarding physical verification of Fixed Assets.

(b) Note No. 2.6 of Schedule 25 regarding transfer of Fixed Assets aggregating to Rs. 1,41,76,823.22 from Project to General Fund upon completion of Project pending approval from the appropriate authority.

6. (a) We have obtained all the information and explanations which to the best of Knowledge and belief were necessary for the purpose of our audit.

(b) In our opinion proper books of account as required by law have been kept by the Centre so far as appears from our examination of those books.

(c) The Balance Sheet, Income & Expenditure Account and Receipts & Payments Account dealt with by this Report are in agreement with the books of account.

(d) In our opinion the Balance Sheet, the Income & Expenditure Account dealt within this report comply with the appropriate Accounting Standard.

For
Roy & Bagchi
Chartered Accountants
FRN No . 301053E

(Amit Mitra)
Partner
Membership No. 060694

Place: Kolkata
Date: September 3, 2015

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

BALANCE SHEET AS AT 31ST MARCH 2015

Amount (Rs.)

	Schedule	Current Year	Previous Year
FUNDS AND LIABILITIES		-	-
CAPITAL / CORPUS FUND	1	1043226974.35	1012218107.76
RESERVES AND SURPLUS	2	-	-
EARMARKED/ENDOWMENT FUNDS	3	190436956.05	217030481.32
SECURED LOANS AND BORROWINGS	4		
UNSECURED LOANS AND BORROWINGS	5		
DEFERRED CREDIT LIABILITIES	6		
CURRENT LIABILITIES AND PROVISIONS	7	39585083.31	32176568.39
TOTAL		**1273249013.71**	**1261425157.47**
ASSETS			
FIXED ASSETS	8	804922255.75	735401225.87
INVESTMENTS-FROM EARMARKED/ENDOWMENT FUNDS	9	110575849.38	112860436.38
INVESTMENTS - OTHERS	10	210248304.00	183743956.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	147502604.58	229419539.22
MISCELLANEOUS EXPENDITURE (to the extent not written off or adjusted)			
TOTAL		**1273249013.71**	**1261425157.47**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN : 301053E

Date : 03.09.2015
Place : Kolkata

(Amit Mitra)
Partner
Membership No : 060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2015	Schedule	Current Year	Previous Year
			Amount (Rs.)
INCOME			
Income from Sales/Services	12	6032006.86	4075736.88
Grants/Subsidies	13	225357894.00	213784065.00
Fees/Subscriptions	14		
Income from Investments (Income on Investment from earmarked/endowment Funds transferred to Funds)	15		
Income from Royalty, Publication etc.	16		
Interest Earned	17	20074784.00	19796074.00
Other Income	18	720013.00	1441773.50
Increase/(decrease) in stock of finished goods and works-in-progress	19		
TOTAL (A)		**252184697.86**	**239097649.38**
EXPENDITURE			
Establishment Expenses	20	92925287.00	86160283.00
Other Administrative Expenses etc.	21	150594693.15	129980574.87
Expenditure on Grants, Subsidies etc.	22		
Interest	23		
TOTAL (B)		**243519980.15**	**216140857.87**
Balance being excess of Income over Expenditure (A-B)		8664717.71	22956791.51
Prior period adjustments (Credit)		451254.00	410070.92
Transfer to/from Capital Fund			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/CAPITAL FUND		**9115971.71**	**23366862.43**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN : 301053E

