ANNUAL REPORT

2015-16

CENTRE FOR BASIC SCIENCES 1986
S. N. BOSE NATIONAL
1894-1974
विज्ञानेन परिपश्यन्ति धीराः

Satyendra Nath Bose
National Centre For Basic Sciences

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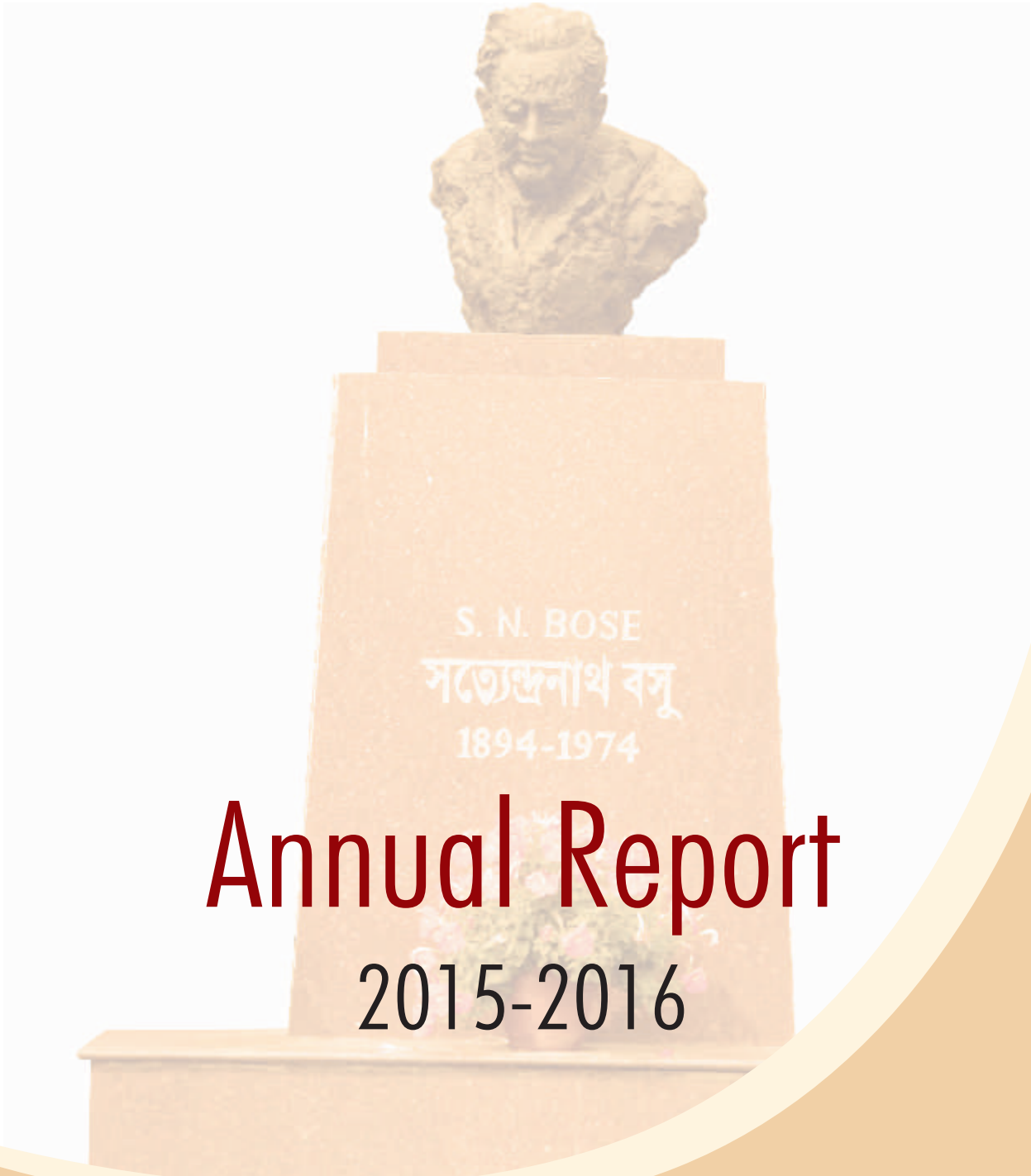

Annual Report

2015-2016

Annual Report 2015-2016

Satyendra Nath Bose National Centre for
Basic Sciences

Annual Report Committee

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Mr. Sukanta Mukherjee
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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 sixth 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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Message

From the Director

I am delighted to present the Annual Report of the Satyendra Nath Bose National Centre for Basic Sciences for the year 2015-16, as the Director (Additional Charge). The Annual Report of an autonomous research institute is not only a statutory requirement; rather it is the face of the Centre to the world, chronicling growth and achievements over the year and presenting the activities of the Centre. The performance of the centre during the financial year 2015-16 is reflected by the usual parameters towards the performance of a scientific institution, like the number of publications in peer-reviewed journals, the impact of publications, the number of students successfully trained at the pre-doctoral, doctoral and post-doctoral stages, the national and international recognitions the members of the institution received, which indicate that the Centre has improved its standing over the past year. In the last one year there have been 177 publications in referred journals and 33 of other types of publications. 10 students were awarded PhD Degree and 14 others submitted their PhD theses. There are 131 PhD students associated with active and productive faculty strength of 31. During 2015-16 the Centre had 38 ongoing/new projects amounting an extramural annual funding of Rs. 4,71,50,347 and I feel happy to state that the performance of the Centre has improved considerably in generation of extra-mural research support, on the basis of stringent expert review.

Sincere thanks to the members of the statutory and advisory and internal administrative committees of the Centre for their cooperation and support. Cordial thanks to all faculty members, staff members and students of the Centre for their sincere involvement towards continuous growth of the Centre.

I wish many more sunny and productive years for the Centre in the years to come.

Santanu Bhattacharya
Director (Additional Charge)

Dean Faculty

Rabin Banerjee

In the year 2015-2016, the Centre was involved in several academic activities related to scientific collaborations, hosting national and international conferences, workshops etc. In this fiscal year, the total number of publications was 177.

Throughout 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 one Scientist and fourteen Post Doctoral Research Associates joined the Centre. During the year, one of our faculty members has been promoted to Senior Professor and two others have been promoted to Associate Professor.

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 in which students join after an MSc 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, UGC-NET, GATE, JEST held for admission to 27 research institutes. We also have an integrated PhD programme in Physics called IPhD, conducted in collaboration with the University of Calcutta, which accepts students after their BSc Students qualify for the IPhD programme through JEST or NGPE, as well as an interview.

In the academic year 2015-16, 21 students joined the PhD Programme. Of these, 04 joined Astrophysics & Cosmology, 10 joined Condensed Matter Physics and Material Sciences, 05 joined Chemical, Biological and Macromolecular Sciences and 02 joined Theoretical Sciences. In addition, 07 students joined the IPhD Programme, all of whom qualified through JEST. Students were also admitted into the PhD Programme of the Centre in January 2016 with a special drive directed towards those with CSIR-NET, RGNF, INSPIRE & similar fellowships.

The centre also runs the TWAS-Bose PhD Fellowships Programme jointly with The World Academy of Sciences (TWAS). One student from Egypt was offered a fellowship this year.

The Centre currently has 131 (as on 31st March 2016) students in the PhD Programme, and another 16 in the IPhD Programme. In the 2015-16 academic year, 10 students received their PhD degrees, and another 14 submitted their PhD thesis. There are 09 more students working as research assistants or fellows in various projects.

In addition 16 students came to the Centre on short term visits, including 15 Summer Research Programme. Groups of students from Presidency University & Lady Brabrourne College, Kolkata also visited the research laboratories of the Centre.

The Centre also celebrated 'National Science Day' – 2016 on 28th-29th Feb 2016. About 80 students from different schools participated along with their teachers in the day-long Programme at the Centre including a special "Sky-watch" Programme at night for the participants.

Courses Taught in 2015-2016

Integrated PhD Programme in Physical Sciences (IPhD-Ph)

1st Semester:

- PHY 101, *Classical Dynamics*, Ramkrishna Das;
- PHY 102, *Mathematical Methods*, Prosenjit Singha Deo;
- PHY 103, *Quantum Mechanics I*, Priya Mahadevan;
- PHY 104, *Computational Methods in Physics I*, Punyabrata Pradhan;
- PHY 191, *Basic Laboratory I*, Arup K Raychaudhuri & Soumen Mondal.

2nd Semester:

- PHY 201, *Statistical Mechanics*, Jaydeb Chakrabarti;
- PHY 202, *Quantum Mechanics II*, Partha Guha;
- PHY 203, *Electromagnetic Theory*, Amitabha Lahiri;
- PHY 204, *Computational Methods in Physics II*, Punyabrata Pradhan;
- PHY 291, *Basic Laboratory II*, Kalyan Mandal & Sandip Sarkar (SINP).

3rd Semester:

- PHY 301, *Atomic & Molecular Physics*, Anjan Barman & Rajib Kumar Mitra;
- PHY 302, *Condensed Matter Physics*, Manoranjan Kumar;
- PHY 303, *Advanced Quantum Mechanics & Applications*, Biswajit Chakraborty & Archan S Majumdar;
- PHY 304, *Project Research II*, Faculty Supervisors;
- PHY 391, *Methods of Experimental Physics*, Kalyan Mandal (Coordinator), A K Raychaudhuri, Barnali Ghosh, Rajib Kumar Mitra, Manik Pradhan, Subhra Jana & 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*, Samir Kumar Pal;
- PHY 409, *Magnetism & Superconductivity*, Arup K Raychaudhuri & Kalyan Mandal;
- PHY 411, *Optical Physics*, M Sanjay Kumar;
- PHY 412, *Physics of Materials*, Sugata Mukherjee.

PhD Programme

Course Work Programme

- 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;
- PHY 510, *Astrophysics*, Sandip K Chakrabarti & Soumen Mondal;
- PHY 511, *High Energy Astrophysics around Compact Stars*, Sandip K Chakrabarti & Soumen Mondal;
- CB 523, *Advanced Equilibrium Statistical Mechanics*, Jaydeb chakrabarti;
- ✦ CB 526, *Fundamentals of Biophysics*, Samir Kumar Pal;
- CB 527, *Molecular Physics & Spectroscopy*, Manik Pradhan;
- CB 528, *Stochastic Processes in Physics & Chemistry*, Gautam Gangopadhyay;
- ✦ PHY 601, *Advanced Condensed Matter Physics - Magnetism & Superconductivity*, Arup K Raychaudhuri & Kalyan Mandal;
- ✦ PHY 602, *Advanced Condensed Matter Physics - Electronic Structure & Physics of Materials*, Sugata Mukherjee;
- ✦ PHY 604, *Quantum Physics (Application)*, Biswajit Chakraborty & Archan S Majumdar.

(Note: ✦ Conducted partially in combination with IPhD Programme.)

PhD AWARDS

Thermodynamic Properties of Mesoscopic Systems, Sreemoyee Mukherjee, Supervisor: Prosenjit Singha Deo, in University of Calcutta, on April 2, 2015

A Study on Characterization and Detection of Quantum Entanglement, Nirman Ganguly, Supervisor: Archan S Majumdar, in University of Calcutta, on June 12, 2015

Magnetization Dynamics in Magnetic Materials with High Magnetic Anisotropy, Semanti Pal, Supervisor: Anjan Barman, in University of Calcutta, on June 17, 2015

Study of Relaxation Phenomenon and Functional Properties in Some Ferromagnetic Shape Memory Alloys, Sandeep Agarwal, Supervisor: Pratip Kumar Mukhopadhyay, in University of Calcutta, on June 17, 2015

Some Studies of Complex Networks in Multidisciplinary Fields, Abhijit Chakraborty, Supervisor: Subhrangshu S Manna, in Jadavpur University, on August, 2015

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

Investigation of Melt Mixtures and Other Complex Systems, Anuradha Das, Supervisor: Ranjit Biswas, in Jadavpur University, on December, 2015

Investigation of Static and Dynamic Magnetic Properties in Array of Magnetic Micro-and Nano elements of Various shapes, Bipul Kumar Mahato, Supervisor: Anjan Barman, in University of Calcutta, on February, 2016

Investigation of Growth, Electrical and Opto-electronic Transport in Nanowires of Charge Transfer Complexes, Rabaya Basori, Supervisor: Arup K Raychaudhuri, in University of Calcutta, on February 22, 2016

Study of Electronic, Structural and Magnetic Properties of the Disordered Solids, Ambika Prasad Jena, Supervisor: Abhijit Mookerjee, in University of Calcutta, on March, 2016

PhD THESES SUBMITTED

Structural, Magnetic, Optical and Electronic Properties of Transition Metal Compounds and Semiconductors, Saikat Debnath, Supervisor: Priya Mahadevan, in University of Calcutta, on April 24, 2015

Non-Linear Aspects of Black Hole Physics, Arindam Lala, Supervisor: Rabin Banerjee, in University of Calcutta, on July 14, 2015

Investigation of transition metal based nanostructures and their application in storage devices, Ashutosh Kumar Singh, Supervisor: Kalyan Mandal, in University of Calcutta, on July 22, 2015

Collective Magnetization Dynamics in Magnetic Nanostructures at Various Length Scales and Time Scales, Susmita Saha, Supervisor: Anjan Barman, in University of Calcutta, on July 24, 2015

Investigation of Static and Dynamic Magnetic Properties of Two-Dimentional Magnetic Crystals, Ruma Mandal, Supervisor: Anjan Barman, in University of Calcutta, on July 28, 2015

Coherence Phenomenon in Mesoscopic Systems, Urbashi Satpathi, Supervisor: Prosenjit Singha Deo, in University of Calcutta, on August 3, 2015

Electronic and Structural Properties of Two Dimensional Semiconductors and Oxides, Ruma Das, Supervisor: Priya Mahadevan, in University of Calcutta, on September 17, 2015

Magnetic, Magnetocaloric and Magneto-Transport Properties of Heusler Alloys, Arup Ghosh, Supervisor: Kalyan Mandal, in University of Calcutta, on September 18, 2015

Surface Modification of Metal Oxides to Induce Multifunctionality at the Nanoscale, Monalisa Pal, Supervisor: Kalyan Mandal, in University of Calcutta, on October 8, 2015

Electronic Structure of Crystalline Solids and Finite-Sized Clusters, Swarnakamal Mukherjee, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, on December 4, 2015

Magnetorheological Fluids with Ferromagnetic Binary Alloys and Oxides, Md. Injamamul Arief, Supervisor: Pratip Kumar Mukhopadhyay, in University of Calcutta, on December 21, 2015

Structure, Dynamics and Activity of Water in Restricted Environments, Animesh Patra, Supervisor: Rajib Kumar Mitra, in University of Calcutta, on December 22, 2015

Understanding of Interaction and Dynamics in Multi-component Chemical Systems, Sandipa Indra, Supervisor: Ranjit Biswas, in Jadavpur University, on December 28, 2015

Spectroscopic Studies on the Medicinally Important Molecules with Various Nanoparticles and their Interaction with Different Cell Lines, Siddhi Chaudhuri, Supervisor: Samir Kumar Pal, in University of Calcutta, on February 1, 2016

POST- DOC PLACEMENT

Abhijit Chakraborty - Institute of Mathematical Sciences (IMSc.), Chennai

Ambika Prasad Jena - Indo-Korea Science & Technology Centre, Bangalore

Anuradha Das - Ludwig Maximilian University, Germany

Arup Ghosh - Indian Institutes of Science Education and Research (IISER), Pune

Ashutosh Kumar Singh - Centre for Nano and Soft Matter Sciences, Bangalore

Bipul Kumar Mahato - University of California, Santa Cruz, USA

Md. Injamamul Arief - Indian Institute of Science (IISc.), Bangalore

Monalisa Pal - Department of Chemical Engineering POSTECH (Pohang University of Science and Technology), South Korea

Rabaya Basori – Indian Institute of Technology (IIT), Kharagpur

Rajib Nath - Tata Institute of Fundamental Research (TIFR), Mumbai

Ruma Mandal - Research Center for Magnetic and Spintronic Materials, NIMS, Ibaraki, Japan

Saikat Debnath - Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore

Sandeep Agarwal - Ningbo Institute of Material Technology & Engineering, Ningbo, Zhejiang, China

Semanti Pal – Indian Institutes of Science Education and Research (IISER), Kolkata

Susmita Saha - ETH, Zurich

Urbashi Satpathi - Raman Research Institute (RRI), Bangalore

AWARDS / ACHIEVEMENTS RECEIVED BY RESEARCH SCHOLARS

Aniruddha Adhikari - Received "Best Poster Award DAE-BRNS Theme Meeting" on "Ultrafast Science- 2015", 19th to 21st November, 2015, organized by: Indian Society for Radiation and Photochemical Sciences (ISRP)

Biplab Bhattacherjee - Received "Excellent Poster Award" for presenting "Topological-distance-dependent transition in flocks with binary interactions", Phys. Rev. E 92, 062134 – December 2015 in CCP2015, IIT Guwahati, Assam, India.

Chiranjit Ghosh - Received "Dr. C. Sita Devi Award" by the "Association of Clinical Biochemists of India" in Chandigarh, India for the year 2015.

Chiranjit Ghosh - Received "1st Runner Up of The Best Oral Paper Presentation" prize in "9th Annual Conference of RSSDI (Research Society for the Study of Diabetes in India)" Maharashtra Chapter held in Pune, India in 2015

Chiranjit Ghosh - Received "One amongst Six Papers for the Best Papers Award" in "3rd Annual Conference of the Integrated Diabetes & Endocrine Academy (IDEACON)", Kolkata in 2015

Debasish Das Mahanta - Received "Best poster award" for the poster presentation in the "International conference on Recent Advances in Molecular Spectroscopy: Fundamentals and Application in Materials and Biology (RAMS-2016)" at School of Chemistry, University of Hyderabad in March 2016.

Ravindra Singh Bisht - Awarded First Prize for poster presented in "International Conference on Nanoscience and Technology 2016" held in IISER Pune (29th Feb- 2nd March), sponsored by: "Royal Society of Chemistry", London. The poster was entitled as "Control of grain boundary depletion layer in a nanostructured ZnO Channel in EDL-TFT: An investigation using impedance spectroscopy".

Subarna Datta - Received "MRSI Young Scientist Poster Award 2015" in "Young Scientists' Colloquium 2015", organized by "Material Research Society of India (MRSI)" Kolkata chapter on 11th September, 2015 at CSIR-CGCRI Kolkata.

RESEARCH SCHOLARS - PhD PROGRAMME (by Year of Joining)

EXTENDED SENIOR RESEARCH FELLOW

2009–2010:	Supervisor
Semanti Pal (UGC) (till 30-07-2015)	Anjan Barman
2010–2011:	
Dattatray P Shinde (SNB) (till 17-06-2015)	Anita Mehta
Animesh Patra (SNB)	Rajib Kumar Mitra
Arindam Lala (CSIR)	Rabin Banerjee
Susmita Saha (UGC) (till 31-12-2015)	Anjan Barman
2011–2012:	
Siddhi Chaudhuri (CSIR)	Samir Kumar Pal
Arup Ghosh (SNB)	Kalyan Mandal
Sandipa Indra (UGC)	Ranjit Biswas
2012–2013:	
Monalisa Pal (SNB) (till 07-12-2015)	Kalyan Mandal

SENIOR RESEARCH FELLOW

2009–2010:	
Md. Injamamul Arief (CSIR) (till 10-11-2015)	Pratip Kumar Mukhopadhyay
Rabaya Basori (SNB) (till 31-08-2015)	Arup Kumar Raychaudhuri

2009–2010:	Supervisor
Saikat Debnath (CSIR) (till 18-05-2015)	Priya Mahadevan
Urbashi Satpathi (INSPIRE) (till 31-07-2015)	Prosenjit Singha Deo
2010-2011:	
Anuradha Das (UGC) (till 25.06.2015)	Ranjit Biswas
Bipul Kumar Mahato (CSIR) (till 01-06-2015)	Anjan Barman
Priyanka Chowdhury (UGC)	Archan S Majumdar
Sreeraj T P (CSIR)	Manu Mathur
Subhajit Sarkar (CSIR)	Ranjan Chaudhury & Samir Kumar Paul
Tanmoy Ghosh (SNB)	Pratip Kumar Mukhopadhyay
Yendrembam Chaoba Devi (SNB)	Biswajit Chakraborty
2011-2012:	
Arindam Das (UGC)	Rajib Kumar Mitra
Basudeb Mandal (CSIR) (till 26-11-2015)	Priya Mahadevan
Ishita Dutta Choudhury (SNB)	Amitabha Lahiri
Kallol Mukherjee (CSIR)	Ranjit Biswas & Anjan Barman
Paramita Saha (SNB)	Mahua Ghosh
Pratik Tarafdar (UGC)	Archan S Majumdar
Rishi Ram Ghimire (TWAS-BOSE)	Arup Kumar Raychaudhuri
Samapan Sikdar (UGC)	Jaydeb Chakrabarti & Mahua Ghosh
Sayani Chatterjee (CSIR)	Punyabrata Pradhan
Suman Das (CSIR)	Ranjit Biswas
Victor U J Nwankwo (TWAS-BOSE)	Sandip Kumar Chakrabarti
2012-2013:	
Abhijit Maity (INSPIRE)	Manik Pradhan
Abhishek Roy (SNB)	Sandip Kumar Chakrabarti
Ambalika Biswas (SNB)	Amitabha Lahiri
Anindita Mondal (SNB)	Ramkrishna Das & Soumen Mondal
Arnab Deb (SNB)	Sandip Kumar Chakrabarti
Arpita Mitra (SNB)	Rabin Banerjee
Aslam Parvej (SNB)	Manoranjan Kumar
Chandrima Banerjee (CSIR)	Anjan Barman
Chiranjit Ghosh (SNB)	Manik Pradhan
Gourab Dutta Banik (INSPIRE)	Manik Pradhan
Hrishit Banerjee (SNB)	Tanusri Saha Dasgupta & Manoranjan Kumar
Karan Savio Fernandes (SNB)	Amitabha Lahiri
Kartik Samanta (SNB)	Tanusri Saha Dasgupta
Krishnendu Pal (SNB)	Gautam Gangopadhyay
Nabarun Polley (INSPIRE)	Samir Kumar Pal
Nirnay Samanta (SNB)	Rajib Kumar Mitra
Poulami Chakraborty (SNB)	Tanusri Saha Dasgupta
Rupali Rakshit (SNB)	Kalyan Mandal
Sagar Sarkar (CSIR)	Priya Mahadevan
Samim Sardar (SNB)	Samir Kumar Pal

2012-2013:	Supervisor
Somnath Dutta (SNB)	Soumen Mondal
Subarna Datta (SNB)	Barnali Ghosh (Saha)
Subrata Dev (SNB)	Sakuntala Chatterjee
Suman Som (SNB)	Manik Pradhan
Sumanto Chanda (SNB)	Partha Guha
Supriyo Ghosh (SNB)	Soumen Mondal
Susobhan Choudhury (CSIR)	Samir Kumar Pal
2013-2014:	
Arindam Ghosh (SNB)	Sandip Kumar Chakrabarti
Poonam Kumari (SNB)	Priya Mahadevan
Prasenjit Kar (SNB)	Samir Kumar Pal
Raj Kumar Sadhu (SNB)	Sakuntala Chatterjee
Rakesh Das (SNB)	Manoranjan Kumar
Ransell Richard Dsouza (SNB)	Sugata Mukherjee & Tanusri Saha Dasgupta
Ravindra Singh Bisht (SNB)	Arup Kumar Raychaudhuri
Sankar Das (SNB)	Subhra Jana
Shaili Sett (SNB)	Arup Kumar Raychaudhuri
Snehasish Rana (SNB) (till 04-08-2015)	Gautam Gangopadhyay
Souvanik Talukdar (SNB)	Kalyan Mandal
Subhadip Chakraborti (SNB)	Punyabrata Pradhan
Sutapa Dutta (INSPIRE)	Jaydeb Chakrabarti & Mahua Ghosh

JUNIOR RESEARCH FELLOW

2012-2013:	
Suman Aich (SNB) (till 01-10-2015)	Anita Mehta
2014-2015:	
Anuvab Banerjee (SNB)	Sandip Kumar Chakrabarti
Aritra Narayan Bose (SNB)	Biswajit Chakraborty
Debasmita Maiti (SNB)	Manoranjan Kumar
Ejaj Tarif (SNB)	Ranjit Biswas
Indranil Chakraborty (SNB)	Kalyan Mandal
Juriti Rajbangshi (SNB)	Ranjit Biswas
Pallabi Paul (SNB)	Tanusri Saha Dasgupta
Priya Singh (SNB)	Samir Kumar Pal
Sudipta Pattanayak (SNB)	Shraddha Mishra & M. Sanjay Kumar
Suraka Bhattacharjee (INSPIRE)	Ranjan Chaudhury
Joydeep Chatterjee (CSIR)	Priya Mahadevan
Sarowar Hossain (TWAS-BOSE)	Pratip Kumar Mukhopadhyay
Anulekha De (INSPIRE)	Manik Pradhan
Damayanti Bagchi (INSPIRE)	Samir Kumar Pal
Debabrata Ghorai (INSPIRE)	Biswajit Chakraborty
Dhrimadri Khata (INSPIRE)	Soumen Mondal
Keshab Karmakar (INSPIRE)	Kalyan Mandal
Mahebub Alam (INSPIRE)	Kalyan Mandal

2014-2015:	Supervisor
Mithun Pal (INSPIRE)	Manik Pradhan
Samrat Ghosh (INSPIRE)	Soumen Mondal
Santanu Pan (INSPIRE)	Anjan Barman
Sucheta Mondal (INSPIRE)	Anjan Barman
Sandip Saha (RGNF)	Gautam Gangopadhyay
Subhadip Basu (SNB) (till 01-07-2015)	Rabin Banerjee
Nayuesh Sharma (CSIR)(till 25-06-2015)	Partha Mahata
Tuhin K Maji (INSPIRE)	Samir Kumar Pal
2015-2016:	
Kajal Kumbhakar (CSIR)	Ranjit Biswas
Jayita Patwari (CSIR)	Samir Kumar Pal
Aniruddha Adhikari (SNB)	Ranjit Biswas
Probir Kumar Sarkar (RGNF)	Samir Kumar Pal
Rajib Adhikary (SNB)	Jaydeb Chakrabarti
Paulamee Pandit (SNB)	Arup Kumar Raychaudhuri
Kartik Adhikary (UGC)	Anjan Barman
Souvik Roy (SNB)	Prosenjit Singha Deo
Mir Alimuddin (SNB till 29-02-2016)	Ranjan Chaudhury
Chandan Samanta (SNB)	Barnali Ghosh (Saha)
Avisek Maity (SNB)	Barnali Ghosh (Saha)
Rahul Bandyopadhyay (SNB)	Ramkrishna Das
Alik Panja (SNB)	Soumen Mondal
Arnab Sarkar (SNB)	Archan S Majumdar
Sreemanti Chakraborti (SNB) (till 23-12-2015)	Biswajit Chakraborty
Sujit Narayanan (SNB) (till 22-09-2015)	Biswajit Chakraborty
Shounak Datta (INSPIRE)	Archan S Majumdar

PROJECT FELLOWS / ASSISTANTS / TRAINEES

2011-2012:	Project PI
Shishir Kumar Pandey (PROJECT SRF)	Priya Mahadevan
2013-2014:	
Camelia Manna (PROJECT JRF)	Jaydeb Chakrabarti
Debal Kanti Singha (PROJECT Assistant) (till 14-06-2015)	Partha Mahata
Dipanjan Samanta (PROJECT Assistant) (till 30-12-2015)	Pratip Kumar Mukhopadhyay
Suvankar Das (PROJECT Assistant)	Amlan Dutta
2014-2015:	
Debmalya Ghosh (till 14-06-2015)	Partha Mahata
Mamta Gautam (PROJECT Assistant) (till 03-08-2015)	Shraddha Mishra
Sanchari Bhattacharya (PROJECT Assistant) (till 26-11-2015)	Shraddha Mishra
Sayan Baral (till 01-07-2015)	Soumendu Datta
Suchetana Goswami (PROJECT JRF)	Archan S Majumdar
Soumi Bhuin (PROJECT JRF) (till 30-11-2015)	Tanusri Saha Dasgupta
Somonnita Roy (PROJECT JRF)	Abhijit Mookerjee
Tuhin Kumar Maji (PROJECT JRF) (till 15-04-2015)	Samir Kumar Pal

2014-2015:	Project PI
Probir Kumar Sarkar (PROJECT JRF) (till 31-07-2015)	Samir Kumar Pal
Shounak Datta (PROJECT JRF) (till 31-07-2015)	Archan S Majumdar
2015-2016:	
Animesh Basak (PROJECT JRF)	Pratip Kumar Mukhopadhyay
Dhiraj Tapader (PROJECT JRF)	Punyabrata Pradhan
Ramesh Nandi (PROJECT JRF)	Samir Kumar Pal
Shubham Agarwal (PROJECT JRF)	Soumendu Datta

RESEARCH SCHOLARS - INTEGRATED PhD (IPhD) PROGRAMME

EXTENDED SENIOR RESEARCH FELLOW

2009-2010	Supervisor
Ashutosh Kumar Singh (SNB) (PhD submitted on 02-08-2015)	Kalyan Mandal

SENIOR RESEARCH FELLOW

2008-2009 :	
Sukla Pal (SNB) (till 31-07-2015)	Jayanta K Bhattacharjee
2009–2010:	
Arnab Ganguly (SNB)	Anjan Barman
Biplab Bhattacherjee (SNB)	Subhrangshu Sekhar Manna
Debanjan Polley (SNB)	Anjan Barman & Rajib Kumar Mitra
Subhasish Chakrabarty (SNB)	Amitabha Lahiri
Arghya Das (SNB)	Punyabrata Pradhan
2010–2011:	
Arpan Krishna Mitra (SNB)	Rabin Banerjee
Soumyakanti Bose (SNB)	M. Sanjay Kumar
Suman Dutta (SNB)	Jaydeb Chakrabarti
2011–2012:	
Anita Halder (SNB)	Tanusri Saha Dasgupta
Chandreyee Roy (SNB)	Subhrangshu Sekhar Manna
Debasish Das Mahanta (INSPIRE)	Rajib Kumar Mitra
Shauri Chakrabarty (SNB)	Sakuntala Chatterjee
Sumanta Kundu (SNB)	Subhrangshu Sekhar Manna

JUNIOR RESEARCH FELLOW

2012–2013:	
Arkadev Roy (till 20-07-2015)	Priya Mahadevan
Ayan Bhattacharjee (SNB)	Sandip Kumar Chakrabarti
Kausik Chanda (SNB)	Ranjit Biswas
Monalisa Singh Roy (SNB)	Manoranjan Kumar
Samiran Choudhury (SNB)	Anjan Barman
Saurav Singha (SNB) (till 11-02-2016)	Soumen Mondal
Sudhanshu Ranjan (CSIR)	Gautam Gangopadhyay
Vibhuti Narayan Rai (SNB)	Arup Kumar Raychaudhuri
2013–2014:	
Amal Garai (SNB)	Punyabrata Pradhan
Ankan Pandey (SNB)	Partha Guha

2013–2014:

	Supervisor
Avinash Kumar Chaurasiya (INSPIRE)	Anjan Barman
Debalina Banerjee (SNB)	Priya Mahadevan
Kumar Neeraj (SNB)	Rajib Kumar Mitra
Riddhi Chatterjee (SNB)	Archan S Majumdar
Ritam Basu (SNB)	Amitabha Lahiri
Sanchi Maithani (INSPIRE)	Manik Pradhan
Santanu Mandal (SNB)	Manik Pradhan
Sourav Kumar Misra (SNB)	Jaydeb Chakrabarti

INTEGRATED PhD (IPhD) PROGRAMME

2014–2015:

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

2015–2016:

- Anupam Gorai
- Atul Rathor
- Shantonu Mukherjee
- Shashank Gupta
- Sudip Majumder
- Surya Narayan Panda
- Swarnali Hait

PART-TIME RESEARCH SCHOLARS - PhD PROGRAMME

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

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

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

Chaitali Dey, Condensed Matter Physics and Material Sciences, under Kalyan Mandal and Madhuri Mandal

Deblina Majumder, Condensed Matter Physics and Material Sciences, under Kalyan Mandal

Debmalya Mukhopadhyay, Theoretical Sciences, under Amitabha Lahiri

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

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

***Piya Patra*,** Chemical, Biological & Macro-Molecular Sciences, under Jaydeb Chakrabarti

***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

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

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

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

Soumi Roy Chowdhury, Condensed Matter Physics and Material Sciences, under Ranjan Chaudhury

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

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

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

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

Amitabha Lahiri
Dean, Academic Programme

Extended Visitors' & Linkage Programme

The S. N. Bose National Centre for Basic Sciences fosters, encourages and promotes the growth of advanced studies and original research in basic sciences. One of the important mandates of the Centre is to have a vigorous outreach and extension programme that would enhance the scientific activities and expand the science base in the country. The Centre's Visitors' Programme and its associated activities are coordinated by the EVLP Office.

Seminar and Colloquia Programme

Memorial Lecture	:	1
Bose Colloquium	:	2
Special Lecture	:	2
Institute Seminar / Colloquium	:	16

Memorial Lecture

Date	Speaker & Affiliation	Lecture & Title
12.06.15	Dr. Stuart S. P. Parkin, Director, Max Planck Institute for Microstructure Physics, Halle, Germany & IBM Fellow, IBM Almaden Research Center, California, USA	**11th C. K. Majumdar Memorial Lecture** *Spintronic and Ionitronic Computing Technologies*

Bose Colloquium

Date	Speaker & Affiliation	Title
12.06.15	Prof. Claudia FELSER, Max Planck Institute of Chemical Physics for Solids, Dresden, Germany	*Topology in Heusler compounds - from a materials perspective*
05.08.15	Prof. Sanjay Puri, School of Physical Sciences, Jawaharlal Nehru University, New Delhi	*Kinetics of Phase Transitions*

Special Lecture

Date	Speaker & Affiliation	Title
24.04.15	Prof. B. M. Deb, INSA, New Delhi and Visva-Bharati University, Santiniketan	*Glimpses into Indian Mathematics, from 3300 B.C. to Around 1600 A.D.*
18.11.15	Dr. Santanu K. Tripathi, Professor & Head, Department of Clinical & Experimental Pharmacology, Calcutta School of Tropical Medicine, Kolkata	*Medicines and You - Health and Medication Literacy*

Institute Seminar/ Colloquium

Date	Speaker & Affiliation	Title
05.05.15	Prof. Shri Singh, Department of Physics, Banaras Hindu University, Varanasi	*Phase Transitions in Liquid Crystals: Ordering kinetics in nematics and properties of ferroic mesogens*
15.05.15	Dr. Rajarshi Chakrabarti, Department of Chemistry, IIT Bombay	*Looping dynamics of a single flexible chain with internal friction*
06.07.15	Prof. Rama Kant, Complex Systems Group, Department of Chemistry, University of Delhi	*Influence of Nanoscopic Disorder in Electrochemical Processes*
17.07.15	Prof. Venimadhav Adyam, Cryogenic Engineering Centre, IIT Kharagpur	*Magnetic phenomena, multiferroicity and the effect of antisite disorder in R2CoMnO6 (R-rare earth) double perovskites*
07.08.15	Dr. Ayanjeet Ghosh, Department of Chemistry, University of Wisconsin-Madison	*Structures and dynamics in peptides and proteins using two-dimensional infrared and sum frequency generation spectroscopy*
14.08.15	Dr. Ujjaini Alam, Cosmology Group, ISI Kolkata	*Constraining the Nature of Dark Energy from Cosmological Observations*
09.10.15	Dr. Chia-Fu Chou, Institute of Physics; Genomics Research Center; Research Center for Applied Sciences, Academia Sinica, Taipei, Taiwan	*Nanobiophysics: using nanoscale structures to study molecular and cellular biophysics*
04.11.15	Dr. Ranjini Bandyopadhyay, Raman Research Institute, Bengaluru	*Microscopic structures and yielding of colloidal clay dispersions in the presence of salt*
26.11.15	Dr. Bijay Kumar Agarwalla, CQIQC, University of Toronto, Canada	*Charge and Energy transfer in molecular junctions: models, methods, mechanisms and fundamental aspects*
18.12.15	Dr. Dhrubaditya Mitra, NORDITA, Stockholm	*Turbulent Soret Effect*
14.01.16	Dr. John W. Freeland, Physicist, X-ray Science Division, Argonne National Laboratory, USA	*Exploring Non-Equilibrium Phases of Complex Oxide Heterostructures*
20.01.16	Prof. Betti Hartmann, Instituto de Física de São Carlos Universidade de São Paulo, Brasil	*The influence of the Gauss-Bonnet interaction on the properties of boson stars and hairy black holes*
29.01.16	Dr. Hidemaro Suwa, Department of Physics, The University of Tokyo, Japan	*Phase-Transition Study of Spin-Phonon Systems by Worldline Quantum Monte Carlo Breaking Detailed Balance*
23.02.16	Prof. Ramesh Pai, Department of Physics, Goa University	*Bose-Hubbard models in optical lattices*
07.03.16	Prof. Richard Buchner, Institut fuer Physikalische und Theoretische Chemie, Universitaet Regensburg, Germany	*Cooperative Dynamics and Solvation Processes in Ionic Liquid + Solvent Mixtures*
09.03.16	Prof. Richard Buchner, Institut fuer Physikalische und Theoretische Chemie, Universitaet Regensburg, Germany	Dielectric spectroscopy - a versatile tool in *solutions chemistry*

Bose Fest 2016

- All students belonging to 4th & 5th year delivered oral presentations; 2nd & 3rd year students prepared poster presentations.
- All Oral presentations were 15 (12 + 3) minutes duration. All modes of presentations were arranged in alphabetical order.
- 40 Talks and 38 posters were presented during the scientific/technical session.
- All faculties were requested to evaluate the scientific/technical sessions.
- Cultural programme was organized by *Muktangan* followed by a Family Banquet Dinner on 30 March 2016 while national award winning singer Shri Rupankar Bagchi was invited to perform at the Centre on 31 March 2016.
- Awards included a total of 18 prizes for the best talk and poster presentations at Rs. 1500/- each. 10 prizes were given in the poster category and 8 prizes (2 prizes from each of the four departments) in the Talk category.

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 2015**	Dr.Saswati Dasgupta (Rammohan College) & Prof. Kalyan Mandal (SNBNCBS)	Total- 2,90,000/- SNBNCBS Support 1,50,000/-	50	50	---	30	26.05.15 – 05.06.15
2.	**Workshop on Advanced Tools for Nanoscopic Materials Characterization (ATNMC2015)**	Dr. Barnali Ghosh Saha (SNBNCBS)	Total - 4,52,700/- SNBNCBS Support - 2,02,700/-	100	100	-----	80	05.11.15 – 07.11.15
3.	**DAE - BRNS Thematic Meeting on Ultrafast Science (UFS2015)**	Prof. Anjan Barman (SNBNCBS) & Prof. Dipak Palit (BARC)	Total - 5,50,000/- SNBNCBS Support - 1,80,000/-	95	90	5	60	19.11.15 – 21.11.15
4.	**Discussion Meeting on Quantum Mechanics**	Prof. Archan S. Majumdar (SNBNCBS) & Prof. Dipankar Home (Bose Institute)	Total - 48,000/- SNBNCBS Support - 38,000/-	35	34	1	28	07.12.15
5.	**Field Theoretic Aspects of Gravity (FTAG XI-2016)**	Prof. Amitabha Lahiri & Prof. Biswajit Chakraborty (SNBNCBS)	Total - 403,000/- SNBNCBS Support - 203,000/-	55	54	1	32	22.02.16 – 26.02.16

Bose Fest

Oral Presentation, Bose Fest 2016

Q&A Session, Bose Fest 2016

Poster Presentation, Bose Fest 2016

Prize Distribution, Bose Fest 2016

Sri Rupankar Bagchi, invited artist, Bose Fest 2016

Cultural Programme, Bose Fest 2016

Extended Visitors' Linkage Programme

11TH C.K MAJUMDAR MEMORIAL LECTURE

ATNMC2015

DISTINGUISHED LECTURE SERIES

DMQM 2015

C.K. MAJUMDAR MEMORIAL SUMMER WORKSHOP IN PHYSICS

UFS2015

FTAG XI 2016

Advanced Post-doctoral Manpower Programme

Post Doctoral Research Associates (PDRA) on roll - 20

Sl. No.	Name	RA Status	Mentor / Department
1	Tilak Das	PDRA I	Prof. T.S. Dasgupta/ Condensed Matter Physics & Material Sciences
2	Suman Ghosh	PDRA II	Prof. Amitabha Lahiri/Theoretical Sciences
3	Sanchari Goswami	PDRA I	Dr. Sakuntala Chatterjee/Theoretical Sciences
4	Partha Sarathi Pal	PDRA II	Prof. Sandip Chakrabarti/Astrophysics & Cosmology
5	Rohit Kumar	PDRA I	Prof. Amitabha Lahiri/ Theoretical Sciences
6	Pabitra Mandal	PDRA I	Prof. A.K Raychaudhuri/Condensed Matter Physics & Material Sciences
7	Lakshmi Maganti	PDRA I	Prof. Jaydeb Chakrabarti/Chemical Biological & Macromolecular Sciences
8	Dipak Kumar Das	PDRA I	Dr. Rajib K. Mitra/Chemical Biological & Macromolecular Sciences
9	Amna Ali	PDRA II	Prof. Archan S. Majumdar/Astrophysics & Cosmology
10	Shreyasi Dutta	PDRA I	Prof. Samir K. Pal/Chemical Biological & Macromolecular Sciences
11	Indrani Banerjee	PDRA I	Prof. Sandip Chakrabarti/Astrophysics & Cosmology
12	Manas Mondal	PDRA I	Prof. Jaydeb Chakrabarti/Chemical Biological & Macromolecular Sciences
13	Dayasindhu Dey	PDRA I	Dr. Manoranjan Kumar/ Condensed Matter Physics & Material Sciences
14	Kumar Abhinav	PDRA I	Dr. Samir Kumar Paul, Prof. Partha Guha/ Theoretical Sciences
15	Tapas Paramanik	PDRA I	Prof. P.K Mukhopadhyay/Condensed Matter Physics & Material Sciences
16	Ravikant Verma	PDRA I	Prof. Biswajit Chakraborty/Theoretical Sciences
17	Sumona Sinha	PDRA I	Prof. Anjan Barman/Condensed Matter Physics & Material Sciences
18	Subhashis Rana	PDRA I	Dr. Punyabrata Pradhan/Theoretical Sciences
19	Soumen Dhara	PDRA II	Prof. A.K Raychaudhuri/Condensed Matter Physics & Material Sciences
20	Ankita Ghatak	PDRA I	Dr. Barnali Ghosh Saha/Condensed Matter Physics & Material Sciences

Visitor, Associates and Students Programme

Dates	Distinguised Lecture Series	
	Speaker & Affiliation	Title of the Talks
16 - 20 November 2015	Professor Thanu Padmanabhan Distinguished Professor, IUCAA, Pune	• Newtonian gravity • Statistical mechanics of gravitating system • Electrostatics in weak gravitational field • Action principle for general relativity • The atoms of space and the nature of gravity

Name of the Visitor	Associates and Short Term Visitors			Host Faculty/ Department
	Affiliation	Period of stay		
		Date From	Date to	
Dr. B. Rajini Kanth (*Associate*)	T. K. R. College of Engineering &Technology, Hyderabad	25.03.15 17.06.15 01.01.16	05.04.15 15.07.15 17.01.16	Prof. P. K Mukhopadhyay/ Condensed Matter Physics & Material Sciences
Dr. Bikash Chandra Paul (Associate)	North Bengal University, Siliguri	16.05.15 19.03.16	24.05.15 27.03.16	Prof. Archan S. Majumdar/ Astrophysics & Cosmology
Dr. Pralay K. Karmakar	Tezpur University, Assam	29.11.15	04.12.15	Prof. Partha Guha/ Theoretical Sciences
Dr. Sujoy Modak	KEK, Japan	21.12.15	23.12.15	Prof. Rabin Banerjee / Theoretical Sciences
Dr. Broja Gopal Dutta	Rishi Bankim Chandra College, Naihati, West Bengal	25.05.15	04.06.15	Prof. Sandip Chakrabarti/ Astrophysics & Cosmology
Dr. Vincent Caudrelier	City University, London	23.06.15	01.08.15	Prof. Partha Guha/ Theoretical Sciences
Mr. Subhadeep Roy	IMSc, Chennai	01.07.15	07.07.15	Prof. Subhrangshu S. Manna/ Theoretical Sciences
Prof. Ramesh Anishetty	IMSc, Chennai	16.08.15	22.08.15	Prof. Manu Mathur/ Theoretical Sciences
Dr. Tanumoy Pramanik	LTCI, Telecom ParisTech, France	16.08.15	27.08.15	Prof. Archan S. Majumdar/ Astrophysics & Cosmology

Name of the Visitor	Affiliation	Period of stay		Host Faculty/ Department
		Date From	Date to	
Prof. D.D. Sarma (*Honorary Professor*)	IISc. Bangalore	04.09.15	04.09.15	Prof. Tanusri S. Dasgupta / Condensed Matter Physics & Material Sciences
Prof. Arnab Rai Choudhuri	IISc. Bangalore	30.09.15	30.09.15	Prof. Partha Guha/ Theoretical Sciences
Dr. Sujit Sarkar (*Associate*)	PPISR, Bangalore	07.11.15	13.11.15	Prof. Prosenjit S. Deo & Dr. Manoranjan Kumar/ Condensed Matter Physics & Material Sciences
Prof. Mukunda P. Das	ANU, Canberra	25.11.15	29.11.15	Dr. Ranjan Chaudhury/ Condensed Matter Physics & Material Sciences
Dr. Gargi Shaw	University of Mumbai	28.12.15	01.01.16	Dr. Soumen Mondal & Dr. Ramkrishna Das/ Astrophysics & Cosmology
Dr. Kuldeep Kumar	Panjab University, Chandigarh	06.12.15	07.01.16	Prof. Rabin Banerjee / Theoretical Sciences
Dr. Jessy Jose	Kavli Institute, Beijing	11.01.16	15.01.16	Dr. Soumen Mondal / Astrophysics & Cosmology
Prof. Sibasish Ghosh	IMSc. Chennai	23.03.16	28.03.16	Prof. Archan S. Majumdar / Astrophysics & Cosmology

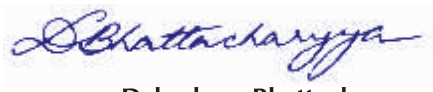
Summer Research Programme (May - July 2015)

Sl. No.	Supervisor	Candidate	Male / Female	Affiliation	Funded by
1	Prof. Kalyan Mandal	Esma Khatun	F	IIT Madras	SNBNCBS
2	Dr. Madhuri Mandal	Kaushik Baishya	M	Tezpur University, Assam	SNBNCBS
3	Prof. Archan S. Majumdar	Nilesh Vyas	M	NISER, Bhubaneswar	INSPIRE
4	Dr. Rajib Kumar Mitra	Debkumar Rana	M	ISM, Dhanbad	SNBNCBS
5	Prof. Anjan Barman	Ankan Mukhopadhyay	M	IIT, Guwahati	SNBNCBS
6	Prof. Samir K. Pal	Aniruddha Adhikari	M	Calcutta University	SNBNCBS
7	Prof. Pratip K. Mukhopadhyay	Ushnanshu Dutta	M	Pune University	INSPIRE
8	Prof. S. S. Manna	Suchismita Das	F	University of Delhi	SNBNCBS
9	Dr. Manik Pradhan	Manobina Karmakar	F	IIT Kanpur	INSPIRE
10	Prof. Gautam Gangopadhyay	Piyali Das	F	IIT Guwahati	SNBNCBS
11	Prof. Biswajit Chakraborty	Ashwin Krishnan	M	BITS Pilani	IAS
12	Dr. Soumen Mondal	Labanya Bhattacharya	F	ISM Dhanbad	SNBNCBS
13	Prof. Ranjit Biswas	Navya Sudha L.Batta	F	Andhra University	IAS
14	Prof. Priya Mahadevan	Gokul Ramesh	M	IIT Madras	IAS
15	Dr. Manoranjan Kumar	Shridhar S.Puranik	M	Fergusson College, Pune	SNBNCBS

Total Students - 15; Male - 9, Female - 6; Centre funded - 9 IAS funded - 3, INSPIRE funded - 3

Network Projects and Exchange Programme

Project	Investigators	Project Number	Date of Commencement	Sanctioned Amount	Remarks
Fabrication of Nano Junction between High Tc and Normal Metal Nano Wires and further Study	Dr. Barnali Ghosh (Saha) PI Dr. Nilotpal Ghosh (External) Prof. Pratip K. Mukhopadhyay (Co-PI)	SNB/BG/ 14-15/130	26/5/2014	Rs.5 L	Synthesis and characterization of nano junctions done
Extension / Upgradation of IAPT Midnapore College Centre for Scientific Culture	Prof. Pratip K. Mukhopadhyay (PI) Dr. Paritosh Dutta (Co-PI) (External)	SNB/PKM/ 14-15/131	26/5/2014	Rs.5 L	Instruments bought, undergraduate/ postgraduate students are working, conferences & workshops conducted



Debashree Bhattacharyya
Extended Visitors' & Linkage Programme Coordinator

Theoretical Physics Seminar Circuit

Academic visits:

- Dr. Sourin Das, Assistant Professor, Department of Physics & Astrophysics, University of Delhi, visited the Centre from 29th June 2015 to 1st July, 2015 and delivered a talk entitled "Non Abelian state of matter: theoretical and experimental developments".
- Dr. Julius Jellinek, Senior Scientist, Chemical Sciences and Engineering Division, Argonne National Laboratory, USA, visited the Centre during 13-16 March 2016 and delivered a talk entitled "Computational Electron Spectroscopy - A Powerful Tool for Exploration of Size, Structure, Charge-State, and Composition Effects on the Nanoscale".