Date : 03.09.2015
Place : Kolkata

(Amit Mitra)
Partner
Membership no:060694

RECEIPTS AND PAYMENTS ACCOUNTS

For the year ended 31st March 2015

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Expenses :**		
a) Cash in hand	31393.00	30582.00	a) Establishment Expenses	108736853.86	95348885.00
b) Bank Balances :			b) Administrative Expenses	104106046.41	89124831.65
I. In current accounts(Schd 11A)	26707922.69	22674295.85	c) Maintenance	35711813.00	36280697.00
ii. In deposit accounts			**II. Payments made against funds for**		
Schedule - 10	183743956.00	213947832.00	**various Projects**		
Schedule - 11A	129128239.00	19093882.00			
iii. Savings accounts (Schd 11A)	13554280.98	19868143.41			
iv. Remittance-in-Transit					
II. Grants Received			**III. Investments and deposits made**		
a) From Government of India			a) Out of Earmarked/Endowment	28529527.00	114915635.38
-For the year	294445254.00	370939159.00	b) CPWD Deposit and NBCC Deposit	0.00	1705190.00
-For the previous year			c) Bank Gurantee & LC A/C	1200000.00	28833830.00
b) From State Government			d) Out of Own Fund	13351683.00	21149929.00
c) From Other sources (details)			e) Bridge&Roof Deposit Account	0.00	39200000.00
(Grants for capital & revenue exp.					
To be shown separately)					
			IV. Expenditure on Fixed Assets &		
			Capital Work-in-Progress		
			a) Purchase of Fixed Assets	125061026.00	54470047.67
III. Income on Investments from			b) Expenditure on Capital Work-in-Progress	2100233.00	3191217.00
a) Earmarked/Endow Funds		-			
b) Own Funds (Oth. Investment)			**V. Refund of surplus money/Loans**		
			a) To the Government of India		

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
IV. Interest Received			b) To the State Government		
a) On Bank deposits	7632274.00	6144769.00	c) To other providers of funds		
			VI. Finance Charges (Interest)		
V. Other Income	5442520.86	3995459.38			
			VII. Other Payments	35853077.23	53427680.39
			VIII. Amount transferred to Current		-
			/SavingsAccount from Deposit Account		
			Encashment of Short Term Deposits	74476330.00	
VI Amount Borrowed		-			
			IX. Closing Balances		
VII. Any other receipts	29629189.00	43044163.12	a) Cash in hand	12001.00	31393.00
			b) Bank Balances :		
VIII. Amount transferred from Current Account/			I. In current accounts(Schd 11A)	18469564.66	26707922.69
Savings Account to Deposit Account.	136100678.00	191075449.00	ii. In deposit accounts		
			Schedule - 10	210248304.00	183743956.00
			Schedule - 11A	54651909.00	129128239.00
			iii. Savings accounts(Schd.11A)	13907339.37	13554280.98
			iv. Remittance-in-Transit		
	826415707.53	**890813734.76**		**826415707.53**	**890813734.76**

Date 03.09.2015
Place: Kolkata

Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN: 301053E

(Amit Mitra)
Partner
Membership no: 060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015				Amount (Rs.)
	Current Year		Previous Year	
SCHEDULE 1 - CAPITAL FUND :	₹	₹	₹	₹
Balance as at the beginning of the year	1012218107.76		953823824.33	
Add : Contributions towards Corpus Capital Fund	49541106.00		78235935.00	
Less : Depreciation for the year	41073252.48		43208514.00	
Add : Surplus during the year	9115971.71		23366862.43	
Add : Adjustment for Depreciation (Overcharged)	13425041.36			
				1012218107.76
		1043226974.35		
BALANCE AS AT THE YEAR - END		**1043226974.35**		**1012218107.76**

	Current Year		Previous Year	
	₹	₹	₹	₹
SCHEDULE 2 - RESERVES AND SURPLUS :				
1. *Capital Reserve :*				
As per last Account				
Addition during the year				
Less : Deductions during the year				
2. *Revaluation Reserve:*				
As per last Account				
Addition during the year				
Less : Deductions during the year				
3. *Special Reserves :*				
As per last Account				
Addition during the year				
Less : Deductions during the year				
4. *General Reserve:*				
As per last Account				
Add : Surplus during the year		-		-
TOTAL		-		-

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

Amount (Rs.)

SCHEDULE 3 - EARMARKED/ ENDOWMENT FUNDS	FUND-WISE BREAK UP					TOTAL	
	Project Fund	Medical Fund	Leave Salary	Gratuity Fund	Corpus Fund	Current Year	Prev. Year
a) Opening balance of the funds	144425167.94	3694778.00	33280321.00	28520550.00	7109664.38	217030481.32	149165998.52
b) Additions to the Funds							
I) Donations/grants/Contributions	47226394.00	276753.00	2605641.00	638065.00	554157.00	51301010.00	125705254.00
ii) Income from investments made on account of funds	3860346.00	512096.00	1402011.00	2517535.00	690000.00	8981988.00	10410001.00
iii) Other additions-Provision during the year						-	0.00
TOTAL (a + b)	**195511907.94**	**4483627.00**	**37287973.00**	**31676150.00**	**8353821.38**	**277313479.32**	**285281253.52**
c) Utilisation/Expenditure towards objectives of funds							
I) Capital Expenditure							
Fixed Assets	52845367.00					52845367.00	37597409.67
Others							
Total							
ii) Revenue Expenditure							
Salaries, Wages and ww	19579823.86					19579823.86	18901257.88
allowances etc.							
Rent							
Other Administrative							
expenses							
Other Payments	11897558.41		1437636.00	1116138.00		14451332.41	11752104.65
iii) Adjustment (Interest)							
TOTAL (c)	**84322749.27**	**-**	**,437,636.00**	**1,116,138.00**	**-**	**86876523.27**	**68250772.20**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**111189158.67**	**4483627.00**	**35850337.00**	**30560012.00**	**8353821.38**	**190436956.05**	**217030481.32**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015				Amount (Rs.)
	Current Year		Previous Year	
SCHEDULE 4 - SECURED LOANS AND BORROWINGS :				
1. Central Government				
2. State Government (Specify)				
3. Financial institutions a) Term Loans b) Interest accrued and due				
4. Banks : a) Term Loans Interest accrued and due b) Other Loans (Specify) Interest accrued and due				
5. Other Institutions and Agencies				
6. Debentures and Bonds				
7. Others (Specify)				
TOTAL	**Nil**	**Nil**	**Nil**	**Nil**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

	Amount (Rs.)			
	Current Year		Previous Year	
SCHEDULE 5 - UNSECURED LOANS AND BORROWINGS				
1. Central Government				
2. State Government (Specify)				
3. Financial Institutions				
4. Banks:				
a) Term Loans				
b) Other Loans (Specify)				
5. Other Institutions and Agencies				
6. Debentures and Bonds				
7. Fixed Deposits				
8. Others (Specify)				
TOTAL	**Nil**	**Nil**	**Nil**	**Nil**

SCHEDULE 6 - DEFERRED CREDIT LIABIILTIES:	Amount (Rs.)			
	Current Year		Previous Year	
a) Acceptances secured by hypothecation of capital equipment and other assets				
b) Others				
TOTAL	**Nil**	**Nil**	**Nil**	**Nil**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

Amount (Rs,)

SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS	Current Year		Previous Year	
A. CURRENT LIABILITIES				
1. Acceptances				
2. Sundry Creditors:				
a) For Capital expenditure	10980162.00			8220217.00
b) Others - Revenue expend.(including Project Rs.30000.00)	11936424.00			5194438.00
3. Current Liabilities	2651578.00			2495665.00
4. Deposit from Contractors	6745308.88			5408978.88
5. Other Liabilities	100237.00			186615.00
6. Deposit from Students	1122700.00			914500.00
7. Deposit from Contractual Employees	1434967.00			1229561.00
8. Provident Fund Account (Payable)	0.00			711340.08
9. Project Overhead Fund	4547688.43			4149235.43
10 Project-Loan from General Fund	0.00			3600000
TOTAL (A)	**39519065.31**			**32110550.39**
B. PROVISIONS				
1. For Taxation				
2. Gratuity				
3. Superannuation/Pension				
4. Accumulated Leave Encashment				
5. Trade Warranties/Claims				
6. Others - Adhoc Bonus	66018.00			66018.00
TOTAL (B)	**66018.00**	**-**		**66018.00**
TOTAL (A + B)	**39585083.31**			**32176568.39**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