The Advanced Research Workshop :

7th Vidyasagar-Satyendranath Bose National Workshop on Theory and Application for Advanced Materials (TAAM 2016) was organized during 15-17 March, 2016 at Department of Physics & Technophysics, Vidyasagar University Campus, Midnapore. The total number of participants was 196.

Sakuntala Chatterjee

Sakuntala Chatterjee

Convener, Theoretical Physics Seminar Circuit

Registrar

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 2015-2016 successful. Staff comprising of strength of approximately 19 in permanent, 12 in temporary and 46 in contractual category as on 31st March 2016, 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 service 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 requirements. The Centre has successfully handled Audit Queries, Parliamentary Questions and various factual informations. 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 2015-2016. The Centre has also adhered to the norms of the Right to Information Act and so far has received 20 (Twenty) cases under the said Act in the last financial year all of which has been successfully disposed off.

Dr. Harsh Vardhan, Union Minister for Science and Technology visited Satyendra Nath Bose National Centre for Basic Sciences (SNBNCBS), Kolkata on 3rd May 2015. Dr. Harsh Vardhan addressed the staff and students of the Centre at Silver Jubilee Hall. He talked about various projects and inventions related to the Centre. He also visited the Centre's various Laboratory facilities. Scientists of the Centre displayed to the Minister their success with (i) developing a non-invasive, diagnostic method to detect H-Pylori and peptic ulcer infections. Type-2 Diabetes and irritable bowel syndrome through breathe analysis, thus doing away with the necessity of undergoing costly and painful forms of traditional diagnostic methods (ii) the process of detecting jaundice by measuring Bilirubin levels in the human eye through shining a beam of white light using a simple LED lamp into

the eye. The Hon'ble Minister expressed satisfaction regarding these instruments and stated that they would find high use in the world market. They would reduce the out-of-pocket expenditure of patients. Most importantly, neonatal jaundice deaths, which comprise by 18 percent of newborn mortality in India, could be reduced as many new mothers disallow timely detection through the traditional method of drawing blood which is painful. On the new Astronomical observatory to be set up, Dr. Harsh Vardhan opined that the establishing of an observatory in eastern India was long overdue.

The Centre organized one-day workshop on 'Gender Sensitization – Issues at Workplace' on 27th May, 2015. The prime focus of the programme was to highlight the menace of Sexual Harassment with special reference to working women. It was organized in the Centre's Silver Jubilee Hall. Around 150 participants registered online for the workshop, including staff, students and faculty members of the Institute and 121 members participated in the same. Members from other Institute's like Saha Institute of Nuclear Physics (SINP), Indian Association for the Cultivation of Science, Kolkata (IACS), Jadavpur University, IISER, Kolkata were also present as invitees in the workshop. The sessions were coordinated by Mrs. Chama Mukherjee, Advocate, Calcutta High Court and Member, Complaints Committee, S.N. Bose Centre. The workshop was graced by eminent speakers like Dr. Bhaswati Chakravorty, Associate Editor, The Telegraph, Prof. Shobhana Narasimhan, Professor, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Ms. Ruchira Gupta, founder and President of 'Aapne Aap Women Worldwide' and Hon'ble Justice Altamas Kabir, Former Chief Justice of India. Topics covering issues related to harassment, media's role in gender discrimination, real life experiences, misconception regarding gender bias, provisions in the Constitution of India were spoken on and deliberated upon. The Question Answer session at the end of the lecture sessions were very fruitful and interactive. The speakers addressed various questions raised by the participants. A 'Feedback Form' was distributed alongwith the registration kit, wherein some positive feedbacks and suggestions by the participants were received.

As part of Vigilance Awareness Week 2015 during 26th October 2015 to 31st October 2015, the Centre organised an Essay Competition (Topic: "Moral Values & Ethics in Good Governance"). The essay competition carried a cash award of Rs.5,000/- (1st prize), Rs.3,000/- (2nd prize) and Rs.1,000/- (3rd prize). The winners were:

- 1st Prize - Mr. Amit Roy, Technical Assistant (Library)
- 2nd Prize – Md Injamamul Arif, Senior Research Fellow
- 3rd Prize – Mr. Gurudas Ghosh, Technical Assistant (Library)

Official Language Policy

The Centre paid emphasis on implementation of the Official Language in the year 2015-16. 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 14th September 2015 by Prof. Sibaji Raha, Director in presence of Prof. Subrata Lahiri, HOD Hindi, Rabindra Bharati University, Shri. R.N.Saroj, Dy. Director, Hindi Teaching Scheme, MHA, Govt. of India and Shri. Vipati, Teacher, Hindi Teaching Scheme, MHA, Govt. of India. The hindi mahina was celebrated through screening of Hindi Film 'ANGUR', staging of an in house Cultural programme by staff members 'KACHRE KA DUBBA', Hindi play 'BHOOL RASTHA' performed by 'Padatik' group and a Hindi Quiz programme. The Centre also organised a Hindi Essay Competition. The title of the essay was "Role of Science &

Technology in Swach Bharat Mission" with a maximum of 750 words. The essay competition carried a cash award of Rs.5,000/- (1st prize), Rs.3,000/- (2nd prize) and Rs.2,000/- (3rd prize). The winners were:

- 1st Prize - Mr. Gurudas Ghosh, Technical Assistant (Library)
- 2nd Prize – Mr. Shishir Kumar Pandey, Senior Research Fellow
- 3rd Prize – Mr. Bhushan Omprakash Awasarmol, Scientist 'D' (Computer Engineer).

The Centre organised 'Hindi Workshops' on i) 11th June 2015 where Shri Hrishikesh Ray, Deputy Director (Rajbhasha), Tea Board, Kolkata spoke on "Rajbhasha Karyanavyan – Karmachariyo ka Dayitya" and on ii) 4th September 2015 where Shri Rajeshwar Vaishishtha, Chief Manager (OL Dept), Allahabad spoke on "Bharat Sarkar ki Rajbhasha Niti Ebong Sarkari Sansthano Mein Uska Safal Karyaniyan". Both the occasions were graced by Shri Vipati, Teacher, Hindi Teaching Scheme, MHA, Govt. of India.

Welfare Measures and Facilities

The Centre has the Contributory Medical Scheme (CMS) under which 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 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 provisions for providing accommodation to its Post Doctoral Fellows.

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.

For recreational facilities 'Muktangan' has been created to promote various creative activities in the Centre divided into 5 broad activities viz. Performing Arts, Literary Arts, Visual Arts, Sports Activities and Social Outreach. 'Muktangan' organised several programmes under its aegis during the year 2015-16.

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. Sibaji Raha, former Director (till February 2016), and Prof. Santanu Bhattacharya, present Director (since March 2016) for their valuable guidance and advice.

Shohini Majumder
Registrar

Committees

Governing Body

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Homi Bhabha Chair Professor
Department of Atomic Energy
Bhabha Atomic Research Centre

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

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Emeritus Scientist
Former Director, IIG, Mumbai

Prof. Sudha Bhattacharya
Member
Professor
School of Environmental Sciences
JNU, New Delhi

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Professor
Dept. of Physics, IIT, Kanpur

Prof. R.C.Budhani — Member
Department of Physics
Center of Laser Technology
IIT, Kanpur

Prof. Santanu Bhattacharya — *Member*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Sibaji Raha — *Member*
Director
Bose Institute

Shri J.B. Mohapatra — *Member*
Joint Secretary & Finance Advisor
Department of Science & Technology
Government of India, New Delhi

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

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

Finance Committee

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S. N. Bose National Centre for Basic Sciences
Kolkata

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Former Director
UGC-DAE Consortium for Scientific Research
Indore

Shri. J.B.Mohapatra — *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

Academic & Research Programme Advisory Committee

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Former Director
UGC-DAE Consortium for Scientific Research
Indore

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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. Santanu Bhattacharya *Member*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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

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

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

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

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

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

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

Building Committee

Prof. Santanu Bhattacharya *Chairman*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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

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

Shri. Ranadhir Dey *Member*
Outstanding Scientist,
VECC, Kolkata

Mr. Sujit Kr. Dasgupta *Special Invitee*
Superintending Engineer
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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Prof. Santanu Bhattacharya *Chairman*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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

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

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

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

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

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

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

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

Official Language Implementation Committee

Prof. Santanu Bhattacharya *Chairman*
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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

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

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

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

Ms. Sadhana Tiwari *Member*
Hindi Officer
S. N. Bose National Centre for Basic Sciences
Kolkata

People at the Centre
Academic Members

Faculty Members

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

Distinguished Professor (Emeritus)

1	Arup Kumar Raychaudhuri	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

Scientist-D

1	Amitava Moitra (till 11.06.2015)	TUECMS
2	Bhushan Omprakash Awasarmol	TUECMS
3	Biswaroop Mukherjee	TUECMS
4	Jaivardhan Sinha	TUENDT
5	Kaustuv Das	TUENDT
6	Saswati Barman (till 31.03.2016)	UNANST
7	Shreemoyee Ganguly (from 10.08.2015)	TUECMS

DST Inspire Faculty Members

1	Amlan Dutta	CMPMS
2	Partha Mahata (till 14.06.2015)	CMPMS
3	Shradha Mishra (till 26.11.2015)	TS
4	Soumendu Datta	CMPMS
5	Subhra Jana	CBMS

Visiting Faculty Members

1	Madhuri Mandal	CMPMS
2	Srabanti Ghosh (till 07.10.2015)	CBMS
3	Sugata Mukherjee	CMPMS

Young Scientist

1	Alo Dutta	CMPMS

Post Doctoral Research Associates

1	Amna Ali (from 16.04.2015)	A&C
2	Ankita Ghatak	CMPMS
3	Dayasindhu Dey	CMPMS
4	Dipak Kumar Das (from 17.04.2015)	CBMS
5	Goutam Kumar Chandra (till 30.09.2015)	CBMS
6	Jashashree Ray	CMPMS
7	Kumar Abhinav (from 16.02.2016)	TS
8	Lakshmi Maganti	CBMS
9	Manas Mondal (from 02.07.2015)	CBMS
10	Pabitra Mandal	CMPMS
11	Partha Sarathi Pal (till 31.10.2015)	A&C
12	Rakhi Acharyya (from 01.09.2015)	CMPMS
13	Ravikant Verma (from 01.03.2016)	TS
14	Rohit Kumar (till 12.11.2015)	TS
15	Rabaya Basori (from 03.09.2015)	CMPMS
16	Rajib Nath	CMPMS
17	Sanchari Goswami (till 19.08.2015)	TS
18	Shreyasi Dutta (from 11.06.2015)	CBMS
19	Soumen Dhara (from 22.06.2015)	CMPMS
20	Shubhashis Rana (from 10.03.2016)	TS
21	Suman Ghosh (till 01.07.2015)	TS
22	Sumona Sinha (from 16.03.2016)	CMPMS
23	Tanumoy Pramanik (from 14.01.2016)	A&C
24	Tapas Paramanik (from 16.02.2016)	CMPMS
25	Tilak Das (till 17.04.2015)	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 and Technical Staff Members

Shohini Majumder	Registrar
Gautam Gangopadhyay	Vigilance Officer
Saumen Adhikari	Public Information Officer

Other Members

Apurba Kanti Sarkar	Deputy Registrar (Finance)
Nibedita Konar	Deputy Registrar (Academic)
Saumen Adhikari	Librarian cum Information Officer
Sukanta Mukherjee	Sr. Assistant Registrar (Projects)
Santosh Kumar Singh	Assistant Registrar (Purchase) & Officiating as Deputy Registrar (Administration)
Sirsendu Ghosh	Programme Coordinating Officer
Tapan Kumar Sen	Senior Programme Assistant (superannuated on 31st August 2015)
Achyut Saha	Personal Assistant to Director
Jaydeep Kar	Programme Assistant
Prosenjit Talukdar	Programme Assistant
Shiba Prasad Nayak	Pump Operator
Bijoy Kumar Pramanik	Junior Assistant (Guest House)
Bhupati Naskar	Library Stack Assistant
Arun Kumar Bhattacharya	Library Stack Attendant (Expired on 28th May 2015)
Sushanta Kumar Biswas	Driver
Pradip Kumar Bose	Tradesman 'A'
Partha Chakraborty	Attendant
Partha Mitra	Attendant
Ratan Acharya	Attendant
Swapan Ghosh	Attendant

Personnel with Temporary Status

Biman Roy	Attendant (Administration)
Dulal Chatterjee	Attendant (Maintenance)
Somnath Roy	Attendant (Accounts)
Sudhanshu Chakraborty	Attendant (Technical Cell)
Sukamal Das	Attendant (Central Registry)
Hiralal Das	Cleaner
Kartick Das	Cleaner
Motilal Das	Cleaner
Prakash Das	Cleaner
Ramchandra Das	Cleaner
Biswanath Das	Gardener
Nimai Naskar	Gardener

Personnel on Contractual Appointment

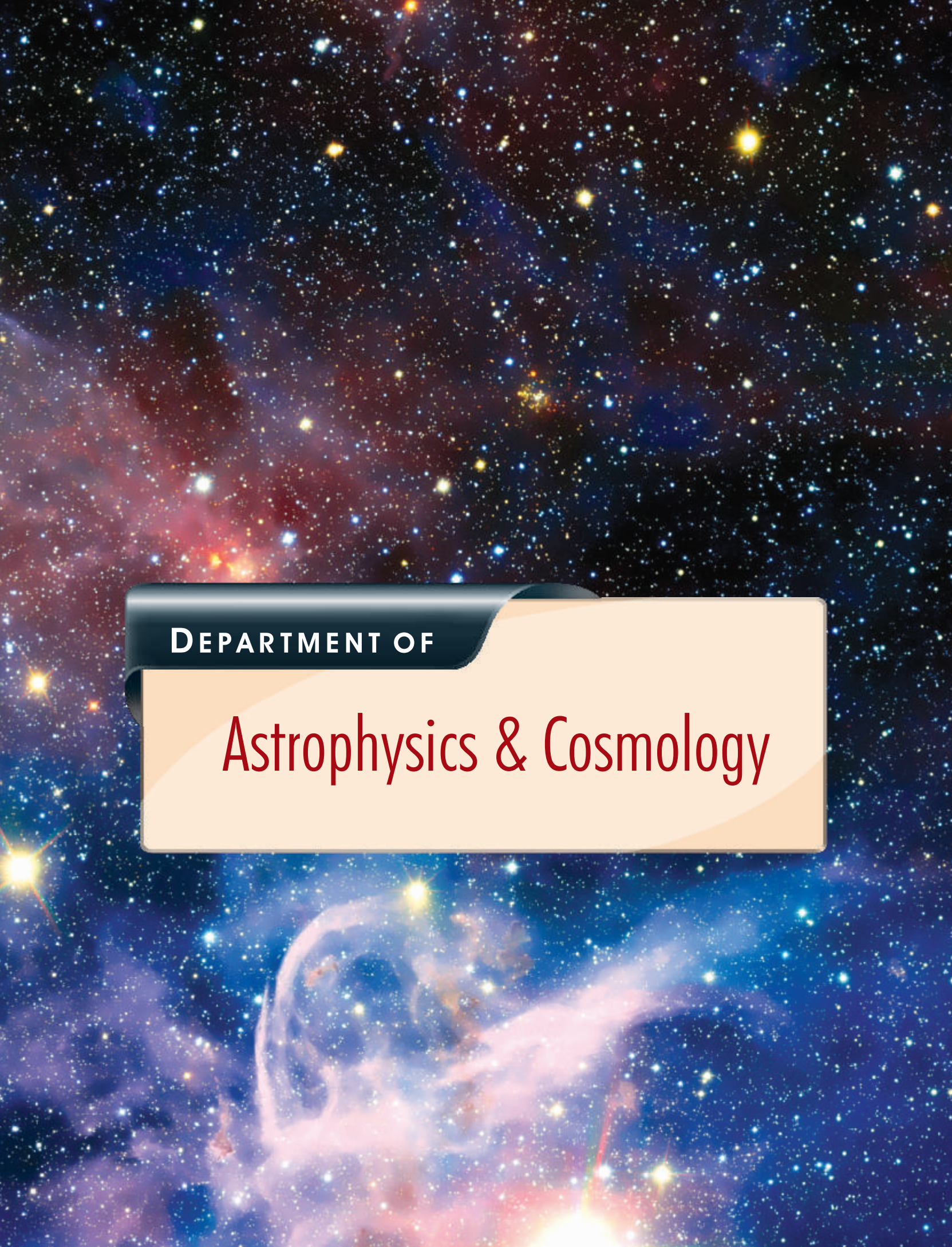
Sukumar Sarkar	Advisor (Administration)
Sunish Kumar Deb	Advisor (Liaison)
Dipankar Mukhopadhyay	Project (Advisor) (left w.e.f. 01.01.2016)
Jnanada Ranjan Bhattacharya	Superintending Engineer (left w.e.f. 01.12.2015)
Sujit Kr. Dasgupta	Superintending Engineer (joined w.e.f. 15.01.2016)
Debashree Bhattacharyya	EVLP Co-ordinator
Ayan Deb	Assistant Engineer (Electrical)
Sutapa Basu	PS to Registrar
Sadhana Tiwari	Hindi Officer (joined w.e.f. 16.03.2016)
Abhijit Ghosh	Junior Computer Engineer
Abhijit Roy	Junior Computer Engineer
Sagar Samrat De	Junior Computer Engineer
Amit Roy	Technical Assistant (Library)
Gurudas Ghosh	Technical Assistant (Library)

Ananya Sarkar	Technical Assistant (Library)
Dipankar Roy	Technical Assistant (left w.e.f. 31.10.2015)
Shakti Nath Das	Technical Assistant
Surajit Mukherjee	Technical Assistant
Urmi Chakraborty	Technical Assistant
Amit Kumar Chanda	Technical Assistant
Ganesh Gupta	Junior Engineer (Electrical)
Supriyo Ganguly	Junior Engineer (Electrical)
Amitava Palit	Junior Engineer (Civil)
Asish Nandy	Junior Engineer (Civil)
Lakshmi Chattopadhyay	Junior Engineer (Civil)
Chandrakana Chatterjee	Office Assistant
Rupam Porel	Office Assistant
Mitali Bose	Office Assistant
Suvodip Mukherjee	Office Assistant
Swarup Dutta	Office Assistant
Moumita Banik	Office Assistant
Suvendu Dutta	Office Assistant
Siddhartha Chatterjee	Office Assistant
Sonali Sen	Office Assistant
Atrayee Bhattacharya	Office Assistant (left w.e.f. 01.07.2015)
Sudipta Das	Office Assistant (joined w.e.f. 01.01.2016)
Lina Mukherjee	Jr. Office Assistant
Debasish Mitra	Telephone Operator
Amit Kumar Ghosh	Mechanic
Sani Amed Ali Molla	Technician (AC & Refrigeration)
Babulal Sardar	Technician (AC & Refrigeration)
Arvind Paswan	Driver
Gobinda Das	Driver
Kalyani Ghosh	Caretaker (Creche)
Suranjan Deb	Telephone Technician
Harishikesh Nandi	Glass Blower (Part-time)

Consultant Physician

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

BOSE CENTRE


DEPARTMENT OF
Astrophysics & Cosmology

DEPARTMENT OF

Astrophysics & Cosmology

Prof. Sandip Kumar Chakrabarti

Head of the Department

Department profile indicators

Table A	Manpower and resources	
Number of faculties		4
Number of Post -doctoral research associate (centre + project)		3
Number of Ph.D students		22
Number of other project staff		0
Number of summer students		2
Projects (ongoing)		1

Table B	Research Activities indicators	
Number of research papers in Journals		23
Number of Book-chapters/books		0
Number of other publications		12
Number of Ph.D students graduated (submitted + degree awarded)		5
Number of M.Tech/M.Sc projects		5

Table C	Academic activities and likeage	
Number of courses taught by faculties		9
Number of Visitors (non -associates)		1
Number of associates		0
Number of Seminars organized		0
Number of Conference/Symposia/ Advanced Schools organized		1
Number of talks delivered by members of department in conferences/Symposia	National	11
	International	6

Most important research highlights

- Estimatied of mass of several black holes using Chakrabarti-Titarchuk Two Component Advective Flow solution
- Reproduced solar injected spectra from Very Low frequency radio signal by using Inverse problem applied on our Ionosphere
- Studied phase and time lag behaviour of X-rays of different energies from several black hole candidates.

- Presented the stellar content of a young cluster NGC 2282, a young star-forming in Monoceros constellation from observations in optical to mid-infrared wavelengths.
- Studied the effect of particle statistics on the gravitational equivalence principle applied to quantum particles (WEQ) and showed that WEQ emerges smoothly in the limit of large mass.
- Derived a fine-grained uncertainty relation for continuous variable systems and showed that it led to an improved lower bound on the secret key rate of a one-sided device independent quantum key distribution protocol.
- Showed that the nonlocality of a single member of an entangled pair of spin 1/2 particles can not be shared among multiple observers who acted sequentially and independently of each other
- Performed photoionization analysis and modeled optical spectra of RS Oph observed during 2006 outburst and quiescence period.
- Constructed a comprehensive grid of NLTE, spherical, hydrostatic model atmospheres for the basic parameter combinations spanning the entire parameter space appropriate for novae.

Summary of research activities

We studied vertical and radial oscillations of shocks when equatorial symmetry of simulations are removed by using TVD code and their effects on the formation of asymmetric jets. We demonstrated that oscillations of shocks which cause observed quasi-periodic oscillations in presence of cooling are due to resonance between the cooling time scale and the infall time scale. Radiations of different energies arrive at a different time to us due to reflection, gravitational bending and the Compton scattering process. We explain the observed time and phase lag of radiations.

We have estimated masses of several black hole candidates by fitting observed spectra using Chakrabarti-Titarchuk solution of radiation emited from two component advective flows. Viscosity operating inside the disks is also estimated from time delay of infall of Keplerian and non-Keplerian components. Emission lines from the matter falling in to a black hole split into red and blue shifted components due to rapid rotations. We find evidence of such radiations and estimate spin of a black hole to be nearly extreme (a $\sim$ 0.99). We have shown that Very Low frequency signal amplitude gets attenuated when it propagates over ice mass in Antarctica. This explains why VTX station data is stronger than NWC station data even though the latter has a powerful transmitter and is located nearby of the Antarctica receiving station.

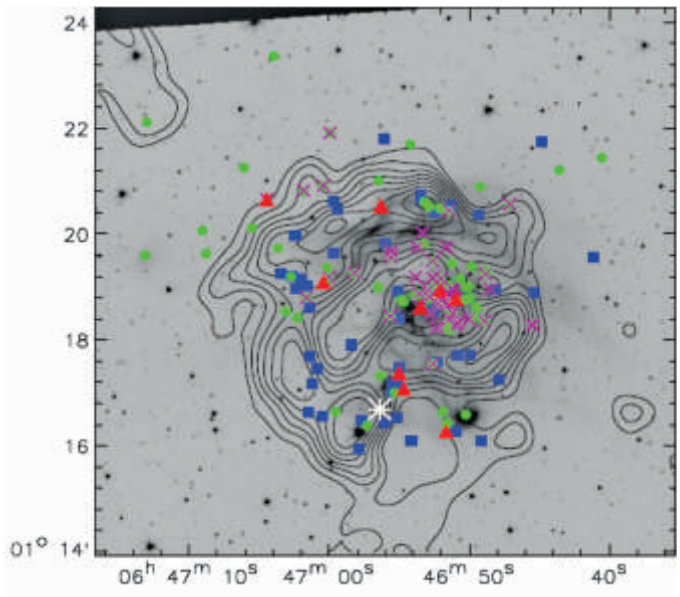
We derive a fine-grained uncertainty relation for the measurement of two incompatible observables on a single quantum system of continuous variables, and show that continuous variable systems are more uncertain than discrete variable systems. Using the derived fine-grained uncertainty relation, we formulate stronger steering criterion that is able to reveal the steerability of N00N states that has hitherto not been possible using other criteria. We further obtain a monogamy relation for our steering inequality which leads to an, in principle, improved lower bound on the secret key rate of a one-sided device independent quantum key distribution protocol for continuous variables.

We study the effect of quantum statistics on the arrival time distribution of quantum particles computed through the probability current density. It is shown that symmetrization or asymmetrization of the wave function affects the arrival time distribution for even freely propagating particles. In order to investigate the effect of statistics on the weak equivalence principle in quantum mechanics (WEQ), we then compute the mean arrival time for wave packets in free fall. The violation of WEQ through the effect of statistics on the mass-dependence of the mean arrival time is clearly exhibited. We finally 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. Our results show WEQ re-emerges smoothly in the limit of large mass.

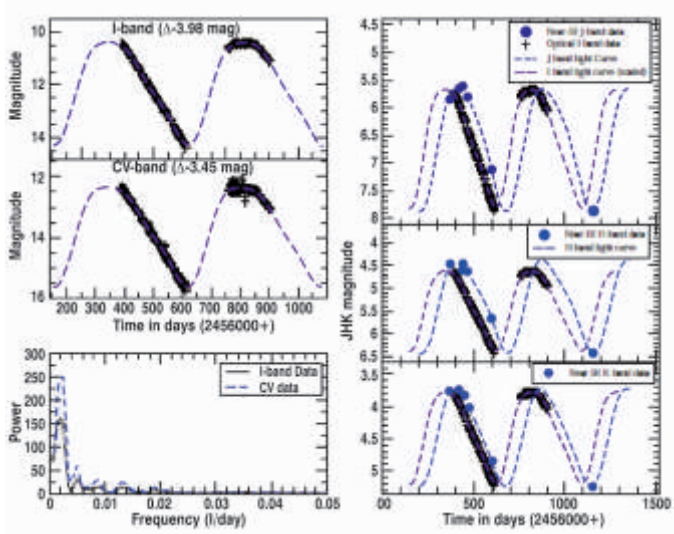
We express the uncertainty relation in a new form where the maximum possible reduction of uncertainty is shown to be given by the extractable classical information. We show that the lower bound of uncertainty matches with that using fine-graining for several examples of two-qubit pure and mixed entangled states, and also separable states with non-vanishing discord. Using our uncertainty relation we further show that even in the absence of any quantum correlations between the two parties, the sum of uncertainties may be reduced with the help of classical correlations.

We address the recently posed question as to whether the nonlocality of a single member of an entangled pair of spin 1/2 particles can be shared among multiple observers on the other wing who act sequentially and independently of each other.

We present the stellar content of a young cluster NGC 2282, a young star-forming in Monoceros constellation from deep optical to mid-infrared (IR) data from our own observations using 1m ARIES telescope and 2m HCT, archival data of 3.8m UKIRT, and space-based mid-IR instrument IRAC on Spitzer. We have identified three early B-type members in the cluster, which help us to constrain the distance to the region. Using IR colour-colour, colour-magnitude diagrams and H-alpha 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. We have estimated the cluster parameters e.g. radial extension, extinction, age including masses and ages of individual YSOs. In the Figure on the left, spatial distribution of Class I (red triangles), Class II (green circles), candidate YSOs from JHK colours (blue squares) overlaid on IRAC 3.6 μm image. The contours of K-band (2.2 μm) extinction map are over-plotted (Dutta et al. 2015).



We reported earlier the discovery of a new Mira variable from MASTER Optical Transient (OT) alert on J212444.87+321738.3 (J2124+32) toward the Cygnus. We are continuing long-term optical/near-IR photometric and spectroscopic observations to characterize this object. From optical light curves, we find that the object has a variability period of about 465 days with amplitude exceeding, DI ~ 4 mag in I-band. The Near-IR variability amplitudes are seen in DJ ~ 2.2, DH ~1.9 and DK ~1.5 mag respectively with similar optical period but have a phase lag of ~ 60 days as seen in Miras. Our optical/near-IR spectra shows molecular features of TiO, VO, CO overtone and water bands, which is a signature of typical cool M-type stars. The Optical/NIR spectra indicate the likely O-rich nature. All these observations confirm that the source is a new O-rich Mira variable. In Figure on the right, optical /Near-IR light curves and periodgram analysis of optical light curve are shown (Mondal et al. 2016; Ghosh et al. 2016).



We have performed photoionization modeling of optical spectra of RS Oph observed during 2006 outburst and quiescence period. The best-fit model parameters are compatible with a hot white dwarf source (T_{BB} ~ 5.5 × 10^5 K and roughly constant a luminosity (~ 6 - 8 × 10^{36} ergs s^{-1}) and shows significantly enhanced abundance, relative to solar, of helium, nitrogen, neon, iron and argon in the ejecta.

In order to investigate physical conditions in the nova-shell, we have constructed a comprehensive grid of NLTE, spherical, hydrostatic model atmospheres (~7000 models) for the basic parameter combinations spanning the entire parameter space appropriate for novae. From the synthetic spectra we measure the line ratio of few selected spectral lines of H & He and derive the trend of change with other parameters by drawing contours.

Sandip Kumar Chakrabarti

Head, Department of Astrophysics and Cosmology

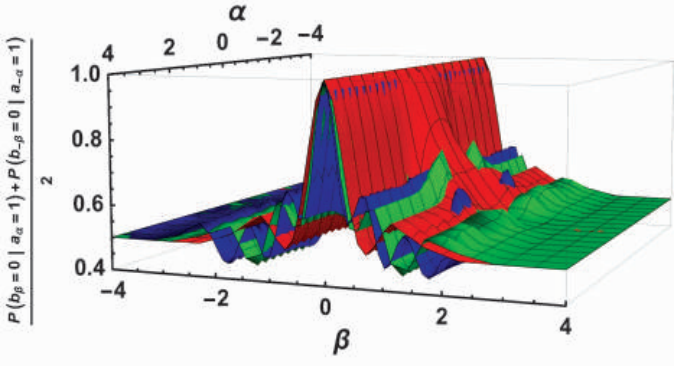
Archan Subhra Majumdar

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 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 formulate stronger steering criterion that is able to reveal the steerability of N00N states that has hitherto not been possible using other criteria. We further obtain a monogamy relation for our steering inequality which leads to an, in principle, improved lower bound on the secret key rate of a one-sided device independent quantum key distribution protocol for continuous variables. We study the effect of quantum statistics on the arrival time distribution of quantum particles computed through the probability current density. It is shown that symmetrization or asymmetrization of the wave function affects the arrival time distribution for even freely propagating particles. In order to investigate the effect of statistics on the weak equivalence principle in quantum mechanics (WEQ), we then compute the mean arrival time for wave packets in free fall. The violation of WEQ through the effect of statistics on the mass-dependence of the mean arrival time is clearly exhibited. We finally 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. Our results show WEQ re-emerges smoothly in the limit of large mass. The sum of entropic uncertainties for the measurement of two non-commuting observables is not always reduced by the amount of entanglement (quantum memory) between two parties, and in certain cases may be impacted by quantum correlations beyond entanglement (discord). An optimal lower bound of entropic uncertainty in the presence of any correlations may be determined by fine-graining. We express the uncertainty relation in a new form where the maximum possible reduction of uncertainty is shown to be given by the extractable classical information. We show that the lower bound of uncertainty matches with that using fine-graining for several examples of two-qubit pure and mixed entangled states, and also separable states with non-vanishing discord. Using our uncertainty relation we further show that even in the absence of any quantum correlations between the two parties, the sum of uncertainties may be reduced with the help of classical correlations. We address the recently posed question as to whether the nonlocality of a single member of an entangled pair of spin 1/2 particles can be shared among multiple observers on the other wing who act sequentially and independently of each other. We first show that the optimality condition for the trade-off between information



gain and disturbance in the context of weak or non-ideal measurements emerges naturally when one employs a one-parameter class of positive operator valued measures (POVMs). Using this formalism we then prove analytically that it is impossible to obtain violation of the Clauser-Horne-Shimony-Holt (CHSH) inequality by more than two Bobs in one of the two wings using unbiased input settings with an Alice in the other wing.

Future Plan

We will investigate the future evolution of the universe using the Buchert framework in two scale inhomogeneous universe. By computing the global acceleration we will show that the Buchert framework allows for the possibility of the global acceleration vanishing at a finite future time, provided that none of the subdomains accelerate individually. We will describe the emergence of a homogeneous scalar fields due to backreaction terms in these partitions and show that the potential of such scalar field is fixed and free from phenomenological parametrisation. We will investigate the dynamics of this scalar field in FRW background to get a viable cosmology. We will use observational data from Type Ia Supernovae, Baryon Acoustic Oscillations, and Cosmic Microwave Background to constrain the parameters of the model, and provide the corresponding likelihood contours. We will show how single system steering can be exhibited by classical light, a feature originating from superposition in classical optics that also enables entanglement and Bell-violation by classical light beams. Single system steering is the temporal analogue of Einstein-Podolsky-Rosen (EPR) steering in the quantum domain, enabling control of the state of a remote system, and can hence be connected to the security of secret key generation between two remote parties. We will derive the steering criterion for a single mode coherent state when displaced parity measurements are performed at two different times. The security bound in the Bennett-Brassard 1984 (BB84) key generation scenario under the gaussian cloning attack will be calculated using a fine-grained uncertainty relation corresponding to the classical phase space. Mermin's inequality is a generalization of the Bell-CHSH inequality for three qubit states. The violation of the Mermin inequality guarantees the fact that there exists quantum non-locality either between two or three qubits in a three qubit system. In the absence of an analytical result to this effect, in order to check for the violation of Mermin's inequality one has to perform a numerical optimization procedure for even pure three qubit states. We will derive analytical formulae for the maximum violation of the Mermin inequality for all three qubit pure and mixed states.

Publications in Journals

1. P. Chowdhury, T. Pramanik, A. S. Majumdar, *Stronger steerability criterion for more uncertain continuous-variable systems*, Phys. Rev. A, 92, 042317, 2015.
2. S. V. Mousavi, A. S. Majumdar, D. Home, *Effect of quantum statistics on the gravitational weak equivalence principle*, Class. Quant. Grav., 32, 215014, 2015.
3. T. Pramanik, S. Mal, A. S. Majumdar, *Lower bound of quantum uncertainty from extractable classical information*, Quant. Inf. Process., 15, 981, 2016.
4. S. Mal, A. S. Majumdar, D. Home, *Sharing of nonlocality of a single member of an entangled pair of Qubits is not possible by more than two unbiased observers on the other wing*, Mathematics, 4, 48, 2016.

Other Publications

1. N. Bose and A. S. Majumdar, *"Effect of cosmic backreaction on the future evolution of an accelerating universe"*, Proceedings of the "MG13 Meeting on General Relativity", (2015) p 1583.
2. A. S. Majumdar, S. V. Mousavi, D. Home, *"Equivalence principle and quantum statistics"*, Proceedings of "International Meeting on Physical Interpretations of Relativity Theory (PIRT-2015)", (2015) p 359; DOI: 10.18698/2309-7604-2015-1-359-364 .
3. A. S. Majumdar, N. Bose, *"Backreaction due to inhomogeneities and the future evolution of an accelerating universe"*, (2015) Proceedings of "International Meeting on Physical Interpretations of Relativity Theory (PIRT-2015)", p 365; DOI: 10.18698/2309-7604-2015-1-365-373 .

Supervision of Students

Ph.D. Students: Nirman Ganguly (Ph.D awarded), Priyanka Chowdhury (Thesis submitted), Subhadipa Das, Shounak Datta, Riddhi Chatterjee, Suchetana Goswami (Project);

Project Students: Debsuvra Mukhopadhyay, "Characterizing entanglement, nonlocality and the role of non-commutativity in quantum theory"; Riddhi Chatterjee, "Lagrangian and Hamiltonian formulation in FRW Cosmology"; Shounak Datta, "Effect of decoherence in quantum steering"; Suchetana Goswami, "A study on effect of weak mesaurement on quantum correlation"; Ananda Gopal Maity, "Perturbations in cosmology and anisotropy of CMBR"; **Post Doctoral Research Scientists:** Amna Ali, Tanumoy Pramanik (Project)

Lectures Delivered

1. *"Equivalence principle and quantum statistics"*, International Meeting on Physical Interpretations of Relativity Theory (PIRT-2015), BMSTU Moscow, June 2015.
2. "*Backreaction due to inhomogeneities and the future evolution of an accelerating universe"*, International Meeting on Physical Interpretations of Relativity Theory (PIRT-2015), BMSTU Moscow, June 2015.
3. *"Classical and quantum correlations in continuous variable systems"*, International Conference on Quantum Foundations, NIT Patna, November 2015.
4. "*Quantum uncertainty and information processing with bosons"*, 2nd International Bose Conference, Univ. Dhaka, December 2015.
5. *"Fine-grained uncertainty relations and quantum steering"*, Quantum Information Processing Applications QIPA-15, HRI Allahabad, December 2015.
6. *"Recent Developments in quantum information science"*, DST Inspire Camp, RKGEC Ghaziabad, January 2016.
7. *"Fine-grained uncertainty and security of key generation"*, International School and Conference on Quantum Information, IOP, Bhubaneswar, February 2016.

Courses Taught

1. PHY 303, Advanced Quantum Mechanics and Applications
2. PHY 604, Quantum Physics (Application)
3. PHY 304, Project Research
4. PHY 591, Project Research

Membership of Committees

Internal Committee: Conference, Workshop and Extension Program (CWEP)

Sponsored Project

1. Fundamental Aspects of Quantum Theory and Quantum Information (DST)

Meeting Organized

1. "Discussion Meeting on Quantum Mechanics", December 7, 2015 | S. N. Bose National Centre for Basic Sciences

Ramkrishna Das

Faculty Fellow
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Dr. Ramkrishna Das received his Ph. D. degree from Physical Research Laboratory, Ahmedabad, India in 2010. He is an observational astronomer. He is presently working on observational studies of novae and other variable stars, modeling of spectra and establishment of the telescope and observational facility of the centre.

During the previous year we have observed several kinds of objects viz. novae, star forming regions, late type stars etc. The observations were made in optical and infrared, using the national facilities, e.g., 2m Himalaya Chandra Telescope, 1.3m Devashtal Fast Optics Telescope and 1m Sampurnanda Telescope. Part of the observed data has been analyzed, interpretaed, modeled where applicable, and results have been published. For example, we performed an analysis of elemental abundances of ejecta of the recurrent nova RS Ophiuchi (RS Oph) (2006 outburst) using the photoionization code Cloudy. Our primary aim was to find the elemental abundances in the ejecta and study different parameters that describe the physical condition of the system. In our previous study (Das & Mondal, New Astronomy, 2015) we modeled infrared spectra of RS Oph (2006 outburst). In continuation to the work, we modeled more optical spectra of the nova, observed during its 2006 outburst and also during quiescenec period. The best-fit model parameters are compatible with a hot white dwarf source with black body temperature of $5.5 - 5.8 \times 10^5$ K and roughly constant a luminosity of $6 - 8 \times 10^{36}$ ergs s^{-1} and the ejecta is significantly enhanced, relative to solar, in helium, nitrogen, neon, iron and argon (paper under preparation). We also have analyzed the stellar content of a young cluster NGC 2282, a reflection nebula in Mon OB2 complex observed in optical and infrared regions. From analyses, fundamental properties of the cluster such as distance, reddening, age etc. have been derived. (Dutta et al., MNRAS, 2015). Analysis of remaining part of data is under process.

In order to constrain the physical conditions in the nova-shell, we have constructed a comprehensive grid of NLTE, spherical, hydrostatic model atmospheres for the basic parameter combinations spanning the entire parameter space appropriate for novae. The principal parameters are the effective temperatures, luminosities, hydrogen density, helium abundance, inner & outer radii and thickness of the shell. In this way, a total of 7168 models were simulated. Finally, from the synthetic spectra we measure the line ratio of few selected spectral lines of H & He and derive the trend of change with other parameters by drawing contours. This provides us a tool to derive the values of other parameters for a particular nova, by matching the observed values with the calculated ones. We compared our results with other observed novae and found a good match between them (paper under preparation).

Also, as a part of the telescope project of our centre, we have established a roll-off roof observatory on the terrace of the main building of our centre. This will house two telescopes (8″ and 14″) for training students and scientific observations.

Future Plan

In the coming year, we hope to complete analysis and interpretation of remaining observed data. We plan to observe and study wide range of astronomical objects using the national facilities, in addition to the observations through ongoing projects.

We expect to complete the analysis of grid model as mentioned above and study other types of novae through modeling. Also, we are interested 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 outbursts and the interaction of this ejected material with the companion star.

We also plan to complete installation of the two telescopes, (8″and 14″ apertures) inside the newly established roll-off roof observatory and use them for observations.

Publication in Journal

1. S. Dutta, S. Mondal, J. Jose, **R. Das**, M. R. Samal, S. Ghosh, *The young cluster NGC 2282: a multiwavelength perspective*, Monthly Notices of the Royal Astronomical Society, **454**, 3597, 2015.

Supervision of Students

Ph.D. Students: Anindita Mondal and Dhimadri Khata (jointly with Dr. Soumen Mondal, SNBNCBS), Rahul Bandyopadhyaya, Ruchi Pandey; Project Students: Ruchi Pandey (3rd & 4th Semester, Integrated PhD, SNBNCBS), Robert Wilson Joute (M.Sc., IIT-Khargapur)

Lectures Delivered

1. Invited talk on "Observational Properties of Novae in Infrared", Workshop on Novae and accretion binaries – a multiwavelength perspective, Centre for Basic Sciences, Mumbai University, Mumbai, December 2-6, 2015.

2. "Spectroscopic and Photometric data analysis", Workshop on Novae and accretion binaries – a multiwavelength perspective, Centre for Basic Sciences, Mumbai University, Mumbai, December 2-6, 2015

Course Taught

1. PHY101 – Classical Dynamics – 1st Semester (Aug – Dec 2015)

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 "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 2016 at S N Bose Centre.

Sandip Kumar Chakrabarti

Senior Professor
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Prof. Sandip Kumar Chakrabarti received PhD degree from University of Chicago in 1985 and was a R.C. Tolman Fellow at CalTech (1985-1987) and a ICTP Post Doctoral Fellow at ICTP. He worked at NASA/GSFC in 1994-1995 as a Senior Research Fellow. He received DSc (Honoris Causa) from University of Gour Banga. He has produced over 500 scientific papers in refereed Journals and Proceedings. He supervised 32 PhD students and wrote/edited several books.

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

1. Demonstrated vertical and radiation oscillations of shocks when equatorial symmetry of simulations are removed
2. Demonstrated that oscillations of shocks which cause observed quasi-periodic oscillations in presence of cooling are due to resonance between the cooling time scale and the infall time scale
3. Studied time/phase lag behaviour of X-rays of different energies from several black hole candidates
4. Estimated masses of several black holes from the spectral fits using Two Component Advective Flow solution of Chakrabarti-Titarchuk (1995)
5. Estimated viscosity in accretion disks around black holes
6. Produced spectra of injected solar radiation from measurements of Very Low Frequency radio wave signals
7. Showed that ice mass is responsible for the attenuation of Very Low Frequency radio wave propagation
8. Showed evidences of red and blue shifted iron lines in soft X-rays in accretion flows just outside the horizon
9. Estimated how much deuterium is enhanced in the grain mantles in the interstellar medium
10. Obtained systematic variation of cosmic ray intensity with solar activity using several years of balloon borne instrument data

Future Plan

1. To study effects of magnetic fields in collimation of outflows from accretion disks around black holes
2. To study the spectral and temporal properties of several black hole candidates and neutron star candidates and to fit the data using TCAF solution
3. To study effects of outflows on the composite spectra of black hole candidates
4. To study evidences of reappearances of Keplerian disk when the Compton cloud is cooled down

Publications in Journals

1. Arghajit Jana, Dipak Debnath, **Sandip K. Chakrabarti**, Santanu Mondal, Aslam Ali Molla, *Accretion Flow Dynamics of MAXI J1836-194 During Its 2011 Outburst from TCAF Solution*, Astrophysical Journal, **819**, 107, 2016.
2. Suman Chakraborty, Sourav Palit, Suman Ray, **Sandip K. Chakrabarti**, *Modeling of the lower ionospheric*

response and VLF signal modulation during a total solar eclipse using ionospheric chemistry and LWPC, Astrophysics and Space Science, **361**, 72, 2016.

3. Ankan Das, Dipen Sahu, Liton Majumdar, **Sandip K. Chakrabarti**, *Deuterium enrichment of the interstellar grain mantle*, Mon. Not. R. Astron. Soc., **455**, 540, 2016.
4. Shreeram Nagarkoti, **Sandip K. Chakrabarti**, *Upper Limit of the Viscosity Parameter in Accretion Flows around a Black Hole with Shock Waves*, Astrophysical Journal, **816**, 7, 2016.
5. Liton Majumdar, Prasanta Gorai, Ankan Das, **Sandip K. Chakrabarti**, *Potential formation of three pyrimidine bases in interstellar regions*, Astrophysics and Space Science, **360**, 64, 2015.
6. **Sandip K. Chakrabarti**, Santanu Mondal, Dipak Debnath, *Resonance condition and low-frequency quasi-periodic oscillations of the outbursting source H1743-322*, Mon. Not. R. Astron. Soc., **452**, 3451, 2015.
7. Sudipta Sasmal, Sourav Palit, **Sandip K. Chakrabarti**, *Modeling of long-path propagation characteristics of VLF radio waves as observed from Indian Antarctic station Maitri*, J. Geophysical Res., **120**, 8872, 2015.
8. Partha Sarathi Pal, **Sandip K. Chakrabarti**, *Comptonizing Efficiencies of IGR 17091-3624 and its similarity to GRS 1915+105*, Advances of Space Research, **56**, 1784, 2015.
9. Dipen Sahu, Ankan Das, Liton Majumdar, **Sandip K. Chakrabarti**, *Monte Carlo simulation to investigate the formation of molecular hydrogen and its deuterated forms*, New Astronomy, **38**, 23, 2015.
10. Ankan Das, Liton Majumdar, Dipen Sahu, Prasanta Gorai, B. Sivaraman, **Sandip K. Chakrabarti**, *Methyl Acetate and Its Singly Deuterated Isotopomers in the Interstellar Medium*, Astrophysical Journal, **808**, 21, 2015.
11. Victor U. J. Nwankwo, **Sandip K. Chakrabarti**, Robert S. Weigel, *Effects of plasma drag on low Earth orbiting satellites due to solar forcing induced perturbations and heating*, Advances in Space Research, **56**, 47, 2015.
12. **Sandip K. Chakrabarti**, *Turning points in black holes astrophysics*, Astronomy Reports, **59**, 447, 2015.
13. **Sandip K. Chakrabarti**, Liton Majumdar, Ankan Das, Sonali Chakrabarti, *Search for interstellar adenine*, Astrophysics and Space Science, **357**, 90, 2015.
14. Kinsuk Giri, Sudip K. Garain, **Sandip K. Chakrabarti**, *Segregation of a Keplerian disc and sub-Keplerian halo from a transonic flow around a black hole by viscosity and cooling processes*, Mon. Not. R. Astron. Soc., **448**, 3221, 2015.
15. B. Sivaraman, N. Radhika, A. Das, G. Gopakumar, L. Majumdar, **S. K. Chakrabarti**, K. P. Subramanian, B. N. Raja Sekhar, M. Hada, *Infrared spectra and chemical abundance of methyl propionate in icy astrochemical conditions*, Mon. Not. R. Astron. Soc., **448**, 1372, 2015.
16. Dipak Debnath, Aslam Ali Molla, **Sandip K. Chakrabarti**, Santanu Mondal, *Accretion Flow Dynamics of MAXI J1659-152 from the Spectral Evolution Study of its 2010 Outburst using the TCAF Solution*, Astrophysical Journal, **803**, 59, 2015.
17. Victor U. J. Nwankwo, **Sandip K. Chakrabarti**, Olugbenga Ogunmodimu, *Probing geomagnetic storm-driven magnetosphere-ionosphere dynamics in D-region via propagation characteristics of very low frequency radio signals*, Journal of Atmospheric and Solar-Terrestrial Physics, **145**, 154, 2016.
18. V. U. J. Nwankwo, **S. K. Chakrabarti**, *Analysis of planetary and solar-induced perturbations on trans-Martian trajectory of Mars missions before and after Mars orbit insertion*, Ind. J. Phys., **89**, 1235, 2015.

Other Publications

1. Chakrabarti, S. K., Whither TCAF?, Astronom. Soc. Ind., 2015, 12, 9.
2. Debnath, Dipak; Mondal, S.; Chakrabarti, S. K.; Jana, A.; Molla, A. A.; Chatterjee, D., Characterization of few transient black hole candidates during their X-ray outbursts with TCAF Solution, Astronom. Soc. Ind., 2015, 12, 87.
3. Chatterjee, Arka; Chakrabarti, Sandip K., Effects of Photon Bending on Spectral and Temporal Properties of Two Component Advective Flow, Astronom. Soc. Ind., 2015, 12, 95.
4. Pal, P. S.; Chakrabarti, S. K., Comptonizing Efficiency -- A Mass Independent Dynamic Hardness Ratio, Astronom. Soc. Ind., 2015, 12, 105.