SCHEDULE 8 - FIXED ASSETS				
	GROSS BLOCK			
DESCRIPTION	Cost/valuation As at begin. of the year	Additions during the year	Adjustment during the year	Cost/valuation at the year-end
A. FIXED ASSETS:				
1. LAND:				
a) Freehold				
b) Leasehold	10950654.60	0.00	0.00	10950654.60
2. BUILDINGS:				
a) On Leasehold Land	283919588.86	7682286.00	0.00	291601874.86
b) On Freehold Land				
c) Ownership Flats/Premises				
d) Superstructures on Land not belonging to the entity				
3. PLANT MACHIENRY & EQUIPMENT	366719266.22	67101829.00	-0.00	433821095.22
4. VEHICLES	321013.00	0.00	0.00	321013.00
5. FURNITURE, FIXTURES	36863332.22	1587485.00	0.00	38450817.22
6. OFFICE EQUIPMENT	2142485.29	2125104.00	0.00	4267589.29
7. COMPUTER & LAN INSTALLATION	65424397.44	1808150.00	0.00	67232547.44
8. ELECTRIC INSTALLATIONS	11699040.00	0.00	0.00	11699040.00
9. LIBRARY BOOKS	198277299.11	7495016.00	0.00	205772315.11
10. TUBEWELLS & W.SUPPLY				
11. OTHER FIXED ASSETS	84225.55	0.00	0.00	84225.55
TOTAL OF CURRENT YEAR	**976401302.29**	**87799870.00**	**-0.00**	**1064201172.29**
PREVIOUS YEAR	**931054290.29**	**45347012.00**	-	**976401302.29**
B. CAPITAL WORK IN PROGRESS	**3623072.00**	**9691612.00**	**322241.00**	**12992443.00**
TOTAL (A + B)	**980024374.29**	**97491482.00**	**322241.00**	**1077193615.29**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 098

Amount (Rs.)

	DEPRECIATION				NET BLOCK	
	As at the beginning of the year	Additions during the year	Adjustment during the year	Total up to the Year-end	Current year-end	Previous year-end
	0.00	0.00	0.00	0.00	10950654.60	10950654.60
	34118194.62	4676942.01	31758.65	38826895.28	252774979.58	249801394.24
	71726103.73	18739406.58	(436082.75)	90029427.56	343791667.66	294993162.49
	320013.00	0.00	998.00	321011.00	2.00	1000.00
	17083265.30	2075521.95	(439911.45)	18718875.80	19731941.42	19780066.92
	814975.53	176976.29	(23116.38)	968835.44	3298753.85	1327509.76
	58092379.46	5163219.91	(11726544.94)	51529054.43	15703493.01	7332017.98
	2576980.02	855704.40	(1188565.28)	2244119.14	9454920.86	9122059.98
	59848566.33	9381480.63	356431.09	69586478.05	136185837.06	138428732.78
	42670.43	4000.71	(8.30)	46662.84	37562.71	41555.12
	244623148.42	**41073252.48**	**(13425041.36)**	**272271359.54**	**791929812.75**	**731778153.87**
	201414634.42	**43208514.00**	**-**	**246423148.42**	**731778153.87**	**729639655.87**
	-	**-**	**-**	**0.00**	**12992443.00**	**3623072.00**
	244623148.42	**41073252.48**	**(13425041.36)**	**272271359.54**	**804922255.75**	**735401225.87**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

SCHEDULE 9 - INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS	Amount (Rs)	
	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Others - Fixed Deposit with Nationalised Banks		
Project Fund Investment	37070690.00	50356178.00
Gratuity Fund Investment	29420396.00	25270930.00
Leave Salary Fund Investment	33280321.00	28406623.00
Staff Medical Fund Investment	3694778.00	2915122.00
Corpus Fund Investment (Project Overhead)	7109664.38	5911583.38
TOTAL	**110575849.38**	**112860436.38**