5. Nagarkoti, Shreeram; Chakrabarti, Sandip K., Estimation of viscosity parameter in Accretion flows around a black hole in presence of shock waves, Astronom. Soc. Ind., 2015, 12, 117.
6. Molla, Aslam Ali; Chakrabarti, S. K.; Debnath, D.; Mondal, S.; Jana, A.; Chatterjee, D., Estimation of mass of MAXI J1659-152 during its very first outburst with TCAF fits, Astronom. Soc. Ind., 2015, 12, 119.
7. Dutta, Broja G.; Sarathi Pal, Partha; Chakrabarti, Sandip K., Lag variability of GRS 1915+105 during Plateau States, Astronom. Soc. Ind., 2015, 12, 121.
8. Jana, A.; Debnath, D.; Mondal, S.; Chakrabarti, S. K.; Molla, A. A.; Chatterjee, D., Spectral and Temporal Properties of MAXI J1836-194 during 2011 Outburst, Astronom. Soc. Ind., 2015, 12, 137.
9. Mondal, S.; Chakrabarti, S. K.; Debnath, D.; Jana, A.; Molla, A. A., Compton cooling and the signature of Quasi Periodic Oscillations for the transient black hole candidate H 1743-322, Astronom. Soc. Ind., 2015, 12, 151.

Supervision of Students

Ph.D. Students: S. Mondal and T. Katoch (received PhD degree), S. Maji (submitted Thesis), Supervising: V. Nwankwo, A. Bhattacharyya, A. Deb, A. Ghosh, S. Chakraborty, A. Banerjee, D. Sahu, A. Chatterjee, S. Nagorkoti, A. A. Molla; Post Doctoral Research Scientist: Indrani Banerjee

Lectures Delivered

1. May, 2015: "Whither TCAF?" Invited talk at "Recent Trends of Study of Compact Objects - Theory and Observations", in "Recent Trends in Compact Objects - II" conference at ARIES, Nainital.
2. June 2015: "Unique high energy astrophysics experiment with weather balloons", at 22nd PAC Symposium at Tromso, Norway.
3. July 2015: Chairman of "Accretion Processes on Black Holes" at the 14th Marcel Grossman meeting in Rome and invited talk on "Study of Accretion processes Around Black Holes becomes Science: Tell Tale Observational Signatures of Two Component Advective Flows".
4. Sept. 2015: "Two Component Advective Flows: Theory and Observations" at the "Conference celebrating 100th Birth Anniversary of Prof. V.V. Sovolev at St. Petersburg.
5. Mar. 2016: "Gravitational Waves and Black Holes" at 'Togetherness for Better Tomorrow' Forum, Tollygaunj, Kolkata.

Courses Taught

1. PHY 403: Introduction to Astrophysics
2. PHY 592: High Energy Astrophysics

Membership of Committees

External Committee: LOC and International Co-ordination Committee Member of 14th Marcel Grossman meeting (Rome, July, 2015); Main Organizer of E1.6 session on Black Hole Astrophysics: Observational Evidence of Theoretical Models at COSPAR 41 (Istanbul), Deputy Organizer of C0.3 Session on Ionospheric Disturbances Observed through very Low Frequency Radio Waves at COSPAR 41 (Istanbul), Deputy Organizer of PSB.1 session on Scientific Ballooning: Recent Development in Technology and Instrumentation at COSPAR 41 (Istanbul); General Secretary of Governing body and In Charge of Indian Centre for Space Physics; Board of Studies (BOS) member of the Dept. of Atmospheric Physics of Calcutta University; Board of Research Studies (BRS) member of the University of Gour Banga**; Internal Committee:** Head of the Department of Astrophysics and Cosmology, Students Curriculum and Research Evaluation Committee

Patent/s Submitted / Received

1. RADIO TRACKING SYSTEM FOR FLYING PLATFORMS, 2015, D. Bhowmick, S. K. Chakrabarti, A. Bhattacharya and R. Sarkar, The Patent Office Journal, No. 874/KOL/2015 (Published on 11/9/2015)

2. A MULTI BALLOON LAUNCH SYSTEM, 2015, S.K. Chakrabarti, D. Bhowmick, R. Sarkar and A. Bhattacharya, The Patent Office Journal, No. 875/KOL/2015 (Published on 11/9/2015)

3. AN ORIENTATION MEASUREMENT UNIT FOR UNGUIDED INSTRUMENTS, 2015, A. Bhattacharya, R. Sarkar, D. Bhowmick and S.K. Chakrabarti, The Patent Office Journal, 876/KOL/2015 (Published on 11/9/2015)

Award / Recognition

1. DSc. (Honoris Causa) from University of Gourbanga at the Convocation in December, 2015.

Soumen Mondal

Associate Professor
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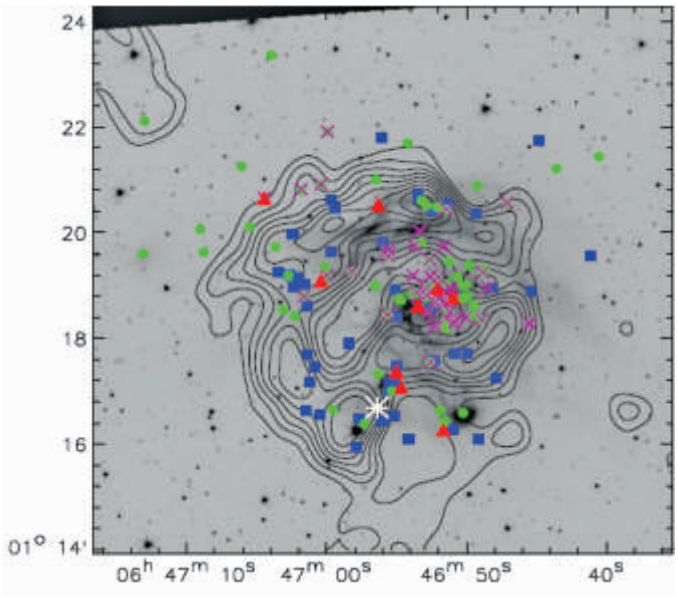
Dr. Soumen Mondal received his Ph.D. degree from Physical Research Laboratory (PRL), Ahemdabad in 2004. He has post doctoral research experience at PRL for a year, and then at National Central University, Taiwan under International Taiwanese-American Occultation Survey (TAOS) program for about two and 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**

1. The young cluster NGC 2282: a multi-wavelength perspective

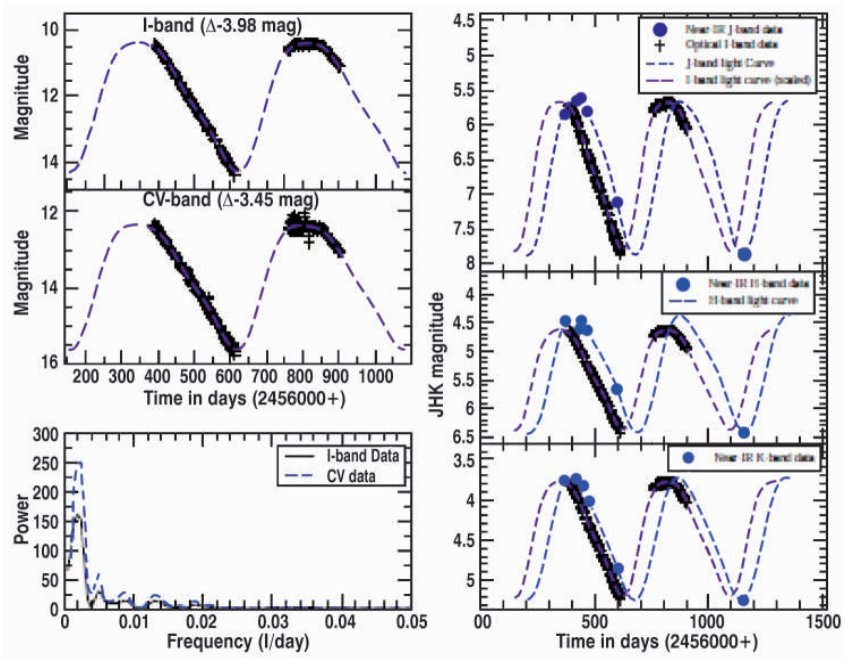
We present here the stellar content of a young cluster NGC 2282, a young star-forming in *Monoceros* constellation from deep optical to mid-infrared (IR) data from own observations of 1m ARIES telescope and 2m HCT, archival data of 3.8m UKIRT, and space-based mid-IR instrument IRAC on *Spitzer*. From optical spectroscopic analysis of few bright sources, we have identified three early B-type members in the cluster, which help us to constrain the distance to the region. Using IR colour-colour, colour-magnitude diagrams 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. . We have estimated the cluster parameters e.g. radial extension, extinction, age including masses and ages of individual YSOs. *In the below figure, the spatial distribution of Class I (red triangles), Class II (green circles), candidate YSOs from JHK colours (blue squares) overlaid on IRAC 3.6 μm image. The contours of K-band (2.2 μm) extinction map are over-plotted (Dutta et al. 2015).*



2. A new Mira variable and fundamental parameters of M-giants from optical/IR spectra

We report here discovery of a new Mira variable from MASTER Optical Transient (OT) alert on J212444.87+321738.3 (J2124+32) toward the Cygnus. We have performed long-term optical/near-IR photometric and spectroscopic observations to characterize that object. From optical light curves, we find that the object has a variability period of about 465 days with amplitude

exceeding, DI ~ 4 mag in I-band,, which is nature of pulsating Mira variable. The Near-IR variability amplitudes are seen in DJ ~ 2.2, DH ~1.9 and DK ~1.5 mag respectively with similar optical period but have a phase lag of ~ 60 days as seen in Miras. Our optical/near-IR spectra shows molecular features of TiO, VO, CO overtone and water bands, which is a signature of typical cool M-type stars. The Optical/NIR spectra indicates the likely O-rich nature. All these observations confirm that the source is a new O-rich Mira variabl. In the below figure, the optical /Near-IR light curves and periodgram analysis of optical light curve are shown (Mondal et al. 2016; Ghosh et al. 2016).



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 at Panchet hill. 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 have built 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. Somnath Dutta, S. Mondal, J. Jose, R. K. Das, M. R. Samal and S. Ghosh, *The young cluster NGC 2282: a multiwavelength perspective*, Monthly Notices of the Royal Astronomical Society (MNRAS), vol. 454, pp. 3597–3612, 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), Alik Panja; Project Student: Summer project: Labanya Bhattacharya (M.Sc. (Physics) of ISM, Dhanbad)

Lectures Delivered

1. Invited talk on "Understanding of Brown Dwarfs in TMT era" at TMT-India science and Instrumentation workshop held at Tezpur University during 1-3 December 2015.
2. Invited talk on "Emission lines in late-type stars" at Novae and accreting binaries: a multiwavelength study held at Mumbai University- Kalina Campus during 4 -6 Dec 2015.
3. Invited talk on "Extra solar planets" at Science Day held at SNBNCBS on 29 February 2016.

Courses Taught

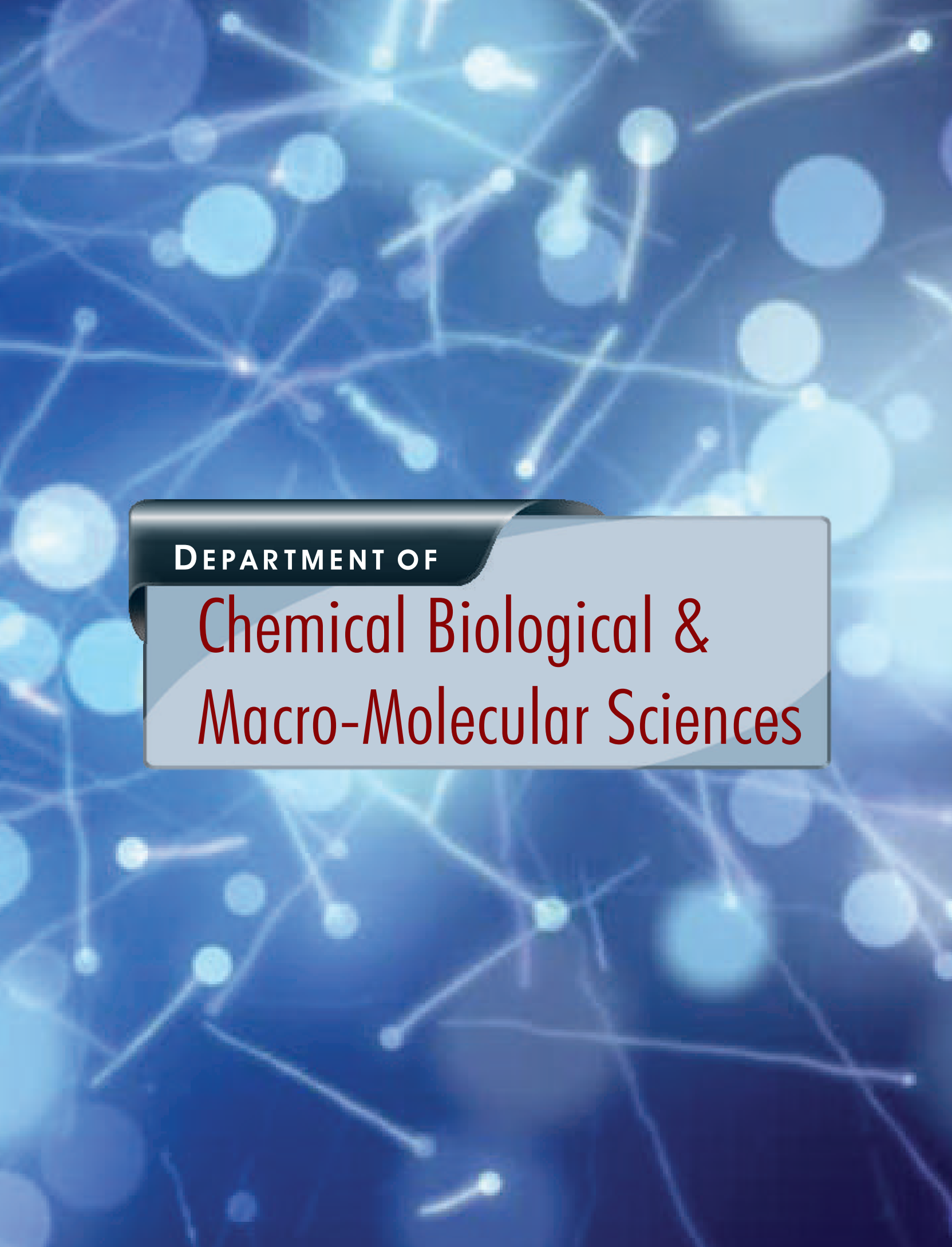
1. PHY-191 – Basic Laboratory 1 optics part (IphD 1st sem, 2015-16)
2. PHY-403 – Astrophysics and Astronomy Elective part (4th Sem, 2015-16)
3. PHY-501 – Astrophysics PhD course work (2015-2016)

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

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)		4
Number of Ph.D students		33
Number of other project staff		4
Number of summer students		2
Projects (ongoing)		13

Table B	Research Activities indicators	
Number of research papers in Journals		47
Number of Book-chapters/books		Nil
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		7
Number of Visitors (non -associates)		2
Number of associates		1
Number of Seminars organized		12
Number of Conference/Symposia/ Advanced Schools organized		2
Number of talks delivered by members of department in conferences/Symposia	National	16
	International	9

Most important research highlights

- Nonequilibrium thermodynamic response of a voltage gated Sodium ion channel studied.
- Effects of noise due to thermo-coherence in the source on quantum current explored.
- Model simulations to understand Troponin I interaction with calcium (Ca^{2+}) ion bound TnC have been carried out.

- Quantum Chemical (QC) calculations for macromolecules with truncation have been carried out to understand the effects of capping.
- STY3178, a yfdX protein from a MDR strain of typhoid fever causing *Salmonella* Typhi, has been studied.
- Early detection of insulin resistance by means of non-invasive human breath analysis has been developed.
- Glucose metabolism of the gastric pathogen *Helicobacter pylori* infection in human stomach has been investigated.
- Terahertz studies on the effects of hydrophilic and hydrophobic cations on water structure have been carried out.
- Molecular recognition of small ligands/drugs by biological macromolecules explored.
- Low cost spectroscopic gadgets for the biomedical/environmental usage have been developed.
- Two-step procedure to fabricate halloysite/metal nanocomposites (NCs) in large-scale has been developed.

Summary of research activities

On the basis of the fermionic coherent state of Cahill and Glauber, the fermionic thermocoherent state has been introduced in terms of the quasiprobability distribution. It is shown that a suppression of noise in current is due to the thermocoherent character of the source. Probe kinetic drug binding mechanism in voltage-gated sodium ion channel for open inactive state blockers has been explored.

Computational prediction of structure for macro-molecular fragments is a formidable challenge. It has been shown that the differences in conformational thermodynamics, computed using equilibrium distribution of dihedral angles from molecular dynamics simulation can identify the better model for the missing residues in the metal ion free (apo) skeletal muscle TroponinC (TnC). Quantum Chemical (QC) calculations for macromolecules require truncation of the molecule, highlighting the portion of interest due to heavy computation cost. As a result, an estimation of the effects of truncation is important to interpret the energy spectrum of such calculations. Density functional theory based QC calculations on calcium ion bound EF-hand loops of Calmodulin isolated from the crystal structure in an implicit solvent have been performed and tested against available experimental data. STY3178, a yfdX protein from a MDR strain of typhoid fever causing *Salmonella* Typhi, has been studied and the experimental results indicate that STY3178 is a helical protein existing in a trimeric oligomerization state in solution.

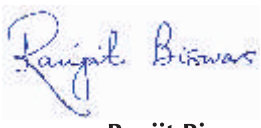
An accurate and early detection technique for insulin resistance by means of non-invasive human breath analysis. Currently, insulin sensitivity index ($ISI_{0,120}$) is considered to be an effective invasive method of whole-body insulin resistance for use in clinical settings in comparison with other invasive sensitivity indexes like homeostasis model assessment (HOMA), and quantitative insulin sensitivity check index (QUICKI). The underlying mechanisms of oxygen-18 (^{18}O) and carbon-13 (^{13}C)-isotopic fractionations of exhaled breath CO_2 during glucose metabolism of the gastric pathogen *Helicobacter pylori* infection in human stomach has been monitored, and results suggest that breath $^{12}C^{18}O^{16}O$ and $^{13}C^{16}O^{16}O$ can be used as potential molecular biomarkers to distinctively track the pathogenesis of *Helicobacter pylori*.

The extent of hydrophobicity in alkylated cations can be increased by increasing the alkyl chain length. It has been found that the hydration behavior of these salts in the THz region is dependent on alkyl chain length. Effects of these salts on the stability of a model protein have been explored. Hydration dynamics of several amino acids of different hydrophobicity in GHz to THz region has been studied.

Molecular recognition of small ligands/drugs by biological macromolecules to complicated protein-DNA, Protein-Protein complexation have been studied by means of ultrafast spectroscopy. Various bio-nano conjugates have been developed, and selective attachment of inorganic semiconductor/metal quantum dots (QD) to various biological macromolecules studied. Biomimetic systems have been studied and model results discussed in light of living systems. Low cost spectroscopic gadgets for the biomedical/environmental usage has been designed and developed.

A two-step procedure to fabricate halloysite/metal nanocomposites (NCs) in large-scale has been developed. Methods for selective trapping of CO_2 by clay based solid adsorbents comprised of several viable amines having varied amine densities and adsorption sites have been designed from ambient air under standard temperature and pressure.

Heterogeneity length and timescales have been revealed by simulation studies of aqueous binary mixtures of ionic liquids, and of cycloethers, showing cluster formation is the main source for spatio-temporal heterogeneity in these mixtures. Theoretical works revealed that ion-solvent interactions play a significant role in governing the dielectric response of a mixture of an ionic liquid with polar solvent. Deep eutectics are found to strongly impact rate of a chemical reaction occurring in it.



Ranjit Biswas

Head, Department of Chemical, Biological and Macromolecular Sciences

Gautam Gangopadhyay

Professor
gautam@bose.res.in

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

- We are working on the classical and quantum dynamical systems to study nonequilibrium processes. We have studied the nonequilibrium thermodynamic response of a voltage gated Sodium ion channel using a stochastic master equation. For quantum systems, we have investigated the nature of the average current and the suppression of noise due to the thermocoherent character of the source for the problem of electronic conduction. For the far away from equilibrium system we have introduced a fluctuation theorem for individual reaction steps in a chemical reaction network

On the basis of the fermionic coherent state of Cahill and Glauber, we have introduced the fermionic thermocoherent state in terms of the quasiprobability distribution. We have shown a suppression of noise in current due to the thermocoherent character of the source. We have shown the possibility of characterization of conical intersection in a cis–trans isomerization reaction through nonclassicality and entanglement of vibrational dynamics. We have introduced an approach to study nonequilibrium thermodynamics of an open chemical reaction network in terms of the propensities of the individual elementary reactions. We have introduced a fluctuation theorem valid for each opposite pair of elementary reactions which is useful in determining the contribution of each sub-reaction on the overall reaction. We have shown how to probe kinetic drug binding mechanism in voltage-gated sodium ion channel fror open inactive state blockers.

Future Plan

1. Our studies on the kinetics and nonequilibrium thermodynamics of open state and inactive state blockers can be extended to study various drug-binding mechanisms using different voltage protocols in sodium ion channel. 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 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. Kinshuk Banerjee and Gautam Gangopadhyay, *Characterization of conical intersection in a cis–trans isomerization through nonclassicality and entanglement*, Journal of Mathematical Chemistry, 53, 1733-1749, 2015.

2. Krishnendu Pal and Gautam Gangopadhyay, *Probing kinetic drug binding mechanism in voltage-gated sodium ion channel: open state versus inactive state blockers*, CHANNELS, 9, Issue 5, 307-316, 2015.

3. Anirban Karmakar and Gautam Gangopadhyay, *Fermionic thermocoherent state: Efficiency of electron transport*, PHYSICAL REVIEW E, 93, 022141, 2016.

4. Krishnendu Pal, Biswajit Das, Kinshuk Banerjee and Gautam Gangopadhyay, *Nonequilibrium thermodynamics and a fluctuation theorem for individual reaction steps in a chemical reaction network*, Journal of Physics: Conference Series, 638, 012002, 2015

Supervision of Students

Ph.D. Students: Krishnendu Pal, Sandip Saha

Course Taught

1. Post MSc course on Stochastic Processes in Physics and Chemistry (CB528)

Membership of Committees

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

Meeting Organized

1. A conference is organized at Indian Association for the Cultivation of Science, on A Discussion Meeting on Prespective in Teaching and Research in Physical Chemistry, 21-22nd August' 2015.

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. Quantum Chemical (QC) calculations for macromolecules require truncation of the molecule, highlighting the portion of interest due to heavy computation cost. As a result, an estimation of the effects of truncation is important to interpret the energy spectrum of such calculations. We perform density functional theory based QC calculations on calcium ion bound EF-hand loops of Calmodulin isolated from the crystal structure in an implicit solvent. We find that the terminal contributions of neutral capping are negligible across the entire ground state energy spectrum. The coordination energy range and the nature of hybridization of the coordination state molecular orbitals remain qualitatively similar across these loops. While the HOMO and LUMO of loops in the N-terminal domain are dominated by the acidic aspartates, and the polar/hydrophobic residues respectively, these levels of the C-terminal domain loops show strong localized electron density on the phenyl rings of the tyrosines. The Fukui index calculation identifies the hydroxyl oxygen in the phenyl ring of Y99 as a potent nucleophile. Our analysis indicates a general way of interpreting the electronic energy spectra to understand stability and functions of large bio-molecules where the truncation of the molecule and hence, the terminal capping effects are inevitable.
2. Computational prediction of structure for macro-molecular fragments is a formidable challenge. Here we show that the differences in conformational thermodynamics, computed using equilibrium distribution of dihedral angles from molecular dynamics simulation can identify the better model for the missing residues in the metal ion free (apo) skeletal muscle TroponinC (TnC). We use the model to understand Troponin I interaction with calcium (Ca^{2+}) ion bound TnC. Our method to compare conformational thermodynamics between different models can be easily generalized to any macro-molecule to understand the structure and function even if experimental structures are not resolved.

Future Plan

I. Projects on biomacromolecules:

1. Dynamics of dihedral fluctuations to understand cooperative phenomena.
2. 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. Equilibrium and dynamic properties of macromolecules in a crowded environment.

Publications in Journals

1. Amit Das, Mahua Ghosh and **J. Chakrabarti**, *Time dependent correlation between dihedral angles as probe for long range communication in proteins*, *Chem Phys Lett,* **645**, 200-204, 2016.
2. Samapan Sikdar, **J. Chakrabarti** and Mahua Ghosh, *Conformational thermodynamics guided structural reconstruction of biomolecular fragments*, Molecular Biosystems, **12** (2), 444-453, 2016.
3. M. Mondal, S. Halder, **J. Chakrabarti** and D. Bhattacharyya, *Hybrid simulation approach incorporating microscopic interaction along with rigid body degrees of freedom for stacking between base pairs,* Biopolymers, **105**(4), 212-226, 2016.
4. Samapan Sikdar, Mahua Ghosh, Molly De Raychaudhury and **J. Chakrabarti**, *Quantum chemical studies on stability and chemical activities in calcium ion bound calmodulin loops,* J. Phys. Chem. B, **119**, 14652-14659, 2015.
5. A. Das, S. Sikdar, Mahua Ghosh and **J. Chakrabarti**, *Conformational thermodynamics of biomolecular complexes: The histogram-based method,* Journal of Physics: Conference Series, **638**, 012013, 2015.

Supervision of Students

Ph.D. Students: Samapan Sikdar, Suman Dutta, Sutapa Dutta and Rajib Adhikary; **Post Doctoral Research Scientists: Lakshmi Maganti and Manas Mondal**

Lectures Delivered

1. Microscopic calculation of conformational thermodynamics in bio-macromolecular complexes, Jawaharlal Nehru Centre for Advanced Scientific Research, September 2015.
2. Long distance dynamic correlations in Biomolecules, Growing Length Scale Phenomena (GLSP) in Condensed Matter Physics, Jawaharlal Nehru Centre for Advanced Scientific Research, October, 2015.
3. Brownian Dynamics simulation of colloidal suspensions, Softmatter conference, BHU, December 2015.
4. Analytical Form of Forces in Hydrophobic Collapse, Meeting on Indian Statistical Physics Community, ICTS Bangalore February 2016.

Courses Taught

1. Statistical Mechanics (PHY 201), Spring 2016
2. Advanced Equilibrium Statistical Mechanics (CB 523), Autumn 2015

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.

Mahua Ghosh

Research Scientist
mahuaghosh@bose.res.in

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**

The yfdX family proteins are known for long time to occur in various virulent bacteria including their multidrug resistant (MDR) strains, without any direct assigned function for them. However, yfdX protein along with other proteins involved in acid tolerance response is reported to be up regulated by the multidrug response regulatory system in *E.coli*. Hence, molecular and functional characterization of this protein is important for understanding of key cellular processes in bacterial cells. We studied STY3178, a yfdX protein from a MDR strain of typhoid fever causing *Salmonella* Typhi. Our experimental results indicate that STY3178 is a helical protein existing in a trimeric oligomerization state in solution (figure 1). We observed many small antibiotics, like ciprofloxacin, rifampin and ampicillin viably interact with this protein. The dissociation constants from the quenching of steady state fluorescence and isothermal titration calorimetry show that ciprofloxacin binding is stronger than rifampin followed by ampicillin.

Future Plan

The following projects are undertaken:

- Thermal response of STY3178 protein
- Variable chemical response of STY3178 protein
- Sequence specific resonance assignments of STY3178 using heteronuclear triple resonance NMR experiments and selective unlabeling.
- Interaction of STY3178 protein with metal ions.
- Interaction studies on bacterial proteins

Publications in Journals

1. P. Saha, C. Manna, S. Das and **Mahua Ghosh**, *Antibiotic binding of STY3178, a yfdX protein from Salmonella Typhi*, *Sci Rep.*, **6**, 21305, 2016.
2. Amit Das, **Mahua Ghosh** and J. Chakrabarti, *Time dependent correlation between dihedral angles as probe for long range communication in proteins*, *Chem Phys Lett*, **645**, 200-204, 2016.
3. Samapan Sikdar, J. Chakrabarti and **Mahua Ghosh**, *Conformational thermodynamics guided structural reconstruction of biomolecular fragments*, Molecular Biosystems, **12** (2), 444-453, 2016.
4. Samapan Sikdar, **Mahua Ghosh**, Molly De Raychaudhury and J. Chakrabarti, *Quantum chemical studies on stability and chemical activities in calcium ion bound calmodulin loops*, J. Phys. Chem. B, **119**, 14652-14659, 2015.

5. A. Das, S. Sikdar, **Mahua Ghosh** and J. Chakrabarti, *Conformational thermodynamics of biomolecular complexes: The histogram-based method,* Journal of Physics: Conference Series, **638**, 012013, 2015.

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

Associate Professor

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Dr Manik Pradhan is currently an Associate Professor at S. N. Bose National Centre for Basic Sciences, Kolkata. Having been awarded a prestigious Dorothy Hodgkin Fellowship, Dr. Pradhan received his PhD from the University of Bristol, UK in 2008. He did his postdoctoral works at Cambridge University, UK (2008-2010) and Stanford University, USA (2010-2011). He also worked as a Visiting Research Fellow (2004-2005) at the Institute of Atomic and Molecular Sciences (IAMS), Academia Sinica, Taiwan. He is leading at present many multi-disciplinary research projects as a Principal Investigator (PI) as well as a Co-PI.

- **Cavity Ring-Down Spectroscopy (CRDS)**
- **High-Resolution Quantum Cascade Laser (QCL) Spectroscopy**
- **Evanescent wave and Nano-Biophotonics**
- **Biomedical Optics and Clinical Diagnostics**
- **Human Breath Analysis**
- **Trace gas sensing and isotope ratio measurements**

We have developed a novel strategy for an accurate and early detection of insulin resistance by means of non-invasive human breath analysis. Currently, insulin sensitivity index ($ISI_{0,120}$) is considered to be an effective invasive method of whole-body insulin resistance for use in clinical settings in comparison with other invasive sensitivity indexes like homeostasis model assessment (HOMA), and quantitative insulin sensitivity check index (QUICKI). We have shown that $^{13}C/^{12}C$-isotope ratios of breath CO_2 were well correlated with blood glucose, insulin, glycosylated-hemoglobin as well as with HOMA-IR and 1/QUICKI. Conversely, the strongest correlation was observed between $1/ISI_{0,120}$ and exhaled breath CO_2 isotopes. Consequently, we determined several optimal diagnostic cut-off points of $1/ISI_{0,120}$ and $^{13}CO_2/^{12}CO_2$-isotope ratios to distinctively track the precise evolution of pre-diabetes prior to the onset of type 2 diabetes. Our findings suggest that isotopic breath CO_2 is a novel method for accurate estimation of $ISI_{0,120}$ and thus may open a new strategy for non-invasive evaluation of insulin resistance.

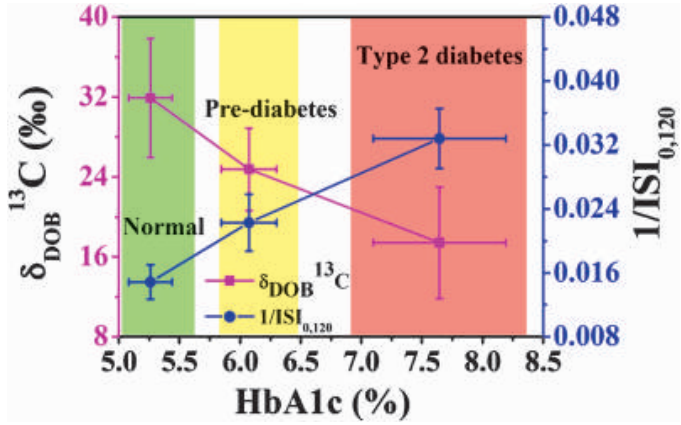


Fig.1: Plot represents the clear transitions of $\delta_{DOB}{}^{13}C‰$ and $1/ISI_{0,120}$ from Normal (green) to Pre-diabetes (yellow) and Type 2 diabetes (red).

(2) We have also explored the underlying mechanisms of the oxygen-18 (^{18}O) and carbon-13 (^{13}C)-isotopic fractionations of exhaled breath CO_2 during glucose metabolism of the gastric pathogen *Helicobacter pylori* infection in human stomach. Our novel findings suggest that breath $^{12}C^{18}O^{16}O$ and $^{13}C^{16}O^{16}O$ can be used as potential molecular biomarkers to distinctively track the pathogenesis of *Helicobacter pylori* and thus may open new perspectives into the pathogen's physiology along with isotope-specific non-invasive diagnosis of the infection without any endoscopy-based biopsy tests.

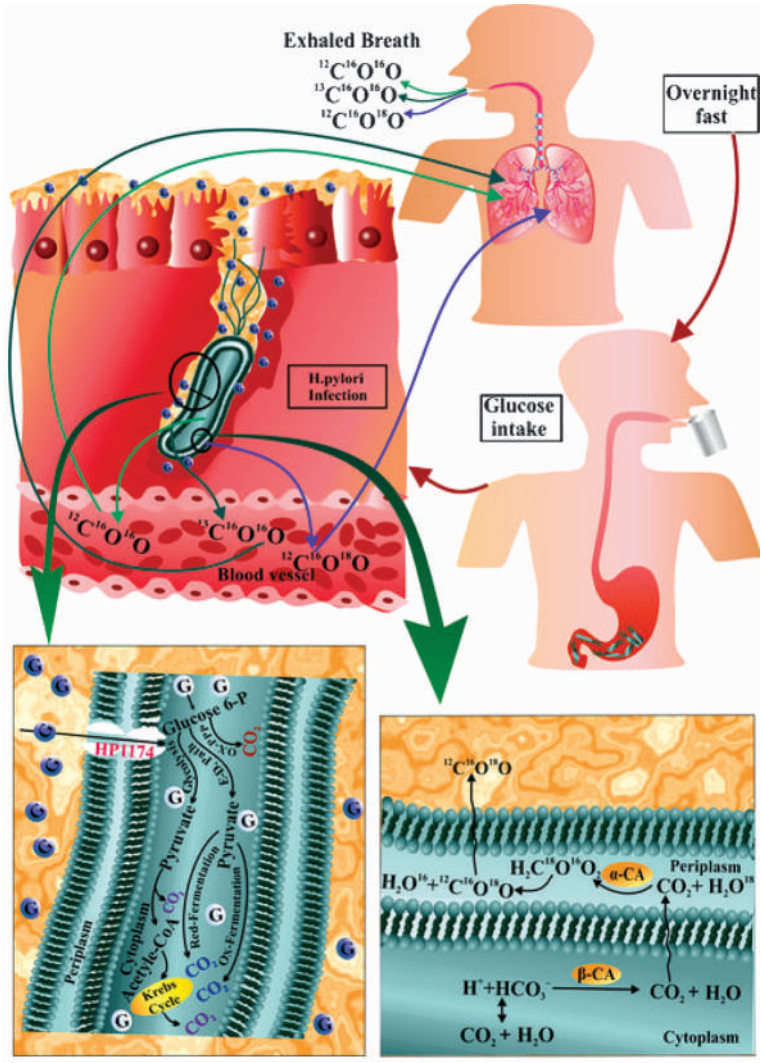


Fig.:2: Potential metabolic pathways for ^{13}C and ^{18}O-isotopic exchanges associated with glucose metabolism by *H. pylori* infection in human stomach.

Future Plan

We are currently developing some new-generation high-resolution cavity ring-down spectroscopy (CRDS) techniques coupled with the cutting-edge quantum cascade laser (QCL) technology in the mid-IR molecular fingerprint region for studying fundamental molecular spectroscopy, trace gas sensing pertinent to the biomedical and environmental science applications.

Publications in Journals

1. C. Ghosh, P. Mukhopadhyay, S. Ghosh and **M. Pradhan**, *Insulin sensitivity index ($ISI_{0,\ 120}$) potentially linked to carbon isotopes of breath CO_2 for pre-diabetes and type 2 diabetes*, Scientific Reports, **5,** 11959, 2015.
2. S. Som, A. De, G. Banik, A. Maity, C. Ghosh, M. Pal, S. Daschakraborty, S. Chaudhuri, S. Jana and **M. Pradhan,** *Mechanisms linking metabolism of Helicobacter pylori to ^{18}O and ^{13}C-isotopes of human breath CO_2*, Scientific Reports, **5,** 10936, 2015.
3. S Das, A Maity, **M. Pradhan**, S Jana, *Assessing atmospheric CO_2 entrapped in clay nanotubes using residual gas analyzer,* Analytical Chemistry, **88** (4), 2205, 2016.

Other Publications

1. *"Clinical Validation of c-PDR: Methodology for Accurate Non-invasive Detection of Helicobacter pylori infection":* S. Som, S. Daschakraborty, S. Chaudhuri and M. Pradhan, *J. Neurogastroenterology and Motility,* **21**, S-11-12 (2015).
2. *"Non-invasive diagnosis of small intestinal bacterial overgrowth in diarrhea-predominant irritable bowel syndrome patients using high precision stable $^{13}CO_2/^{12}CO_2$ isotope ratios in exhaled Breath":* G. D. Banik, S Daschakraborty, S. Chaudhuri and M. Pradhan, *J. Neurogastroenterology and Motility,* **21**, S-31 (2015).

Supervision of Students

Ph.D. Students: Gourab Dutta Banik, Abhijit Maity, Suman Som, Chiranjit Ghosh, Mithun Pal, Sanchi Maithani and Santanu Mandal; Project Student: Monabina Karmokar (M.Sc), IIT Kanpur

Lecture Delivered

1. *Invited Speaker:* International Association of Breath Research (IABR) Summit-2015 (14-16 September, 2015): Vienna, Austria.

Membership of Committee

Internal Committee: Various Thesis, Interview and Technical Cell Committees

Patents Submitted / Received

1. **Patent filed: 201631002214;** Title: "A system and kit for non-invasive detection of peptic ulcer disease, non-ulcerous dyspepsia and helicobacter pylori infection".
2. **Patent filed: 201631003758;** Title: "System and kit for monitoring blood glucose profile based on breath analysis".

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".
3. RSSDI (Research Society for the study of Diabetes in India):2015-2017; Title: " Non-invasive detection of diabetes mellitus from breath analysis using cavity enhanced absorption spectroscopy"
4. Department of Science and Technology (DST), Government of India: 2015-2018; Title: "New-frontiers in quantitative mid-IR high-resolution cavity ring-down spectroscopy using quantum cascade laser".

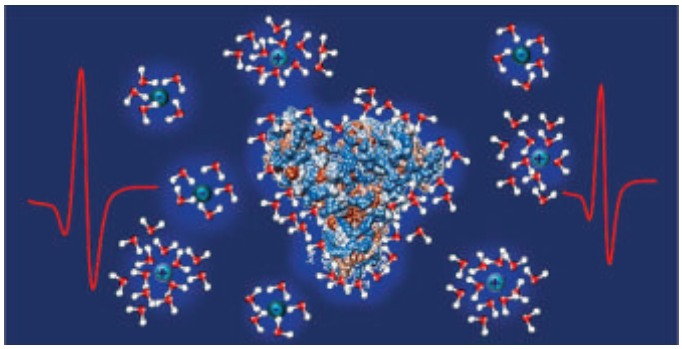
Rajib Kumar Mitra

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 and promoted to Associate Professor in January, 2015.

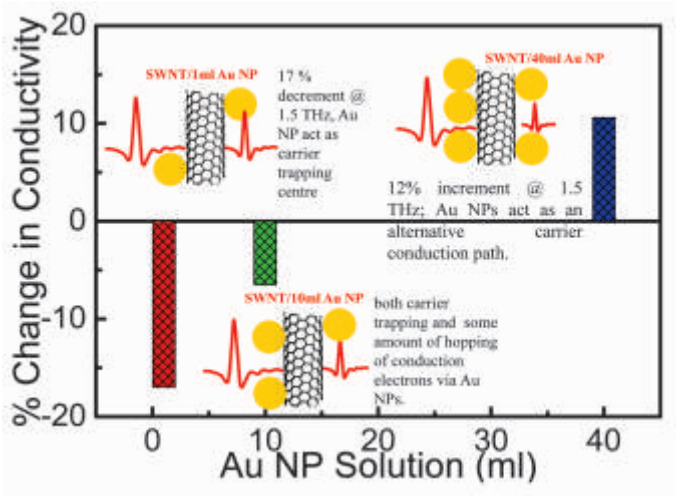
- **Terahertz Spectroscopy, Time resolved fluorescence spectroscopy, Hydration dynamics, Biophysics, Protein folding, Self-assembled systems (micelles, reverse micelles, lamellae, vesicles etc.), Nanomaterials**

1. Our group is involved in investigating the collective hydration dynamics around various solutes, with special references to salts of biological importance. In this context we measure the collective hydration dynamics (in THz region) of a series of monovalent alkali cations and it is found that these cations act essentially as water structure breakers, the extent of structure breaking being cation specific, the effect is found to be optimum in K^+ and Na^+. We also investigated the difference in the hydration of a protein in presence of these salts and a protein denaturant ion-H^+.



2. We extended this study to hydrophobic salts (e.g. alkylammonium cations). The extent of hydrophobicity in these cations was increased by increasing the alkyl chain length. It was found that the hydration behavior of these salts in the THz region was indeed dependent on the alkyl chain length. We also investigated the effect of these salts on the stability of a model protein and found that some of these salts act as protein denaturants whereas others are protein stabilizers.
3. We obtained the hydration dynamics of several amino acids of different hydrophobicity in GHz to THz region and found that their hydration changed systematically, however, it was the solvent accessible surface area (SASA) of the solute that showed a clear correlation with the hydration dynamics rather than the hydrophobicity of the amino acids.
4. We determined the changes in the collective hydration dynamins of a model protein lysozyme as it underwent conformational changes in presence of dimethylsulfoxide (DMSO) using THz spectroscopy. It was found that hydration at the protein surface did follow DMSO induced conformational changes.
5. THz electromagnetic shielding effectiveness (SE) of single walled carbon nanotubes (SWNT)/polymer composite films was studied and its relation with the weight fraction of SWNT inclusion was established. The modification of the THz properties of composite materials was thoroughly investigated by varying the material parameters and morphology. We have

established that while the real conductivity (also the SE) can be increased up to ~ 80% by simply changing the average length and weight fraction of the SWNT inside the polymer matrix, it can be tuned in a minuscule range (± 15%) by decorating the sidewalls of SWNT with gold nanoparticles (AuNP). The results were discussed in the light of a modified universal di-electric relaxation (UDR) model. The intrinsic conductivity spectra were analyzed using a combination of Maxwell-Garnett effective medium theory and Drude-Lorentz model.



6. We investigated the catalytic activity of a model enzyme -chymotrypsin on two different substrates in presence of cationic surfactants of different chain lengths. It was found that in the least hydrophobic surfactant the activity increased drastically ('superactivity') while in the other surfactants it decreased. The observation has been explained in terms of different pairwise interactions between enzyme, substrate and surfactant.

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 hydration dynamics of amino acids of varying hydrophobicity changes as they form di-, tri- and long chain peptides. We will also investigate if replacement of the L-isomers with the D-isomers produce any changes in the dynamics.
3. 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.
4. 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, with functionalized tube walls) – polymer composites and model their composite 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 nanoparticles, fabrication of structured materials (e.g. antidote metamaterials etc.) in order to manipulate THz radiation.

Publications in Journals

1. S. Pal, D. Polley, R. K. Mitra, and A. Barman, *Ultrafast dynamics and THz oscillation in $[Co/Pd]_8$ multilayers*, *Solid State Comm.*, 221, 50-54, 2015.
2. A. Patra, S. Hazra, N. Samanta, G. S. Kumar and R. K. Mitra, *Micelle induced dissociation of DNA–ligand complexes: The effect of ligand binding specificity*, *Int. J. Biol. Macromol.*, 82, 418–424, 2016.
3. D. Das Mahanta, N. Samanta and R. K. Mitra, *The effect of monovalent cations on the collective dynamics of water and on a model protein*, *J. Mol. Liq.*, 215, 197–203, 2016.
4. N. *Samanta*, T. Q. *Luong*, D. *Das Mahanta*, R. K. Mitra and *M. Havenith, Effect of Short Chain Poly(ethylene glycol)s on the Hydration Structure and Dynamics around Human Serum Albumin, Langmuir*, 32, 831–837, 2016.
5. A. Das, A. Patra and R. K. Mitra, *Modulation of anionic reverse micellar interface with non-ionic surfactants can regulate enzyme activity within the micellar waterpool*, *Colloid Polym. Sci.*, 294, 715–726, 2016.

Supervision of Students

Ph.D. Students: Animesh Patra, Arindam Das, Nirnay Samanta, Debanjan Polley, Debasis Das Mahanta, Neeraj Kumar; Project Student: Amit Bhar; Post Doctoral Research Scientist: Dipak Kumar Das

Lectures Delivered

1. The Effect of Salts on the Collective Dynamics of Water: A THz Spectroscopic Study, Theme Meeting on Ultrafast Sciences (UFS-2015), 19 - 21 November, 2015, S.N. Bose National Centre for Basic Sciences, Kolkata
2. Application of THz Spectroscopy to Study Biologically Important Phenomena, 5th IEEE Applied Electromagnetics Conference (AEMC-2015), 18-21 December, 2015, IIT Guwahati
3. Collective Dynamics of Water in Binary Mixtures Probed by THz Time Domain Spectroscopy, 13th DAE-BRNS Trombay Symposium of Radiation and Photochemistry (TSRP-2016) 5-9 January, 2016, BARC, Mumbai
4. Application of Terahertz Spectroscopy in Chemistry and Biology, National Conference on Recent Developments on Photochemistry and Photobiology *(RDPAP-2016)* 4-6 March, 2016, School of Chemistry, Sambalpur University
5. Effect of Short Chain Polyethyleneglycols on the Structure and Collective Hydration Dynamics of a Model Protein Human Serum Albumin, Optics Within Life (OWLS-2016), 16-19 March, 2016, TIFR, Mumbai

Course Taught

1. PHY 301, Atomic and Molecular Physics, 3rd Semester (Aug-Dec 2015)

Membership of Committees

Internal 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).

Meeting Organized

1. Theme Meeting on Ultrafast Sciences (UFS-2015), 19 - 21 November, 2015, S.N. Bose National Centre for Basic Sciences, Kolkata (Secretary).

Ranjit Biswas

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Prof. Ranjit Biswas and his group's work has led to (i) the development of theory for studying dielectric relaxation in ionic liquid/ solvent binary mixtures, (ii) microscopic understanding of heterogeneity in cycloether/water binary mixtures, (iii) heterogeneity induced correlated length- and time-scales in ionic liquid/water binary mixtures, and (iv) an understanding of dynamic solvent control of a reaction occurring in deep eutectic solvents.

- **Heterogeneity length and timescales have been revealed by our simulation studies of aqueous binary mixtures of ionic liquids, and of cycloethers, showing cluster formation is the main source for spatio-temporal heterogeneity in these mixtures. Theoretical works revealed that ion-solvent interactions play a significant role in governing the dielectric response of a mixture of an ionic liquid with polar solvent. Deep eutectics are found to strongly impact rate of a chemical reaction occurring in it**

Composition dependence of four-point dynamic susceptibilities, overlap functions, and other dynamic heterogeneity (DH) parameters have been investigated by using all-atom molecular dynamics simulations for aqueous solutions of the ionic liquid (IL), 1-octyl-3-methyl imidazolium tetrafluoroborate ([Omim][BF4]) covering the pure-to-pure range. Upon addition of water in the IL, the DH time scales become faster and the fourpoint dynamic susceptibility time scale softens. Evidences for jump motions for both water and ions have been found from the simulated single particle displacements that show strong deviation from Gaussian distribution. Estimated dynamic correlation length for water reflects effects of IL, whereas those for ions remain largely insensitive to the mixture composition. Simulated structural aspects and DH time scales provide microscopic explanations to the existing experimental observations from time-resolved fluorescence and Kerr spectroscopic measurements. Fig. 1 is a representative result where composition dependent four-point dynamic susceptibility is shown.

A semi-molecular theory is developed here for studying dielectric relaxation (DR) in binary mixtures of ionic liquids (ILs) with common dipolar solvents. Effects of ion translation on DR time scale, and those of ion rotation on conductivity relaxation time scale are explored. Two different models for the theoretical calculations have been considered: (i) separate medium approach, where molecularities of both the IL and dipolar solvent molecules are retained, and (ii) effective medium approach, where the added dipolar solvent molecules are assumed to combine with the dipolar ions of the IL, producing a fictitious effective medium characterized via effective dipole moment, density, and diameter. Semi-molecular expressions for the diffusive DR times have been derived which incorporates the effects of wavenumber dependent orientational static correlations, ion dynamic structure factors, and ion translation. Subsequently, the theory has been applied to the binary mixtures of 1-butyl-3-methylimidazolium tetrafluoroborate ([Bmim][BF4]) with water (H2O), and acetonitrile (CH3CN) for which experimental DR data are available. On comparison, predicted DR time scales show close agreement with the measured DR times at low IL mole fractions (xIL). At higher IL concentrations (xIL $>$ 0.05), the theory over-estimates the relaxation times and increasingly deviates from the measurements with xIL, deviation being the maximum for the neat IL by almost two orders of magnitude. The theory predicts negligible contributions to this deviation from the

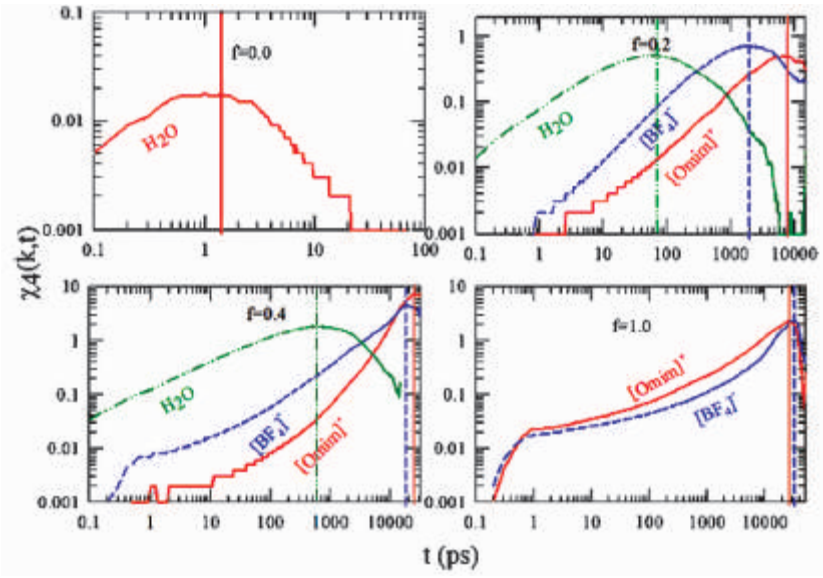


Figure 1. A comparison of the simulated four-point dynamic susceptibility, $\chi_4(k,t)$, among different components at a specific IL mole fraction at 298 K. The vertical lines denoted the respective peak times (approximately), t_4^{max}.

xIL dependent collective orientational static correlations. The drastic difference between DR time scales for IL/solvent mixtures from theory and experiments arises primarily due to the use of the actual molecular volume (Vdip mol) for the rotating dipolar moiety in the present theory and suggests that only a fraction of Vdip mol is involved at high xIL. Expectedly, nice agreement between theory and experiments appears when experimental estimates for the

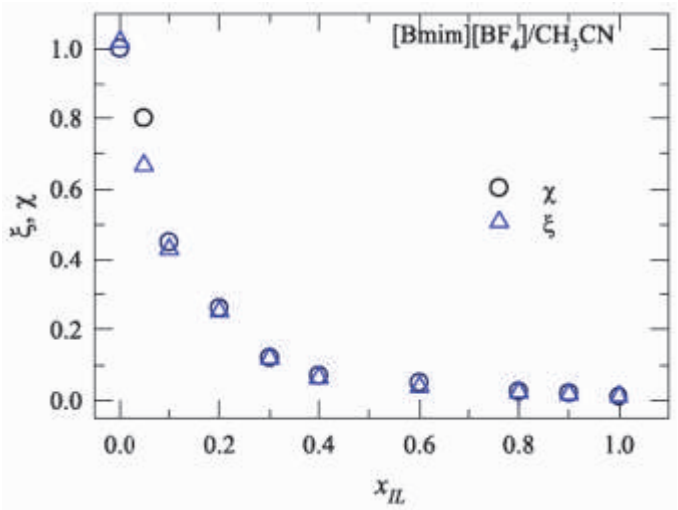


Figure 2. Comparison between $\chi\left(=V_{eff}^{dip}/V_{mol}^{dip}\right)$ and $\xi\left(=\tau_{DR,slowest}^{expt}/\tau_{dd}^{SM}\right)$ as a function of x_{IL} for [Bmim] $[BF_4]/CH_3CN$ binary mixtures.

effective rotational volume (Vdip eff) are used as inputs. The fraction, Vdip eff /Vdipmol, sharply decreases from ~1 at pure dipolar solvent to ~0.01 at neat IL,reflecting a dramatic crossover from viscosity- coupled hydrodynamic angular diffusion at low IL mole fractions to orientational relaxation predominantly via large angle jumps at high xIL.Fig. 2 represents such an observation.

Future Plan

We plan to study (i) ion orientation jumps in neat ionic liquid (ii) how jump activity softens to stochastic Brownian angular moves upon addition of water/acetonitrile, (iii)structural aspects of deep eutectics and its connection to spatio-temporal heterogeneity, (iv) dielectric relaxation of deep eutectics, and (v) interaction and dynamics of systems containing polymer as one of the mixture components.

Publications in Journals

1. Kallol Mukherjee, Anjan Barman and **Ranjit Biswas**, *Impact of Aggregation Behaviour of Sodium Cholate and Sodium Deoxycholate on Aqueous Solution Structure and Dynamics: A Combined Time Resolved Fluorescence and Dielectric Relaxation Spectroscopic Study*, Journal of Molecular Liquids – Special Issue (Invited Article), **222**, 495-502, **2016**.

2. Snehasis Daschakraborty and **Ranjit Biswas**, *Dielectric Relaxation in Ionic Liquid/ Dipolar Solvent Binary Mixtures: A Semi-Molecular Theory*, Journal of Chemical Physics, **144**, 104505, **2016**.

3. Sandipa Indra, Biswajit Guchhait and **Ranjit Biswas**, *Structural Anomaly and Dynamic Heterogeneity in Cycloether/Water Binary Mixtures: Signatures from Composition Dependent Dynamic Fluorescence Measurements and Computer Simulations*, Journal of Chemical Physics, ***144***, 124506, **2016.**

4. Sandipa Indra and **Ranjit Biswas,** *Are N-methyl Groups of Tetramethylurea (TMU) Hydrophobic? A Composition and Temperature-Dependent Fluorescence Spectroscopic Investigation of TMU/Water Binary Mixtures*, Journal of Chemical Sciences, **128**, 753-761, 2016.

5. Tamisra Pal and **Ranjit Biswas,** *Composition Dependence of Dynamic Heterogeneity Time- and Length Scales in [Omim][BF_4]/Water Binary Mixtures: Molecular Dynamics Simulation Study*, Journal of Physical Chemistry B, **119,** 15683-15695, 2015.
6. Anuradha Das and **Ranjit Biswas,** *Dynamic Solvent Control of a Reaction in Ionic Deep Eutectic Solvents: Time-Resolved Fluorescence Measurements of Reactive and Nonreactive Dynamics in (Choline chloride + Urea) Melts*, Journal of Physical Chemistry B, **119**, 10102-10113, 2015.

Supervision of Students

Ph.D. Students: Atanu Baksi, Ejaj Tarif, Juriti Rajbangshi, Kajal Kumbhakar; Post Doctoral Research Scientists: Suman Das (ESRF), Kallol Mukherjee (ESRF)

Lectures Delivered

1. "Ion-Amide Interactions, Cluster Size and Lifetime Distributions in Acetamide /Electrolyte Deep Eutectics: A Simulation Study" IISER-Kolkata, March 08, 2016.
2. "Temporal Heterogeneity, Four-Point Correlation and Dynamic Susceptibility in Neat Ionic Liquid (IL) and IL/Water Binary Mixtures: A Simulation Investigation" Hyderabad Central University, March 02 – 04, 2016.
3. "Decoding Deep Eutectics: Experiments and Simulations" IACS, Jadavpur, Kolkata, February 25, 2016.
4. "Softening of Spatio-Temporal Heterogeneity in Ionic Deep Eutectics by Urea: Experiments and Simulations" BARC, Mumbai, January 05-09, 2016.
5. "Dielectric and Fluorescence Spectral Relaxation Measurements of Deep Eutectic Solvents: Origin for Picosecond and Slower Dynamics", S. N. Bose National Centre for Basic Science, Kolkata during November 19-21, 2015.
6. "Decoding Deep Eutectics: Experiments and Simulations", IIT-Delhi on June 23, 2015.

Membership of Committees

Internal Committee: Head, CBMS

Samir Kumar Pal

Professor
skpal@bose.res.in

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 199 research papers published in various international peer-reviewed journals, 16 patent applications, 8 extramural research funding and 5 book chapters resulting more than 7000 citations, 45 h-index, 134 i10 index, 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. S. Choudhury, B. Ghosh, P. Singh, R. Ghosh, S. Roy and **S. K. Pal**, *Ultrafast Differential Flexibility of Cro-protein Binding Domains of Two Operator DNAs with Different Sequences*, Phys. Chem. Chem. Phys., **18**, 17983, 2016.
2. Z. S. Seddigi, S. A. Ahmed, S. Sardar and **S. K. Pal**, *Heterodimerization at the Dye Sensitized TiO_2 Surface: An Efficient Strategy toward Quick Removal of Water Contaminants*, Phtochem. Photobiol. Sciences, **15**, 920, 2016.
3. P. K. Sarkar, N. Polley, S. Chakrabarti, P. Lemmens and **S. K. Pal**, *Nanosurface Energy Transfer Based Highly Selective and Ultrasensitive "Turn on" Fluorescence Mercury Sensor*, ACS Sensors, **1**, 789, 2016.
4. T. Mahata, A. Kanungo, S. Ganguly, E. K.Modugula, S. Choudhury, **S. K. Pal**, G. Basu and S. Dutta, *A benzyl moiety in a quinoxaline-based scaffold acts as a DNA intercalation switch*, Angewandte Chemie (Communication), **55**, 7733, 2016.
5. Z. S. Seddigi, S. A. Ahmed, S. Sardar and **S. K. Pal**, *Carbonate Doping in TiO_2 Microsphere: The Key Parameter Influencing Others for Efficient Dye Sensitized Solar Cell*, Scinentific Reports (Nature Publications), **6**, 23209, 2016.
6. S. Choudhury, G. Naiya, P. Singh, P. Lemmens, S. Roy and **S. K. Pal**, *Modulation of Ultrafast Conformational Dynamics in Allosteric Interaction of Gal Repressor Protein with Different Operator DNA Sequences*, ChemBioChem, **17**, 605, 2016 (Cover Article).
7. S. Sardar, and **S. K. Pal**, *Ultrafast Photoinduced Carrier Dynamics at ZnO Nanohybrid Interfaces for Light-Harvesting Applications*, Nanotechnology Reviews, **5**, 113, 2016.
8. S. Sardar, S. Ghosh, H. Remita, P. Kar, B. Liu, C. Bhattacharya, P. Lemmens and **S. K. Pal**, *Enhanced Photovoltage in DSSCs: Synergistic Combination of a Silver Modified TiO_2 Photoanode and a Low Cost Counter Electrode*, RSC Advances, **6**, 33433, 2016.
9. S. Ghosh, P. Kar, N. Bhandary, S. Basu, S. Sardar, T. Maiyalagan, D. Majumdar, S. K. Bhattacharya, A. Bhaumik, P. Lemmens and **S. K. Pal**, *Microwave-assisted synthesis of porous Mn_2O_3 nanoballs as Bifunctional Electrocatalyst for Oxygen Reduction and Evolution Reaction*, Catalysis Science & Technology, **6**, 1417, 2016.
10. P. Singh, S. Choudhury, G. K. Chandra, P. Lemmens and **S. K. Pal**, *Molecular Recognition of Genomic DNA in a Condensate with a Model Surfactant for Potential Gene-delivery Applications*, J. Photochem. Photobiol. B, **157**, 105, 2016.
11. S. Chaudhuri, S. Sardar, D. Bagchi, S. Dutta, S. Debnath, P. Saha, P. Lemmens and **S. K. Pal**, *Photoinduced Dynamics and Toxicity of a Cancer Drug in Proximity of Inorganic Nanoparticles under Visible Light*, ChemPhysChem, **17**, 270, 2016.
12. D. Bagchi, S. Chaudhuri, S. Sardar, S. Choudhury, N. Polley, P. Lemmens and **S. K. Pal**, *Modulation of Stability and Functionality of a phyto-antioxidant by weakly interacting metal ions: Curcumin in Aqueous Solution*, RSC Advances, **5**, 102516, 2015.
13. S. Sardar, P. Kar, H. Remita, B. Liu, P. Lemmens, **S. K. Pal** and S. Ghosh, *Enhanced Charge Separation and FRET at Heterojunctions between Semiconductor Nanoparticles and Conducting Polymer Nanofibers for Efficient Solar Light Harvesting*, Scientific Reports (Nature Publication), **5**, 17313, 2015.
14. S. Choudhury, S. Batabyal, P. K. Mondal, P. Singh, P. Lemmens and **S. K. Pal**, *Direct Observation of Kinetic Pathways of Biomolecular Recognition*, Chemistry: A European J., **21**, 16172, 2015.
15. A. Mathew, E. Varghese, S. Choudhury, **S. K. Pal**, and T. Pradeep, *Efficient red luminescence from organic-soluble Au_{25} clusters by ligand structure modification*, Nanoscale, **7**, 14305, 2015.
16. N. Polley, S. Saha, A. Adhikari, S. Banerjee, S. Darbar, S. Das and **S. K. Pal**, *Safe and Symptomatic Medicinal Use of Surface- Functionalized Mn_3O_4 Nanoparticles for Hyperbilirubinemia Treatment in Mice*, Nanomedicine, **10**, 2349, 2015.
17. S. Choudhury, P. K. Mondal, V. Sharma, S. Mitra, V. Garcia-Sakai, R. Mukhopadhyay and **S. K. Pal**, *Direct Observation of Coupling between Structural Fluctuation and Ultrafast Hydration Dynamics of*

Fluorescent Probes in Anionic Micelles, J. Phys. Chem. B, **119**, 10849, 2015.

18. P. Kar, S. Sardar, S. Ghosh, M. R. Parida, B. Liu, O. F. Mohammed, P. Lemmens and **S. K. Pal**, *Nano Surface Engineering of Mn_2O_3 for Potential Light-Harvesting Application*, J. Mat. Chem. C, **3**, 8200, 2015.

20. Z. S. Seddigi, S. A. Ahmed, S. Sardar and **S. K. Pal**, *Ultrafast Dynamics at the Zinc Phthalocyanine/Zinc Oxide Nanohybrid Interface for Efficient Solar Light Harvesting in the near Red Region*, Solar Energy Materials & Solar Cells, **143**, 63, 2015.

21. N. Polley and **S. K. Pal**, *Medical Diagnosis and Remote Sensing at Fiber-tip: Picosecond Resolved FRET Sensor*, SPIE Proc., **9702**, 970211, 2016.

Supervision of Students

Ph.D. Students: Probir Kumar Sarkar, Tuhin Kumar Maji, Jayita Patwari, Samim Sardar, Susobhan Choudhury, Nabarun Polley, Siddhi Chaudhuri, Prasenjit Kar, Damayanti Bagchi, Priya Singh, Soumendra Singh (External); **Project Student:** Sounak Banerjee; **Post Doctoral Research Scientists:** Srabanti Ghosh, Shreyasi Dutta

Lectures Delivered

1. Invited talk International Conference on "Advanced Materials for Energy, Environment and Health" (ICAM-2016) during 04th to 07th March 2016 at Indian Institute of Technology Roorkee, Roorkee.
2. Invited Talk National Conference on "Recent Development & Applications in Chemical Sciences" (RDACS-2016) on 20-21, May, 2016 at NIT Agartala
3. Invited talk National Conference on Chemical Sciences – Recent Trends on 30th and 31st March 2016 at the West Bengal State University
4. Invited Talk National Conference on conference on Recent Advances in Optical Sciences in University of Hyderabad during May 6-7, 2016.
5. Invited talk National Conference on Trends in Nanomaterials and Biomedical Science Research, Dept. of Biochemistry & Biophysics, University of Kalyani, March 04, 2016
6. Prof. P K Sarma Memorial Talk, 23 April 2016, Department of Chemistry, Gauhati University
7. Invited Talk International Conference on Physics and Chemistries at Hydrophobic Interfaces, February 14-17, 2016 at KAUST, Saudi Arabia

Course Taught

1. PHY 405, CB 526

Membership of Committee

Internal Committee: Pest Control Committee, Chairman

Patents Submitted / Received

1. Expression of Interest on Bio-Templated Nanosensor for Mercury Detection in PPB Level. Indian Pat. Appl. (2016), 201621004916 dated 11th Feb 2016.
2. Ultrasensitive Fluorescence-based Efficient Mercury Sensor. Indian Pat. Appl. (2016), 201621005597 dated 17th Feb 2016.

Sponsored Projects

1. Title: "Nanogels: Biophysical Characterization and Potential Biomedical Applications in Drug Delivery" Department of Biotechnology (DBT), Approved in 2015.
2. Title: "In(Ga)As/GaAs Quantum Dot Solar Cells" (Award No. DST/TMC/SERI/FR/117) Department of Science and Technology (DST), Approved on 2015.

Subhra Jana

DST INSPIRE Faculty

subhra.jana@bose.res.in

Subhra Jana received her Ph.D. from Indian Institute of Technology Kharagpur, India. She did her postdoctoral research work in the Department of Chemical Engineering, The Pennsylvania State University, University Park, USA. She is currently working as a DST INSPIRE faculty at S. N. Bose National Centre for Basic Sciences, Kolkata. Recently, she has been selected as Young Associate of Indian Academy of Sciences, Bangalore. Her multi-disciplinary research involves solution phase synthesis and potential applications of alloys, intermetallics and inorganic-organic hybrid nanomaterials.

Experimental Materials Science

- **Colloidal Synthesis of Nanoscale Alloys and Intermetallics**
- **Chemistry of Inorganic-Organic Hybrid Nanomaterials**
- **Fabrication of Metal-Semiconductor Nanocomposites**
- **Environmental and Catalytic Applications**

As a DST INSPIRE faculty, I am actively involved in developing a research laboratory at S. N. Bose National Centre for Basic Sciences to carry out the synthesis of nanoscale alloys and intermetallics and inorganic-organic hybrid nanocomposites for catalysis and environmental applications. I am also trying to develop a route for the successful fabrication of inorganic-organic hybrid nanomaterials to be used as adsorbents to cpature selective gases and a template/nanoreactor for the synthesis of numerous transition metal and metal oxide nanoparticles.

We have established a two-step procedure to fabricate halloysite/metal nanocomposites (NCs) in a large-scale through the immobilization of metal precursors followed by reduction or by direct loading of preformed metal nanoparticles (NPs) over the surface of aminosilane modified halloysite nanotubes (HNTs), which in turn develop environmentally benign and low-cost heterogeneous catalysts. Characterization by different physical methods authenticates the successful fabrication of *in situ* and preformed HNTs/Ag and HNTs/Au NCs by these two different synthetic approaches, having monodispersed spherical morphology of the metal NPs. The Raman spectroscopy reveals intensive peaks of local phonons in the nanocomposites, which are more pronounced in the sample with silver nanoparticles that can be related to the plasmonic enhancement of the light scattering and further probes the formation of metal/clay nanocomposites. The obtained results therefore, demonstrate the potentials application of

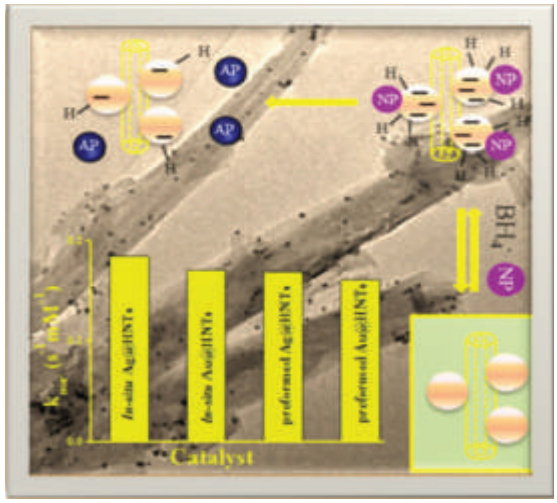


Fig.1: Synthesis of halloysite/metal nanocomposites through the immobilization of preformed and in-situ synthesized metal nanoparticles over halloysite surfaces, which in turn produce efficient, cost-effective, and environmentally benign heterogeneous catalysts with enhanced catalytic activity.

these clay nanocomposites in photonics and biomedicine. The nanocomposites were then used as a heterogeneous catalysts and their catalytic activity has been studied in detail (Fig. 1). A comparison study of their catalytic activity has been carried out with the reported heterogeneous catalysts, indicating the higher activity of these NCs for the reduction of nitroaromatics. Nevertheless, such an outstanding catalytic efficiency was only observed from HNTs/Au and HNTs/Ag NCs, with no activity from pristine HNTs or aminosilane modified HNTs. However, a detailed kinetic study demonstrates the enhanced catalytic activity of *in-situ* synthesized HNTs/Ag among the four NCs, owing to the absence of any capping materials over the surface of NPs.

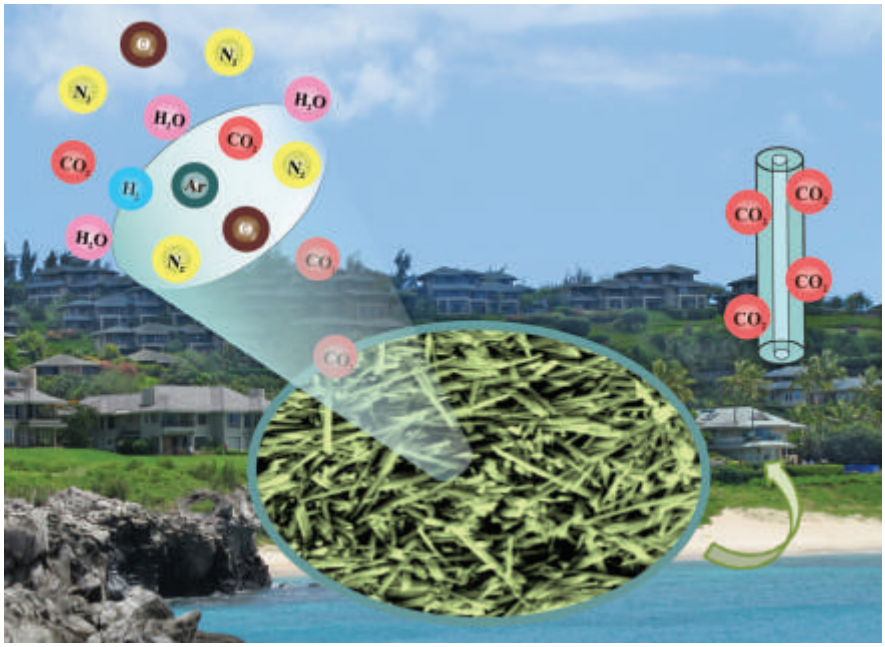


Fig.2: Demonstrating a study on the trapping of isotopic carbon dioxide from the seasonal ambient air in clay based nanocomposites. This work has been highlighted as back cover of ***Journal of Materials Chemistry A*** 2016, *4*, 7632–7640.

With the aim to capture and subsequent selective trapping of CO_2, clay based solid adsorbents comprised of several viable amines having varied amine densities and adsorption sites were designed to capture isotopic CO_2 from ambient air under standard temperature and pressure, keeping an eye on the preferential adsorption of the three major abundant isotopes of CO_2 (Fig. 2). Another major aim of this study is to find out the moisture dependent isotopic CO_2 adsorption together with the stability of these novel adsorbents towards the repetitive use for CO_2 uptake in oxidative environment. Relative humidity induced isotopic CO_2 adsorption which appears to have received still little or even no attention, has been demonstrated and the adsorption kinetics describing CO_2 uptake rate was investigated to evaluate the efficiency of the adsorbents as well as to explore the underlying adsorption mechanism. The adsorption kinetics of atmospheric CO_2 on these clay nanotubes followed the fractional-order kinetic model compared to that of the pseudo-first-order or pseudo-second-order rate equations. In addition, all these novel adsorbents exhibit reversible CO_2 adsorption in oxidative environment and exceptional durability even after prolonged cyclic adsorption-desorption study, introducing a new route to the adsorption of atmospheric CO_2.

Future Plan

Proposed research plan has been summarized below:

1. Synthesis of new inorganic-organic hybrid nanocomposites for environmental application

2. Preparation of size- and shape-tunable plasmonic alloy nanoparticles for surface-enhanced Raman spectroscopy studies.

3. Utilize these nanocomposites as well as nanoscale alloys as heterogeneous catalysts in various chemical and photochemical reactions.

Publications in Journals.

1. S. Das, C. Ghosh, **S. Jana**, *Moisture Induced Isotopic Carbon Dioxide Trapping from Ambient Air*, Journal of Materials Chemistry A, **4**, 7632–7640, 2016. (Featured as Back Cover)

2. A. Bhowmik, H. Kaur, S. Koley, **S. Jana**, S. Ghosh, *Diffusion Assisted Bimolecular Electron Injection to CdS Quantum Dots: Existence of Different Regimes in Time*

Dependent Sink Term of Collins-Kimball Model, Journal of Physical Chemistry C, **120**, 5308–5314, 2016.

3. S. Das, A. Maity, M. Pradhan, **S. Jana**, *Assessing Atmospheric CO_2 Entrapped in Clay Nanotubes using Residual Gas Analyzer*, Analytical Chemistry, **88**, 2205-2211, 2016.

4. K. A. Gonchar,. V. Kondakova, **S. Jana**, V. Yu. Timoshenko, A. N. Vasilev, *Investigation of Halloysite Nanotubes with Deposited Silver Nanoparticles by Methods of Optical Spectroscopy*, Physics of the Solid State, **58**, 601-605, 2016.

5. S. Som, A. De, G. D. Banik, A. Maity, C. Ghosh, M. Pal, S. Daschakraborty, S. Chaudhuri, **S. Jana**, M. Pradhan, *Mechanisms Linking Metabolism of Helicobacter Pylori to ^{18}O and ^{13}C-Isotopes of Human Breath CO_2*, Scientific Reports, **5**, 10936, 2015.

6. **S. Jana**, *Advances in Nanoscale Alloys and Intermetallics: Low Temperature Solution Chemistry Synthesis and Application in Catalysis*, Dalton Transactions, **44**, 18692–18717, 2015.

Supervision of Students

Ph.D. Student: Sankar Das

Lectures Delivered

1. 81st Annual Meeting of Indian Academy of Sciences, Bangalore, November 6-8, 2015 held at IISER Pune.

2. *"National Science Day 2016" on 29th Feb, 2016 at the Centre.*

Course Taught

1. PHY 391: Methods of Experimental Physics for I-PhD

Membership Of Committees

External Committee: Editorial Board Member of Scientific Reports (*Nature Publishing Group*) from 2015 onward; **Internal Committee:** Member of Seminar and Colloquia Programme (SCOLP) and interview committees

Award / Recognition

1. **Young Associate** of Indian Academy of Sciences, Bangalore in 2015.

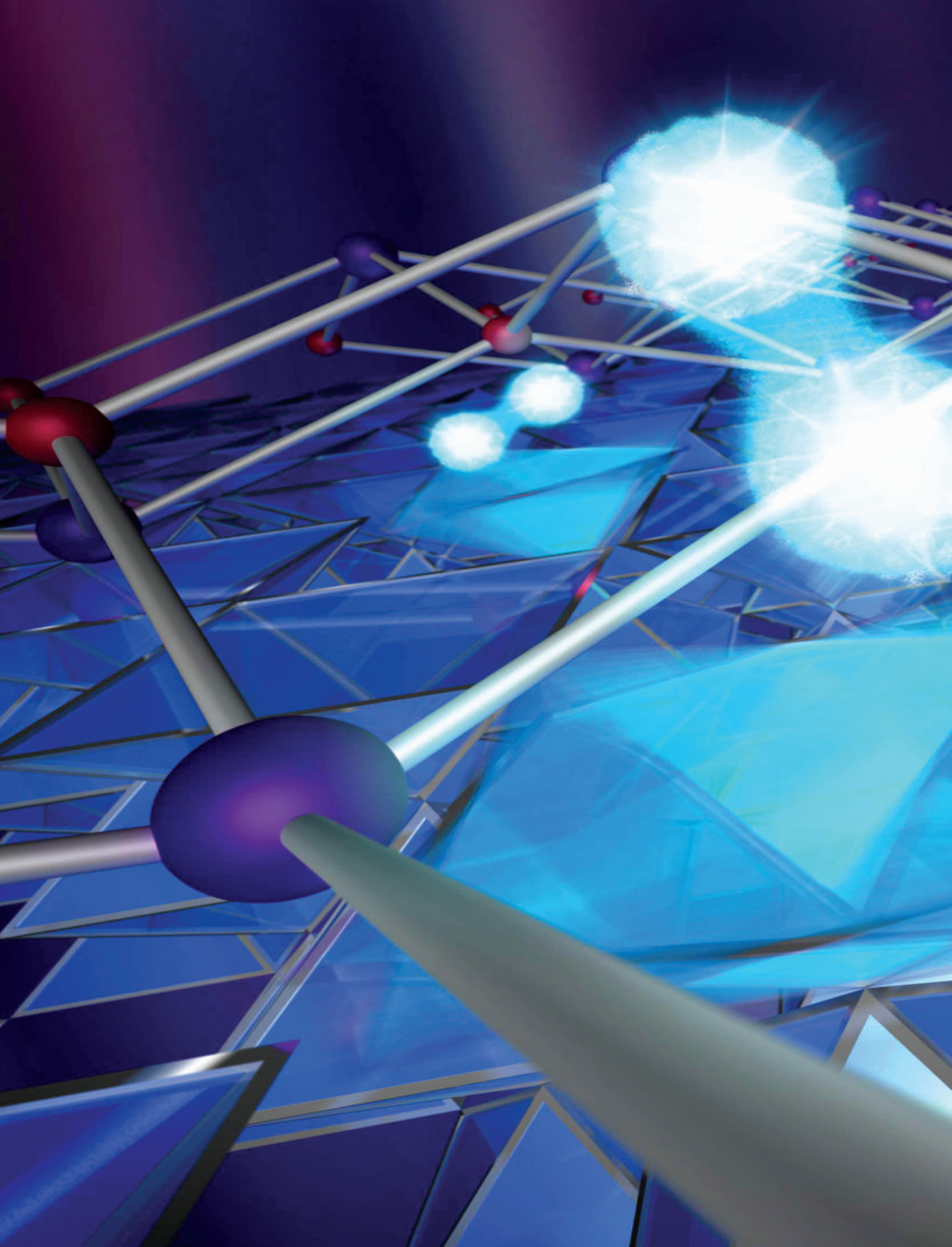
2. Editorial Board Member of Scientific Reports (Nature Publishing Group)

Sponsored Projects

1. Setting up of Technical Research Centre (TRC) funded by Department of Science & Technology (DST) India.

2. Received Extramural Research Grant as a Project Investigator funded by Nano Mission, Ministry of Science & Technology and Department of Science & Technology, Government of India, 2016-2019.

3. INSPIRE Research Grant funded by Department of Science & Technology (DST) India.



DEPARTMENT OF

Condensed Matter Physics and Material Sciences

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Condensed Matter Physics and Material Sciences

Pratip Kumar Mukhopadhyay

Head of the Department

Department profile indicators

Table A	Manpower and resources	
Number of faculties		9
Number of Post -doctoral research associate (centre + project)		7 + 4 = 11
Number of Ph.D students		56
Number of other project staff		10 (student) + 9 (academic staff)
Number of summer students		6
Projects (ongoing)		16 (External Fund) + 3 (Inspire) + 1 (Ramanujan)

Table B	Research Activities indicators	
Number of research papers in Journals		74
Number of Book-chapters/books		NIL
Number of other publications		16
Number of Ph.D students graduated (submitted + degree awarded)		10 + 7 = 17
Number of M.Tech/M.Sc projects		1

Table C	Academic activities and likeage		
Number of courses taught by faculties			10
Number of Visitors (non -associates)			1
Number of associates			2
Number of Seminars organized			8
Number of Conference/Symposia/ Advanced Schools organized			2
Number of talks delivered by members of department in conferences/Symposia	National		23
	International		14

Most important research highlights

- Study of magnetism in different morphologies in various transition metals and oxides through ab initio band structure calculation methods.
- Calculation of thermoelectric properties of graphene/h-BN/graphene hetrostructures
- Ab initio methods and model Hamiltonian based calculations to find electronic structures of transition metal dichalcogenides

- Development of numerical techniques in DMRG type methods and studied quantum phase transitions theoretically
- Investigation of connections between topological excitations and conventional excitations in two dimensional spins
- Molecular dynamics simulation and experimental studies on plasticity mediated collapse and recrystallization of hollow copper nanowires
- Tuning of ultrafast magnetization dynamics in bilayer thin wires and nano stripes
- Investigation of THz conductivity in ferrite nano structures
- Synthesis, characterization and tuning of fluorescent properties of ferrite nano particles
- Discovery of a new multipolar type anisotropic dependence of magnetic field on yield stress of magneto rheological fluids
- Control of coexisting phases and electronic properties in thin films by electric bilayer gates

Summary of research activities

Like in previous years, various work of different groups can be partitioned into theoretical and experimental sections. The theoretical section can further be subdivided into computer calculations and simulations work, as applied to various solid systems. The minor part uses microscopic theories and phenomenological modelling. In the experimental section, the main focus is on magnetism of different materials, from nano to bulk length scale and over femtosecond to ordinary time scale, in solid and as in liquid state. Various other functional properties are also studied simultaneously.

In the first part, people worked with various methods, like augmented space recursion method, density matrix renormalization group etc. to study a variety of properties like Magnetism on rough surfaces of transition metallic alloys and oxides. Chalcogenides and oxides were studied by another group in a similar way. Breakdown of J=0 Nonmagnetic State in d^4 Iridate Double Perovskites were studied in a similar vein by another group. Yet another group worked on molecular dynamic simulation of elastic and plastic properties of hollow copper nano tubes, and also its recrystallization effects after plasticity mediated collapse. They collaborated with an experimental group for analyzing their data. The next group worked on evaluation of electronic properties by ab initio and model Hamiltonian methods on interesting systems like transition metal dichalcogenides. Quantum phase transitions in various model systems, and various other non equilibrium properties were studied by a group who developed modified codes for the simulations. Finally in this line, an interesting work was carried out by some members on thermoelectric property evaluation of stacks of graphene and h-BN sheets.

A faculty and his group was looking into various field theoretic techniques to apply on systems like layered quantum Heisenberg anti ferromagnets and also using generalized Hamiltonian methods to study multi layered superconductors. Spontaneous symmetry breaking in quasi one dimension and other systems were worked on by another group.

In case of experiments, nano particles, structures and the like were mainly used by most of the group members. While one group specialized in ultrafast dynamics of magnetization in various materials in thin film form, as various patterned and various spin materials. In a similar way, THz spectroscopic tools were used to find conductivity of nano patterned ferrites. Another group was developing ferritic nano particles for hypothermia and could identify ways to tune its various functional properties like luminescence. Similarly another group went on to find a way to electrically control of coexisting phases in thin films. This lead to variation of charge transport in this system, somewhat similar to the effect of controlling grain boundary layer in ZnO films.

A different approach was used by another group to work with magnetic smart materials in both solid and in fluids. A remarkable effect was found in magneto rheological studies of CoNi nano particle based system in which the yield response due to various applied filed was found to have unusual multipolar contributions in the system. Finally, another member was working multifunctional ferrites for their practical use.

Pratip Kumar Mukhopadhyay

Head, Department of Condensed Matter Physics and Material Sciences

Abhijit Mookerjee

Professor Emeritus
abhijit.mookerjee61@gmail.com

Prof. Abhijit Mookerjee is the seniormost faculty member at the Centre. His work has led to more than 215 publications. H-index is 26 and 10! index – 75. So far he has guided 35 students for their PhD and 3 are still working with him.

- We have developed the augmented space recursion program for the study of systems with long-ranged and topological disorder. Application has been made to electronic, optical and magnetic effects of disorder on graphene and BN

Apart from the new developed Augmented Space Recursion package, we have studied details of "spatial ergodicity" and the effects of both chemical and topological disorder on different systems. We have also studied effect of disorder on magnetic relaxation in different systems like FeCo, FeAl, and doped graphene and BN.

Future Plan

We plan to introduce and publicize the new ASF-Recursion Package.

Publications in Journals

1. Prashant Singh, Manoj K. Harbola, M. Hemanadhan, **Abhijit Mookerjee**, and D. D. Johnson, *Better band gaps with asymptotically corrected local exchange potentials*, Phys. Rev. B, **93**, 085204, 2016.
2. Suman Chowdhury, Debnarayan Jana, **Abhijit Mookerjee**, *Conductance of disordered graphene sheets: A real space approach*, Physica E: Low-dimensional Systems and Nanostructures, **74**, 347, 2015.
3. Priyadarshini Parida, Biplab Ganguli, **Abhijit Mookerjee**, *Magnetism on rough surfaces of Fe, Co and Ni: An augmented space approach*, Superlattices and Microstructures, **86**, 173, 2015.
4. Soumendu Datta, Gopi Chandra Kaphle, Sayan Baral and **Abhijit Mookerjee**, *Study of morphology effects on magnetic interactions and band gap variations for 3d late transition metal bi-doped ZnO nanostructures by hybrid DFT calculations*, J. Chem. Phys., **143**, 084309, 2015.
5. Suman Chowdhury, D Jana, B Sadhukhan, D Nafday, S Baidya, Tanusri Saha-Dasgupta, **Abhijit Mookerjee**, *Configuration and self-averaging in disordered systems*, Indian Journal of Physics, **90,** 649 (2016).

Supervision of Students

Ph.D. Students: A.K. Jena: received his PhD from Calcutta University; Suman Chaudhury: submitted his PhD to Calcutta University; Banashri Sadhu Khan: working in Presidency University in collaboration with me; Sujoy Datta: working in Lady Brabourne College in collaboration with me.

Alo Dutta

Young Scientist of DST Fast Track Project

alo.dutta@bose.res.in

Dr. Alo Dutta has been associated with the design and synthesis of advanced materials with novel electronic properties. The structural, electrical, magnetic, vibrational and optical properties of these materials have been investigated by various experimental techniques. For physical understanding of these properties, density functional theory with generalized gradient approximation has been explored.

- **Synthesize of perovskite oxides**
- **Analysis of crystal structure by Rietveld refinement of XRD pattern**
- **Dielectric properties of the materials in radio frequency and microwave frequency rage.**
- **Magnetic properties of transition metal based perovskite oxides.**
- **The study of electronic structure of perovskites oxides using density functional theory and X-ray photoemission spectroscopy**

I have synthesized some rare-earth based perovskite oxides and investigated their physical properties mainly vibrational, electrical and magnetic.

(1) $CaLa(CaNb)O_6$, $CaLa(CaTa)O_6$ and Ba_2LaNbO_6

The Rietveld refinement of the X-ray diffraction patterns suggests the monoclinic crystal structure of all the materials at room temperature. The X-ray photoemission spectroscopic (XPS) study confirms the presence of Ca in two octahedral co-ordination sites for Ca-based materials. The negative and positive chemical shift of the core level XPS spectrum of O-1s and Nb-$3d_{3/2}$/Ta-$4f_{5/2}$ respectively suggest the covalent bonding between Nb/Ta cations and O ion. A large covalency of Ta-based compound than Nb compound is confirmed from the relative shifting of the Raman modes of the materials.

(2) Sr_2LaSbO_6

The Rietveld refinement of the X-ray diffraction pattern of Sr_2LaSbO_6 (SLS) shows monoclinic phase at room temperature. The Raman spectrum substantiates the monoclinic structure of SLS with space group P21/n (C^5_{2h}). The relaxation peak is observed in the frequency dependence of of dielectric permittivity. The frequency dependence conductivity data follow the power law. The values of power law exponents suggest that large polaron hopping is responsible for suggests that the relaxationcharge carrier transport in SLS. The most probable relaxation frequencies at various temperatures are found to obey the Arrhenius law with an activation energy of 0.36 eV, which indicates that polaron hopping plays the main role in the dielectric relaxation of SLS.

(3) $NdGaO_3$

The X-ray diffraction analysis of $NdGaO_3$ (NGO) synthesized by the sol–gel process suggests the orthorhombic Pbnm space group at room temperature. Two relaxation processes with different relaxation times are observed from the impedance as well as modulus spectroscopic measurements, which have been attributed to the grain and the grain boundary effects at different temperatures in NGO. The temperature dependent electrical conductivity shows the negative temperature coefficient of resistance.

(4) $La_{1-x}Pr_xFeO_3$ (x = 0, 0.1, 0.2, 0.3, 0.4 and 0.5)

The Pr doped $LaFeO_3$ are synthesized by the sole-gel citrate method. The crystal structure of the samples can be described by the Pbnm space group. The Raman spectra of the materials show that the vibrational modes are heavily

influenced by the magnitude of the orthorhombic distortion. The substitution of La^{3+} ions by Pr^{3+} ions effectively enhances the magnetization of $LaFeO_3$ and decrease the anti-ferromagnetic transition temperature T_N. A signature of weak ferromagnetic phase is observed in the samples at low temperature due to canting of the iron sublattices. A significant change of the conductivity is observed with the increase of Pr concentration

(5) A_2ErSbO_6 (A = Ba, Sr and Ca)

The Rietveld refinement of the X-ray diffraction pattern at room temperature shows that BES is cubic (Fm3m) but SES and CESare monoclinic ($P2_1/n$). When Sr is replaced by Ca in the monoclinic symmetry the A_{1g} Raman mode shifts toward lower frequency side whereas F_{2g} modes shift toward higher frequency side. On the other hand the FWHM for the A_{1g} mode is increased from BES to CES which results the lower quality factor or larger loss factor in dielectric study.

Future Plan

Synthesize of the solid-solution of some perovskite oxides having the opposite sign of temperature co-efficient of resonant frequency. The phase formation and crystal structure of the materials will be studied by the Reitveld refinement of the X-ray diffraction data. Fourier transfer infrared (FTIR) spectra and Raman spectra of the materials will be taken to find out the vibrational modes in these materials. The MW dielectric properties of the materials will be investigated in two different ways: (1) from the reflectivity spectra in IR region and fitting the experimental data with the generalized four parameter oscillator model and (2) from the direct measurement of dielectric constant in GHz frequency range.

The vibrational phonon modes of the synthesized materials will be studied by the Raman and infra-red spectroscopy studies. The density functional theory will be used to assign the nature of various vibrational modes in these materials by obtaining the eigen values and eigen vectors.

Publications in Journals

1. **Alo Dutta**, Sujoy Saha, Premlata Kumari, T.P. Sinha and Santiranjan Shannigrahi, *Crystal structure and X-ray photoemission spectroscopic study of A_2LaMO_6 [A = Ba, Ca; M = Nb, Ta]*, Journal of Solid State Chemistry, **229**, 296-302, 2015.
2. **Alo Dutta**, Premlata Kumari and T.P. Sinha, *Electrical properties of double perovskite oxide Sr_2LaSbO_6: an impedance spectroscopic study*, *Electronic Materials Letters*, **11**, 775-781, 2015.
3. Anup Pradhan Sakhya, **Alo Dutta** and T.P. Sinha, *Dielectric and impedance spectroscopic studies of neodymium gallate*, *Physica B*, **488**, 1-7, 2016.
4. Sadhan Chanda, Sujoy Saha, **Alo Dutta**, Bushra Irfan, Ratnamala Chatterjee and T.P. Sinha, *Magnetic and dielectric properties of orthoferrites $La_{1-x}Pr_xFeO_3$ (x = 0, 0.1, 0.2, 0.3, 0.4 and 0.5)*, *Journal of Alloys and Compounds*, **649**, 1260-1266, 2015.
5. Rajesh Mukherjee, Sujoy Saha, **Alo Dutta** and T. P. Sinha, *Dielectric and Raman spectroscopic studies of A_2ErSbO_6 (A = Ba, Sr and Ca)*, *Journal of Alloys and Compounds*, **651**, 222-229, 2015.

Lectures Delivered

1. Oral presentation has been given on "Dielectric relaxation of Sr_2AlTaO_6: Frequency and time domain approach" in the "International conference on Advances in Functional Materials" held at Stony Brook University, New York, USA, during June 29th to 3rd July, 2015
2. Oral presentation has been given on "Dielectric Relaxation and Charge Transport Process in $PrCrO_3$ Nano-Ceramic" the "International conference on Nanomaterilas and Nanotechnology" held at K.S. Rangasamy College of Technology, Tamil Nadu, India during December 7th to 10th, 2015.

Academic Visit

1. I visited department of Physics, IIT Madras and DST facilities in IISC Bangalore on the moth of December, 2015 for the collaborative study of the microwave dielectric properties of some perovskite materials.

Sponsored Project

1. DST Fast Track Project for Young Scientist "Microwave dielectric properties and collective vibrational modes of double perovskite oxides"

Amlan Dutta

DST INSPIRE Faculty

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Dr. Amlan Dutta's major research interests are theoretical and computational material science. He employs the tools of molecular dynamics simulations to investigate the elasto-plastic properties of solids. Presently, he is studying metallic nanostructures like bcc nanopillars, hollow nanowires and nanocrystalline fcc polycrystals. Additionally, semiconductor nanocomposites are also being explored.

- **Molecular dynamics simulations, Elastic behavior of core-shell nanowires, Thermal stability of metallic nanowires, Elastic property of nanocomposites**

1. Using MD simulations, we have analyzed the thermal stress and resulting buckling instability in core-shell Si-Ge nanowires. Our calculations reveal how the thermal stress varies with the configuration of the wire. In particular, a novel stability diagram is produced with can help the designers of nanoelectronic components. This diagram shows a trade-off between design parameters and operational parameters of the device.
2. We have employed atomistic computations to study the thermal stability of hollow Cu NW. The simulations indicate that under the influence of elevated temperature, the hollow nanostructure collapses to yield a solid Cu NW. This involves dislocation mediated plasticity and an anomalous diffusion of surface atoms has been detected.
3. We have investigated the elastic behavior of amorphous-crystalline Si nanocomposite. The results obtained from the simulations have been fitted to an effective medium theory model. This exercise reveals strong effect of the amorphous-crystalline interphase. The computations also exhibit an anomalous trend of the bulk modulus of the composite.

Future Plan

1. Studying the fracture behavior of amorphous-crystalline nanolaminate.
2. Using MD simulations to explore the modalities of dislocation dynamics in deforming bcc metallic nanopillar.
3. Studying the evolution of grain boundary structure of deforming fcc nanocrystalline metals.

Publications in Journals

1. Suvankar Das, Amitava Moitra, Mishreyee Bhattacharya and **Amlan Dutta**, *Simulation of thermal stress and buckling instability in Si/Ge and Ge/Si core/shell nanowires*, *Beilstein. J. Nanotechnol.*, **6**, 1970–1977, 2015.
2. **Amlan Dutta**, Arup Kumar Raychaudhuri and Tanusri Saha-Dasgupta, *Plasticity-mediated collapse and recrystallization in hollow copper nanowires: a molecular dynamics simulation*, Beilstein J. Nanotechnol., **7**, 228–235, 2016.

Supervision of Students

Ph.D. Student: Suvankar Das

Lectures Delivered

1. In-silico estimation of thermally induced elastic instability in semiconductor core-shell nanowires, Maulana Azad college, Kolkata, Dec., 2015.
2. Dislocation pinning at localized obstacles: A statistical perspective, YSC-2015, CGCRI – Kolkata, Sep., 2015.

Membership of Committees

Internal Committee: SCOLP Committee, Interview Committees

Sponsored Project

1. Development of Statistical model of dislocation dynamics, INSPIRE faculty project, DST.

Anjan Barman

Professor
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Professor Barman obtained Ph.D. from IACS (Jadavpur University) in 1999. He worked as Postdoctoral Fellow in Europe and USA between 1999 and 2006, and as Assistant Professor at University of South Carolina, USA and IIT Delhi between 2006 and 2009. He joined SNBNCBS in 2009. He works in Magnonics and Spintronics, including ultrafast magnetization dynamics, nanomagnetism, spin Hall effect and interface magnetism.

- **Magnetic thin films; multilayers; patterned nanostructures; ultrafast magnetization dynamics; Brillouin light scattering, ferromagnetic resonance, magnonics; spintronics, spin Hall effect, interface magnetism, magnetic vortex and skyrmions, micromagnetic simulations**

Observation of specific energy storage in magnetic nanodisks for magnetically coupled vortex pair: We experimentally demonstrated the energy transfer and storage in the magnetostatically coupled vortices in a pair of nanodisks. By measuring the frequency dependence of the rectified voltage, we observed a specific gyrating motion due to anomalous energy storage at the off-resonance frequency. Micromagnetic simulations based on the Landau-Lifshitz-Gilbert equation qualitatively reproduce the experimental results, and reveal that the behavior arises from the modulation of effective damping constant of the pair disks, originating from the phase difference between coupled vortex cores. These findings can be of use in magnetic vortex based logic operations.