SCHEDULE 10 - INVESTMENTS - OTHERS	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Others - Fixed Deposit with Indian Overseas Bank (including Project OH Fund Invest.)	33525945.00	23225685.00
Fixed Deposit with Union Bank of India	176722359.00	160518271.00
Fixed Deposit with Bank of India		
TOTAL	**210248304.00**	**183743956.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.				Amount (Rs.)
A. CURRENT ASSETS:	**Current Year**		**Previous Year**	
1. Inventories:				
a) Stores and Spares		106431.55		61411.55
2) Cash balances in hand		12001.00		31393.00
3) Bank Balances:				
a) With Scheduled Banks:				
On Current Accoutns:				
Indian Overseas Bank (CA-089302000000220)	10669197.86		5991227.23	
Indian Overseas Bank (CA-089302000000273)	6830065.30		8643154.96	
Union Bank of India (CA-460901010034252)	970301.50	18469564.66	12073540.50	26707922.69
On Deposit Accounts for LC&BG:				
Indian Overseas Bank (CA-089302000000220)	9331909.00		43128239.00	
Indian Overseas Bank (CA-089302000000273)	45320000.00	54651909.00	86000000.00	129128239.00
On Savings Accounts:				
Indian Overseas Bank (SB-089301000010662 UNAST)	2414336.62		5565818.62	
Indian Overseas Bank (SB-089301000012029 SYNC.)	1630826.00		1567499.00	
Indian Overseas Bank (SB-089301000011479 NANO TECH)	3433035.00		3299726.00	
Union Bank of India (SB-460901110050013)	5943821.75		493389.36	
Axis Bank (SB-775010100024408)	449931.00		1967582.00	
Axis Bank (SB-775010100017860)	35389.00		660266.00	
		13907339.37		13554280.98
5. Remittance - in - Transit				
6. Post Office-Savings Accounts				
TOTAL (A)		**87147245.58**		**169483247.22**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEUDLES FORMING PART OF BALANCE SHEET AS AT 31.03.2015

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.(Contd.)		Amount (Rs.)		
	Current Year		Previous Year	
B. LOANS, ADVACNES AND OTHER ASSETS				
1. Loans:				
a) Staff including HBA ,Vehicle &PC Advance (includes Project A/c Rs.281908.00)		2828467.00		1737137.00
b) Other Entitites engaged in activities/objectives similar to that of the Entity				
c) Other - Advance to Project A/c				3,600,000.00
		0.00		
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account - Bridge & Roof and CPWD Deposit Account		40438840.00		42178830.00
b) Prepayments				
c) Others (Security Deposits)		107218.00		106018.00
d) Contractors & Suppliers		91941.00		91941.00
3. Income Accrued:				
a) On Investments from Earmarked/Endowment Funds(Including Project Rs.184316.00)		15366230.00		10216410.00
b) On investmetns - Others		1522663.00		2005956.00
c) On Loans and Advances				
d) Others				
4. Claims Receivable - Grant -in- Aid Receivable		-		-
TOTAL (B)		**60355359.00**		**59936292.00**
TOTAL (A + B)		**147502604.58**		**229419539.22**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015		Amount (Rs.)
SCHEDULE 12 - INCOME FROM SALES/SERVICES	**Current Year**	**Previous Year**
1) Income from Sales		
a) Sale of Finished Goods		
b) Sale of Raw Material		
c) Sale of Scraps		
2) Income from Services		
a) Guest House Rent	2537200.00	1088550.00
b) Hostel Charges (Recovery of HRA)	633053.86	1183749.88
c) Equipment Utilisation Fees	588200.00	462400.00
d) Hostel Maintenance Fees	1881153.00	874882.00
e) Project Overhead	276000.00	297730.00
f) Others	0.00	0.00
g) Income from BSNL	66000.00	66000.00
h) Rent for ATM	0.00	87425.00
i) Seminer Room Rent	47000.00	15000.00
j) Dining Hall Rent	3400.00	0.00
TOTAL	**6032006.86**	**4075736.88**