Field Dependent Spin Waves in High Aspect Ratio Single Crystalline Ferromagnetic Nanowires: We investigated spin waves in high aspect ratio single crystalline ferromagnetic nanowires (FMNWs) using time-resolved magneto-optical Kerr microscope. The precessional magnetization dynamics unveils the presence of uniform and quantized spin wave modes that are tunable by varying the bias magnetic field (H). The frequencies of the modes are seen to decrease systematically with decreasing magnetic field and the number of modes in the spectrum is reduced from four to three for $H < 0.7$ kOe. Our simulations clearly show how the standing and uniform spin wave modes coalesce to form a single mode with uniform precession over the entire nanowire for $H < 0.7$ kOe, reproducing the experimentally observed reduction in modes.

Tunable Magnetization Dynamics in Interfacially Modified $Ni_{81}Fe_{19}$/Pt Bilayer Thin Film Microstructures: Interface modification for control of ultrafast magnetic properties using low-dose focused ion beam irradiation is demonstrated for bilayers of $Ni_{81}Fe_{19}$ and Pt. Magnetization relaxation, precession, damping and the spatial coherence of magnetization dynamics were studied. A systematic study of the Gilbert damping parameter and frequency as a function of irradiation dose shows a complex dependence upon ion beam dose. This is interpreted in terms of both intrinsic effects and extrinsic two-magnon scattering effects resulting from the expansion of the interfacial region and the creation of a compositionally graded alloy. The results suggest a new direction for the control of magnetization dynamics, and open the opportunity to optimize high-speed magnetic devices.

Improved Magnetic Damping in CoFeB|MgO with N-doped Ta Underlayer Investigated using Brillouin Light Scattering Technique: Understanding the role of interfacial roughness on magnetic damping is important for developing advanced spintronics based devices. Using Brillouin light scattering (BLS), we investigated the interfacial roughness contributing to magnetic inhomogeneity in the technologically important ultrathin CoFeB|MgO heterostructures with Ta and N-doped Ta underlayers. The spin wave frequencies corresponding to uniform precession

modes in the BLS spectra for perpendicularly magnetized as well as in-plane magnetized films are investigated. The linewidth shows pronounced dependence on the N-doping in the underlayer. The analysis of linewidth suggests that the magnetic inhomogeneity and the damping reduce significantly by N-doping in the underlayer.

Tunable magnetization dynamics in ferromagnetic nanostripe with width down to 50 nm: Ferromagnetic nanostripes are important elements for a number of interesting technologies including magnetic racetrack memory, spin logic and magnonics. Understanding and controlling magnetization dynamics in such nanostripes are hence important problems in nanoscience and technology. We used an all-optical excitation and detection of ultrafast magnetization dynamics, including spin waves, in 5 m long $Ni_{80}Fe_{20}$ nanostripes with varying stripe width from 200 nm down to 50 nm. We observed a strong width dependent variation in the frequency, anisotropy and spatial nature of spin waves in these systems. The effect of inter-stripe interaction is also studied and the 50 nm wide stripe is found to be nearly magnetostatically isolated, allowing us to detect the dynamics of a 50 nm wide individual stripe using an all-optical measurement technique. The tunability in magnetization dynamics with stripe width is important for their applications in various spin based technologies.

Future Plan

Investigation of spin orbit torque at the interface of ferromagnet/heavy metal and ferromagnet/insulator: An electric current in thin films with spin-orbit coupling can produce spin accumulation, which can exert significant torques on magnetic moments. These torques can arise from (a) spin-dependent scattering of conduction electrons in the bulk of the heavy metal (*spin Hall effect*) and (b) momentum-dependent spin polarization at the HM/FM interface, i.e., the *Rashba-Edelstein effect*. We will investigate the effects of the torques on the magnetization damping and precession frequency of the ferromagnetic layer. The electric dipole at the FM/insulator interface may also give rise to a Rashba-Edelstein effect. We will investigate this in different combination of FM/insulator thin film systems.

Propagating Spin Waves in Nanomagnet Arrays for Spin Logic Devices: We will use microfocused Brillouin light scattering to investigate and image propagating spin waves in various spin wave nano-waveguide and nanomagnet arrays to develop new generation of spin logic devices.

Development of 3-D Magnonic Crystals: We will use two-photon lithography system for the development of three-dimensional nanostructures and magnonic crystals. We will investigate the ultrafast magnetization dynamics and magnon dispersion in these systems.

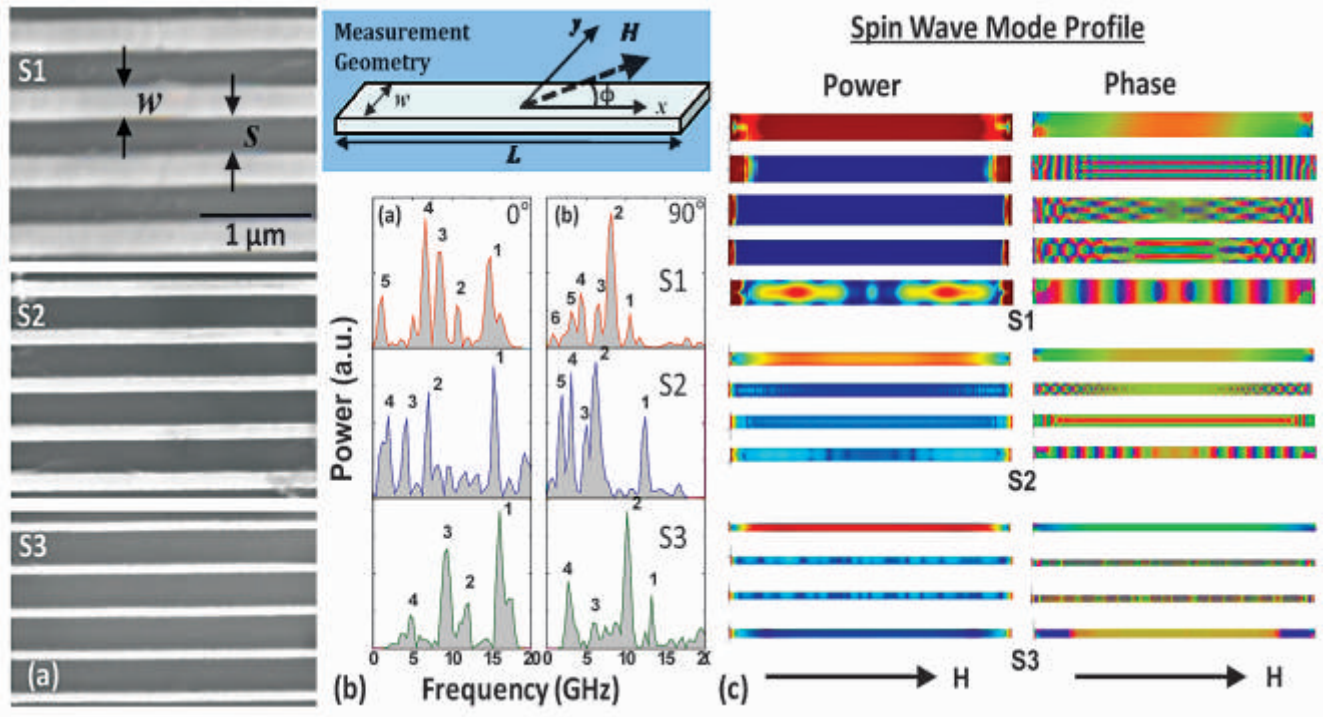

Fig. 1 (a) Scanning electron micrographs of the NiFe nanostripes with width down to 50 nm. (b) Measurement geometry and measured spin wave spectra from the nanostripes with the bias field (***H***) applied at $\phi = 0^0$ and 90^0. Simulated spin wave mode profiles for $\phi = 0^0$ for all three nanostripes.

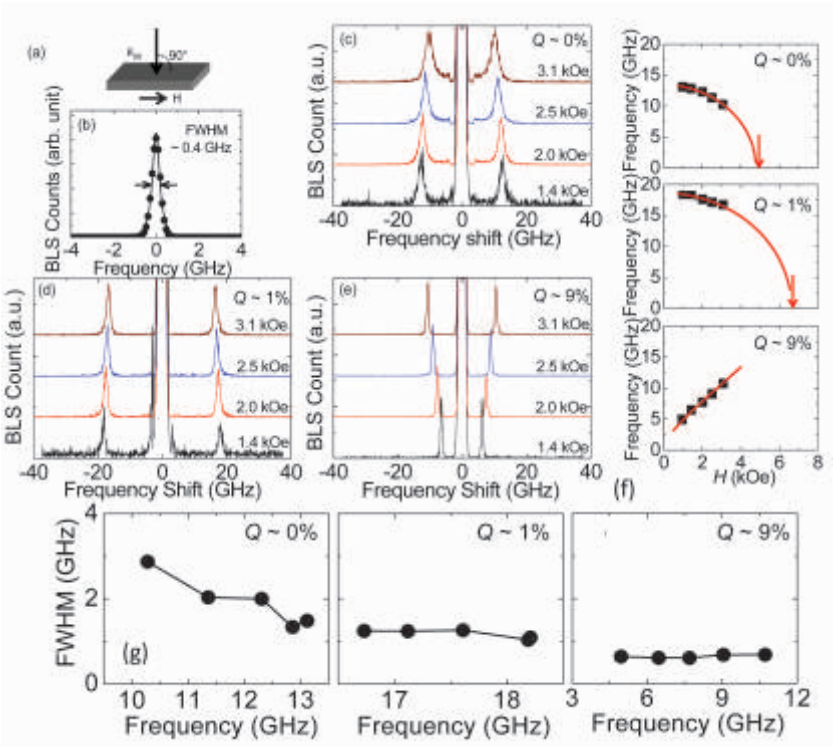

Fig. 2 (a) Schematic and (b) Instrumental linewidth of the Brillouin light scattering (BLS) technique. (c) - (e) BLS spectra of thermal magnons from Ta(N)|CoFeB|MgO heterostructures with varying N-doing in Ta layer. (f) Variation of precession frequency with bias field showing out-of-plane (Q = 0, 1%) and in-plane (Q = 9%) characters for different samples. BLS linewidth of three samples vs. frequency showing a drastic variation in linewidth (damping) and their extrinsic (Q = 0%) and intrinsic (Q = 1, 9%) character.

Investigation of Interfacial Dzyaloshinskii-Moriya Interaction and Skyrmion Dynamics: We will investigate interfacial DMI in various heavy metal/ferromagnet/oxide heterostructures using asymmetric spin wave propagation using Brillouin light scattering. Further, we will develop nanostructures of such multilayers for stabilization of skyrmions and study their dynamics.

Magnetization Dynamics in 2D Spin Ice Systems: Two-dimensional spin ices are frustrated magnetic systems and have scientific interest for a long time due to their highly degenerated ground states, which result in complex magnetic ordering and collective behavior. Artificially structured spin-ice lattices have the unique possibilities of engineering the interactions between the elements by their geometric properties and orientation. We will investigate the spin wave dynamics in 2D spin ice lattices and study how specific magnetization states of individual islands or defects can affect their collective spin dynamics.

Publications in Journals

1. S. Pal, S. Saha, M. V. Kamalakar, and **A. Barman**, *Field Dependent Spin Waves in High-Aspect-Ratio Single-Crystal Ferromagnetic Nanowires,* Nano Research, **9**, 1426, 2016.
2. S. Azzawi, A. Ganguly, M. Tokac , R. M. Rowan-Robinson, J. Sinha, A. T. Hindmarch, **A. Barman**, and D. Atkinson, *Evolution of Damping in Ferromagnetic/Nonmagnetic Thin Film Bilayers as a Function of Nonmagnetic Layer Thickness*, Phys. Rev. B, **93**, 054402, 2016.
3. A. Ganguly, S. Azzawi, S. Saha, J. A. King, R.M. Rowan-Robinson, A. T. Hindmarch, J. Sinha, D. Atkinson and **A. Barman**, *Tunable Magnetization Dynamics in Interfacially Modified $Ni_{81}Fe_{19}$/Pt Bilayer Thin Film Microstructures*, *Scientific Reports,* 5, 17596, 2015.
4. S. Saha, S. Barman, Y. Otani and **A. Barman**, *All-Optical Investigation of Tunable Picosecond Magnetization Dynamics in Ferromagnetic Nanostripes with a Width Down to 50 nm,* Nanoscale, **7**, 18312, 2015.
5. C. Banerjee, A. K. Chaurasiya, S. Saha, J. Sinha and **A. Barman,** *Tunable spin wave properties in $[Co/Ni_{80}Fe_{20}]_r$ multilayers with the number of bilayer repetition, J. Phys. D: Appl. Phys.*, **48**, 395001, 2015.
6. S. Pal, D. Polley, R. K. Mitra and **A. Barman,** *Ultrafast Dynamics and THz Oscillation in $[Co/Pd]_8$ Multilayers,* Solid State Commun., **221**, 50, 2015.
7. R. K. Upadhyay, N. Soin, S. Saha, **A. Barman** and S. S. Roy, *Grape Extract Assisted Green Synthesis of Reduced Graphene Oxide for Water Treatment Application,* Materials Letters, **160**, 355, 2015.
8. R. Mandal, S. Barman, S. Saha, Y. Otani and **A. Barman,** *Tunable Spin Wave Spectra in Two-Dimensional $Ni_{80}Fe_{20}$ Antidot Lattices with Varying Lattice Symmetry,* J. Appl. Phys., **118**, 053910, 2015.
9. B. Rana and **A. Barman,** *Ultrafast Magnetization Dynamics of Chemically Synthesized Ni Nanoparticles*, J. Phys. Chem. C, **119**, 17444, 2015.
10. J. Sinha, C. Banerjee, A. K. Chaurasiya, M. Hayashi and **A. Barman**, *Improved Magnetic Damping in CoFeB|MgO with an N-doped Ta Underlayer Investigated using the Brilliouin Light Scattering Technique*, *RSC Advances,* **5**, 57815, 2015.

11. R. K. Upadhyay, S. Deshmukh, S. Saha, **A. Barman** and S. S. Roy, *Optical, Structural, Catalytic and Electrochemical Properties of the Au Nanoparticles Synthesized Using CTAB Based Gels, J. Mater. Sci.: Mater. in Electronics,* **26**, 7515, 2015.
12. K. Mukherjee, A. Das, S. Choudhury, **A. Barman** and R. Biswas, *Dielectric Relaxations of (Acetamide + Electrolyte) Deep Eutectic Solvents in the Frequency Window, 0.2 ≤ v/GHz ≤ 50 : Anion and Cation Dependence,* J. Phys. Chem. B, **119**, 8063, 2015.
13. B. K. Mahato, S. Choudhury, R. Mandal, S. Barman, Y. Otani and *A. Barman, Tunable Configurational Anisotropy in Collective Magnetization Dynamics of* $Ni_{80}Fe_{20}$ *Nanodot Arrays with Varying Dot Shapes,* J. Appl. Phys., **117**, 213909, 2015.
14. D. Mahesh, B. K. Mahato, **A. Barman** and S. K. Mandal, *Size effect on the magnetic properties of oleic acid stabilized substrate free* $BiFeO_3$ *nanocrystals,* Eur. Phys. J. Appl. Phys., **70**, 10601, 2015.

Other Publications

1. Nickel nanochain composite: An improved terahertz shielding material, D. Polley, A. Barh, **A. Barman**, and R. K. Mitra, IEEE Applied Electromagnetics Conference (AEMC), p 1-2 (2015); DOI: 10.1109/AEMC.2015.7509124
2. Controlling terahertz conductivity in SWNT/polymer composite, D. Polley, **A. Barman**, R. K. Mitra, 2015 40th International Conference on Infrared, Millimeter, and Terahertz waves (IRMMW-THz), p 1-2 (2015); DOI: 10.1109/IRMMW-THz.2015.7327654

Supervision of Students

Ph.D. Students: Bipul Kumar Mahato, Susmita Saha, Arnab Ganguly, Debanjan Polley, Kallol Mukherjee, Chandrima Banerjee, Samiran Choudhury, Sucheta Mondal, Santanu Pan, Avinash K. Chaurashiya, Kartik Adhikary; Project Students: Saurav Sahoo (post B.Sc.), Neha Jha (post B. Sc.), Ankan Mukhopadhyay (M. Sc., IIT Guwahati), Bikash Das Mohapatra (M. Sc., NISER Bhubneswar); Post Doctoral Research Scientists: Jaivardhan Sinha (Scientist D), Rakhi Acharya (Research Associate), Semanti Pal (ESRF)

Lectures Delivered

Invited Talks:

1. All-Optical and Spin Torque Induced Ultrafast Spin Dynamics in Ferromagnetic Thin Films, Multilayers and Patterned Nanostructures, **A. Barman,** Ultrafast Science 2015, Kolkata, Nov. 19-21, 2015.
2. All-optical and Spin Torque Induced Spin Dynamics in Two Dimensional Magnonic Crystals and Ferromagnetic/ Nonmagnetic Bilayers, **A. Barman**, Magnonics 2015, Kloster Seeon, Germany, 2-6 Aug., 2015.

Courses Taught

1. PHY301: Atomic and Molecular Physics; 2015-16
2. PHY401: M. Sc. Project Research III; 2015-16
3. PHY304: Project Course II; 2015-16

Membership of Committees

External Committee: Member of Executive Committee of MRSI- Kolkata Chapter; Expert for PhD Thesis Examination Committee at IISc Bangalore, IISER Kolkata, IIEST Shibpur, Jadavpur University; Expert for BRNS Technical Program Discussion Meeting; 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; Convener of the Theme Unit of Excellence on Nanodevice Technology; Convener of Advanced Spectro-Microscopy Unit.

Awards / Recognitions

1. Editorial Board Member of *Scientific Reports* (Nature Publishing Group)
2. Session Chair in IUMRS-ICEM 2016 Conference, Suntec City, Singapore, 4-8 July, 2016.

Sponsored Projects

1. Project Title: Nanoscale Modifications and Active Control of Magnonic Crystals for On-chip Microwave Communications; Funding agency: Department of Science and Technology (DST).
2. Project Title: Advanced Spectro-Microscopy for Novel Materials; Funding agency: S. N. Bose National Centre for Basic Sciences
3. Project Title: Thematic Unit of Excellence on Nanodevice Technology; Funding Agency: Nano Mission, DST

Meeting Organized

As Convener

1. Ultrafast Science 2015 (UFS-2015), 19-21 Nov., 2015, S. N. Bose National Centre for Basic Sciences, Kolkata.

Arup Kumar Raychaudhuri

Distinguished Professor Emeritus

arup@bose.res.in

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, Physics of correlated oxides, Some of the specific problems investigated: Optical response in Plasma produced black silicon, Use of EDL gate to control electronic phases in oxides, Charge ordering in CuTCNQ, Fluctuation near the metal-insulator transition in correlated oxide VO_2.**
- **Research Keywords: Nanomaterials, Nanolithography, Correlated electron systems, Optoelectronics**

1. **Dynamic phase coexistence and non-Gaussian resistance fluctuations in VO_2 near the metal-insulator transition:** Resistance fluctuations (noise) in an epitaxial thin film of VO_2 encompassing the metal-insulator transition (MIT) region has been done to investigate the dynamic phase coexistence of metal and insulating phases. The flicker noise evolves with temperature in the transition region following the evolution of the phase fractions. Closer to the insulating end of the transition, the noise shows an anomaly and a strong non-Gaussian component. The local electron temperature (as measured through the Nyquist noise) shows a deviation from the equilibrium bath temperature. This behavior arises due to current crowding where a substantial amount of the current is carried through well separated small metallic islands.

2. **Low temperature transport of a charge transfer complex nanowire grown from the vapour phase:** Suspended Cu:TCNQ (Cu–tetracyanoquinodimethane) nanowires connecting two electrodes (~1.0 micron gap) have been grown laterally from the vapour phase. The nanowires show a strong non-linear conductance. Below 100 K, the non-linear conductance can be fitted to a modified Zener tunneling model, raising the possibility of the onset of a charge density wave type of transport in the Cu:TCNQ nanowires.

3. **Control of co-existing phases and charge transport in a nanostructured manganite film by field effects with an electric double layer as the gate dielectric:** We report bipolar control of co-existing phases in a film of manganite, $La_{0.85}Ca_{0.15}MnO_3$, using an applied gate bias in a field effect (FE) device configuration. $La_{0.85}Ca_{0.15}MnO_3$ shows co-existence of different electronic phases and a ferromagnetic insulating (FMI) state at low temperatures. Using electric double layer (EDL) as a gate dielectric the relative fraction of the coexisting phases as well as the characteristic phase transition temperatures were significantly altered.

4. **Control of Grain Boundary Depletion Layer and Capacitance in ZnO Thin Film by a Gate with Electric Double Layer Dielectric:** We have used impedance spectroscopy on the channel of thin film transistor with a gate induced charge to understand the nature of grain boundary potentials. We have shown that large charge induced by a gate with electrolyte as dielectric can change the frequency dependent complex impedance of the channel (ZnO). The observed data were

explained as arising from control of the grain boundary depletion layer and the associated grain boundary capacitance (C_{GB}) as well as the grain boundary potential barrier (φ_{GB}) by the field induced large charge density.

5. **Enhancement of Efficiency of a Solar Cell Fabricated on Black Si Made by Inductively Coupled Plasma – Reactive Ion Etching Process:** A significant enhancement of efficiency can be achieved in solar cells fabricated on black Si made using inductively coupled plasma – reactive ion etching (ICP-RIE). The ICPRIE- fabricated black Si results in an array of vertically oriented defect free Si nanocones exhibiting an average reflectance ≤ 2%. Simulation analysis shows that the nano cone structure leads to the effective dielectric constant varying smoothly from the value of the air at the top to the value of Si at the base, leading to low a reflectance.

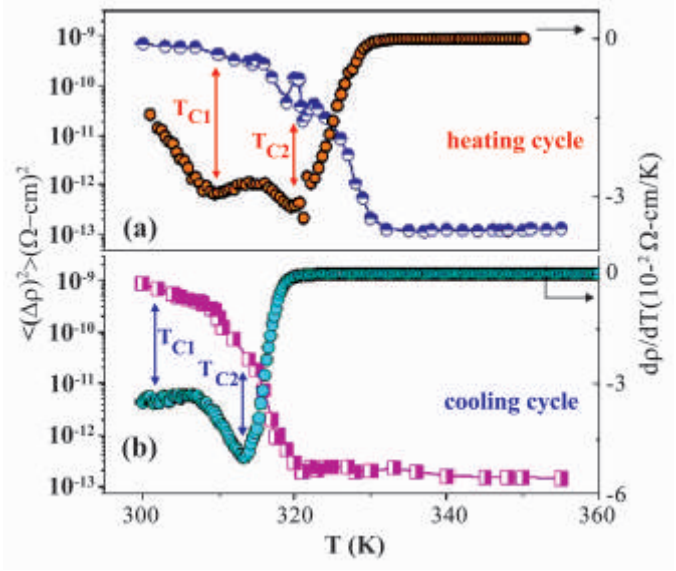

Fig.1: Mean square resistivity fluctuations $<(\Delta\rho)2>$ along with the resistivity derivative dρ/dT plotted as a function of T in the transition region

Future Plan

Our group has acquired the capability to work with single nanowires and nanotubes using nanolithography tools. We plan to investigate the following nanowires using this capability. 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). The work on Ge nanowire has been initiated and growth of Ge nanowires using a vapour phase method has been developed. We have also developed a soft chemistry based route to synthesize nanowires and micro crystals of Cu:TCNQ.

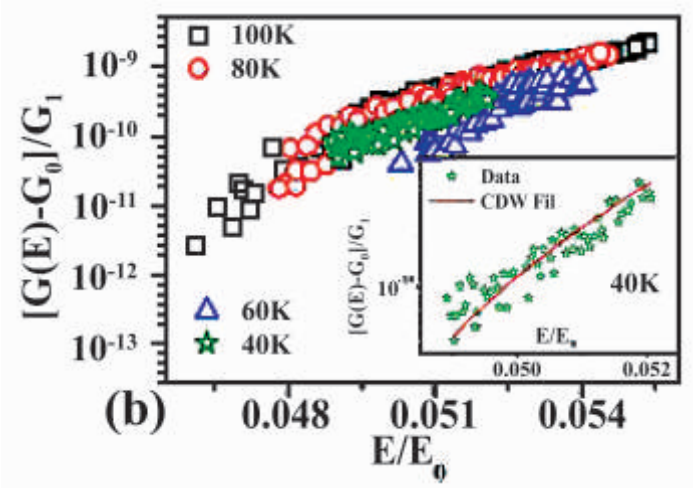

Fig.2: The non-linear part of conductance for the NWs grown (different temperatures fitted to the modified Zener tunneling relation for Charge Density wave transport. Insets indicate the Zener model fit at 40K

Presence of a solid electrolyte creates an electric double layer (EDL) that can induce large surface charge when soild electrolytes are used as gate dilectric. We will develop a high quality Flexible thin film transistor (Flex-TFT) using PLD grown ZnO on flexible substrate like Kapton with EDL gate. We will also explore how decoration of ZnO nanowires by Au Nanoparticles can lead to enhanced absorption (and photo-response) in the visible range due to plasmons in Au nanoparticles.

We will investigate the dynamic co-existence of phases near metal-insulator transitions in epitaxial films of $NdNiO_3$ using such techniques as: 1/f noise spectroscopy, Scanning Tunneling Microscopy /Spectroscopy and Impedance spectroscopy. In particular we will investigate how built-in strain changes the MI transition and co-existing phases.

We will also investigate magnetism in nanostructured Gd (that has very small spin wave stiffness constant). In particular, it will be investigated whether magnons in nanocrystalline Gd can undergo Bose Einstien Condensation.

Publications in Journals

1. Rajib Nath and A. K. Raychaudhuri, *Control of co-existing phases and charge transport in a nanostructured manganite film by field effects with an electric double layer as the gate dielectric*, *RSC ADVANCES*, **5**, 57875, 2015.

2. Rabaya Basori and A. K. Raychaudhuri, *Low temperature transport of a charge transfer complex nanowire grown with an electric field from the vapour phase*, *RSC ADVANCES*, **5**, 86497, 2015.

3. Ajit K. Katiyar, S. Mukherjee, M. Zeeshan, Samit. K. Ray,,and A. K. Raychaudhuri, *Enhancement of Efficiency of a Solar Cell Fabricated on Black Si Made by Inductively Coupled Plasma–Reactive Ion Etching Process: A Case Study of a n-CdS/p-Si Heterojunction Cell*, *ACS Appl. Mater. Interfaces*, **7**, 23445, 2015.

4. Sudeshna Samanta , A. K. Raychaudhuri, Xing Zhong and A. Gupta, Dynamic phase coexistence and non-Gaussian resistance fluctuations in VO_2 near the metal-insulator transition, PHYSICAL REVIEW B, **92**, 195125, 2015.

5. Ravindra Singh Bisht, Rishi Ram Ghimire, and A. K. Raychaudhuri, Control of Grain Boundary Depletion Layer and Capacitance in ZnO Thin Film by a Gate with Electric Double Layer Dielectric, J. Phys. Chem. C, **119**, 27813, 2015.

6. Pabitra Mandal, Bipul Das, and A. K. Raychaudhuri, Stability of a current carrying single nanowire of Tungsten (W) deposited by Focused Ion Beam, J. Appl. Phys., **119**, 084301, 2016.

7. Amlan Dutta, A. K. Raychaudhuri, T. Saha-Dasgupta, Plasticity-mediated Collapse and Recrystallization in Hollow Copper Nanowires: A Molecular Dynamics Simulation, Beilstein J. Nanotechnology, **7**, 228, 2016.

Other Publication

1. *Rabaya Basori and A.K.Raychaudhuri, Graphitic oxide-induced enhanced electrical conductance in CuTCNQ nanorod film, 2nd International Conference on Emerging Electronics (ICEE 2014)*, 2015, DOI:10.1109/ICEmElec.2014.7151170

Supervision of Students

Ph.D. Students: Rabeya Basori (submitted), Rishi Ghimire, Ravindra Singh Bisht, Shaili Sett, Vibhuti Narayan Rai, Paulamee Pandit, Kalyan Joyti Sarkar (co-Guide/IIT/kgp); **Post Doctoral Research Scientists:** Kaustuv Das, Sudheshna Samanta, Bipul Das, Pabitra Mandal, Jashashree Rai, Rajib Nath, Soumen Dhara

Lectures Delivered

1. Introduction to Nanolithography and nanofabrication using Dual Beam Machines (Electron beam and Ion beam), Workshop on Advanced Tools for Nanoscopic Materials Characterization, S.N.Bose National Centre for Basic Sciences, Kolkata, November, 2015.

2. Introduction to Nanolithography and nanofabrication using Electron beam and Ion beam lithography" (A set of 2 lectures), IIT/Kharagpur, Kharagpur, October, 2015.

3. NT 70002 - INTRODUCTION TO NANO SCIENCE AND TECHNOLOGY (Part of nanotechnology course), IIT/Kharagpur, Kharagpur, March, 2016.

4. Experimenting with Single nanowires: Physics, techniques and some results, JNCASR, Bangalore, December, 2015.

5. Experimenting with Single nanowires: A new paradigm to do materials science, INTERNATIONAL CONFERENCE ON FRONTIERS IN NANOSCIENCE & NANOTECHNOLOGY, Sastra University, Tanjavore, February, 2016.

6. Fabrication and Characterization of Ultra Sensitive Photo-Detectors Based on Single Functional Nanowires, Xian Xitong University, Xian, September, 2015.

7. Fabrication and Characterization of Ultra Sensitive Photo-Detectors Based on Single Functional Nanowires, ICMAT 2015, Invited Talk, Singapore, June-July, 2015.

8. Control of physical properties of functional oxides by a gate with Electric Double Layer Dielectric, Energy Materials Nano 2015, Invited talk, Quingdao, June, 2015.

9. Control of physical properties of functional oxides by a gate with Electric Double Layer Dielectric, Condensed Matter days 2015, Invited Talk, Viswabharathi, Shantiniketan, August, 2015.

10. Reversible Control of defects in ZnO for enhanced optical and electrical response, India-China –Korea Trilateral conference MRS INST, Mohali, October, 2015.

11. Reversible Control of physical properties of Materials using solid electrolyte gate, Presidency University, Kolkata, January, 2016.

12. Reversible Control of physical properties of functional oxides, 9th India-Singapore Joint Physics Symposium NUS, Singapore, February, 2016.
13. Metal Insulator Transition Revisited, Colloquium IACS, Kolkata, March, 2016.

Academic Visit

1. Visit made to Institute Laue Langevin (ILL), Grenoble to carry out neutron diffraction studies July 2015

Courses Taught

1. PHY 191 : Basic Laboratory I, Fall 2015
2. PHY 391 : Experimental Methods in Physics, Fall 2015
3. PHY 409: Magnetism and Superconductivity, Spring 2016

Membership of Committees

External Committee: 1.Chairman, Scientific Advisory Committee ,UGC-DAE Consortium of Research, Indore; 2. Member, Governing Board and Governing Council, UGC-DAE Consortium of Research, Indore; 3. Convenor, Sectional committee VI- INSA; 4. Chairman, PAC of Physics , International Division (DST); Member of National Science and Engineering Board (SERB), Executive Council NEHU Shillong, Programme Advisory Committee Solar Energy Research Initiative (DST), Programme Management Committee SERIUS Indo-US Science and Technology Forum; Internal Committee: Nodal officer, Technical Research Centre, SNBNCBS

Patent Submitted / Received

1. Growth of Metal / Compound Nanotube Arrays (Patent granted)

Sponsored Projects

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

Barnali Ghosh (Saha)

Scientist – E

barnali@bose.res.in

Dr. Barnali Ghosh (Saha) received her Ph.D. from University of Kalyani. 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.

- **Growth of high performance thin film transistors and physical property study**
- **Growth and physical property study of perovskite lead hallide**
- **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**
- **Fabrication of single nanowire device of multifunctional perovskite oxide systems by using different lithographic techniques and transport measurement on single nanowire**
- **Cross-sectional TEM study in binary and complex oxide nanowires, nanocrystals and thin films**
- **Study of Photoresponse and gas sensing property 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:

Cross-sectional transmission electron microscopy study of interface of substrate and vertically aligned nanowires:

A systematic study of growth of aligned WO_3 (002)-oriented nanowires (NWs) on (111)-oriented Platinised silicon substrate using a pulsed laser deposition (PLD) method. Transmission electron microscopy (TEM) analysis has shown that the wires are single-crystalline and grow along $[001]_t$ or $[100]_t$ directions. X-ray diffraction (XRD) measurements confirm phase and structural analysis. We investigated the effect of ablated particle flux on nanowire growth, in particular, the role of the nucleating centre at the interface as it get modified by the ablated particle flux. We observe a critical value of the laser energy (that determines a critical flux and energy of ablated moieties) at which a compact nanograin film gets converted to aligned nanowire film. We attribute the existence of such a threshold to the desorption process from the catalyst droplet. By cross-sectional TEM and compositional mapping accompanied by simulation, we confirm that the interfacial layer between the substrate and NW is modified by the ablated particle flux and energy (Fig 1 and 2). Aligned NWs above threshold energy can be attributed to formation of favorable nucleation sites for a preferred orientation.

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) 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.

Tuning of Magnetic phases in complex oxide nanowires:

The stability of crystallographic phases and resulting physical properties on reducing the size of nanoparticles /crystallites is under extensive research. We wanted to do structural and magnetic structural investigation on manganite nanowires to see stability of crystallographic and magnetic phases under size reduction at low temperatures. Investigation on half doped manganite nanowire $La_{0.5}Sr_{0.5}MnO_3$ (LSMO, x = 0.5)) shows existence of phase co-existence by magnetic measurement. \We compare the results with its bulk form using neutron diffraction and magnetic measurements. The room temperature neutron diffraction pattern of the nanowires was refined with tetragonal phase of space group *I4/mcm* by the Rietveld refinement technique. When the temperature decreases below 235 K then orthorhombic phase arises along with tetragonal phase. The nanowires are ferromagnetic (FM) at 300 K and below 175 K there is magnetic phase coexistence of FM and anti- ferromagnetic

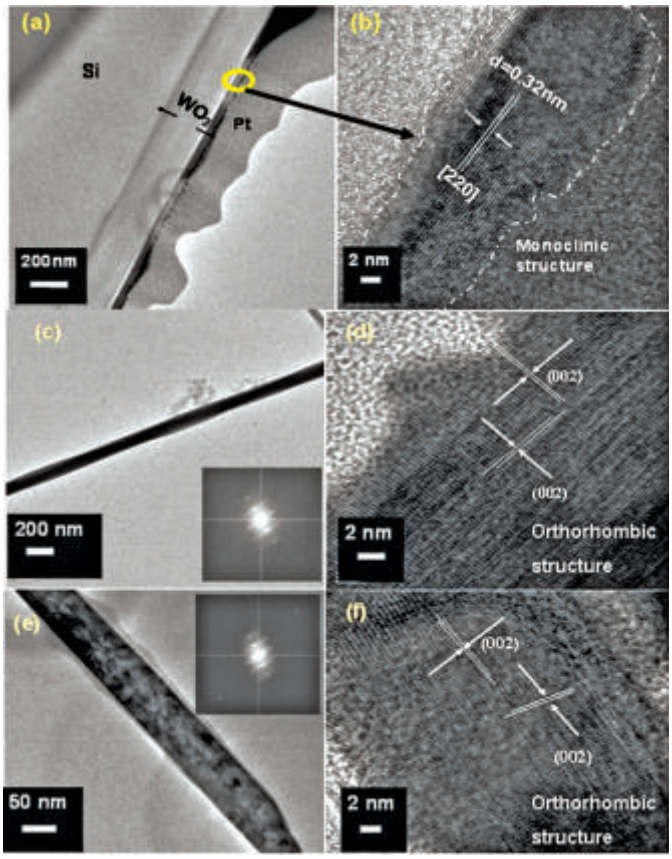

Fig.2: High resolution transmission electron microscopy study of binary oxide nanowires

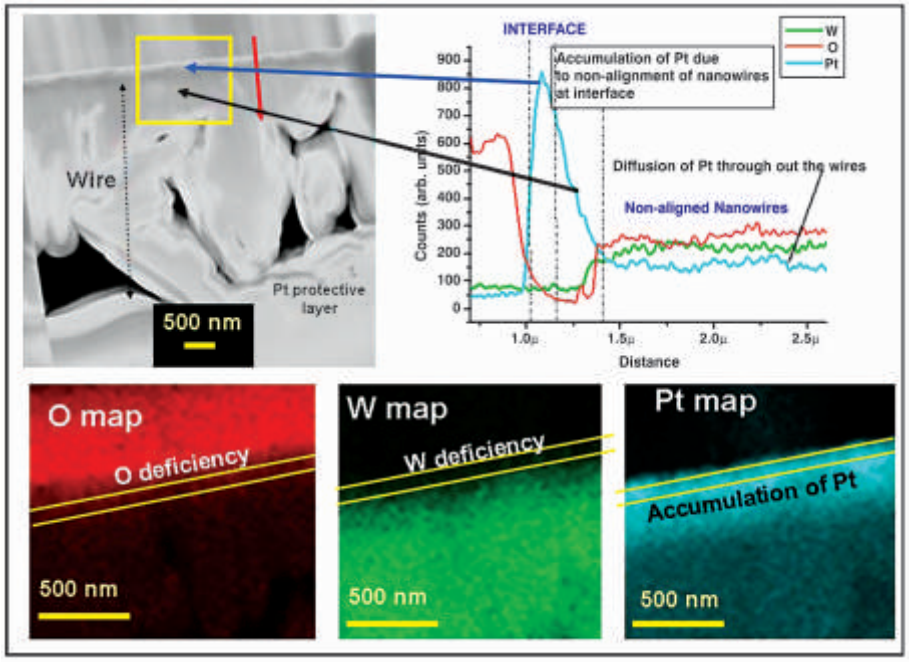

Fig.1: Study of interface of nanowires with the substrate

(AFM) phase. Bulk $La_{0.5}Sr_{0.5}MnO_3$ was refined with tetragonal phase throughout the temperature range (6-300 K) and it shows FM behaviour up to 6 K.. Neutron diffraction experiment done at ILL Grenoble, France.

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 IGZO 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 transistors . A work on EDL gate control device on thin film of IGZO 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 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. A precise electron microscopy analysis i.e, structural simulation by Java Electron Microscopy Software (JEMS) which provides knowledge on growth direction, epitaxy of the materials with respect to the substrate and simulation of the data for understanding the physical property at the interface. Finally, the physical properties (electrical, dielectric, optical, ferroelectric, magnetic, etc.) in terms of the interface of the multilayered materials will be done

3) 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.

Publication in Journal

1. Ankita Ghatak, Samik Roy Moulik, **Barnali Ghosh,** *Pulsed laser assisted growth of aligned nanowires of WO_3 : Role of interface with substrate*, RSC Adv., **6**, 31705, 2016.

Other Publication

1. Subarna Datta and Barnali Ghosh, Critical Behavior near the Ferromagnetic – Paramagnetic Phase Transition in La0.7Sr0.3MnO3+d Nanowires Synthesized by Hydrothermal Method, AIP Conference Proceedings, 2015, 1665, 050045

Supervision of Students

Ph.D. Students: Subarna Datta, Samik Roy Moulik (part time), Chandan Samanta, Avisek Maity; **Post Doctoral Research Scientist:** Ankita Ghatak

Lectures Delivered

1. Short Term Training Programme (STTP) on Science & Technology of Advanced Materials (STAM 2015), Venue: Institute Guest House, SVNIT, Surat 21-23 August, 2015.
2. Advanced Tools for Nanoscopic Materials Characterization ATNMC2015, S. N. Bose National Centre for Basic Sciences, Kolkata, November, 5 – 6, 2015
3. EMN Bangkok Meeting 2015 on materials Bangkok, Thailand 10-13 November,2015.
4. Theory and Application of Advanced Materials (TAAM 2016), Vidyasagar University, Midnapore, March 15-17, 2016.
5. National Symposium on Modern Applications of Electron Microscopy in Interdisciplinary Research, Tripura University, Tripura, March 19, 2016.

Academic Visit

1. Research Proposal No: 5-31-2390, Accepted for Neuron Diffraction experiment at D-20, Beamline, ILL, Grenoble, France, visit during July 05 – 10, 2015.

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, iv)Journal of Alloys and Compounds, v)Journal of Physics and Chemistry of Solids, vi) Journal of Materials; **Internal Committee:** Various committees related to Technical cell, Various purchase committees

Meeting Organized

1. Advanced Tools for Nanoscopic Materials Characterization ATNMC2015, November, 5 – 6, 2015, S. N. Bose National Centre for Basic Sciences, Kolkata

Kalyan Mandal

Professor
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Kalyan Mandal was a student of Ramkrishna Mission (Asansol), Presidency College (Calcutta) and the University of Calcutta. He received his Ph.D. degree in Physics from the 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**

Thz conductivity of semi-metallic ferrite nanostructures: We applied THz time domain spectroscopy in the frequency range of 0.1-1.0 THz to probe the ultrafast conduction dynamics of the charge carriers in semi-metallic $CoFe_2O_4$ ferrite nanoparticles (NPs) and nano-hollow spheres (NHSs) with different nanocrystalline shell thickness varying from 18nm to 110nm. The picosecond THz conductivity reveals microscopic polaron hopping with significant interface scattering within the nanocrystals, as well as percolative transport between the consecutive nanocrystals. Finally, the morphology and size dependent conductivity study of NP and its hollow configuration with increasing diameter indicates that the magnitude of conductivity depends sensitively on the THz absorptivity of the nanostructure.

Future Plan

Surface functionalisation of transition metal oxide nanostructures will be performed using various ligands having different head and tail to introduce multifunctionalities. The magnetic, ferroelectric and magnetoelectic properties of double perovskite oxides will be improved by doping. Our activities on magnetocaloric effects and supercapacitors will be continued.

Publications in Journals

1. A. Chaudhury and **K. Mandal**, *Large magnetoelectric properties in $CoFe_2O_4$:$BaTiO_3$ core-shell nanocomposites*, Journal of Magnetism and Magnetic Materials, **377,** 441-445, 2015.
2. A. K. Singh and **K. Mandal**, *Engineering of high performance supercapacitor electrode based on Fe-Ni/Fe_2O_3-NiO core/shell hybrid nanostructures*, Journal of Applied Physics, **117**, 105101, 2015.
3. A. Ghosh and **K. Mandal**, *Effect of Fe substitution on the magnetic and magnetocaloric properties of Mn-rich Mn-Ni-Fe-Sn off-stoichiometric Heusler alloys*, Journal of Applied Physics, **117**, 093909, 2015.
4. M. Pal, A. K. Singh, R. Rakshit and **K. Mandal**, *Surface chemistry modulated introduction of multifunctionality within Co_3O_4 nanocubes*, RSC Advances , **5**, 16311-16318, 2015.
5. R. Rakshit, M. Pal, M. Mandal, **K. Mandal**, *Charge transfer mediated magnetic response of cobalt ferrite nanoparticles*, Materials Letters, **151**, 64-67, 2015.
6. R. Rakshit, D. Sarkar, M. Pal, K. Serita, M. Tonouchi and **K. Mandal**, *Acoustic vibration induced high electromagnetic responses of Fe_3O_4 nano-hollow spheres in THz regime*, Journal of Physics D: Applied Physics, **48**, 245301, 2015.
7. M. Pal, A. Kundu, R. Rakshit, **K. Mandal**, *Ligand-induced evolution of intrinsic fluorescence and catalytic activity from cobalt ferrite nanoparticles*,

Journal of Chemical Physics and Physical Chemistry (ChemPhys Chem) **16**, 1627-1634, 2015.

8. D. Sarkar, A. Ghosh, R. Rakshit and **K. Mandal**, *Magnetic properties of Fe_3O_4 nano-hollow spheres*, Journal of Magnetism and Magnetic Materials, **393**, 192-198, 2015.
9. A. Sarkar, A. K. Singh, D. Sarkar, G. G. Khan, **K. Mandal**, *Three-dimensional nanoarchitecture of $BiFeO_3$ anchored TiO_2 nanotube arrays for electrochemical energy storage and solar energy conversion*, ACS Sustainable Chemistry & Engineering **3 (9)**, 2254-2263, 2015.
10. Arka Chaudhuri, **Kalyan Mandal**, *Comparative study of the Magnetoelectric Properties in Core-Shell Nanocomposites as well as mixture of $CoFe_2O_4$: $BaTiO_3$*, International Journal of Composite and Constituent Materials, **1(1)**, 1, 2015.
11. R Rakshit, M Pal, A Chaudhuri, M Mandal, **K Mandal**, *Facile synthesis of $CoFe_2O_4$ nano-hollow spheres for efficient bilirubin adsorption*, APL Materials **3**, 110701, 2015.

Supervision of Students

Ph.D. Students: Arup Ghosh, Rupali Rakshit, Mahebub Alam, Souvanik Talukdar, Indranil Chakraborty, Kesab Karmakar, Subrata Ghosh, Dipika Mandal; Project Student: Esma Khatun, Project title: "Synthesis of magnetic nano-hollow spheres and preferential adsorption of industrial dyes" (May-June 2015); Post Doctoral Research Scientist: Madhuri Mandal

Lectures Delivered

1. "Novel Properties in Transition Metal Oxide Nanostructures", Friedrich-Schiller-Universität Jena, Germany, 21 October 2015.
2. "Magnetism in nanostructured materials" in C. K. Majumdar Memorial Workshop-2015, at S. N. Bose National Centre for Basic Sciences, 31 May 2015.

Academic Visit

1. AvH Renewed Research Stay, Friedrich-Schiller-Universität Jena, Germany, October-November 2015.

Courses Taught

1. PHY 291, Basic experiments, second semester
2. PHY 391, Advanced experiments, third semester
3. PHY 409, Magnetism and superconductivity, fourth semester
4. PHY 601, Advanced Condensed Matter Physics-II, fourth semester

Membership of Committees

External Committee: Member of Executive Committee, Magnetics Society of India; Member, Executive Committee of Material Research Society of India (Kolkata Chapter); 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

Award / Recognition

AvH fellowship for renewed research stay

Meetings Organized

1. Young Scientists'Colloquium-2015, 11 September 2015 at CSIR-CGCRI, Kolkata
2. C. K. Majumdar Mamorial Workshop-2015, 26 May-05 June 2015

Madhuri Mandal (Goswami)

Visiting Faculty Fellow
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Dr. Madhuri Mandal has expertise on synthesis of several kinds of nanoparticles and their use in spectroscopy, catalysis, cancer therapy, biosensor etc. She completed PhD from IIT, Kharagpur then completed two years Postdoctoral research in University of Alabama, USA. Currently she is working in S. N. Bose Centre, Kolkata as Visiting Faculty Fellow.

- **Synthesis and characterization of fluorescent magnetic nanoparticles**
- **Tuning of different properties of the particles such as magnetic, fluorescence, electrical, Raman etc**
- **Application of particles for hyperthermia therapy, cell imaging, biosensor, catalysis etc**

Different magnetic nanoparticles of magnetite, Mn-ferrite, Zn-ferrite, Co-ferrite, quantum dots etc. have been synthesized in very simple and general method. These ferrites show magnetically exclusive properties by tuning them different organic molecules. On the other hand we have fabricated one instrument (shown in figure below) which can measure AC hysteresis loop for the magnetic sample kept under AC applied magnetic field and from the AC hysteresis loop area calculation we can have specific adsorption rate (SAR) obtained from hysteresis loss which gives the idea about power loss of the magnetic samples. From these data it is possible to predict the feasibility and suitability of the magnetic samples for the application in hyperthermia treatment as well as hyperthermic drug release. With change of magnetic properties heat dissipation by the particles show a different trend. Some results obtained have high potentiality in technological and biological applications such as in drug delivery and release using magnetic field directed way through hyperthermia treatment. We have engineered the particles with different organic molecules like oleic acid, folic acid, ascorbic acid etc. to see their selectivity to be attached with cancer cells and fluorescence properties. Tagging many fluorescent molecules with these magnetic particles they have been used for cell imaging purpose also. We have used these particles for cell imaging purpose one picture is shown below. To

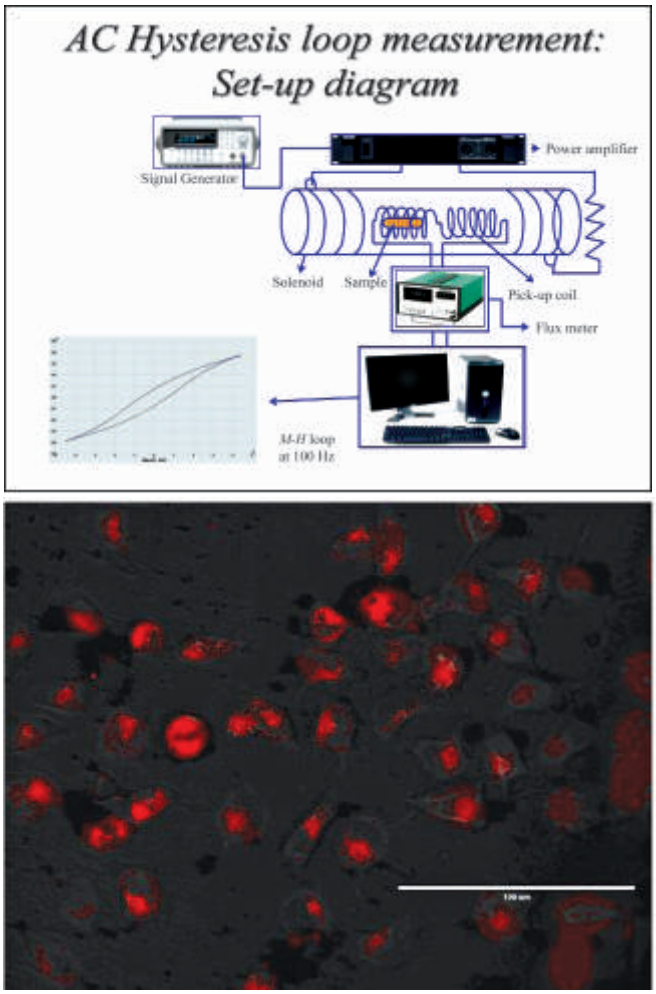

Fig. : Cell imaging by fluorescent particles

study the drug release activity the particles are loaded with cancer drugs and many stimuli like temperature, PH etc triggered drug release properties by these materials have been studied. We have received some significant results from these studies which can give idea about selectivity of attachment of the particles to the cancer cells and drug release potentiality of these particles.

Future Plan

My future plan is to check the biocompatibility of the particles applying them on cells. Before their use in human body in-vitro cytotoxicity study should be made. We have seen with change of organic molecules attached to nanoparticles, the toxicity level of the particles changes. Therefore our next goal is to make a thorough investigation with change of many organic molecules attached to particles by tuning their fluorescence properties, with change of shape of particles how toxicity level of particles are changed. To check the feasibility of the particles for their use in drug delivery and drug release using hyperthermia technique their cytotoxicity parameters must be checked. The selectivity on attachment of the particles to different types of cancer cells will be investigated by functionalizing the particles with different biomolecules like proteins, DNA, antigen etc. It is well known that over dose of cancer drug is fatal so control way of release of the cancer drug will be very much helpful and will be a new potential avenue in cancer treatment therefore by using many stimulants the control over drug release process will also be studied.

Publications in Journals

1. **Madhuri Mandal Goswami**, Chaitali Dey, Ayan Bandyopadhyay, Debasish Sarkar and Manisha Ahir, *Micelles driven magnetite (Fe_3O_4) hollow spheres and a study on AC magnetic properties for hyperthermia application*, J. Mag. Mag. Mater., **417**, 376-381 p., 2016.
2. Gouranga H. Debnath, Arijita Chakraborty, Ankita Ghatak, **Madhuri Mandal**, and Prasun Mukherjee, *Controlled Terbium(III) Luminescence in Zinc Sulfide Nanoparticles: An Assessment of Competitive Photophysical Processes*, J. Phys. Chem. C, **119** (42), 24132–24141 p., 2015.
3. Rupali Rakshit, Monalisa Pal, **Madhuri Mandal**, Kalyan Mandal, *Charge transfer mediated magnetic response of cobalt ferrite nanoparticles*, Materials Letters, **151**, 64-67 p., 2015.

Other Publications

1. Chaitali Dey, Kaushik Baishya, Arup Ghosh, Madhuri Mandal Goswami, Manisha Ahir, Arghya Adhikary, Ajay Ghosh and Kalyan Mandal 'Improvement of drug delivery by hyperthermia treatment using magnetic cubic cobalt ferrite nanoparticle' 11th International Conf. on the Scientific and clinical applications of magnetic carriers, UBC, Bancouver, Canada, 31st May to 4th June, 2016.
2. Madhuri Mandal Goswami, Debarati De, Arpita Das, Arghya Adhikari, Urs Hafeli, Ajay Ghosh 'Biocompatibility of DNA Engineered Cobalt-ferrite Nanoparticles for Cancer Cell Imaging and Hyperthermia Therapy' 11th International Conf. on the Scientific and clinical applications of magnetic carriers, UBC, Bancouver, Canada, 31st May to 4th June, 2016.
3. Madhuri Mandal, 'Temperature and PH Sensitive Drug release by Magnetite (Fe3O4) Hollow Spheres through Hyperthermia Therapy for Cancer Treatment' January 18-21, 2016, ETAFM-2016, IOP Bhubaneswar.

Supervision of Students

Ph.D. Student: Chaitali Dey (Part time); Project Students: Arpita Das and Madhumanti Neogi (M.Tech. students from CRNN, CU. Kolkata)

Lectures Delivered

1. Biocompatibility of DNA Engineered Cobalt-ferrite Nanoparticles for Cancer Cell Imaging and Hyperthermia Therapy' 11th International Conf. on the Scientific and clinical applications of magnetic carriers, UBC, Bancouver, Canada, 31st May to 4th June, 2016.
2. Temperature and PH Sensitive Drug release by Magnetite (Fe3O4) Hollow Spheres through Hyperthermia Therapy for Cancer Treatment' ETAFM-2016, IOP Bhubaneswar, January 18-21, 2016.

Course Taught

1. Physics practical, PHY291, Experimental method on spectroscopy, IPhd, 2nd Semester

Membership of Committee

External Committee: Life member of Magnetic Society of India

Sponsored Project

1. "Preparation of magnetic nanoparticles and proper biofunctionalization for their use in drug delivery and release" Funding Agency: DST, New Delhi, PI: Dr. Madhuri Mandal, Period of funding: For 3 years

Manoranjan Kumar

Assistant Professor
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Manoranjan Kumar received his MSc (SPS) degree from JNU New Delhi. He received his Phd degree from IISc Bangalore. He was a postdoctoral research associate at Princeton University USA.

- Mostly interested in quantum phase transitions in electronic systems. My current interest includes modeling of magnetic properties, neutron scattering experimental and optical properties of low dimensional materials. Our group is also interested no-equilibrium phenomenon the frustrated spin systems

1. Development of numerical techniques and new algorithm in Density matrix renormalization group (DMRG) method:

The degrees of freedom in quantum many body systems increase exponentially for example for spin-1/2 systems the degree of freedom goes as 2^N. Therefore, solving a model with N = 100 is almost impossible. Unfortunately, there are only few exactly solvable models and most of these models fail to give any understanding of real systems i.e most of the realistic models are not exactly solvable and most of time these models are solved by approximate numerical technique. Our group has been actively involved in developing the numerical methods. Recently, we have developed the stochastic series expansion Monte Carlo for anisotropic Heisenberg Model. We have also developed Density Matrix embedding Theory (DMET) plus DMRG method in collaboration with Dr. S R Hassan (IMSc Chennai). DMET is a very efficient numerical technique to solve the electronic properties in solids.

Density matrix renormalization group (DMRG) method is one of state of art numerical technique to solve the strongly correlated systems in low dimension. It is based on the systematic truncation of irrelevant degrees of freedom. The conventional DMRG gives excellent results for one dimensional system, but it fails for higher dimensional systems, because of exponential growth of entanglement in the blocks Hamiltonian. In the last four years, we have proposed DMRG algorithm for Y-junction and for periodic boundary conditions in 1D system. Currently we are trying to extend these calculations to two dimensional systems.

2. Quantum Phase transition in various model systems

The competition between the kinetic and electronic interactions can drive system from metallic to insulator. In the insulating regime, there are many magnetic systems, where spin on the lattice can exchange their energy through spin flip. The spin flip in these systems can be because of super exchange or direct exchange interaction between the spins, and these exchange can lead to many interesting phases. In most of the cases, these phases arise because of quantum fluctuations at low temperature. We are interested in quantum fluctuations driven phase transitions. We have been interested in quantum phase diagram of various electronic models like Extended Hubbard model, J_1-J_2 Heisenberg model for spin systems.

Recently we have started working on the edge modes in spin systems. We are also trying to map these modes with the Majorana modes. These modes are also present in an induced superconducting system with spin orbit coupling in a magnetic field. There are claims that these phases can be modeled by an attractive Hubbard model with spin orbit coupling in an axial magnetic field. We are trying to construct the quantum phase diagram of the model Hamiltonians. Our preliminary calculation suggests that Majorana modes are present in these systems.

3. Modeling of Materials

Our group has been actively collaborating with

experimentalist to understand the magnetic and transport properties of materials. We have tried to explain and model the mechanism of explosive detection properties of metal organic frameworks (MOF). We have also recently modeled resistive switching in the single strand Cu-TCNQ materials.

4. Non-equilibrium Phenomenon

Recently we have started our activity in the non-equilibrium systems to model the active matters and magnetic systems. Active matter forms a special branch of soft matter physics that has drawn a significant attention of the scientific community in the last two decades. An incessant input of external energy into the system and its dissipation through some mechanical manifestation of the constituents facilitates non-equilibrium phenomena in the system. The nature is abundant with these kinds of systems, e.g., bacterial colony, melanocytes, microtubules, flocking birds, animal herds, shoal of fishes. Many artificially designed systems like agitated granular rods, polar disks; active colloids etc. also imitate the physics of the active matters. In these systems we try to understand the different phases induced by the thermal fluctuations and internal interactions. We are also trying to understand the effect of non-equilibrium perturbation in the magnetic systems.

Future Plan

a. Multipolar and Spin nematic phase in a frustrated ferromagnetic spin chain

Frustrated isotropic J_1 -J_2 model system with ferromagnetic J_1 and in the presence of an axial magnetic field shows many exotic phases, such as vector chiral, spin nematic and multipolar phases. The model has attracted much interest because of their potential application in modeling of magnetic properties of quasi one dimensional edge-sharing chain cuprates, such as $LiCuVO_4$ etc. In this work our main focus is on the spin nematic and multipolar phases and their characterization. In the spin nematic phase, condensation of two magnons occurs, whereas, more than two magnons condensate in the multipolar phase. All the calculations are carried out using DMRG and exact diagonalization (ED) method.

The multipolar phases of order up to $p = 12$ is calculated by using DMRG and ED method from spin density as well as from transverse spin correlation function for spin-1/2 system. The spin nematic phase is characterized by showing linear relationship of the pitch angle vs. magnetization and jump of two in the magnetization curve for spin-1/2 system. The binding energy of two magnons is calculated in extended range of exchange parameter regime for different magnetization. The binding energy is non-monotonic function of next nearest neighbor interaction. The binding of two magnons is shown for a real material $LiCuVO_4$ also at $J_1 = -1.6$eV and $J_2 = 3.8$eV. The dynamical spin structure factor is also calculated to show the spin excitation in this system. The pitch angle vs. magnetization is shown by calculating pitch angle from the maximum of the dynamical spin structure factor. It also shows the same relation with the pitch angle calculated from the spin density. These features can be examined by inelastic neutron scattering experiments. The existence of spin nematic phase is shown for $S = 1$ by calculating jump of two in the magnetization vs. magnetic field plot.

In summary, we have studied the order of the multipolar phases for very small frustration ratio using different approaches such as, by calculating pitch angle from spin density and by calculating nearest neighbor energy gap as a function of the magnetic field. In the field induced spin nematic phase the binding of two magnons is shown in extended range of parameter regime. This calculation is also carried out for a real material $LiCuVO_4$. The field dependence of the longitudinal spin structure factor is calculated to see the spin excitation dynamics of the frustrated ferromagnetic spin-1/2 chain. The effect of higher spin i.e for $S = 1$ on the spin nematic phase is shown. We will be looking into other dynamical probes like NMR will be studied to establish the experimental evidence.

b. *Effect of Coulomb Interaction in Aggregation of Charged Colloids:*

We often encounter aggregation phenomena like gellation, protein crystallization, coagualtion of blood particles, self aggregation of colloidal particles in the nature. The understanding of these phenomena constructs an important realm in the mesoscopic physics. The building blocks of these aggregates (clusters) depends on the nature of the forces those compelling the individual particles to form a cluster. In a recent study of Manoharan et al. In 2010, they have shown that in the presence of a short – range interaction only, among the two possible configurations of the six particle cluster, polytetrahedron configuration is twenty times more probable than the octahedron one. Though energetically none of these two configurations is favored over another, the preference in the specific configuration attributes to the entropic differences among them. It is well known that an increment in the range of interaction smoothes the energy surfaces. Therefore, the relative preference of these two configurations in the presence of the coulomb interaction is important to know. We have

modeled our system as a six charged macro particle cluster dispersed into a monovalent ionic solution of specific salt concentration. Assuming this model, we use Metropolis Monte – Carlo method to calculate the system energy at different temperatures, and from these results, we calculate the system free energy for both kind of configurations. The results suggest that at the ambient temperature, polytetrahedron configuration is more probable than the other one, and the relative occurrence probability increases with the individual macro particles. But these numbers are much less than the number (twenty) which Manoharan et al. find in presence of the short – range interaction only. This suggests that the presence of long – range interation smoothes the energy surface of the system.

c. Searching Majorana on a Topological Insulators

Searching for Majorana fermions in condensed matter system has emerged as a very competitive field of research, especially as edge modes of Topological materials, whose experimental synthesis has become possible only recently. Various toy models, starting from Kitaev's proposition are also being explored for the possible existence of Majorana modes, the majority of which embed the proximity induced superconductivity effect. We propose a 1-d fermion gas model with SOC interactions and an external magnetic field introduced perpendicular to each other, to observe the presence of Majorana modes in the topological phase that exists for certain parameter regimes of the SOC strength and magnetic field h. We compute various correlations in the system, the variation of binding energy with system size, and single fermions excitation spectrum for quantitatively characterizing this topological phase.

d. Short Range to Quasi-Long Range Order Crossover in Interacting spin-1 and ½ spin ladder

Spin-1/2 system with nearest neighbour with Heisenberg antiferromagnetic (HAF) interaction is well studied model and its exact ground state shows quasi-long range order. Haldane conjectured that the spin-1 HAFs have gapped excitation with a short range correlation length. Therefore, there is a short range order in the system. We studied a ladder with one leg spin-1/2 and other with spin-1 and both the legs have anti-ferromagnetic interaction. We find there is crossover from short range to quasi-long-range order in system.

Publications in Journals

1. Zoltán G. Soos, Aslam Parvej, **Manoranjan Kumar**, *Numerical study of incommensurate and decoupled phases of spin-1/2 chains with isotropic exchange J_1, J_2 between first and second neighbors*, Journal of Physics: Condensed Matter, **28,** 175603, 2016.
2. Aslam Parvej and **Manoranjan Kumar**, *Degeneracies and exotic phases in an isotropic frustrated spin-1/2 chain*, Journal of Magnetism and Magnetic Materials, **401**, 96, 2016.
3. **Manoranjan Kumar**, Aslam Parvej, Simil Thomas, S. Ramasesha and Z G Soos, *Efficient Density Matrix Renormalization Group algorithm to study Y Junctions with integer and half-integer spin*, Phys Rev B, **93**, 075107, 2016.
4. **M Kumar**, A Parvej, Z G Soos, *Level crossing, spin structure factor and quantum phases of the frustrated spin-1/2 chain with first and second neighbor exchange*, Journal of Physics: Condensed Matter **27** (31), 316001, 2015.

Other Publication

1. Quantum phases of a frustrated spin-1/2 chain:Reconsidering a familiar model in the sector of weakly coupled sublattices, Zoltán G. Soos, Aslam Parvej Manoranjan Kumar Journal of Physics: Condensed Matter , **Labtalk** (2016)

Supervision of Students

Ph.D. Students: Aslam Parvej (2012), Hrishit Banerjee (in collaboration with Prof. Tanusri Saha Dasgupta) (2012), Rakesh Das (2013), Debasmita Maiti (2014), Monalisa Singh Roy (2015), Sudip Kumar Saha (2016); Post Doctoral Research Scientist: Dayasindhu Dey (2015)

Lecture Delivered

1. Invited speaker in Workshop and Symposium on DMRG Technique for Strongly Correlated Systems in Physics and Chemistry IIP Natal, Brazil (2015)

Course Taught

1. Condensed Matter, 302

Sponsored Project

1. Ramanujan Fellowship

Meeting Organized

1. Ramanujan Review meeting in Darjeeling (March 3-4, 2016)

Pratip Kumar Mukhopadhyay

Professor and HOD
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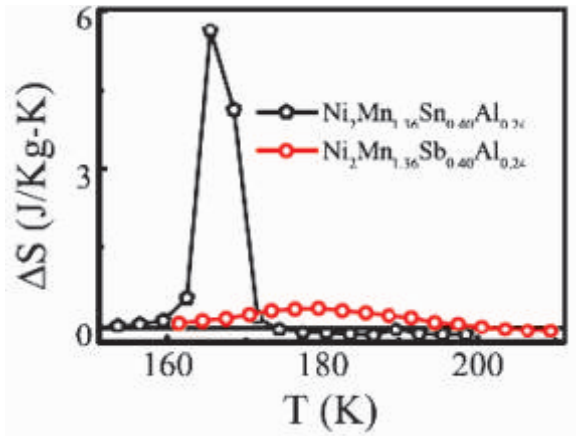
Prof. Pratip Kumar Mukhopadhyay's lab works on smart materials, also called multiferroic materials that respond interconnectedly to mechanical strain, magnetic and electric fields. These are new age materials in the forefront of research worldwide. These can be solids and fluids and they work on both phases.

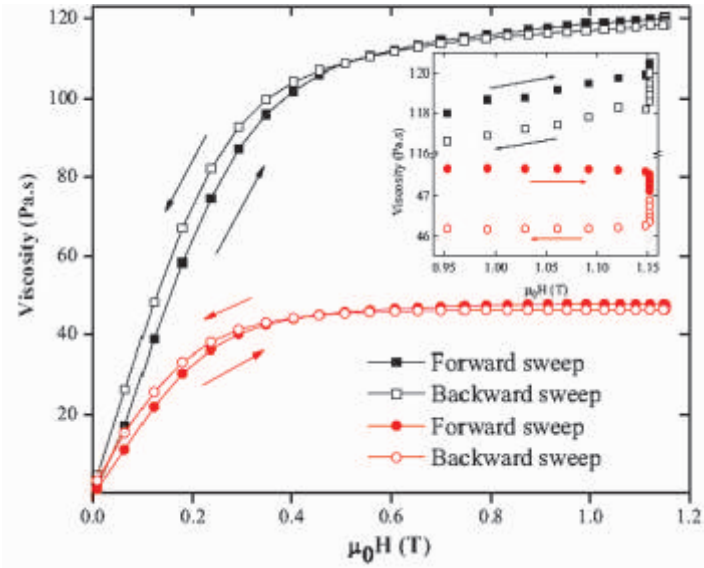
- **Magnetism is the key aspect that bond our interest in two diverse fields – in regular solids and in soft materials. This year magnetocaloric effects and magnetorheological effects were studied thoroughly. Very interesting effects were obtained from seemingly simple binary magnetic alloy system. Interesting memory effect was observed in a magnetorheological fluid system**

Magnetism and functional properties in solids (alloys) and in fluids were mainly studied in this time frame. In case of solids, we studied various ferromagnetic shape memory alloys by substitutions of elements in a prototype Ni_2Mn-AlZ system, where Z was either Sn or Sb. We investigated its effect on magnetism, entropy change and magnetoresistance in the vicinity of martensitic transformation. While both the samples had identical lattice parameters as well as Mn contents, which are mostly responsible for magnetism in these systems, yet there were marked changes in magnetic and functional properties of these systems. It was found that the magnetization increased in Sb alloy, while entropy change and magnetoresistance decreased as compared to Sn alloy. These changes are attributed to the change in antiferromagnetic interaction as a result of variation in the Ni_d – Mn_d hybridization arising due to presence of different sp elements.



In case of disordered magnetic alloys, we are working on basically iron based binary alloys of Al, a non magnetic element. They are showing a wealth of interesting structural and magnetic transitions that were not seen before. This work is currently in progress and the communications and publications will be shown in next year's report.

We continued our work on magnetorheological fluids from the previous years, this year concentrating on CoNi microcluster based fluids. During the course of work, we discovered a few very interesting effects in these. One is a



strong multipolar anisotropic dependence of yield stress in the system – this was not seen before and unexpected as well. Further, we found a strong and unusual memory effect in the mechanical strain induced by magnetic field.

There is a DRDO granted project work in making a smart body armor through rheological fluids. We made some progress in this. These may not be disclosed in public. 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 are also working on the discovery effect of photo induced microactuation. Some preliminary measurements are already done and will be published in a short time.

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. Injamamul Arief and **P. K. Mukhopadhyay**, *Dynamic and rate-dependent yielding behavior of $Co_{0.9}Ni_{0.1}$ microcluster based magnetorheological fluids*, J. Magn. Magn. Mater., **397**, 57, 2016
2. Sandeep Agarwal and **P. K. Mukhopadhyay**, *Effect of Sn and Sb element on the magnetism and functional properties of Ni-Mn-Al ferromagnetic shape memory alloys*, J. Magn. Magn. Mater. **402**, 161, 2016.
3. Injamamul Arief and **P. K. Mukhopadhyay**, *Two-step yielding in novel CoNi nanoplatelet-based magnetic fluids under oscillatory rheology*, Mater Lett., **167**, 192, 2016
4. K. Srinivasarao, Ch. Prameela, P. Venkata Kala, **P. K. Mukhopadhyay**, *Preparation and Characterization of r.f. Magnetron Sputtered Porous ZnO Thin Films*; Mater. Today: Proc., **2**, 4503, 2015.
5. C. Bora, A. Kalita, D. Das, S. K. Dolui and **P. K. Mukhopadhyay**, *Preparation of polyaniline/nickel oxide nanocomposites by liquid/liquid interfacial polymerization and evaluation of their electrical, electrochemical and magnetic properties*, Polym. Int., **63**, 445–452, 2014.

Supervision of Students

Ph.D. Students: Md. Injamamul Arief (CSIR) – Submitted in Dec. 2015, Tanmoy Ghosh (SNB), Md. Sarowar Hussain (TWAS, Italy), Abhisekh Bagchi (CSIR/SRF); **Project Students:** Dipanjan Samanta (till Dec. 2015), Animesh Basak (since Feb. 2016), Ushnanshu Dutta (Summer 2015); **Post Doctoral Research Scientists:** Alo Dutta (DST/Young Scientist), Tapas Paramanik

Lectures Delivered

1. Magnetorheological studies of CoNi nanocluster based magnetic fluids – FimPART 2015, Hyderabad, June 2015
2. Interesting properties of smart materials – HIT Haldia, August 2015
3. Studies of temperature dependence in some ferrofluids - ICMAGMA, VIT University, Vellore, December 2015
4. Interesting world of smart materials- SKU Purulia, March 2016

Course Taught

1. PHY501, Research Methodology, Fall 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 2016 international conference series; Convenor of NSU 2016, Co-convenor for ATNMC 2015; Ph.D. viva voce examiner in CU and JU; 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, SCREC; 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

Award / Recognition

1. Referee for various international and Indian journals

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 –
3. Measurement of Magnetic Field Induced Strain in some Ferro Magnetic Shape Memory Alloys – Centre's project, 2016 –

Meeting Organized

1. ATNMC 2015 – November 2015, in S. N. Bose Centre

Priya Mahadevan

Professor
priya@bose.res.in

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

- **We have worked on layered transition metal dichalcogenides to understand their electronic structure, magnetic structure as well as its evolution under strain**

A monolayer of $MoSe_2$ is found to be a direct bandgap semiconductor. We show, within ab-initio electronic structure calculations, that a modest biaxial tensile strain of 3% is able to drive it into an indirect bandgap semiconductor with the valence band maximum (VBM) shifting from K point to G point. An analysis of the charge density reveals that while Mo-Mo interactions contribute to the VBM at 0 % strain, Mo-Se interactions contribute to the highest occupied band at G point. A scaling of the hopping interaction strengths within an appropriate tight binding model is able to capture the transition.

The electronic structure of $Mn_{0.25}TaS_2$ has been studied with ab-initio electronic structure calculations. Various magnetic configurations have been considered for the ordering of the spins on Mn. Despite the typical separation of the Mn atoms being ~ 6Å, one finds that the ferromagnetic configuration is strongly stabilized. This is traced to a pathway between Mn d_{z^2} orbitals and Ta d_{z^2} orbitals.

Future Plan

We would like to continue our analysis of the electronic structure of transition metal dichalcogenides by examining the evolution of the electronic structure as a function of thickness. A crossover from a direct band gap semiconductor to an indirect band gap one has been seen with thickness. The changes in the electronic structure have been attributed to both quantum confinement effects as well as due to interlayer interactions as each layer was added. We would like to construct a microscopic model that captures the electronic structure and which would help us quantify the contrubutions from each of these effects.

A large spin-splitting has been seen in the highest occupied band at K-point in Mo based dichalcogenides for an odd number of layers. We would like to examine this by using a tight binding mapping of the ab-initio bandstructure for $MoSe_2$ to examine the role of interlayer interactions in the magnitude of spin-splitting.

Publications in Journals

1. R. Das and **P. Mahadevan**, *A model for the direct-to-indirect band-gap transition in monolayer $MoSe_2$ under strain*, Pramana, **84**, 1033, 2015.
2. S. Debnath and **P. Mahadevan**, *Electronic structure of $Mn_{0.25}TaS_2$*, Journal of Electron Spectroscopy and Related Phenomena, **208**, 74, 2016.
3. P.A. Bhobe, A. Kumar, M. Taguchi, R. Eguchi, M. Matsunami, Y. Takata, A.K. Nandy, **P. Mahadevan**, D.D. Sarma, A. Neroni, E. Sasioglu, M. Lezaic, M. Oura, Y. Senba, H. Ohashi, K. Ishizaka, M. Okawa, S. Shin, K. Tamasaku, Y. Kohmura, M. Yabashi, T. Ishikawa, K. Hasegawa, M. Isobe, Y. Ueda, A. Chainani, *Electronic Structure Evolution across the Peierls metal-insulator transition in a correlated ferromagnet*, Phys. Rev. X, **5**, 041004, 2015.

Supervision of Students

Ph.D. Students: Saikar Debnath, Ruma Das, Shishir Pandey, Basudeb Mandal, Sagar Sarkar, Poonam Kumari, Joydeep Chatterjee, Debalina Banerjee; Project Student: Manas Pratim Das

Lectures Delivered

1. Invited talk at Workshop on Multiferroics, Coorg, November 2015.
2. Invited talk at CCP2015, IIT Guwahati, Guwahati, December 2015.
3. Invited talk at AESET 2016, IIT Mandi, Mandi, January 2016.
4. Invited talk at ICONSAT 2016, IISER Pune, Pune, March 2016.
5. Contributed talk at APS March Meeting, Baltimore, March 2016.
6. Invited talk at Indo Japan Meeting, IISc Bangalore, March 2016.

Academic Visits

1. DST Austria IISc Bangalore August 2015
2. Indo US University of Arkansas March 2016

Course Taught

1. PH 103 Quantum Mechanics Aug-Dec

Membership of Committees

External Committee: IUPAP National Committee, IUPAP Committee on Computational Physics; Internal Committee: Various thesis committees in the centre, CWEP, SCOLP

Sponsored Projects

1. PI of DAE project on Functional transition metal oxides
2. Coinvestigator of DST-Austria project on Electron correlations and spin orbit coupling in 4d and 5d oxides: A joint experimental and frontier theoretical research

Prosenjit Singha Deo

Professor
deo@bose.res.in

Prof. Prosenjit Singha Deo did his PhD from Institue of Physics, Bhubaneswar and then did a couple of post docs abroad before joining SN Bose Centre in 1999.

- **I worked on scattering phase shift in low dimensional systems like quantum wires and explored its connection to negativity of partial density of states.**
- **Also worked on spontanous symmetry breaking in quantum systems**

We have shown that spontanous symmetry breaking is possible in a quantum many body system wherein the ground state develops into a crystal like charge and spin density wave with well defined rotational and viabrational modes. This is in violation of some well defined notions and theorems in physics.

Future Plan

Magnetization due to evanescent modes in open quantum rings.

Publications in Journals

1. U. Satpathi and **P. Singha Deo**, *Spontaneous symmetry breaking in quasi one dimension*, AIP conference proceedings, **1665**, 090019, 2015.
2. U. Satpathi, S. Ghosh, Ashim Ray and **P. Singha Deo**, *Localization of electrons in internal frame*, IJMP B, **30**, 1550266, 2016.

Supervision of Students

Ph.D. Students: U. Satpathi and Souvik Roy

Course Taught

1. From August to December 2015 I taught Mathematical methods (PHY102) to 1st semistar MSc (post BSc) students at S.N. Bose Centre.

Ranjan Chaudhury

Associate Professor
ranjan@bose.res.in

Dr. Ranjan Chaudhury received his PhD (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); Full Faculty at S.N. Bose Centre since 1994; His Awards/Honours include : NSTS scholarship 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 Physics Division of American Chemical Society since 2010; Fellow of Minnesota Supercomputer Institute (Minneapolis) since 1992; Member of Rayonnement du CNRS since 1995.

- **Theoretical investigation of superconductivity in multi-layered systems with the inclusion of intra-layer pair formation and inter-layer pair tunneling processes**
- **Detailed theoretical study of the spin stiffness properties of the strongly correlated doped systems in low dimensions and comparison with other theoretical approaches and experiments (with S. Bhattacharjee, my PhD student at SNBS)**
- **Detailed investigation of the spin dynamics and characterization of the topological excitations in layered quantum Heisenberg anti-ferromagnet (with S. Sarkar, my PhD student at SNBS and Dr. S.K. Paul)**
- **Realistic refinement of the theoretical treatment for pairing instabilty on 2D lattice system and possible applications to layered superconductors (with S. Roy Chowdhury, my PhD student at SNBS)**

(i) My recent calculations with the generalized Hamiltonian for multi-layered anisotropic superconductors (MLASC) proposed and developed earlier by me, have brought out a few interesting features. One of them is the emergence of an inequality to be satisfied in order to have stable quasi-particles in the superconducting state. This further leads to an important constraint involving the intra-layer and inter-layer parameters and the existence of a lower bound on out-of-plane gap parameter when there is a phase difference between the in-plane and out-of-plane gap parameters, even with s-wave intra-layer pairing.

(ii) Our calculational results for the generalized spin stiffness constants for the doped strongly correlated systems described by the t-J model on low-dimensional lattices, have been further analysed. For the 2D lattice, our calculations bring out the strong limitations of an earlier theoretical approach by Himeda and Ogata in the low doping regime. For the 1D case, our results show that the spin stiffness constant as a function of doping concentration exhibits a maximum. This is very much in agreement with the experimental results from Nuclear Magnetic Resonance performed by Slichter and company and neutron scattering done by Tranquada and collaborators for spin susceptibility versus doping concentration, obtained for the Cu-O_x chains of $YaBa_2Cu_3O_{(6+x)}$.

(iii) The dynamical structure function (DSF) obtained from the semi-classical vortex/ meron dynamics for 2D quantum Heisenberg anti-ferromagnet under the conventional Berezinskii-Kosterlitz-Thouless (BKT) scenario , was convoluted with various spectral resolution functions for appropriate comparison with the inelastic neutron scattering experimental results of Shirane and collaborators for La_2CuO_4. The breakdown of semi-classical treatment was found to be more severe compared to that in the case of ferromagnet and persisted for all the spectral resolution functions. At sufficiently high temperature however, the semi-classsical approach yielded better results as expected. Besides, from the integrated DSF results the total spin dynamics was found to have a substantial component from vortex dynamics at temperatures much higher than the BKT transition temperature.

(iv) The Cooper pairing instability corresponding to 2D tight binding lattice under the influence of a boson exchange mechanism, was further examined by replacing the background of a passive Fermi Sea with an active Fermi Sea. This ensures the presence of multiple pairs and the Pauli blocking effect in the realistic pair formation scenario relevant for the layered superconductors. The magnitude of calculated coherence lengths for various band fillings show reduction compared to those for the case with passive Fermi Sea.

Future Plan

(i) Calculation of superconducting transition temperature and other thermodynamic properties for my MLASC with inter-layer pair tunneling model would be taken up soon.

(ii) Theoretical determination of generalized charge stiffness constants for strongly correlated doped quantum anti-ferromagnet on low-dimensional lattices would be initiated.

(iii) Calculation for full quantum mechanical DSF corresponding to 2-dimensional XY-anisotropic ferromagnetic and anti-ferromagnetic models will be reinitiated to strengthen the idea of quantum BKT scenario.

(iv) To extend the theoretical investigation for Cooper pairing instability on lattices to next nearest neighbour tight binding model for more realistic comparison with the experimental results from overdoped cuprates.

Publication in Journal

1. Subhajit Sarkar, **Ranjan Chaudhury** and Samir K. Paul, *The connection between vortex-like topological excitations and conventional excitations in quantum ferromagnetic spin systems on two-dimensional lattice and their stability*, International Journal of Modern Physics B, **29**, 1550209, 2015.

Other Publications

1. Subhajit Sarkar, Ranjan Chaudhury and Samir K. Paul, Theoretical analysis of neutron scattering results for quasi-two dimensional quantum antiferromagnet---possible role of Berezinskii-Kosterlitz-Thouless transition | arXiv:1506.06856v2 [Cond-mat.str-el] | 2015

2. Soumi Roy Chowdhury and Ranjan Chaudhury, Investigation of fermionic pairing on two-dimensional tight binding lattice under phonon and electronic mechanisms within a Fermi liquid-like scenario and possible application to superconductivity in overdoped Cuprates | arXiv:1506.08373v2 [Cond-mat.supr-con] | 2015

3. Suraka Bhattacharjee and Ranjan Chaudhury, Calculation of generalized spin stiffness constant of strongly correlated doped quantum anti-ferromagnet on two-dimensional lattice and its application to effective exchange constant for semi-itinerant systems | arXiv:1510.01428v2 [Cond-mat.str-el] | 2015

Supervision of Students

Ph.D. Students: Soumi Roy Chowdhury (SRF till 31.01.16; then External Student), Subhajit Sarkar (SRF), Suraka Bhattacharjee (JRF)

Lectures Delivered

1. How Much Can Condensed Matter Physics Help In The Understanding Of Molecular Bio-physical Processes?, S.N. Bose Centre; for C.K. Majumdar Memorial Summer Workshop in Physics, Kolkata, June, 2015.

Award / Recognition

1. Became Editor-in-Chief of 'Journal Of Opinion In Condensed Matter Physics' (Singapore) since February 2016.

Soumendu Datta

INSPIRE Faculty

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Dr. Soumendu Datta is currently completing the fourth year of his present tenure of INSPIRE faculty. His research is broadly related to theoretical condensed matter physics. He uses density functional theory based electronic structure calculations to determine the properties of materials, with particular emphasis on the structural as well as catalytic properties of metal nano-particles, and photocatalytic properties of crystalline semiconducting materials.

- **With a motivation to have some microscopic understanding for *engineering the catalytic properties*, I focused mainly on two nano-systems during the last one year – one is related to the study of optimized structure, alloying behavior and magnetic properties *for the bimetallic nano alloys of silver and 3d-late transition metal atoms*, while the other is related to the study of the *morphology effects on the catalytic properties for the oxide nano-clusters of transition metal atoms***

Finite sized nano systems are associated with large surface-to-volume ratio and highly size-dependent properties, which render them promising candidates for various applications including catalysis. Bimetallic alloyed nano-clusters show interesting catalytic activity as their properties can be tuned by changing not only size but also by changing chemical composition. The degree of mixing/segregation between the two species of atoms in a bimetallic nano alloyed system, depends on a complex interplay of various properties of the constituent atomic species. With the decrease of particle size, especially to the point where the critical dimensions are in the nano-meter regime, many properties can be significantly different from those of their bulk counterparts. Consequently, it is occasionally seen that a pair of elements which do not mix in bulk phase, show favorable mixing tendency in the nano dimension. I focus on the Ni-Ag nano alloy systems, which show many novel applications in recent time, specially for catalysis, sensor and optoelectronics. In case of the NiAg nano alloy systems, a large size-mismatch (more than 10%) exists in the atomic diameters of the two species of atoms with Ag being the larger atom. The Ag atoms are also associated with lower surface energy and weaker cohesion (almost half of Ni). Consequently, though both the elements have a face-centered cubic crystal structure in their bulk phases, a wide miscibility-gap persists in the bulk phase of the NiAg alloy with a positive formation energy even at the high temperature. Therefore, we expect the two species not to mix in case of their nano-alloy. The reported results on the structural patterns of the NiAg nano alloy systems, also reveal a conflicting picture in the sense that while most of the reports indicate a core-shell like segregated pattern, others indicate a homogeneous alloy formation. I have, therefore, studied the optimized structures, alloy *versus* segregation behavior and magnetic properties of the Ni_{13-n} Ag_n alloy clusters for all compositions using first principles DFT based electronic structure calculations.

The novelty of my study is that it reports favorable mixing of the bimetallic Ni-Ag nano-clusters for all compositions. Furthermore, the most stable structures of the Ni-Ag alloy clusters adopt a core-shell like structural pattern with the smaller sized, higher cohesive Ni atoms at the core and the larger sized, less cohesive Ag atoms at the shell. We note that the interfacial Ni-Ag interactions play important role for the favorable mixing as well as determining the other properties. The magic composition with the highest stability has been identified for the $Ag_{12}Ni$ alloy cluster. The Ni-Ag alloy clusters are highly spin polarized. The magnetic moments of NiAg alloy clusters are mainly contributed by the Ferro-magnetically coupled Ni-atoms at the core and decrease

monotonically with the decrease of Ni-content. In addition, our analysis shows that the overall average nearest neighbor bond lengths increase with the increasing Ag-concentration. It is interesting to mention that this increase of the average bond length follows roughly a linear interpolation between the average nearest neighbor bond lengths of the two pure clusters. This can be regarded as the Vegard's law on nanoscale for the NiAg alloy clusters, which traced back to the linear variations of the orbital hybridization as well as surface energy in our calculations for the NiAg alloy clusters.

In an another work, I have performed a comparative study of the structural stability and electronic properties for isolated and CO-ligated M_4O_4 nanoclusters between their two closely lying stable isomers: a planar rhombus-like 2D structure and a cubane-like 3D structure with M = Mn, Fe, Co, Ni and Cu. Each 3d late transition atom is associated with a more than half-filled d-shell. Therefore, hybridization between the valence orbitals of the constituent atoms is significant and play an important role in deciding the relative structural stability. We figure out that the preference of one structure over the other is governed by the enhanced hybridization effect.

Future Plan

A systematic study to derive trends in the structural, alloying and electronic properties for a series of different bimetallic nano alloy systems within the same computational scheme, would be a useful study. Presently, I am also carrying out the similar analysis (as mentioned above) for the structure, alloying and electronic properties in cases of the AgMn, AgFe, AgCo and AgCu nano alloy systems. As the transition metal elements Mn, Fe, Co, Ni, Cu have different magnetic character, such study will also bring out the effect of magnetism on the mixing property of the nano alloy systems.

Dopings with nonmagnetic elements such as Ag, Pd, Cu, Bi in the N-doped ZnO nano structures, are promising for band gap narrowing and have also been shown recently to exhibit enhanced absorption of CO_2 gas molecule. Therefore such codoped ZnO nano structures are promising candidate for future CO_2 capture. Presently, I am studying the morphology effects of the host system on the band gap variation and CO_2 absorption ability for these codoped ZnO nano structures.

Publications in Journals

1. **S. Datta** and B. Rahaman, *First principles study of electronic structure for cubane-like and ring-shaped structures of M_4O_4, M_4S_4 clusters (M = Mn, Fe, Co, Ni, Cu)*, AIP Advances, **5**, 117231, 2015.
2. **S. Datta**, G. Kaphle, S. Baral and A. Mookerjee, *Study of morphology effects on magnetic interactions and band gap variations for 3d late transition metal bi-doped ZnO nanostructures by hybrid DFT calculations*, J. Chem. Phys., **143**, 084309, 2015.

Supervision of Students

Ph.D. Student: Sangita Dutta (JRF); Project Student: Lalit Kumar Sahoo from ISM, Dhanbad did his M.Sc. project

Lectures Delivered

1. Oral presentation at MRS Spring Meeting, San Francisco, USA during 6-10 April, 2015
2. Oral presentation at "Condensed Matter Days 2015", Visva-Bharati, Santiniketan during 27-29 August, 2015
3. Oral presentation at ISCAN 2016", IISER-TVM, Kerela during 9-12 March, 2016
4. Invited talk at Theoretical Condensed Matter Physics department, Saha Institute of Nuclear Physics, Kolkkata on March 31, 2016

Course Taught

1. Conducted a course titled "Mathematical Physics" for the IPhD first semester-2015 batch along with Prof. P. S. Deo

Membership of Committees

Internal Committee: Included in the selection committee for selecting IPhD and PhD students for admission-2016

Award / Recognition

1. Selected for travel grant by the Science and Engineering Research Board (SERB), government of India for attending the "2015 MRS Spring Meeting & Exhibitions"

Sponsored Project

1. INSPIRE Faculty

Sugata Mukherjee

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

Research Areas of Dr. Sugata Mukherjee includes Two-dimensional Nanomaterials, First-principles Electronic Structure, Electron & Thermal Transport in Nanomaterials.

- **Electrical and thermal transport in monolayer- and bilayer-graphene**
- **Thermoelectric tramsport properties of Graphene & h-BN multilayers**
- **Phase stability of CBN nanomaterials**

We have published a paper on the calculation of thermoelectric properties of Graphene/h-BN/Graphene multilayers. Calculations were performed using first-principles electronic structure and Boltzmann transport theory of band electrons for the electrical conductance. We used equilibrium molecular dynamics simulation to obtain the lattice thermal conductivity. The calculated Power Factor and Figure-of-merit are in good agreement with recent experimental results.

We have performed detailed transport calculations for monolayer- and bilayer-graphene (MLG, BLG) and have obtained the Bloch-Grueneisen kind of behaviour in MLG as observed experimentally by Kim et al. Enhance of the Seebeck coefficient upon doping and also by applying electric field in MLG and BLG was observed.

We have calculated the lattice thermal conductivity of MLG and BLG using phonon-Boltzmann transport theory from the first-principles calculation of the phonon bandstructure. The calculated thermal conductivity shows an excellent agreement with experimental results.

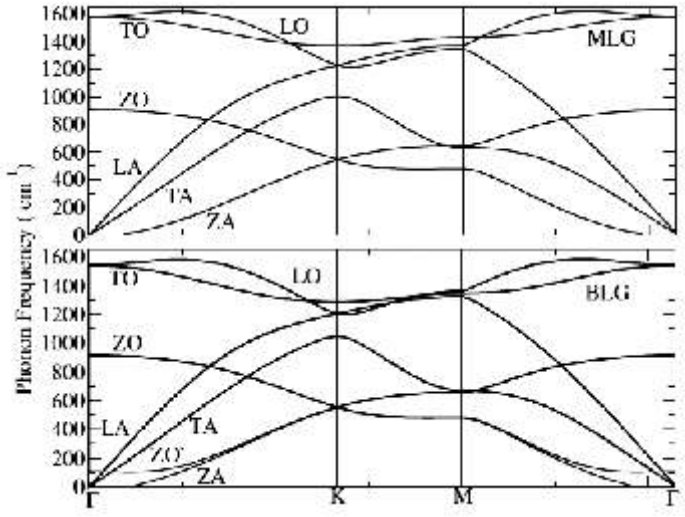


Fig.1: Phonon dispersion of MLG (top) and BLG (down) along the high symmetry k-points in the first BZ.

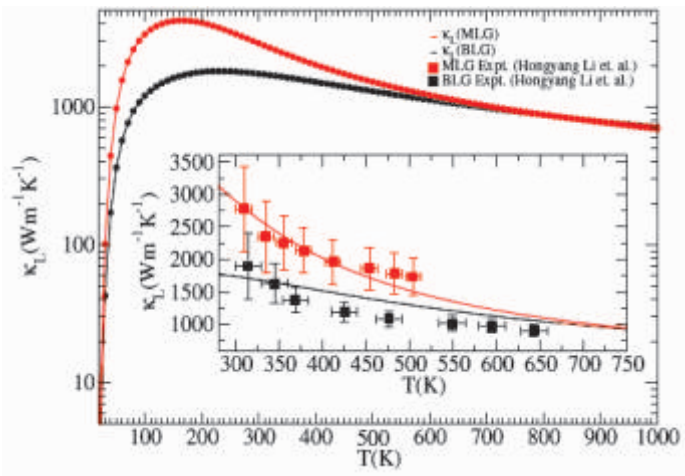


Fig.2: Lattice thermal conductivity (K_l) in log scale of monolayer (Red) and bilayer (Black) grapheme in the temperature range 20K to 1000K. Inset: K_L of MLG and BLG in linear scale in the temperature range temperature 300K to 700K to compare with experimental results by [44] shown with red and black square points.

Future Plan

Further calculations are in progress of the lattice thermal conductivity of h-BN multilayers. Calculations are also planned using the Non-equilibrium Greens function method of the transport in nanomaterials.

Publication in Journal

1. R. D'Souza and **S. Mukherjee**, *Thermoelectric transport in Graphene/h-BN/Graphene heterostructures: A computational study*, Physica E, **81**, 96-101, 2016. (http://dx.doi.org/10.1016/j.physe.2016.03.006)

Other Publications

1. First-principles calculations of the transport properties of Graphene/hBN/Graphene heterostructured nanomaterials. S. Mukherjee, 27th IUPAP-CCP2015 conference, IIT Guwahati, 2-5 Dec 2015, p 169.
2. Thermoelectric properties of Nanomaterials, S. Mukherjee, 7th Vidyasagar-S.N. Bose national Worshop, Vidyasagar University, 15-17 March 2016, p 5.
3. Calculation of Thermoelectric transport properties of heterostructures of Graphene and h-BN and related 2d nanomaterials. S. Mukherjee, in International Symposium on Clusters, Cluster-assembles and Nanomaterials, Thiruvananthapuram, 9-12 march 2016, p 89.

Supervision of Student

Ph.D. Student: Ransell D'Souza

Lectures Delivered

1. First-principles calculations of the transport properties of Graphene/hBN/Graphene heterostructured nanomaterials. S. Mukherjee, 27th IUPAP-CCP2015 conference, IIT Guwahati, 2-5 Dec 2015.
2. Thermoelectric properties of Nanomaterials, S. Mukherjee, 7th Vidyasagar-S.N. Bose national Workshop, Vidyasagar University, 15-17 March 2016.
3. Calculation of Thermoelectric transport properties of heterostructures of Graphene and h-BN and related 2d nanomaterials. S. Mukherjee, in International Symposium on Clusters, Cluster-assembles and Nanomaterials, Thiruvananthapuram, 9-12 march 2016.

Course Taught

1. PHY 412 and PHY 602 "Physics of Materials" during 2015-16

Membership of Committees

External Committee: Acted as external thesis examiner and oral-examiner of a PhD thesis at IIT Guwahati, Nov 2015; Acted as external member of SRF evaluation at IACS, Jadavpur, Sept 2015; Acted as referee of following journals – Computational Materials Science, Journal of Appled Physics, Chemical Physics Letters, Journal of Physics & Chemistry of Solids; Internal Committee: Member of the organizing committee of National Conference on Ultrasonics

Meeting Organized

1. Organizing committee member of National Conference on Ultrasonics (Nov 2015)

Tanusri Saha-Dasgupta

Senior 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**
- **Oxide heterostructures**
- **2D materials**
- **Spin systems**
- **Organic-inorganic hybrid materials**

Breakdown of J = 0 Nonmagnetic State in d^4 Iridate Double Perovskites: A First-principles Study *[Sayantika Bhowal, Santu Baidya, Indra Dasgupta, and Tanusri Saha Dasgupta, Phys. Rev. B (Rapid) 92, 121113(R) (2015)]*

Through first-principles calculations, we study the electronic structure of double perovskite Iridates with Ir in d^4 valence state. Contrary to the expected strong spin-orbit driven J = 0 nonmagnetic state, we find finite moment at Ir site, exhibiting breakdown of J = 0 state. We further find the band structure effect rather than the crystal field effect to be responsible for this breakdown, as shown schematically in the Fig 1. The antiferromagnetic superexchange interaction between Ir moments, in general, makes these compounds insulating.

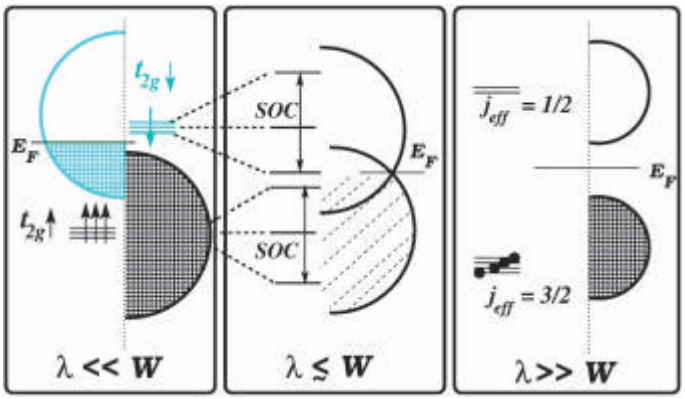


Fig 1: The evolution of the t_{2g} electronic states of Ir^{5+} upon increasing λ/W. The scenario including the finite bandwidth effect starting from the atomic energy levels at different strengths of λ/W is shown. Double perovskite compounds lie in intermediate situation.