SCHEDULE 13 - GRANTS/SUBSIDIES	**Current Year**	**Previous Year**
1) Central Government	225357894.00	213784065.00
2) State Government(s)		
3) Government Agencies		
4) Institutions/Welfare Bodies		
5) International Organsations		
6) Others		
TOTAL	**225357894.00**	**213784065.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015		
		Amount (Rs.)
SCHEDULE 14 - FEES/SUBSCRIPTIONS	**Current Year**	**Previous Year**
1) Entrace Fees		
2) Annual Fees/Subscriptions		
3) Seminar/Program Fees		
4) Consultancy Fees		
5) Others		
TOTAL	**Nil**	**Nil**
Note: Accounting Policies towards each item are to be disclosed		

Amount (Rs.)

SCHEDULE 15 - INCOME FROM INVESTMENTS	**Investment from Earmarked Fund**		**Investment - Others**	
(Income on I nvest. From Earmarked/ Endowment Funds transferred to Funds)	**Current Year**	**Previous Year**	**Currnet Year**	**Previous Year**
1) Interest				
a) On Govt. Securities				
b) Other Bonds/Debentures				
2) Dividents:				
a) On Shares				
b) On Mutual Fund Securities				
3) Rents				
4) Others				
TOTAL	**Nil**	**Nil**	Nil	Nil
TRANSFERRED TO EARMARKED/ ENDOWMENT FUNDS	**Nil**	Nil	Nil	Nil

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015		
		Amount (Rs.)
SCHEDULE 16 - INCOME FROM ROYALTY, PUBLICATION ETC.	**Current Year**	**Previous year**
1. Income from Royalty		
2. Income from Publications		
3. Others		
TOTAL	**Nil**	**Nil**
SCHEDULE 17 - INTEREST EARNED	**Current Year**	**Previous year**
1) On Term Deposits:		
a) With Scheduled Banks	19855159.00	19432301.00
b) With Institutions		
c) Others		
2) On Savings Accounts:		
a) With Scheduled Banks	23521.00	105737.00
b) Post Office Savings Accounts		
c) Others		
3) On Loans:		
a) Employees/Staff (Interest on HBA etc.)	196104.00	258036.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	**20074784.00**	**19796074.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015		
		Amount (Rs.)
SCHEDULE 18 - OTHER INCOME	**Current Year**	**Previous Year**
1) Profit on Sale/disposal of Assets:		
a) Owned assets		
b) Assets acquired out of grants, or received free of cost		
2) Export Incentives realized		
3) Fees for Miscellaneous Services		
4) Miscellaneous Income	720013.00	1441773.50
TOTAL	**720013.00**	**1441773.50**
SCHEDULE 19 - INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS	**Current Year**	**Previous Year**
a) Closing stock		
Finished Goods		
Work-in-progress		
b) Less: Opening Stock		
Finished Goods		
Work-in-progress		
NET INCREASE/(DECREASE) [a-b]	**Nil**	**Nil**
SCHEDULE 20 - ESTABLISHMENT EXPENSES	**Current Year**	**Previous Year**
a) Salaries and Wages	83708487.00	74724418.00
b) Other Allowances and Bonus	66018.00	66018.00
c) Contribution to Provident Fund	2084806.00	2143221.00
d) Contribution to Other Fund - Gratuity Fund , Leave Salary Fund etc.	2040076.00	4885163.00
e) Staff Welfare Expenses (Medical)	1591112.00	1684635.00
f) Contribution to NPS	1302737.00	783902.00
f) Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	2132051.00	1872926.00
TOTAL	**92925287.00**	**86160283.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015

Amount (Rs.)

SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.	Current Year	Previous Year
a) Extended Visitors Programme.(Including Seminars & Workshops)	7153228.00	6846897.00
b) Meeting Expenses	1431534.00	1177025.00
c) Library General Expenses	123177.00	106140.00
d) Electricity and Power	34969686.00	27774866.00
e) Laboratory Expenses	21511839.00	9195371.00
f) Insurance	9910.00	9253.00
g) Repairs and Maintenance	44281630.00	42444901.48
h) TPSC Programme	680000.00	1236397.00
i) Student Hostel Rent	390278.00	445806.00
j) Vehicles Hire Charges	1396943.00	1411956.00
k) Postage, Telephone and Communication Charges	2381694.00	2265768.00
l) Printing and Stationary	1004011.00	1145491.00
m) Travelling and Conveyance Expenses	3580115.00	3587238.00
n) Contingency to Faculty	121259.00	100,295.00
o) Auditors' Remuneration	45600.00	40450.00
p) Bank Charges	863648.15	474126.39
q) Professional Charges (Legal Charges)	223425.00	282914.00
r) Staff Training & Welfare	370250.00	454771.00
s) Patent & Trademark	37,350.00	21950.00
t) Integrated Ph.D.	27080927.00	28544056.00
u) Hindi Programme	296496.00	45,458.00
v) Advertisement and Publicity	1174612.00	1704233.00
w) Others	1300843.00	518244.00
x) Municipal Tax	146968.00	146968.00
y) Entry Tax	19270.00	0.00
TOTAL	**150594693.15**	**129980574.87**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 098

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2015		
		Amount (Rs.)
SCHEDULE 22 - EXPENDITURE ON GRANTS, SUBSIDIES ETC.	**Current Year**	**Previous Year**
a) Grants given to Institutions/Organisations b) Subsidies given to Institutions/Organisations		
TOTAL	**Nil**	**Nil**
SCHEDULE 23 - INTEREST	**Current Year**	**Previous Year**
a) On Fixed Loans b) On Other Loans (including Bank Charges) c) Others (specify)		
TOTAL	**Nil**	**Nil**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 098

SCHEDULE 24

SIGNIFICANT ACCOUNTING POLICIES

1. ACCOUNTING CONVENTION

The financial statements are prepared on the basis of historical cost convention, unless otherwise stated and on the accrual method of accounting. Interest on interest bearing loans/advances granted to the staff and Guest House Rent are accounted on cash basis. Interest on Fixed deposit on lien against BG/LC is accounted on Cash basis.

2. INVENTORY VALUATION

2.1 Stores and Spares (including machinery spares) are valued at cost.

3. INVESTMENTS

3.1 Investments are valued at cost.

4. FIXED ASSETS

4.1 Fixed assets are stated at cost of acquisition inclusive of inward freight, duties and taxes and incidental and direct expenses related to acquisition, as well as customs duty & clearing charges on imported equipment are also capitalized.

4.2 Fixed Assets received by way of non-monetary grants (other than towards the Capital Fund), are capitalized at value stated / agreed by corresponding credit to Capital Fund. Incomplete work is shown as Capital-Work- in Progress to be capitalized on completion.

4.3 Library Books are accounted for on receipt basis and Journals are accounted for on payment basis.

5. DEPRECIATION

5.1 Depreciation on capitalization has been charged on the value determined / estimated at the time of take over and as and when on further items were added subsequently to Assets.

5.2 Depreciation is provided on straight-line method as per rates specified in the Companies Act, 1956.

5.3 In respect of additions to / deletion from fixed assets during the year, depreciation is considered on pro-rata basis. Depreciation is provided from the date of acquisition of the assets.

5.4 Depreciation arising on Fixed Assets is deducted from Fixed Assets and also from Capital Fund out of which Fixed Assets are created and not passed through the Income and Expenditure Account and directly debited to Capital Fund.

5.5 Regarding depreciation undercharged and overcharged has been adjusted to the tune of ₹.5,05,63,787.29 and ₹.6,39,88,828.25 during the financial year 2014-15. However, the net effect of ₹.1,34,25,041.36 (overcharged) has not been given in Income and Expenditure Account but adjusted directly in the Capital/Corpus fund Account of the Institution.