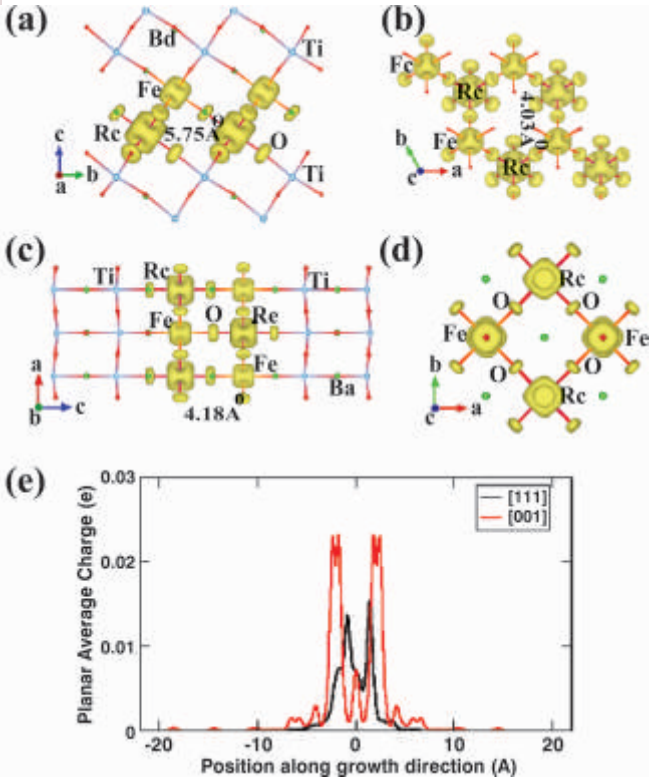


Fig 2: Out-of-plane and inplane projection of the conducting charge density in (111) [panels (a) and (b), respectively] and (001) heterostructure geometries [panels (c) and (d), respectively]. Panel (e): Planar averaged conducting charge density versus distance along the growth direction for (111) and (001) heterostructures.

Controlled confinement of half-metallic two-dimensional electron gas in $BaTiO_3/Ba_2FeReO_6/BaTiO_3$ heterostructures: A first-principles study *[Santu Baidya, Umesh V. Waghmare, Arun Paramekanti, and Tanusri Saha-Dasgupta, Phys. Rev. B (Rapid) 92, 161106(R) (2015)]*

Using density functional theory calculations, we establish that the half-metallicity of bulk Ba_2FeReO_6 survives down to 1 nm thickness in $BaTiO_3/Ba_2FeReO_6/BaTiO_3$ heterostructures grown along the (001) and (111) directions (cf Fig 2). The confinement of the two-dimensional (2D) electron gas in this quantum well structure arises from the suppressed hybridization between Re/Fe *d* states and unoccupied Ti *d* states, and it is further strengthened by polar fields for the (111) direction. Our work opens up the possibility of realizing ultra-thin spintronic devices.

Future Plan

- Structure prediction in oxide materials.
- Hybrid Perovskites
- Organic-inorganic layered materials.
- A site ordered perovskites

Publications in Journals

1. Prabuddha Sanyal, Anita Halder, Liang Si, Markus Wallerberger, Karsten Held, and **Tanusri Saha-Dasgupta**, *Magnetism in Sr_2CrMoO_6: A combined ab initio and model study*, Phys. Rev. B **94**, 035132, 2016.
2. K Samanta, S Kar, **T Saha-Dasgupta,** *Magnetic modeling and effect of biaxial strain on the Haldane chain compound $SrNi_2V_2O_8$*, Physical Review B **93**, 224404 (2016).
3. Suman Chowdhury, D Jana, B Sadhukhan, D Nafday, S Baidya, **Tanusri Saha-Dasgupta**, Abhijit Mookerjee, *Configuration and self-averaging in disordered systems*, Indian Journal of Physics, **90,** 649 (2016).
4. Ryan Morrow, Kartik Samanta, **Tanusri Saha Dasgupta**, Jie Xiong, John W Freeland, Daniel Haskel, Patrick M Woodward, *Magnetism in Ca_2CoOsO_6 and Ca_2NiOsO_6: Unraveling the mystery of superexchange interactions between 3d and 5d ions*, Chemistry of Materials, **28,** 3666 (2016).
5. **T Saha-Dasgupta**, *Electronic structure of spin systems*, Journal of Electron Spectroscopy and Related Phenomena **208**, 83 (2016).
6. A Dutta, AK Raychaudhuri, **T Saha-Dasgupta**, *Plasticity-mediated collapse and recrystallization in hollow copper nanowires: a molecular dynamics simulation*, Beilstein journal of nanotechnology **7**, 228 (2016)
7. D Nafday, M Kabir, **T Saha-Dasgupta,** *Controlling adatom magnetism on bilayer graphene by external field*, Physical Review B **93**, 045433 (2016).
8. Igor Danilovich, Anna Merkulova, Anastasia Polovkova, Elena Zvereva, Yevgeniy Ovchenkov, Igor Morozov, Badiur Rahaman, **Tanusri Saha-Dasgupta**, Christian Balz, Hubertus Luetkens, Olga Volkova, Alexander Shakin, Alexander Vasiliev, *Vehement Competition of Multiple Superexchange Interactions and Peculiar Magnetically Disordered State in Cu(OH)F*, J. Phys. Soc. Jpn **85**, 024709 (2016).
9. AV Koshelev, EA Zvereva, DA Chareev, OS Volkova, A Vymazalova, F Laufek, EV Kovalchuk, B Rahaman, **T Saha-Dasgupta**, AN Vasiliev, *The long-range magnetic order and underlying spin model in shattuckite $Cu_5(SiO_3)_4(OH)_2$*, Physics and Chemistry of Minerals **43**, 43 (2015).
10. P Chakraborty, A Moitra, **T Saha-Dasgupta**, *Effect of hydrogen on degradation mechanism of zirconium: A molecular dynamics study*, Journal of Nuclear Materials **466**, 172 (2015).
11. S Baidya, UV Waghmare, A Paramekanti, **T Saha-Dasgupta**, *Controlled confinement of half-metallic two-dimensional electron gas in $BaTiO_3/Ba_2FeReO_6/BaTiO_3$ heterostructures: A first-principles study*, Physical Review B (Rapid) **92**, 161106 (2015).
12. S Bhowal, S Baidya, I Dasgupta, **T Saha-Dasgupta**, *Breakdown of $J = 0$ nonmagnetic state in d^4 iridate double perovskites: A first-principles study*, Physical Review B (Rapid) **92**, 121113 (2015).
13. A Valli, H Das, G Sangiovanni, **T Saha-Dasgupta**, K Held, *Tunable site-and orbital-selective Mott transition and quantum confinement effects in $La_{0.5}Ca_{0.5}MnO_3$ nanoclusters*, Physical Review B **92**, 115143 (2015).
14. SK Panda, I Dasgupta, **T Saha-Dasgupta**, *Electronic structure and magnetism of K-intercalated iron chalcogenides*, Physical Review B **92**, 104421 (2015).

Other Publications

1. M Kabir, D Nafday, **T Saha-Dasgupta**, Controlling Adatom Magnetism on Bilayer Graphene by External Field, APS Meeting Abstracts, 2016
2. **T Saha-Dasgupta**, S Baidya, U Waghmare, A Paramekanti, Controlled Confinement of Half-metallic 2D Electron Gas in $BaTiO_3/Ba_2FeReO_6/BaTiO_3$ Heterostructures: A First-principles Study, APS Meeting Abstracts, 2015

Supervision of Students

Ph.D. Students: Dhani Nafday (SRF, funded by project), Hrishit Banerjee (SRF), Kartick Samanta (SRF), Ransell D'souza (SRF), Paulomi Chakraborty (SRF), Anita Halder (JRF), Pallavi Paul (JRF), Shreya Das (JRF); **Post Doctoral Research Scientist:** Tilak Das (Funded by project)

Lectures Delivered

1. Oxide Heterostructures, Tokyo Tech Univ, January 2016
2. Double perovskites, Koyto University, January 2016
3. Physics of Complex Materials, Osaka Univ, February 2016
4. Physics in Double perovskites, Univ of Toronto, Oct 2015
5. Magnetism in and on graphene, Melbourne, Nov 2015
6. A site cations in perovskites, Ohio State Univ, April 2015
7. Magnetism in and on graphene, University of Groningen, April 2015

Academic Visits

1. Indo-Russian, Moscow State University, September, 2015
2. Indo-Austrian, Univ of Graz, November, 2015
3. Tokyo Technical University, January, 2016

Membership of Committees

External Committee: Editorial board member, Pramana; Member, PAC meeting under Physical Sciences; Member, Sectional Committee Academy; Member, ICC, IACS, Kolkata; **Internal Committee:** Member, Director Advisory Board; Associate Dean (Faculty); Convener, Advanced Post Doctoral Manpower Program; Convener, Faculty search committee; Chairperson, Computer Services Cell Advisory Committee & Working Group Committee

Awards / Recognitions

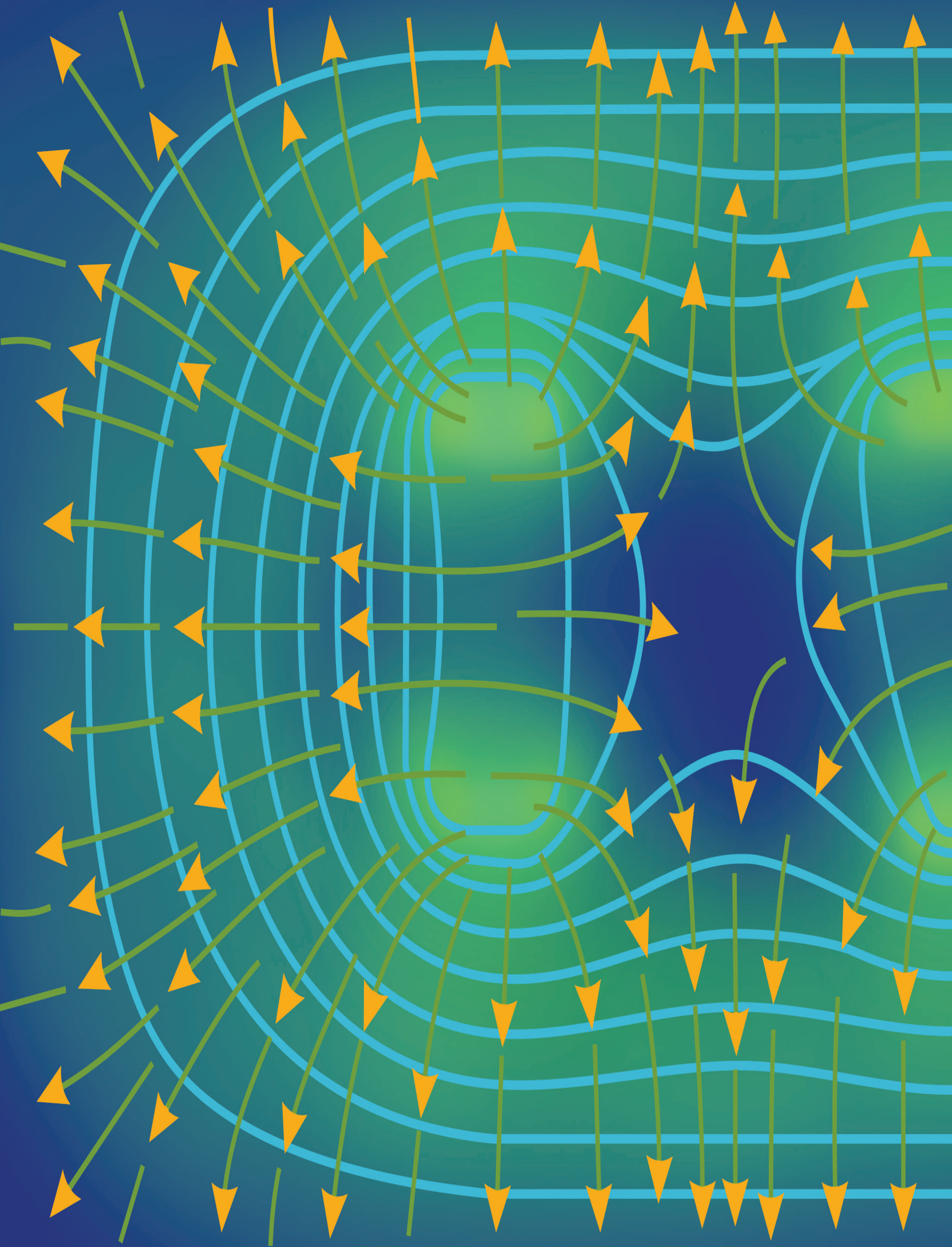
1. "MRSI-ICSC Superconductivity & Materials Science Annual Prize" for the year 2016
2. Elected Fellow of American Physical Society, 2015

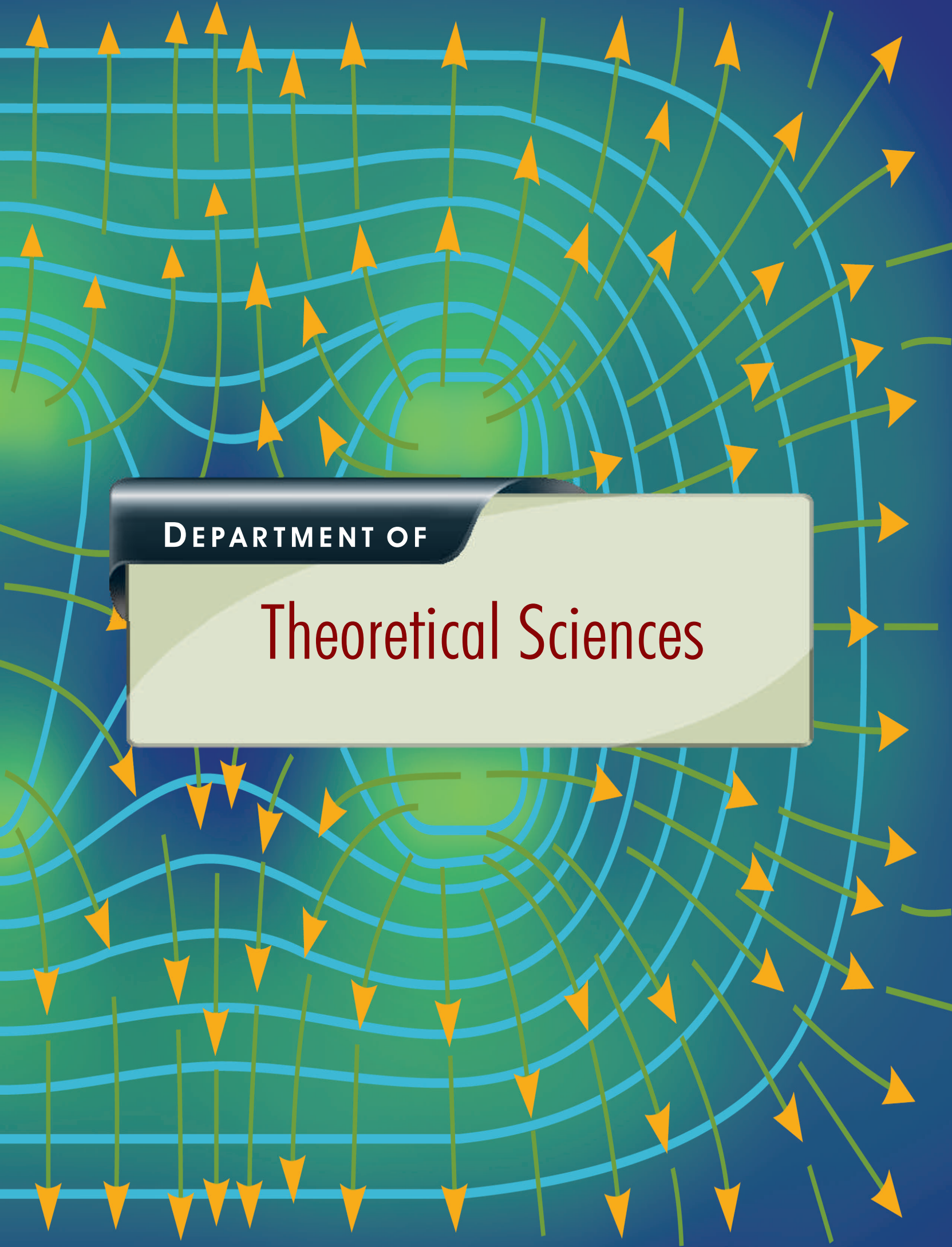
Sponsored Projects

1. Graphene Spintronics with Complex Oxides, Funding Agency: DST-NWO
2. Magnetism in low dimensional quantum spin systems, Funding Agency: DST-RFBR
3. Physical properties of elemental solids, their compounds and oxides, and mineral phases at extreme conditions of pressure and temperature: an experimental and theoretical study, Funding Agency: Ministry of Earth Sciences
4. Electronic Structure of MAX and MAXene phases, Funding Agency: DST-BMWF
5. Thematic Unit of Excellence of Computational Materials Science, Funding Agency: Nanomission, DST

Meeting Organized

1. 7th APCTP-Academy Joint Meeting on Multiferroics, Orange County, Coorg, India, November 29-30, 2015




DEPARTMENT OF
Theoretical Sciences

DEPARTMENT OF

Theoretical Sciences

Manu Mathur

Head of the Department

Department profile indicators

Table A	Manpower and resources	
Number of faculties		11
Number of Post -doctoral research associate (centre + project)		6
Number of Ph.D students		32
Number of other project staff		3 (student)
Number of summer students		19
Projects (ongoing)		1

Table B	Research Activities indicators	
Number of research papers in Journals		31
Number of Book-chapters/books		0
Number of other publications		3
Number of Ph.D students graduated (submitted + degree awarded)		2
Number of M.Tech/M.Sc projects		0

Table C	Academic activities and likeage	
Number of courses taught by faculties		6
Number of Visitors (non -associates)		7
Number of associates		0
Number of Seminars organized		4
Number of Conference/Symposia/ Advanced Schools organized		1
Number of talks delivered by members of department in conferences/Symposia	National	9
	International	1

Most important research highlights

- Nonrelativistic diffeomorphism symmetry and its applications to fluid dynamics, Newton-Cartan geometry, fractional quantum Hall effect etc. Action principles for fluid dynamics and magnetohydrodynamics
- Non-commutative geometry and Quantum Field Theory, computations of infinitesimal spectral distance, *a la* Connes on Non-commutative spaces

- Investigations on spin dynamics induced by topological excitations in spin ½ layered anti-ferromagnetic systems
- calculated the effect of a small gluon mass on the anomalous chromomagnetic moment of quarks, both for a Proca mass and for a topologically generated mass
- Extention of the integrability analysis to four dimensions and investigation of the behavior of chaotic dynamical systems
- Construction of Canonical Transformations leading to a Loop Formulation of SU(N) Lattice Gauge Theories
- Study of desert roses and their geometrical structure using computer assisted tomography
- Study of complexity in nature and intelligent system
- Study of additivity property and fluctuations in nonequilibrium steady state
- Study of phase separation in interacting particle systems
- Study of chemotaxis of E.coli bacteria

Summary of research activities

The Galilean gauge theory approach was used to show that a covariant formulation of nonrelativistic diffeomorphism naturally led to a coupling of the Schrodinger theory with Newton-Cartan geometry. The analysis was extended to include the effects of torsion.

The effect of small gluon mass on anomalous chrmomagnetic moment of quarks, both of a Proca mass and for topologically generated mass, was calculated. A significant mass dependence for the light quarks but very little effect on the heavy quarks was found.

Investigations on spin dynamics induced by topological excitations in spin ½ layered antiferromagnetic systems: theoretical analysis of the neutron scattering results for spin ½ anti-ferromagnet La_2CuO_4.

Non-commutative studies in quantum field theory and computation of infinitesimal distance, a la Connes on non-commutative spaces like fuzzy spheres, to computation of the finite distances.

Extension of the integrability analysis to four dimensions and investigation of the behaviour of dynamical system which are chaotic for generic values of parameters.

Using canonical transformations an exact equivalence between the physical Hilbert space of pure SU(2) lattice gauge theory and the Hilbert space of hydrogen atoms was demonstrated.

Additivity properties and fluctuations in nonequilibrium steady states were studied. Two point spatial correations in steady state in a broad class of conserved mass transport processes were computed.

Particle clustering on macroscopic scales in a coupled non-equilibrium system where two species of particles are advected by a fluctuating landscape was demonstrated.

A new model of percolation phenomena, with an additive source of disorder, is introduced to understand fluctuating ranges of transmission and global connectivity in mobile networks.

The survivor distributions of a spatially extended model of competitive dynamics in different geometries were investigated.

Issues related to nonclassicality and entanglement were studied.

Models for halo formation around X-ray emitting stars were studied.

Manu Mathur

Head, Department of Theretical Sciences

Amitabha Lahiri

Professor

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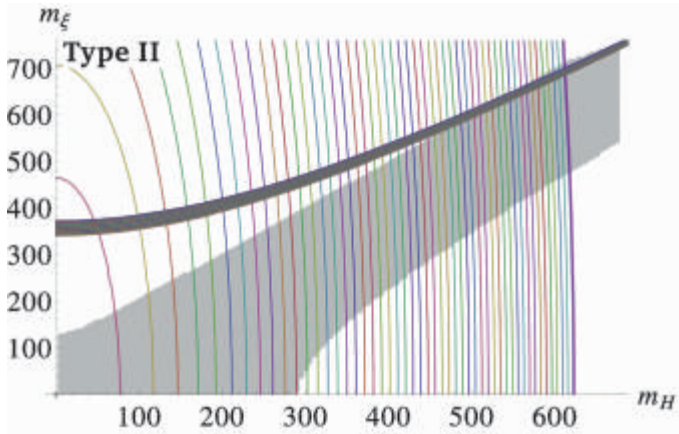
Prof. Amitabha Lahiri did his PhD from Syracuse University. He held Post-Doctoral Fellowships at Los Alamos National Laboratory and University of Sussex. He joined Satyendra Nath Bose National Centre for Basic Sciences in 1996. He is a theoretical physicist working in mathematical physics, general relativity, quantum field theory and particle physics.

- **Mathematical Physics, Quantum field Theory, Gravitation; Differential geometry of path spaces; Categorical fiber bundles and connections on path spaces; Topological mass generation for gauge bosons, 2-Higgs doublet models, Field theory on curved spacetime, Field theoretic aspects of gravity**

We calculated the effect of a small gluon mass on the anomalous chromomagnetic moment of quarks, both for a Proca mass and for a topologically generated mass. In both cases, we found significant mass dependence for the light quarks, but very little effect on the heavy quarks.

Categorical gauge theories provide a natural framework for the interactions of charged extended objects. The geometrical setting for such theories are categorical bundles, for which the notion of local trivialization is quite different from that of ordinary principal bundles. We introduced a notion of twisted-product categorical bundles in which the local `trivialization' is a special kind of product between the base category and the categorical group of the fiber. These bundles are related to decorated categorical bundles defined in our earlier works.

The 2-Higgs doublet model (2HDM) is one of the simplest extensions of the Standard Model, which predicts additional scalar particles. In 2HDMs with additional U(1) symmetry, we imposed a specific kind of *naturalness condition* and found the range of masses of the scalars consistent with various theoretical and phenomenological constraints, namely stability, perturbative unitarity, and the electroweak ρ parameter. The mass range of the CP-even heavy Higgs was found to be $450 < m_H < 620$ GeV, and that for the charged Higgs was $550 < m_{\Box} < 700$ GeV, corresponding to the overlap region of constraints, as in the accompanying plot.



We proposed a novel non-local interaction between charged fermions and an antisymmetric tensor potential, and showed that at low energy the effective action, after integrating out the fermions, contained a topological mass generation mechanism for photons. In other words, the photons gained an effective mass. This could find useful application in models of superconductivity.

Future Plan

In mathematical physics we plan to continue our investigations of categorical gauge theories and categorical bundles, specifically the construction of connections on these bundles and also the gauge transformations of these

connections.

In quantum field theory we plan to further investigate 2HDMs of different kinds and look for restrictions on the allowed mass ranges of scalars, as well as decay properties of Higgs particles and bound states.

We also plan to calculate the static electron-electron potential in the non-local interaction model we constructed, and look for applications of the model in superconductivity.

We will also investigate classical gauge field theories on curved space-times, in particular looking for modifications of the constraint structure of such theories in presence of black hole and cosmological horizons.

Publications in Journals

1. Ambalika Biswas and **Amitabha Lahiri**, *Masses of physical scalars in two Higgs doublet models,* Phys. Rev. D, 91, 115012, 2015.
2. Ishita Dutta Choudhury, M. C. Diamantini, G. Guarnaccia, Amitabha Lahiri and C. A. Trugenberger, *4D Topological mass by gauging spin,* JHEP, **81**, 1506, 2015.
3. Ishita Dutta Choudhury and **Amitabha Lahiri**, *Anomalous chromomagnetic moment of quarks,* Mod. Phys. Lett. A, **30**, 1550113, 2015.
4. Saikat Chatterjee, **Amitabha Lahiri** and Ambar N. Sengupta, *Twisted-product categorical bundles*, J. Geom. Phys., **98**, 128, 2015.
5. Ishita Dutta Choudhury and **Amitabha Lahiri**, *Quark ACM with topologically generated gluon mass,* Mod. Phys. Lett. A, **31**, 1650048, 2016.

Other Publications

1. Ishita Dutta Choudhury and **Amitabha Lahiri**, *Quark ACM with Massive Gluon,* in the Proceedings of the 21st DAE-BRNS High Energy Physics Symposium (hepbrns2014), Guwahati, India 8-12 Dec, 2014, Published in **Springer Proc.Phys. 174** (2016) 75-79.
2. Ambalika Biswas and **Amitabha Lahiri**, *Masses of Physical Scalars in Two Higgs Doublet Models,* in the Proceedings of the 21st DAE-BRNS High Energy Physics Symposium (hepbrns2014), Guwahati, India 8-12 Dec, 2014, Published in **Springer Proc.Phys. 174** (2016) 605-609.

Supervision of Students

Ph.D. Students: Debmalya Mukhopadhyay (External), Subhasish Chakrabarty, Ishita Dutta Choudhury, Ambalika Biswas, Karan Fernandes, Ritam Basu

Lecture Delivered

1. "Much Ado About Nothing – How Physicists See the Vacuum", St. Xavier's College, Kolkata, 21 March 2016.

Course Taught

1. PHY 203 Electromagnetic Theory, Spring 2016

Membership of Committees

Internal Committee: Director's Advisory Board, Consultative Advisory Committee, Admission 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

Meeting Organized

1. Field Theory Aspects of Gravity 2016 (FTAG XI), February 22-26, SNBNCBS (Organizer)

Anita Mehta

Senior Professor

anita@bose.res.in

Prof. 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, spontaneous crystallization in granular media, citation network dynamics, encodings of NP complete problems and investigations of stochasticity in the visual system of the fruitfly. Her current collaborations include scientists based at New York University, the Institut de Physique Theorique, Saclay, the Institut Laue Langevin, Grenoble 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; granular dynamics; optimization in NP-complete problems**

The survivor distributions of a spatially extended model of competitive dynamics in different geometries were investigated. The model was chosen to be a deterministic dynamical system of individual agents at specified nodes, with all stochasticity brought in by the initial state. Every such initial state led to a unique and extended pattern of survivors and non-survivors, known as an attractor of the dynamics. The number of such attractors was shown to grow exponentially with system size, so that their exact characterization was limited to only very small systems. An analytical approach based on inhomogeneous mean-field theory was thus formulated and used to calculate survival probabilities for arbitrary networks. This powerful approach showed how universality arises in survivor distributions via a key concept—the *dynamical fugacity*. Remarkably, in the large-mass limit, the survivor probability of a node was shown to become independent of network geometry and to assume a simple form, which depends only on its mass and degree.

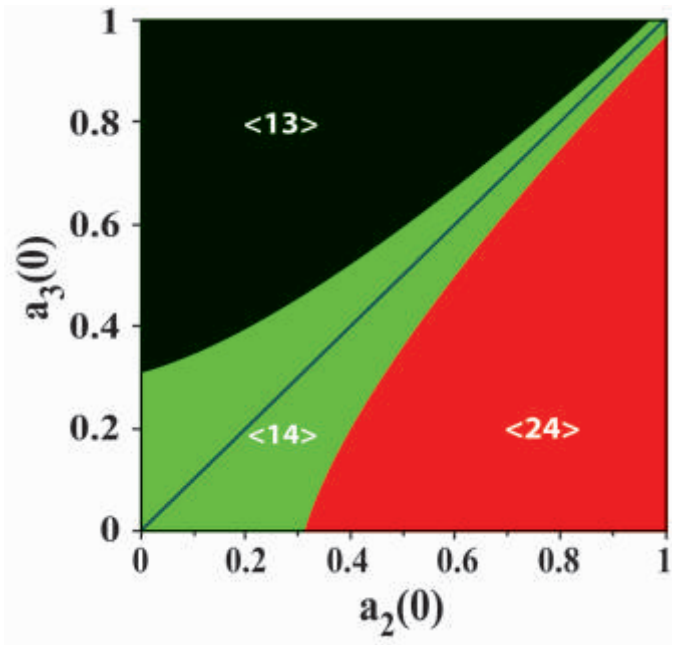


Fig.1: (Color online) Attractor on the chain with $N = 4$ in the $_{a2}(0) - _{a3}(0)$ plane, for fixed $_{a1}(0) = _{a4}(0) = 0.3$

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 mechanism for each species. The ultimate objective is to construct a phase

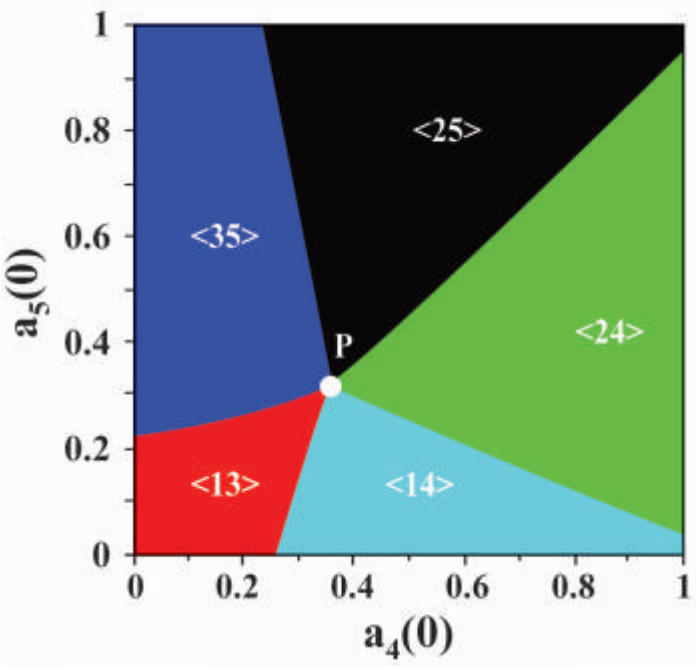


Fig.2: (Color online) Attractor on the ring with $N = 5$ in the $a_4(0) - a_5(0)$ plane, for fixed $a_1(0) = 0.5$, $a_2(0) = 0.7$, and $a_3(0) = 0.6$. The five attractors meet at point P

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.

Inspired by recent work from Barabasi's group, I have in collaboration with a colleague in Saclay proposed a model of citation networks, to explore whether or not a universal scaling form can describe the growth of citation counts of papers within a given community. We aim to combine theory and numerical analysis to examine the total activity, as well as the fates of individual papers, as a function of their fitness.

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.

Finally, in collaboration with an experimental colleague in Grenoble, I am analyzing experimental data on spontaneous crystallization in granular media with the objective of comparing them with theoretical predictions made earlier by my group.

Publication in Journal

1. J. M. Luck and A. Mehta, *Universality in survivor distributions: Characterizing the winners of competitive dynamics*, Physical Review E, 92, 052810, 2015.

Academic Visits

1. Visiting Professor at Department of Bioinformatics, University of Leipzig (May-June 2015)
2. Visiting Senior scientist at Service de Physique Theorique, Saclay, France (June 2016)

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

1. Fellow of the American Physical Society

Biswajit Chakraborty

Professor
biswajit@bose.res.in

Prof. Biswajit Chakaraborty was born and brought up in Shillong. Having passed Pre-University examination from North Eastern Hill University, he moved to Delhi and completed his B.Sc and M.Sc. from Delhi University and eventually got his Ph.D. degree from Institute of Mathematical Sciences (Affiliated to Madras University) in 1992. Then he spent a couple of years as a PDF/visiting fellow at IIT, Kanpur and HRI, Allahabad. Finally, he joined SNBNCBS in 1994 and was absorbed in the faculty in 1997.

- **Non-commutative geometry and Quantum Field Theory**
- **We extended our earlier work on the computations of infinitesimal spectral distance, *a la* Connes on Non-commutative spaces like Moyal plane and fuzzy sphere to the computation of the corresponding finite distances**

The main motivation for undertaking the computation of finite distance on Non-commutative spaces is that unlike commutative differential manifolds, knowledge of infinitesimal distances does not allow one to compute finite distance, by integrating along the geodesic, simply because of the fact that a generic non-commutative space may not allow the luxury of defining the geodesic in the first place- in the conventional sense, where all the interpolating points correspond to pure states of the involutive C*-algebra. Indeed, by first devising a modified algorithm in our Hilbert-Schmidt operatorial formulation, and then applying in our specific problems, we find that although Moyal plane admits conventional geodesic, the fuzzy sphere does not; the counterpart of the geodesic in the latter case passes through a family of mixed states, in the case of extremal non-commutativity i.e. In the spin-1/2 representation. The spectral distance therefore provides an alternative characterization of mixed-ness of a generic mixed state. All these computations were facilitated by carrying out these analyses in the eigen-spinor basis of the Dirac operator, occurring in the spectral triples. In fact, the corresponding distance for $n=1$ could also be carried out, albeit with the help of Mathematica.

Future Plan

1. We would like to extend the study of spectral distance to doubled Moyal plane and try to relate it with the quantum length, introduced by Doplicher *et. al.*

2. We would like to compute the spectral distance in the almost commutative space, describing the unified theory of gravity and electrodynamics and study whether the corresponding geodesic describes the trajectory of a charged particle, moving under the joint influence of electromagnetic and gravitational field.

Publication in Journal

1. Kaushlendra Kumar, Shivraj Prajapat and **Biswajit Chakraborty**, *On the role of Schwinger's SU(2) generators for simple harmonic oscillator in 2D Moyal plane*, Eur. Phys. J. Plus, **130**, 120, 2015.

Independent Publication of Student

1. Debabrata Ghorai and Sunandan Gangopadhyay, *Higher dimensional holographic superconductors in Born-Infeld electrodynamics with back-reaction*, Eur. Phys. J. C, **76**, 146, 2016.

Supervision of Students

Ph.D. Students: Yendrenbam Chaoba Devi, Aritra Narayan Bose, Debabrata Ghorai (jointly with Dr.Sunandan Gangopadhyay (IISER, Kolkata)); Project Student: Supervised the 5-th year (9th and 10th semester) project of Mr. Alpesh Avinash Patil for his integrated B.S-M.S. Course in IISER, Pune, during this period; Post Doctoral Research Scientist: Ravikant Verma

Lectures Delivered

1. Gave a talk on ``Finite spectral distance on Non-commutative spaces", at the International Workshop on ``Quantum Physics: Foundations and Applications", held during 1st to 13th February 2016, at the Physics Department, Indian Institute of Science, Bangalore.
2. Delivered the keynote lecture on ``A historical survey of the developments of General theory of Relativity and related areas, before and after Einstein", at the ``National Seminar on Analysis and Applications: celebrating 100 years of General Relativity (NSAA-2016)", held during 10th and 11th March 2016, at the Mathematics Department, West Bengal State University, Barasat.

Course Taught

1. Advanced Quantum Mechanics and Applications (PHY-303) for the 3rd semester batch IPhD students, during August-November 2015, jointly with Prof. Archan S. Majumdar.

Membership of Committees

External Committee: Member, Board of Research Studies (BRS) of the Physics Department, West Bengal State University, Barasat; Was the external member of the Faculty selection committee of Physics Department, IIT, Patna.The selection committee meeting was held, during 9th and 10th November 2015; Was the external examiner of the Ph.D. viva-voce examination of Dr. Baishali Chakraborty, held at SINP on 16th February 2016; **Internal Committee:** Member of CWEP (Conference, Workshop and Extension Programme) committee

Meeting Organized

1. Member of the Local Organizing Committee of the Conference on "Field Theoretic aspects of Gravity", held during 22nd to 26th February 2016 at SNBNCBS.

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: Issues relating to nonclassicality, nongaussianity and entanglement of quantum optical states**

Is the entanglement potential a good measure of nonclassicality?

There exists a proposal in the literature that the amount of entanglement of the output of a beam splitter when nonclassical light is input could be taken as a measure of the nonclassicality of the input light. However our recent study has shown that for a certain class of input states the entanglement of the beam splitter output shows a non-monotonic behaviour as a function of the input nonclassicality as measured by well-known standard measures. Thus our work calls in question the reasonableness of using the beam splitter output entanglement as a measure of input nonclassicality.

Future Plan

Continue work on the above-mentioned problems.

Supervision of Students

Ph.D. Student: Soumyakanti Bose; Project Students: Summer Project of IPhD students (June-July 2015): (1) Mr. Arunava Adak titled 'Exponential Decay and the Quantum Zeno Effect', and (2) Mr. Balwant Singh titled 'Gaussian States in Quantum Optics'; Third Semester Project of IPhD students (August-November 2015): (1) Mr. Debsuvra Mukhopadhyay titled 'Separability Criteria for Gaussian two-mode States', and (2) Mr. Balwant Singh titled 'Quantum State Tomography'; Fourth Semester Project of IPhD students (January-April 2016): (1) Mr. Debsuvra Mukhopadhyay titled 'Continuous Variable Nonlocality and Quantum Communication', and (2) Mr. Balwant Singh titled 'Coherent and Squeezed States of Spin'

Course Taught

1. Quantum Optics (officially called Optical Physics) IPhD course (January-April 2016) (Advanced/Elective)

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 Quantum field theories on lattice, Duality in gauge theories and statistical mechanics, Group theory & Coherent states.

- **Quantum field theories on lattice, Duality in gauge theories and statistical mechanics, Group theory & Coherent states**

1. From Lattice Gauge Theories to Hydrogen Atoms:

We construct canonical transformations to obtain a complete and most economical realization of the physical Hilbert space of pure SU(2)2+1 lattice gauge theory in terms of Wigner coupled Hilbert spaces of hydrogen atoms. One hydrogen atom is assigned to every plaquette of the lattice. A complete orthonormal description of the Wilson loop basis in the physical Hilbert space is obtained by all possible angular momentum Wigner couplings of hydrogen atom energy eigenstates $|n\ l\ m>$ describing electric fuxes on the loops. The SU(2) gauge invariance implies that the total angular momenta of all hydrogen atoms vanish. The canonical transformations leading to the loop Hamiltonian are also valid for any SU(N). The ideas and techniques can also be extended to higher dimensions.

2. **Canonical Transformations and Loop Formulation of SU(N) Lattice Gauge Theories:**

We construct canonical transformations to reformulate SU(N) Kogut-Susskind lattice gauge theory in terms of a set of fundamental loop & string flux operators along with their canonically conjugate loop & string electric fields. The canonical relations between the initial SU(N) link operators and the final SU(N) loop & string operators, consistent with SU(N) gauge transformations, are explicitly constructed over the entire lattice. We show that as a consequence of SU(N) Gauss laws all SU(N) string degrees of freedom become cyclic and decouple from the physical Hilbert space. The Kogut-Susskind Hamiltonian rewritten in terms of the fundamental physical loop operators has global SU(N) invariance. There are no gauge fields. We further show that the magnetic field terms create and annihilate the fundamental plaquette loop fluxes while the electric field terms describe all their interactions. In the weak coupling continuum limit the SU(N) loop dynamics is described by SU(N) spin Hamiltonian with nearest neighbour interactions. In the simplest SU(2) case, where the canonical transformations map the SU(2) loop Hilbert space into the Hilbert spaces of hydrogen atoms, we analyze the special role of the hydrogen atom dynamical symmetry group SO(4,2) in the loop dynamics and the spectrum. A simple tensor network ansatz in the SU(2) gauge invariant hydrogen atom loop basis is discussed.

Future Plan

To continue with the loop approach to pure SU(2) lattice gauge theories and compute the glueball spectrum and scaling in (2+1) and the (3+1) dimensions.

Publications in Journals

1. **Manu Mathur**, T. P. Sreeraj, *From Lattice Gauge Theories to Hydrogen Atoms*, Physics Letters B, **749**, 137-143, 2015.
2. **Manu Mathur**, T. P. Sreeraj, *Canonical Transformations and Loop Formulation of SU(N) Lattice Gauge Theories*, Phys. Rev. D, **92**, 125018, 2015.

Supervision of Students

Ph.D. Student: T P Sreeraj

Partha Guha

Professor
partha@bose.res.in

Prof. Partha Guha's research interests are centered around nonlinear dynamics, integrable systems and geometrical mechanics.

- **Nonlinear dynamics, integrable systems, geometrical mechanics and nonholonomic dynamics**

We have extended the integrability analysis to four dimensions and to investigate the behavior of dynamical systems which are known to be chaotic for generic values of their physical parameters.

We have discussed the occurrence of left symmetry in a generalized Virasoro algebra and its link to geometry and nonlinear systems of hydrodynamic type.

We have studied presence of an additional symmetry of a generic central potential in the *kappa*-space-time. An explicit construction of Fradkin and Bacry, Ruegg, Souriau (FBRS) for a central potential is carried out and the piece-wise conserved nature of the vector is established. We have also extended the study to Kepler systems with a drag term, particularly Gorringe-Leach equation is generalized to the *kappa*-deformed space.

Future Plan

Apart from what we are doing now we wish to take-up following two areas seriously:

We wish to study integrable evolution equations whose field variables take values in an associative algebra and construction of Hamiltonian structures for associative algebra-valued systems.

We wish to study the applications integrable systems and generalized Poisson geometry to string theory. We are interested to go beyond the stringy applications of integrable systems and moment map techniques.

Publications in Journals

1. O. Esen, A.G. Choudhury, **P. Guha**, H. Gümral, *Superintegrable cases of four-dimensional dynamical systems*, Regul. Chaotic Dyn., **21**, no. 2, 175–188, 2016.
2. N. Hounkonnou, Mahouton, **P. Guha**, T. Ratiu, *Generalized Virasoro algebra: left-symmetry and related algebraic and hydrodynamic properties*, J. Nonlinear Math. Phys., **23**, no. 1, 47–73, 2016.
3. S. Chanda, **P. Guha**, R. Roychowdhury, *Bianchi-IX, Darboux-Halphen and Chazy-Ramanujan*, Int. J. Geom. Methods Mod. Phys., **13**, no. 4, 1650042, 2016.
4. A. Ghose Choudhury, **P. Guha**, *Quantum Liénard II equation and Jacobi's last multiplier*, Surv. Math. Appl., **10**, 1–21, 2015.
5. **P. Guha**, A. Ghose-Choudhury, *Lie symmetries, Lagrangians and Hamiltonian framework of a class of nonlinear nonautonomous equations*, Chaos Solitons Fractals, **75**, 204–211, 2015.
6. **P. Guha**, *Euler-Poincare formalism of peakon equations with cubic nonlinearity*, Journal of Generalized Lie theory and applications, Volume **9**, Issue 1, 1000225, 2015.
7. **P.Guha**, *Nonholonomic deformation of coupled and supersymmetric KdV equations and Euler-Poincare-Suslov method*, Reviews in Mathematical Physics, **27**, no. 4, 1550011, 2015.

8. **P. Guha**, E. Harikumar, M. S. Zuhair, *Fradkin-Bacry-Ruegg-Souriau vector in kappa-deformed space-time*, European Physical Journal Plus, **130**, 205, 2015.

Supervision of Students

Ph.D. Students: Sumanto Chanda, Ankan Pandey; Post Doctoral Research Scientist: Kumar Abhinav

Lectures Delivered

1. Six lectures on Bifurcation theory and Normal form techniques at Winter School on Nonlinear Dynamics, ISI, Kolkata, December 9-18, 2015.
2. Four lectures on Bifurcation theory, in the Refresher Course ``Emerging trends in Mathematics and its Applications'' 16 June - 9 July, 2015, Mathematics department, Jadavpur University.
3. Three lectures given on ``Adler-Kostant-Symes scheme and integrable systems at Department of Mathematics, University of Warmia and Mazury, Poland, May-June, 2015.
4. Invited speaker at {\it Meetings on Differential Equations}at Ramanujan Mathematical Insitute, Chennai, 2-4 March, 2016.
5. Invited speaker at {\it Geometry of jets and fields}, Banach Center, Warsaw, 10-16 May, 2015.

Academic Visits

1. Visited Department of Mathematics, University of Warmia and Mazury, May-June, 2015, (3 weeks).
2. Visited Banach Center, Warsaw, Poland, 8th May to 16th May, 2015.

Course Taught

1. Quantum Mechanics II, Spring 2016

Membership of Committees

External Committee: Organizing committee of Winter School on Nonlinear Dynamics, Indian Statistical Institute, Kolkata, 9-18 December 2015

Punyabrata Pradhan

Assistant Professor
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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.

- **Additivity property and fluctuations in nonequilibrium steady state; fluctuations in systems of self-propelled particles; single-file diffusion in the presence of moving defects**

1. Using an additivity property, we study particle-number fluctuations in a system of interacting self-propelled particles, called active Brownian particles (ABPs), consisting of repulsive disks with random self-propulsion velocities. We formulate a thermodynamic theory which captures the previously observed features of nonequilibrium phase transition in the ABPs from a homogeneous fluid phase to an inhomogeneous phase of coexisting gas and liquid.

2. We have studied the effect of time-periodic drive on a system of hardcore particles on a ring. The defects move with uniform velocity and change the particle hopping rates locally. When the defects are placed far apart in the system, they act independently andtheir influence on the system can be described by using the results for the single-defect case. However, when the defects are close to each other, the density patterns created individually around the single defects now start overlapping, which gives rise to interesting collective effects, such as polarity reversal and multiple peaks in particle current upon variation of defect velocity and density.

3. We exactly calculate two-point spatial correlation functions in steady state in a broad class of conserved-mass transport processes, which are governed by chipping, diffusion, and coalescence of masses. We find that the spatial correlations are in general short-ranged and, consequently, on a large scale, these transport processes have an equilibrium-like additivity property, which helps us to obtain subsystem mass distributions in the thermodynamic limit.

Future Plan

1. Fluctuating hydrodynamics and current distribution in mass transport processes.
2. The effect of time-periodic drive on a system of hardcore particles on a ring.

Publications in Journals

1. Sayani Chatterjee, **Punyabrata Pradhan**, and P. K. Mohanty, *Zeroth law and nonequilibrium thermodynamics for steady states in contact*, Phys. Rev. E, **91**, 062136 p., 2015.
2. Amit Chatterjee, **Punyabrata Pradhan**, and P. K. Mohanty, *Cluster-factorized steady states in finite-range processes*, Phys. Rev. E, **92**, 032103 p., 2015.
3. Arghya Das, Sayani Chatterjee, **Punyabrata Pradhan**, and P. K. Mohanty, *Additivity property and emergence of power laws in nonequilibrium steady states*, Phys. Rev. E, **92**, 052107 p., 2015.

Supervision of Students

Ph.D. Students: Sayani Chatterjee, Arghya Das, Subhodip Chakraborti, Amal Garai, and Dhiraj Tapader (SERB project student); **Post Doctoral Research Scientist:** Subhashis Rana

Lectures Delivered

1. Oral presentation: Symmetric exclusion processes on a ring with moving defects; International Centre for Theoretical Physics (ICTS), Bangalore; February, 2016.
2. Invited talk: Additivity property and mass fluctuation in conserved-mass transport processes; Jawaharlal Nehru University, Delhi; November, 2015.
3. Invited talk: Additivity property and mass fluctuation in conserved-mass transport processes; International Centre for Theoretical Sciences (ICTS), Bangalore; November, 2015.

Academic Visits

1. Indian Statistical Physics Community Discussion Meeting; International Centre for Theoretical Physics (ICTS), Bangalore; February, 2016.
2. Academic visit; Jawaharlal Nehru University, Delhi; November, 2015.
3. Workshop on Nonequilibrium Statistical Physics (NESP2015); International Centre for Theoretical Sciences (ICTS), Bangalore; November, 2015.

Courses Taught

1. PHY 104; Computational methods in physics I; 1st semester
2. PHY 204; Computational methods in physics II; 2nd semester

Membership of Committee

Internal Committee: Thesis committees, Library committee, Placement committee, Creche committee, Junior computer engineer selection committee

Sponsored Projects

1. PI in the project [Grant No. EMR/2014/000719 under SERB (DST)].
2. PI in a project under Thematic Unit of Excellence under DST (Nanomission).

Rabin Banerjee

Senior Professor
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Dr. Rabin Banerjee received his M.Sc. from IIT Kharagpur and Ph.D. 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.

- **Nonrelativistic diffeomorphism symmetry and its applications to fluid dynamics, Newton-Cartan geometry, fractional quantum Hall effect etc. Action principles for fluid dynamics and magnetohydrodynamics**

We continued our investigations on nonrelativistic diffeomorphism invariance and its applications in various contexts. The Galilean gauge theory approach initiated by us was used to show that a covariant formulation of nonrelativistic diffeomorphism naturally led to a coupling of the Schrodinger theory with Newton-Cartan geometry. We also extended our analysis to include the effects of torsion. It may be recalled that in the literature there is no clear and unambiguous exposition of torsional Newton Cartan geometry. We were able to give an explicit form for the contorsion tensor which was shown to be an analogue of the known expression in general theory of relativity.