6. FOREIGN CURRENCY TRANSACTIONS

6.1 Transactions denominated in foreign currency are accounted at the exchange rate prevailing at the date of transaction.

7. RETIREMENT BENEFITS

7.1 Liability towards gratuity payable on death/retirement of employees is computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.2 Provision for accumulated leave encashment benefit to the employees is accrued and computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.3 Liabilities under above accounts are invested separately in fixed deposit accounts with nationalized bank.

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 098

SCHEDULE 25

CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Centre not acknowledged as debts – ₹. Nil (Previous year ₹. Nil).

1.2 In respect of

- Bank guarantees given by/on behalf of the Centre – ₹. 7049409.00 against 100% margin money by way of fixed deposit (Previous year ₹. 5849409.00).
- Letters of Credit opened by Bank on behalf of the Centre and Project–Rs. 47602500.00 (Previous year ₹. 123278830.00) against 100% margin money by way of fixed deposit.
- Bills discounted with banks – ₹. Nil (Previous year ₹. Nil).

1.3 Disputed demands in respect of:

Income-tax	₹. Nil (Previous year ₹. Nil)
Sales-tax	₹. Nil (Previous year ₹. Nil)

1.4 In respect of claims from parties for non-execution of orders, but contested by the Centre – ₹. Nil (Previous year ₹. Nil).

2. NOTES ON ACCOUNTS

2.1.1 Capital Commitments:

Estimated value of contracts remaining to be executed on capital account and not provided for Rs. Nil (Previous year ₹. Nil).

2.2.1 Physical verification of fixed assets was conducted by the Centre internally in August, 2013.Pending final reconciliation no adjustment is given in the Accounts in this year. Fixed assets register is in the process of being updated.

2.2.2 Capital work-in-progress as on 1st April, 2014 was ₹. 36,23,072/- addition during the year is ₹. 96,91,612/-, totaling to ₹. 1,33,14,684/ an amount of ₹. 3,22,241/-has been capitalized, leaving balance of ₹. 12992443.00 which has been carried forward.

2.2..4 Current Assets, Loans and Advances

In the opinion of the Management, the current assets, loans and advances have a value on realization in the ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

2.4 Taxation

In view of there being no taxable income under Income-tax Act 1961, no provision for Income tax has been considered necessary.

2.5 Foreign Currency Transactions

i) Expenditure in foreign currency:

a) Travel: Nil

b) Remittances and Interest payment to Financial Institutions/Banks in Foreign Currency : Nil

c) Other expenditure: Nil

- Commission on Sales
- Legal and Professional Expenses
- Miscellaneous Expenses
- Bank Charges

ii) Earnings: Value of Exports on FOB basis: Nil

2.6 Transfer of Fixed Assets aggregating to ₹.1,41,76,823.22 from project to general fund upon completion of project has not been done pending approval from the appropriate authority.

2.7 In absence of any specific directions from Appropriate Authority balance of Medical Fund ₹.44,83,627.00 (previous year ₹. 36,94,778.00) by the employees are appearing under Earmarked & Endowment Fund as on 31-03-2015.

2.8 Corresponding figures for the previous year have been re-grouped/re-arranged, wherever necessary.

Kolkata

Dated: September 3, 2015

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 098

Para-wise replies to the audit observations

Sl	Audit Observations	Para-wise replies
1	Note No. 2.2.1 of the Schedule 25 regarding physical verification of Fixed Assets.	Physical verification has been conducted internally by the Centre. Adjustment required for shortage and excess found on such physical verification will be effected after final reconciliation in consultation with the statutory auditor and after getting the approval of the competent authority.
b	Note No. 2.6 of Schedule 25 regarding transfer of Fixed Assets aggregating to ₹.1,41,76,823.22 from Project to General Fund upon completion of Project pending approval from the appropriate authority.	The matter of transferring Fixed Assets of the completed projects to the Centre had been taken up with the funding agencies (mainly DST). However no response has been received after repeated reminder.