An interesting as well as an important outcome of our research was to clarify the confusion regarding the flat limit of nonrelativistic diffeomorphism invariance. This limit is expected to yield the usual Galilean invariance. However in conventional approaches this was not achievable. Indeed one had to take a particular relation between the gauge parameter and the boost parameter to take the flat limit. This is not acceptable. Our method does not require such a restriction and the flat limit can be reproduced smoothly. The relativistic root of the nonrelativistic diffeomorphism was shown by obtaining this symmetry by taking the nonrelativistic limit of a relativistic theory. This limit was taken by putting the velocity of light to infinity. An alternative approach based on a light cone formulation was also presented.

In the context of hydrodynamics we have provided a physical basis for the Clebsch parametrization that is used to express the fluid velocity in terms of certain scalars. Using this approach we were able to reproduce the action, both in the lagrangian and Hamiltonian formulations. The noncanonical brackets were shown to be the Dirac brackets. Interestingly, we reported the existence of Schwinger type relations from which various properties like conservation of current or the stress tensor could be demonstrated. Our analysis was extended to include magnetohydrodynamics also where a more involved Clebsch decomposition is necessary.

Future Plan

1. Possible connection of our approach based on Galilean gauge theory to the recent analysis of nonrelativistic Ads/CFT correspondence.
2. The connection of Poincare gauge theory of gravity to our Galilean gauge theory of gravity.
3. Extending the analysis on fluids to include the effects of dissipation.

Publications in Journals

1. **R. Banerjee** and P. Mukherjee, *Elementary modes of coupled oscillators as whispering-gallery microresonators*, Mod. Phys. Lett. A, **30**, no.39, 1550193, 2015

2. **R. Banerjee**, S. Dey and B. R. Majhi, *Entropy current in two dimensional anomalous hydrodynamics and a bound on the sum of the response parameters*, Phys. Rev. D, **92**, no.4, 044019, 2015.
3. **R. Banerjee** and P. Mukherjee, *PT symmetry and a dynamical realization of the SU(1, 1) algebra*, Mod. Phys. Lett. A, **31**, no.04, 1650028, 2016.
4. **R. Banerjee** and P. Mukherjee, *New approach to nonrelativistic diffeomorphism invariance and its applications*, Phys. Rev. D, **93**, no.8, 085020, 2016.
5. **R. Banerjee** and K. Kumar, *New approach to nonrelativistic ideal magnetohydrodynamics*, Eur.Phys.J. C, **76**, no.7, 406, 2016.

Other Publications

1. R. Banerjee, "Anomalous hydrodynamics in two dimensions," Pramana 86 (2016) no.2, 453 (Proceedings, International Workshop on Unification and Cosmology after Higgs Discovery and BICEP2 : Chandigarh, India, May 13-15, 2014).

Supervision of Students

Ph.D. Students: Arpita Mitra, Arpan K. Mitra, Shirsendu Dey (External), Arindam Lala (Degree Awarded); Project Student: Paulami Mandal, IIT Kharagpur (M.Sc. project)

Lectures Delivered

1. "Spatial diffeomorphism from Galilean gauge theory and its applications," FTAG XI-2016, S N Bose National Centre, 22-26 February, 2016.
2. Invited speaker at a workshop organized by Bangabasi College, Kolkata, for undergraduate students on "Integrated Ph.D. interviews in physics – a positive march towards a Research Career," 16.05.2016.
3. "From Conic sections to gravity", one day National Seminar on International Year of Light, The University of Burdwan, 31-03-2016

Meeting Organized

1. Organized the Distinguished Lecture Series by Prof. T. Padmanabhan (IUCAA) on "Gravitation" (five lectures from 16 to 20 November 2015).

Sakuntala Chatterjee

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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, Dynamics of actin polymerization , Ion-channel transport**

Large compact clusters and fast dynamics in coupled nonequilibrium systems:

We demonstrate particle clustering on macroscopic scales in a coupled nonequilibrium system where two species of particles are advected by a fluctuating landscape and modify the landscape in the process. The phase diagram generated by varying the particle-landscape coupling, valid for all particle density and in both one and two dimensions, shows novel nonequilibrium phases. While particle species are completely phase separated, the landscape develops macroscopically ordered regions coexisting with a disordered region, resulting in coarsening and steady state dynamics on time scales which grow algebraically with size, not seen earlier in systems with pure domains.

Actin filaments growing against a barrier with fluctuating shape:

We study force generation by a set of parallel actin filaments growing against a non-rigid obstacle, in presence of an external load. The filaments polymerize by either moving the whole obstacle, with a large energy cost, or by causing local distortion in its shape which costs much less energy. The non-rigid obstacle also has local thermal fluctuations due to which its shape can change with time and we describe this using fluctuations in the height profile of a one dimensional interface with Kardar-Parisi-Zhang dynamics. We find the shape fluctuations of the barrier strongly affects the force generation mechanism. The qualitative nature of the force-velocity curve is crucially determined by the relative time-scale of filament and barrier dynamics. The height profile of the barrier also shows interesting variation with the external load. Our analytical calculation within mean-field theory shows reasonable agreement with our simulation results.

Future Plan

1. Characterizing the nature of ordering in coupled nonequilibrium systems
2. Effect of selectivity on ion-channel transport
3. Actin polymerization against elastic membrane
4. Characterizing efficiency of chemotactic performance of a single-cell E.coli

Publication in Journal

1. Subrata Dev and **Sakuntala Chatterjee**, *Optimal search in E.coli chemotaxis*, Physical Review E, **91**, 042714, 2015.

Supervision of Students

Ph.D. Students: Subrata Dev, Rajkumar Sadhu, Shauri Chakraborty; Post Doctoral Research Scientist: Sanchari Goswami

Lectures Delivered

1. Fast coarsening in strong phase separation, Nonequilibrium Statistical Physics Workshop, ICTS, Bangalore, October, 2015
2. Actin filaments growing against a barreir with fluctuating shape |ndian Statistical Physics Community Meeting, ICTS, Bangalore, February, 2016

Membership of Committees

Internal Committee: Project Cell, Creche Committee, Medical Committee

Samir Kumar Paul

Associate Professor

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Samir Kumar Paul is a Mathematical physicist who worked on Theoretical Particle Physics and some aspects String theory and Conformal Field Theory. Presently he is working in (a) Topological Excitations in Low dimensional Spin systems (b) various properties algebraic functions for Riemann Surfaces.

- **Investigations on spin dynamics induced by topological excitations in spin ½ layered anti-ferromagnetic systems: theoretical analysis of the neutron scattering results for spin 1⁄2 anti-ferromagnet La_2CuO_4.**
- **Construction and study of rational functions for establishing holomorphic maps between two algebraic curves: sphere and first two genus zero members in the family of elliptic and hyperelliptic algebraic curves.**

i) In continuation of the work reported earlier we have further calculated the zero-th moment of the available dynamical structure function for the anti-ferromagnet La_2CuO_4, at four different temperatures. The values of the moment indicate that at temperature above and near T_BKT (1.07T_BKT) the dynamics of the topological excitations can capture only 4% of of the entire spin dynamics. On the other hand at temperature around 1.39T_BKT the dynamics of topological excitations can capture around 48% of the spin dynamics. These results indicate that the contributions from the conventional (fragile spin-wave like) excitations play very important role in the spin dynamics in the vicinity of T_BKT. Therefore a thorough understanding of the interplay between these fragile conventional excitations and topological excitations are extremely important. It has already been described earlier that the interaction between magnons and the multimagnon composite states originating in the spin ½ 2d XY-anisotropic ferromagnetic Heisenberg model can very well generate stable topological excitations (see publication). These works are done in collaboration with Ranjan Chaudhury and Subhajit Sarkar .

ii) The interesting result is the explicit construction of rational functions on S^2 characterising holomorphic map from S^2 to ${w^2} = z$ and a from S^2 to ${w^2} = z(z-1)$. These in turn induce automorphisms in the Virasoro algebra on S^2 and also on the graded modules.

Future Plan

i) We now want to make a thorough study for developing a systematic method to calculate time dependent spin-spin correlation at a finite temperature (whose Fourier transform is S(q, ω)) .

ii) My first aim in the study of algebraic functions will be to prove nonexistence of rational functions on S^2 for which a relation $P(f, g) = 0$ is satisfied where $P(w, z) = 0$ is the equation for the elliptic or hyperelliptic curve.

Publication in Journal

1. S. Sarkar, R. Chaudhury and **S. K. Paul**, *The connection between vortex-like topological excitations and conventional excitations in quantum ferromagnetic*

spin systems on two-dimensional lattice and their stability, Int. J. Mod. Phys. B, **29**, 1550209, 2015.

Supervision of Students

Ph.D. Student: Subhajit Sarkar

Lectures Delivered

1. 'Complex Analysis' (Three talks,each of 1 hour 30 minutes duration) , Department of Mathematics , Jadavpur University , Jadavpur , Kolkata during 16 June to 06 July , 2015 (Emerging trends in Mathematics and its Applications)
2. 'Compact Course on Manifold Theory' , Department ofApplied Mathematics, University of Calcutta, during 30.06.15- 11.07.15 (organized by Ramanujan Mathematical Society).

Membership of Committees

Internal Committee: SCREC

Subhrangshu Sekhar Manna

Senior Professor
manna@bose.res.in

Dr. S. S. Manna worked for his Ph. D. in Saha Institute of Nuclear Physics and received the degree from the Calcutta University. Later, he did Post doctoral researches in Mebourne University, Australia; Forschungzentrum, Germany; St. Francis Xavier University, Canada and Yale University, USA. He joined the Physics department in I. I. T. Bombay in June 1992 and later moved to Satyendra Nath Bose National Centre for Basic Sciences in January, 1998.

- **Percolation phenomena and disordered systems, Fiber bundle models, Collective behavior, and Naming games**

1. The ranges of transmission of the mobiles in a Mobile *ad hoc* Network are not uniform in reality. They are affected by the temperature fluctuation in air, obstruction due to the solid objects, even the humidity difference in the environment, etc. How the varying range of transmission of the individual active elements affects the global connectivity in the network may be an important practical question to ask. Here a new model of percolation phenomena, with an additional source of disorder, has been introduced for a theoretical understanding of this problem. As in ordinary percolation, sites of a square lattice are occupied randomly with the probability p. Each occupied site is then assigned a circular disc of random value R for its radius. A bond is defined to be occupied if and only if the radii R_1 and R_2 of the discs centered at the ends satisfy certain pre-defined condition. In a very general formulation, one divides the R_1 - R_2 plane into two regions by an arbitrary closed curve. One defines that a point within one region represents an occupied bond, otherwise it is a vacant bond. Study of three different rules under this general formulation, indicates that the percolation threshold is always larger and varies continuously. This threshold has two limiting values, one is p_c(sq), the percolation threshold for the ordinary site percolation on the square lattice and the other being unity. The variation of the thresholds are characterized by exponents, which are not known in the literature. In a special case, all lattice sites are occupied by discs of random radii $R \in \{0,R_0\}$and a percolation transition is observed with R_0 as the control variable, similar to the site occupation probability.

2. Desert roses are gypsum crystals that consist of intersecting disks. We determine their geometrical structure using computer assisted tomography. By mapping the

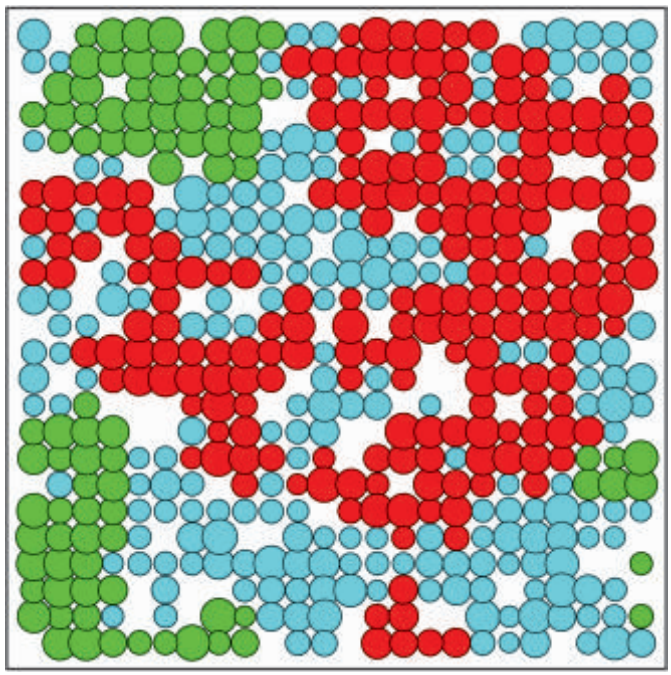

Fig.1: A percolating configuration of 501 circular discs is drawn. The largest and the second largest clusters are of sizes 208 (red) and 90 (green) respectively. Because of the blue disc these two clusters merge and the maximal jump in the order parameter takes place. Discs at all other occupied sites are painted in cyan.

geometrical structure onto a graph, the topology of the desert rose is analyzed and compared to a model based on diffusion limited aggregation. By comparing the topology, we find that the model gets a number of the features of the real desert rose right, whereas others do not fit so well.

Fig.2: The desert rose in the figure is the one we have analyzed. It measures approximately 76 × 49 × 37 cm.

Publications in Journals

1. Biplab Bhattacherjee, Shradha Mishra, and S. S. Manna, *Topological-distance-dependent transition in flocks with binary interactions*, Physical Review E, 92, 062134, 2015.
2. Sigmund Mongstad Hope, Sumanta Kundu, Chandreyee Roy, S. S. Manna, and Alex Hansen, *Network topology of the desert rose*, Frontiers in Physics, 3, 00072, 2015.

Supervision of Students

Ph.D. Students: Biplab Bhattacherjee, Sumanta Kundu, Chandreyee Roy

Lecture Delivered

1. "Retarded Percolation with Continuously Tunable Critical Threshold", Department of Physics, Tezpur University, 22 March, 2016.

Subodh Kumar Sharma

Emeritus Professor

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Dr. Sharma obtained his Ph.D working at Saha Institute of Nuclear Physics in 1977. He worked at BITS Pilani, SINP Kolkata, IWMED Kolkata, UWCC Cardiff, Imperial College London and S N Bose Centre for Basic Sciences. He co-authored a book (with Dr. D J Somerford of UWCC) "Light Scattering by optically soft particles: Theory and Applications" published by Springer Praxis.

- **Biomedical tissue characterization using light scattering technique**
- **Study of interstellar medium from analysis of X-ray halos around stars**

The electromagnetic radiation emitted by a star arrives at the observer after interacting with interstellar medium including dust grains. The knowledge of nature of these grains is of importance for answering multiple astrophysical questions. We have recently, started studies on models for halo formation around X-ray emitting stars.

A widely used approximation in these studies is the Rayleigh-Gans-Debye approximation. However, its applicability is limited to energies greater than about 1KeV. We have proposed a modification to this approximation to broaden its range of applicability.

Future Plan

Studies on both the areas of interest will continue. Specifically, we will continue our efforts to look into how we can obtain information on scatterers from the X-ray scattering data.

Publication in Journal

1. **S K Sharma**, *Scattering approximations in X-ray halo analysis*, Asian Journal of Physics, **24**, 8:1087-1094, 2015.

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Facilities

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 14658 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 have been 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. Digital version of the archive is available in the website.

Library Hours

The Library is open from morning 9.00 AM to 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 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 in Hindi and English versions, 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 a section where newly processed books are displayed for users in every month. Same list is uploaded in the website in 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. 2015-16

1 Approximately 543 new books and some new journals have been added in the library collection during the above mentioned 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 the years 2014, 2006 and 2005 have been uploaded in the repository.

3. In the Financial Year 2015-16, the Fiction Section has been enriched by procuring 165 books of classic literature, novel, short story, biography and books of general interests.

4. 97 Hindi books are added in the Library collection the mentioned financial year.

5. Five new Desktop Computers are added in the library with dual operating system to provide smooth service library users.

6. A new Scanner has been installed in the library. It has ability to scan large page (size A3).

7. A new colour Photocopier Machine is added with the existing photocopier machine to provide better service to users.

8. The library has been decorated with photographs, flowers and quotes of eminent personalities to make an ideal reading ambience.

9. Emergency exit door with fire alarm has been installed in the library to cope with any emergency situation.

Saumen Adhikari
Librarian – cum – Information Officer

Engineering Section

1. Report on Engineering Section (Infrastructure Development, Maintenance & Housekeeping, Estate Management and Support Services)

A. CIVIL

i) 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 for a contract value of Rs 13.03 crores 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. With all round efforts of M/s Bridge and Roof Co. (India) Ltd. and the Engineering Section, the First phase of work for G + 3 Floors have been completed within due time schedule upto July, 2016. The 1st phase of work consists of 25 nos. Single room with attached bath, 6 nos 2 now 2-room Suits, and 10 nos 1-room Suits apart from Crèche and Kitchen-cum-Dining hall at Ground Floor with modern amenities with future provision of Lift facility.

2 BHK Room in IHB&TQC

IHB&TQC Entrance

IHB&TQC Side View

ii) 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 and one smaller size laboratories at three different locations 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. The Civil Superstructure and Structural erection work (except sheeting and finishing work) have been completed.

New Lab under construction

iii) Furnishing Offices, Hostels, Staff Quarters and Laboratories

According to the demand of different faculties and other officials, different types of cubicles, sometimes in modular shape suitable to their office spaces are fabricated and placed.

iv) Apart from above mentioned construction works, the Engineering Section has to look after day to day

Upkeep and Cleaning Services for the Main Building, the Hostel Buildings, Guest House, Director's Bunglow and ESQ Building.

Radhachura Hostel Building

v) The Centre has around 3.5 Km of Water pipeline network of various sizes spread all over the Campus and also in the buildings being maintained by the Engineering Section.

vi) There is also a vast network of sewerage and storm water drainage line of an approximate length of about 3 Km with innumerous Gulley pits, Yard gulley, Manholes etc which are being maintained and kept congestion-free round the year.

vii) The Centre has about 27 nos. of overhead PVC water tanks over roof of various buildings which gets water supply from the RCC Overhead Water Tank (Capacity 1,60,000 lt.) all of which are maintained and regularly cleaned to ensure hygiene for the users. There is an Iron-removal plant of 35,000 litre/hr. capacity efficiently operated and maintained to supply Iron-free potable water for the entire Campus.

RCC Overhead Water Tank

viii) In addition, it is the responsibility of the Engineering section to nurture and grow the flora and fauna of the entire Campus to maintain a pleasant green environment for the Horticulture & Landscaping beauty of the Centre. The cleaning of all the open area including roads and parking area and disposal of huge garbage generated day by day is also under the purview of the Engineering Section.

Horticulture

ix) Maintaining all the records and accounts of all the assets of the offices, hostels, guest houses, proper co-ordination during allotment and surrender of office/living areas by new entrants and outgoing students/PDRAs

B. Electrical Work

(a) Erection, Installation, Testing and Commissioning of 11KV/433V New Electrical Sub-Station

2 Nos 630 KVA ONAN type transformer and its corresponding HT & LT distribution panels were procured after successful testing and inspection at works. All the equipments were received and installed at Centre's new substation block. The interconnection work of all the components has also been done. The commissioning of the entire system is awaited for the approval & clearance from Central Electricity Authority (CEA) & subsequent charging by WBSEDCL.

MV-LT

(b) Supply, Installation, Testing & Commissioning of New Electrical Panel Boards & Additional Power Cable Laid for Computer Centre Servers of S N Bose National Centre for Basic Sciences

The work was taken up keeping in mind the future expansion and probable additional power demand at Computer Centre Servers. The cabling was done with 2 Nos. 95 sq.mm XLPE cables and corresponding new electrical panel boards were also installed to meet up the requirement of entire system. The panels have been designed in such a way that it will receive uninterrupted power either from old or new substation blocks.

(c) Installation of Automatic Fire Alarm System (AFAS) at Technical Cell Laboratories, Main Building, SNBNCBS

To protect and safe guard the advanced research equipments/instruments from the fire hazard, the

AFAS system is installed with Heat cum Smoke Detector, Manual Call Box, Hooter, Response Indicator which is working satisfactorily.

(d) Electrical Work for IHB&TQC Building

The entire electrical work including cable laying, internal electrical installation work is carried out by M/s Bridge & Roof Co. (India) Ltd. and it is supervised by the Engineering section.

(e) Installation of Automatic Fire Alarm System (AFAS) at 2nd Floor, Main Building, SNBNCBS

To protect and safe guard the advanced research equipments/instruments and the lecture halls from the fire hazard, the AFAS system is installed with Heat cum Smoke Detector, Manual Call Box, Hooter, Response Indicator which is working satisfactorily

(f) Electrical & AC Installation Work for New Lab Space

To meet up the newly procured sophisticated research equipments, the electrical infrastructure as well as AC system are being provided from time to time in various labs to facilitate research work.

(g) Maintenance of Centre's Air-conditioners

The Centre has about 450 nos of Air-conditioners of various capacities. The upkeep and maintenance of these are efficiently carried out by the Engineering Section round the year.

(h) Dedicated Earthing System for Various Laboratories at Main Building, SNBNCBS

Dedicated copper plate earthing system was installed at various laboratories to protect the sophisticated research equipments/instruments and also for the proper electrical installation.

(i) Annual Maintenance, Preventive Maintenance and daily requirement of electrical support for every corner of SNBNCBS

The electrical safety for the campus takes the maximum priority. To achieve this, electrical maintenance along with periodic preventive maintenance has been carried out throughout the year.

Any fault detected, is also rectified with priority. New installations and any electrical requirements are also taken care by the concerned staff round the clock at the entire campus of SNBNCBS.

(j) DG Sets

Two 500 KVA and one 320 KVA DG Sets are maintained to provide energy power.

(k) Rectification of compressor units of Blue Star make Package Unit at Computer Centre

The work was taken up on urgent basis and now the entire system is working satisfactorily.

(l) Apart from 2 nos. 12.5 H.P. Submersible Pump (Borewell type), 4 nos. 10 HP Centrifugal Pumps, 2 nos. Submersible Domestic Pump, 1 no. 3HP and 1 no. 5 HP Mono Block Pump, 1 no. 75 HP Fire Pump, 1 no. 75 HP Diesel Driven Pump, 1 no. 5HP Jocky Pump with an Iron-removal unit and Pump House, the operation and maintenance for which is looked after by the Engineering Section.

Sujit Kr. Dasgupta
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.

Academic Work - General research areas and problems worked on:

i) Hybrid Computing (CPU and GPU, Collaborative Research Work with- Institute of Bioinformatics and Applied Biotechnology (IBAB)): High-throughput DNA sequencers are becoming indispensable in our understanding of diseases at molecular level, in marker-assisted selection in human Genome and in microbial genetics research. These sequencing instruments produce enormous amount of data (often terabytes of raw data in a month) that requires efficient analysis, management and interpretation.

ii) Fastest way to compute Massive Human Genome Raw Data Processing and Analysis using data pipeline through Multiscale Parallel Hybrid Programming

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.

Case study:

1. High Performance Data Processing Pipeline in Real Life & Fastest way to compute Astronomical Data Movement and Processing, journal of open research software, 2015, (accepted).
2. Performance improvement of MUSIC BWA algorithm using data-parallel with concurrent parallelization, journal of open research software, 2015, (accepted).

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 2015-16, 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 15Mbps line by Sify Technologies 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	-	55
Phonon	84	-	27
HPC	344	2.2 TB	72
UNANST (partial)	96	12 TB	30
AMRU1	360	6 TB	31
AMRU2	48	-	27

Summary of project sponsored computational facilities

Machine Name	Processor Core	Storage	User
ATHENA	320	-	12
UNANST (partial)	480	12 TB	25
CRAY	7808	255	50

CSC-AC Members: Sr. 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: Sr. Prof. Tanusri Saha Dasgupta, Prof. Amitabha Lahiri, Dr. Manoranjan Kumar, Mr. S. K. Singh, Ms. Nibedita Konar, Mr. Soumen Adhikari, Mr. Sanjoy Choudhury, Mr. Abhijit Ghosh, Mr. Abhijit Roy, Mr. Sagar S. De.

Central Computational Resources (2015-16)

S.N. Bose National Centre for Basic Sciences, Computing Facility for its academic research & administrative pursuit:

SNBNCBS is the top 12 in the List of Top Supercomputers in India as of June 2015, Cray XE6 cluster, Massively Parallel Cray Supercomputing Facility with 75 TF Theoretical Peak Performance.

SNBNCBS Computing Facility provides researchers from national laboratories, academia, and industry with access to high-performance computing capabilities – some of the most powerful in the India – to conduct breakthrough in Basic Science research.

Range of research: 4 Basic science research seeks to understand how nature works. This research includes modelling and simulation of physical, chemical, and biological processes, and high-energy physics. This research focuses primarily on Basic Sciences and related challenges.

Resources for open science: This program allocates time on computational resources. Innovative and Novel Computational Impact on Theory and Experiment. This program competitively awards large blocks of time for computationally intensive, large-scale research projects that address grand challenges in science and engineering.

User support and services : Skilled experts at the SNBNCBS enable researchers to conduct breakthrough science on the High Performance Computing(HPC) system in key ways. Operations ensures that system hardware and software work reliably and optimally; system tools are matched to the unique system architectures and scale of SNBNCBS resources; the entire system software stack works smoothly together; and I/O performance issues, bug fixes, and

requests for system software are addressed. User Services and Outreach provides frontline services and support to existing and potential SNBNCBS users.

Access to primary high-performance computing (HPC) resource facility is allowed to external users also (Academic/Research, Organizations only) on case to case basis and in the mode of research projects through a peer-reviewed proposal system. The Proposal should have detail requirements of specific facility and persuasive narration describing the work. These clusters are a shared Linux environment for most of the popular applications, compilers and programs to support the research. It has been heavily utilized by researchers from a very broad range of disciplines.

The SNBNCBS using National Knowledge Network (NKN) as live line for its Basic research pursuit:

1. Establishing Connectivity for Knowledge and information sharing.
2. Conducting Collaborative Research in emerging research areas.
3. The Centre has digital repository which is connected to world through NKN.
4. S. N. Bose National Centre for Basic Sciences uses the NKN for easy access to knowledge, better knowledge services and dissemination of knowledge, the Centre has own scalable campus wide local area network.
5. The Centre has a set of servers, 114 nodes/884 cores, storage of more than 9TB with maximum speed nearly 3.5 TF for parallel computing and serial machines.
6. The Centre has sophisticated computing facility with extra mural research support including high performance clusters and recently a CRAY (244 node, 7808 Core) has been installed with extramural support that allows 75 TF speed with 255 TB memory, network security components, and set of applications.
7. S N Bose National Centre for Basic Sciences uses NKN for high speed Internet, VPN, etc. In addition to this NKN also helps connecting servers to provide E-Mail, Website, DNS, Video Portals and streaming etc.
8. S. N. Bose National Centre for Basic Sciences utilizes NKN network for Country wide Virtual Classroom, Collaborative Research, Virtual Library, and Sharing of Computing Resources, and Security.
9. S N Bose National Centre for Basic Sciences has redundant, Multihomed ISP connection. For this the Centre has acquired a pool of 256 public IP addresses along with Autonomous System Number (ASN) from Indian Registry for Internet Name and Numbers (IRINN). The Centre has configured a Linux based Gateway Firewall and VPN Server for the Centre. VPN service has been revised and configured for supporting LAN as well as Journal access via VPN service service.
10. Centre Website had been developed for bilingual (English and Hindi) facility.
11. For day-to-day use, new web applications had been developed and deployed - to work within intranet.
12. Newly developed Administrative & Academic software has been deployed for keeping records of all the staffs and students of the Centre.
13. New Faculty Search Committee blog had been developed as per the recommendations of Faculty Search Committee.
14. Ticketing system for the Engineering and Estate Office Complaints had been introduced.

15. Hall Booking application had been developed for reliable and sophisticated use with new feature.
16. Backup systems had been configured for any unusual accidental breakdown.
17. Govt. of India Central Public Procurement Portal (CPPP) E-Procurement Portal has been implemented for the transparency of every new procurements through Centre.
18. Initiate Computational Training/Workshop for the Scientists and Researchers for the better way of utilizing Central Computational Resources.
19. Enable the Centre Website for social networking site for publishing the Centre's novel and innovative research ideas and day to day broad discussions with the academic and research communities of the entire world.
20. Network racks had been rearranged for better arrangement and maintenance concern.
21. CSC configured Linux based new personal firewall, gateway for the centre.
22. Web applications such as Radhachura booking, Guesthouse Billing, Visitor pass, Asset Manager, Online Confreg had been developed and deployed in the intranet server.
23. Admission application has been modified to fulfil 2016 admission criteria.
24. BCRC blog has been created & upgraded.
25. 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.
26. Old CO_2 and Dry Powder based fire extinguishers had been replaced with safer clean agent based fire extinguishers in the cell.
27. Comprehensive fire safety solution had been design and proposed for the entire computer centre which will be implemented very soon.

Sanjoy Choudhury
In-charge, Computer Services Cell

Project and Patent Cell

The cell, established long time back to keep track of administrative processes involved during project application, through the execution and eventual completion, now caters to even projects that are brought from outsides, like inspire faculties etc. It was recently upgraded to cater to patent applications also. To help with the expanded responsibilities, new members were inducted in the cell.

The relevant forms for use of the cell are available in appropriate parts in the webpage of the centre, namely http://newweb.bose.res.in/facilities/ProjectPatentCell/ and in intranet.

The incharge and convener of the project cell is the convener of the patent application examining committee, Prof. B. B. Bhattacharya was nominated to be the chairman and an external expert was selected by the competent authority for examining the concerned case.

The following tables summarises the status of various projects and patents in the centre

Year	No. of Projects	Amount Received (Rs.)
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
2015-2016	38	4,71,50,347=00

Apart from this, Technical Research Centre has been launched in the Centre in January 2016 (Ref. No. AI/1/64/SNB/2014 dated 29.12.2015), with a goal for enabling Science and Technology platforms from materials science and spectroscopic techniques. The board vision is, "Making us effective in the innovation space leaving our core activities unchanged". The care, environment, metal and alloy industry, advanced materials and equipment industry. The initial year will be used mostly to create necessary intellectual properties (IP's) and to establish the proof-of-concepts, wherever it is not established and build the link for delivery where we have already proven the deliverable. From 3rd year onwards, we will initiate incubation activities in some of the "flagged" deliverables.

The Centre has also received the first installment of the TRC project during January 2016 (Ref. No. AI/1/64/SNB/2014 (c) dated 29.12.2015).

Projects during 2015-16

Sl.	Project Title & internal project number	PI / Co - PI	Funding Agency
1.	"J.C. Bose Fellowship"	Prof. A.K. Raychaudhuri	DST SR/S2/JCB-17/2006
2.	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
3.	DST/AKR/09-10/40 - "Unit on Nanoscience at SNBNCBS, Kolkata (UNANST - II)	Prof. A.K. Raychaudhuri	DST SR/NM/NS-53/2010
4.	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)
5.	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

Sl.	Project Title & internal project number	PI / Co - PI	Funding Agency
6.	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
7.	"Thematic Unit of Excellence on Computational Materials Science at the SNBNCBS, Kolkata"	Prof. Tanusri Saha Dasgupta	DST SR/NM/NS-29/2011
8.	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
9.	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
10.	DST/MP/11-12/81 - "New Frontiers in Quantitative mid-Infrared High Resolution Cavity ring-Down Spectroscopy using Quantum Cascade Laser"	Dr. Manik Pradhan	DST (SERB) SB/S2/LOP-18/2013 dated 20-7-2015
11.	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
12.	DST/JC/12-13/91 - "Microscopic calculations of metal ion binding to proteins"	Dr. Jaydeb Chakrabarti	DST (SERB) SR/S2/CMP-100/2012
13.	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
14.	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
15.	DST-UKIERI/AB/12-13/102 - "Nano-Engineered Magnetic Materials for Spintronic Applications"	Dr. Anjan Barman	DST-UKIERI INT/UK/UKIERI/P-44/2013
16.	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
17.	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
18.	"Ramanujan Fellowship"	Dr. Manoranjan Kumar	DST SR/S2/RJN-69/2012
19.	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

Sl.	Project Title & internal project number	PI / Co - PI	Funding Agency
20.	DST/ASM/13-14/112 - "Fundamental aspects of Quantum Theory and Quantum Information Science"	Prof. Archan S. Majumdar	SERB SB/S2/LOP-008/2013
21.	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)
22.	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
23.	CSIR/RB/13-14/116 - "Jump Dynamics in Ionic Liquids and non-exponential Relaxation"	Prof. Ranjit Biswas	(CSIR) 01(2811)/14/EMR-II
24.	DAE(BRNS)/PM/13-14/117 - "Functional transition metal oxides"	Dr. Priya Mahadevan	BRNS (DAE) 37(3)/14/22/2014-BRNS/554
25.	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
26.	DST/TSD/13-14/124 - "Magnetism in low dimensional quantum spin systems"	Dr. Tanusri Saha - Dasgupta	(DST-RFBR) INT/RUS/RFBR/P-166
27.	DST/AB/14-15/133 - "Nanoscale Modifications and Active Control of Magnonic Crystals for On-Chip Microwave Communication"	Prof. Anjan Barman	DST DST/INT/POL/P-11/2014 dated 20-4-2015
28.	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
29.	DST(DST-BMWF)/TSD/14-15/140 - "Search for Superconductivity and Magnetism in Mxene Phases"	Prof. Tanusri Saha Dasgupta	INT/AUA/BMWF/P-33/2015 dated 21-5-2015
30.	DST(SERB)/PP/14-15/141 - "Additivity Principle and Thermodynamic Characterization of Mass Transport Processes"	Dr. Punyabrata Pradhan	DST (SERB) EMR/2014/000719 dated 8-6-2015
31.	DST(SERI)/SKP/14-15/151 - "In(Ga)As/GaAs Quantum Dot Solar Cells"	Prof. S.K. Pal (Co.PI) Prof. Subhananda Chakrabarti, IITB (PI)	DST DST/TM/SERI/FR/117(G) dated 21-7-2015
32.	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
33.	RSSDI/MP/15-16/162 - "Non-invasive detection of diabetes mellitus from breath analysis using cavity enhanced absorption spectroscopy"	Dr. Manik Pradhan	RSSDI (Research Society for the Study of Diabetes in India)

Post doctorates and scientists in various projects -

Sl.	Name	Designation	Remarks
1.	Dr. Madhuri Mandal	Visiting Faculty Fellow	
2.	Dr. Saswati Barman	Scientist-D	Tenure Completed
3.	Dr. Kaustuv Das	Scientist - D	
4.	Dr. Amitava Moitra	Scientist D Academic	Resigned on 11.06.2015
5.	Dr. Biswaroop Mukherjee	Scientist D	
6.	Dr. Jaivardhan Sinha	Scientist D	
7.	Dr. Alo Dutta	Young Scientist of SERB Fast Track Scheme of DST	
8.	Mr. Dayasindhu Dey	Research Associate - I	Resigned on 22.02.2016
9.	Dr. Goutam Kumar Chandra	Research Associate - I (Ad-hoc)	Resigned on 30.09.2015
10.	Ms. Jashashree Ray	Research Associate - I	
11.	Mr. Rajib Nath	Research Associate - I	Tenure Completed
12.	Mr. Bhushan Omprakash Awasarmol	Scientist D- Computer Engineer	
13.	Dr. Shreemoyee Ganguly	Scientist D	
14.	Dr. Rakhi Acharyya	Research Associate - I	
15.	Dr. Rabaya Basori	Research Associate - I	
16.	Dr. Tanumoy Pramanik	Research Associate - I	
17.	Dr. Subhra Jana	DST INSPIRE Faculty	
18.	Dr. Soumendu Dutta	DST INSPIRE Faculty	
19.	Dr. Amlan Dutta	DST INSPIRE Faculty	
20.	Dr. Partha Mahata	DST INSPIRE Faculty	Resigned on 14.06.2015
21.	Dr. Shradha Mishra	DST INSPIRE Faculty	Resigned on 26.11.2015

Patents:

(1) Patent No.: 269712
Application No.: 1204/KOL/2007
Date of Filing: 30/08/2007
Date of Grant: 03/11/2015
Growth of Metal / Compound Nanotube Arrays

(2) Patent No.: 270966
Application No.: 467/KOL/2009
Date of Filing: 17/03/2009
Date of Grant: 28/01/2016
A method and system for non-invasive quantitative estimation of Bilirubin in human body

(3) Patent No.: 271830
Application No.: 545/KOL/2009
Date of Filing: 27/03/2009
Date of Grant: 07/03/2016
A method and system for the non-destructive characterization of Organic Gems

Pratip Kumar Mukhopadhyay
Convenor, Project Cell

Technical Cell

Central Equipment Facility of the Centre

Technical Cell is maintaining all the central experimental facilities. The facilities are available to use for free to the Centre's staffs and students and are made available to the external users on payment basis.

Organization of the Technical Cell

The Cell has 2-tier organization,

(a) broad policy making body called the Technical Cell Advisory Committee and

(b) a management group called the Technical Cell Working Group

The details about the facility is available in the website

http://newweb.bose.res.in/facilities/TechnicalCell/

Major equipments, UPS, chillers are maintained by AMC on non comprehensive basis.

Current experimental facilities and infrastructure under Technical Cell in the Centre

No	Name of instruments
1	X-ray Diffractometer (XRD)
2	Mini X-ray Diffractometer (Mini XRD)
3	Field Emission Scanning Electron Microscopy (FESEM)
4	High Resolution Transmission Electron Microscope (HRTEM)
5	Vibrating Sample Magnetometer (VSM)
6	Atomic Force Microscopy (AFM)
7	Pulsed Laser Deposition (PLD)
8	Thermmo Gravimetry/Differential Thermal aanalyzer (TG/DTA)

9	Dynamic Light Scattering (DLS)
10	Spectroscopic Ellipsometer
11	DSC / Modulated DSC
12	FTIR 6300
13	Dual beam Helios
14	Flurolog
15	FluroMax
16	UV-VIS 2600
17	UV/VIS 2450
18	Helium Leak Detector
19	DC/RF Sputtering unit
20	Millipore Water system
21	Circular Dichroism (CD)
22	Viscometer
23	Density meter

Equipment utilization time

The usage and status reports of the equipments under Technical cell are kept in the intranet at the URL, http://intranet.bose.res.in/TechnicalCell.html on monthly basis.

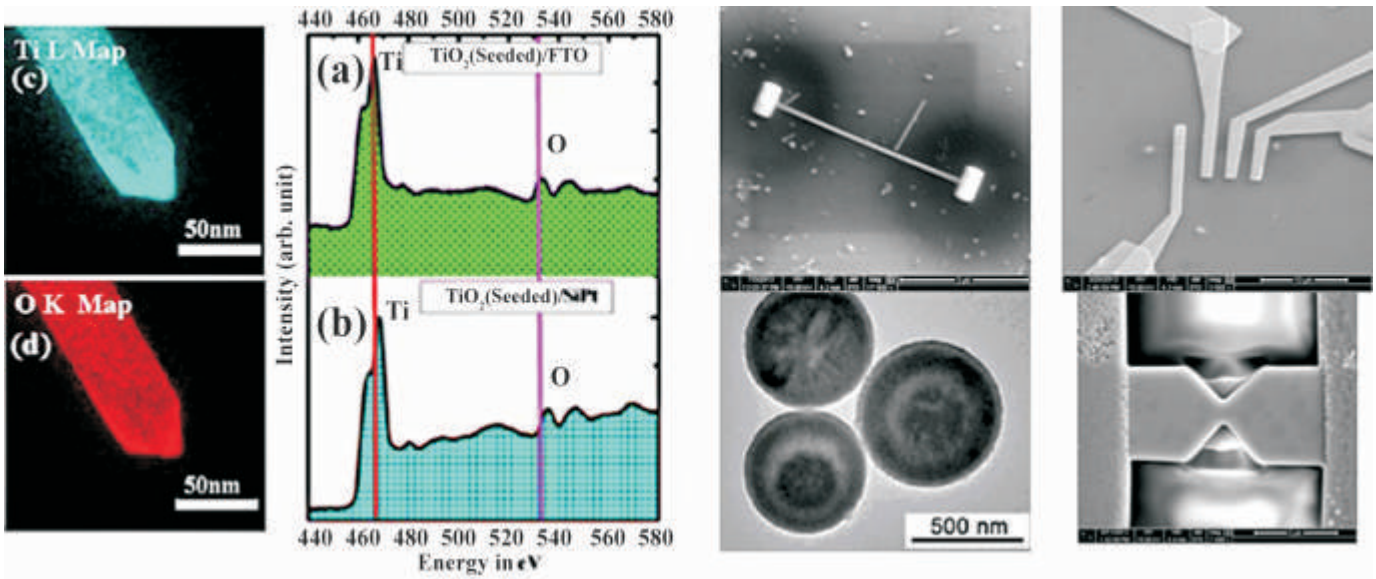
ITEM	USAGE TIME (Hr)	UP TIME (%)
PLD	1191	92 %
FESEM	578	100 %
XPERT PRO	515	95 %
MINI XRD	364	100 %
TG/DTA	505	100 %
DSC	144	100 %
VSM	1766	91 %
ELLIPSOMETER	23	100 %
TEM	1780	80%

Note: Other equipments are not included in the list, the users are less but uptime is 95%

Few images taken by using the instruments under Technical Cell:

Barnali Ghosh (Saha)

Barnali Ghosh (Saha)
Scientist in-charge,
Technical Cell



Mechanical Workshop and Glass Blowing Unit

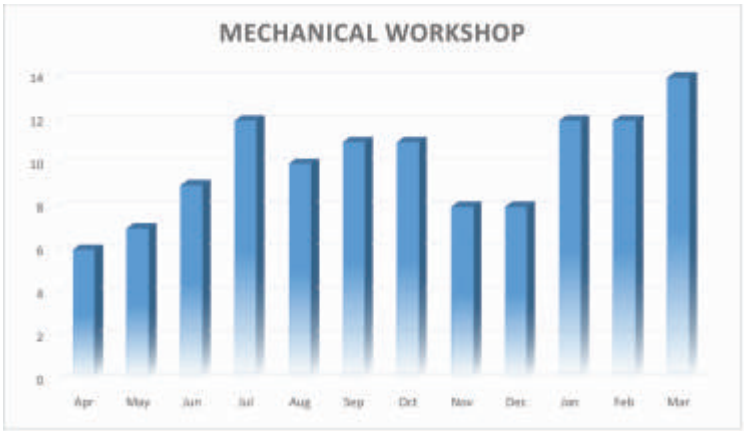
Throughout the year these two units functioned and catered to the demands of different departments and to the outside. While the mechanical workshop is handled by a mechanic in all days of the week, the glass blowing section operates one fixed day in a week and is also available on other days on demand.

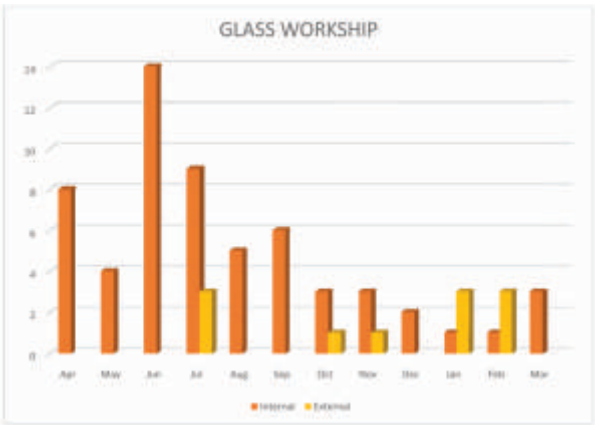
The specialized vacuum glass (and quartz) ampouling facility is a special feature in the glass blowing section. The mechanical section has a lathe machine, a milling machine and a drilling machine among other facilities for use. The users are required to enter their demands of major jobs in a log book for record, along with at least a rough sketch each.

Total number of jobs finished: mechanical workshop – 120, glass blowing section – 59 inside and 11 jobs for outside. Outside jobs are charged to the users.

Month wise breakups are given below: (2015 – 2016)

Pratip Kumar Mukhopadhyay
In-charge, Mechanical Workshop





Guest House

Bhagirathi – The Guest House

The Centre has its own upfront 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. Apart from accommodating Centre's guests and visitors, the Centre also extends its guest house facility to various government departments, organizations, research laboratories, universities etc.

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 4 (four) 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 67th Republic Day on 26th January 2016 and 69th Independence Day on 15th August 2015, the Director hoisted the national flag in the premises of the Centre. A sapling was planted on 15th August 2015 in reverence to Dr. A.P.J. Abdul Kalam. 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 snacks and sweets were distributed.
- The Performing Arts Group of 'Muktanagan' organised a cultural programme titled "Nabo Anonde Jaago" at Silver Jubilee Hall of the Centre on 14th May 2015 to observe the birthday of Kobiguru Rabindranath Tagore.

Like previous years, the Centre organised number of programmes in September 2015 to celebrate the Hindi Mahina, viz:

- 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 'ANGUR'.
- In house Hindi Cultural Programme 'KACHRE KA DUBBA' was staged by staff members of the Centre.
- Hindi play 'BHOOL RASTHA' performed by 'Padatik' group.
- A Hindi quiz session.
- A Hindi Essay competition on 'Role of Science & Technology in Swach Bharat Mission' was organised during the Hindi Mahina.
- The Centre organised Cleanliness Oath/Pledge [Swachh Shapath] on 2nd October 2015 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 Centre celebrated Satyendra Nath Bose's 122nd birthday on 1st January 2016. The bust of Satyendra Nath Bose was garlanded by Dean (Faculty) and other senior faculties and high tea was arranged for the occasion. On the said occasion the names of the winners for 'Vigilance Essay Competition' and 'Hindi Essay Competition' were announced followed by distribution of prize money.
- The Sports Activity Group of 'Muktangan' organised an Intra - Institute Cricket Tournament on 6th & 7th February 2016, Intra Institute Badminton Tournament on 3rd & 4th February 2016 and "2nd Inter

Institute Badminton Tournament" on 26th & 27th February 2016 within the Centre's premises. Students from the neighbouring colleges in Kolkata participated in the inter institute tournaments with great zeal. The winners of the Badminton Tournament (s) 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 2016' held during 30th March 2016 – 1st April 2016, Family Day was celebrated on the evening of 30th March 2016. On 30th March 2016, the Performing Arts Group of 'Muktangan' organised an in-house programme comprising of individual and group performances of singing, recitation, Hindi Drama named - 'Kissa Mantri Ka'. The programmes were attended by friends and family members of staff and students and were a huge success. 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. On the evening of 31st March 2016, renowned singer Shri Rupankar Bagchi entertained the audience with his popular numbers.

Majumder

Shohini Majumder
Registrar

Publications

Publications

Journal Publications

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Department of Theoretical Sciences

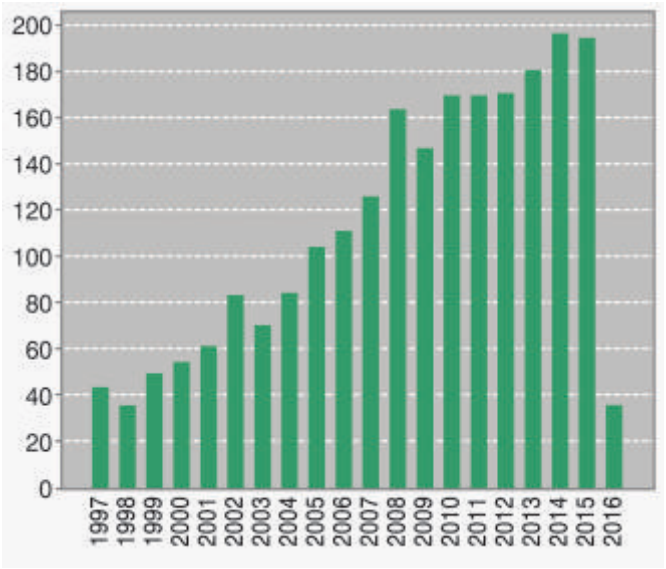
31. Ishita Dutta Choudhury and Amitabha Lahiri, *Quark ACM with Massive Gluon,* in the Proceedings of the 21st DAE-BRNS High Energy Physics Symposium (hepbrns2014), Guwahati, India 8-12 Dec, 2014, Published in Springer Proc.Phys. **174** (2016) 75-79.
32. Ambalika Biswas and Amitabha Lahiri, *Masses of Physical Scalars in Two Higgs Doublet Models,* in the Proceedings of the 21st DAE-BRNS High Energy Physics Symposium (hepbrns2014), Guwahati, India 8-12 Dec, 2014, Published in Springer Proc.Phys. **174** (2016) 605-609.
33. R. Banerjee, "Anomalous hydrodynamics in two dimensions," Pramana 86 (2016) no.2, 453 (Proceedings, International Workshop on Unification and Cosmology after Higgs Discovery and BICEP2 : Chandigarh, India, May 13-15, 2014).

Web of Science
Citation Report (On 31st March, 2016)

Address = (SN Bose Natl Ctr Basic Sci OR Satyendra Nath Bose Natl Ctr Basic Sci OR SNBNCBS)

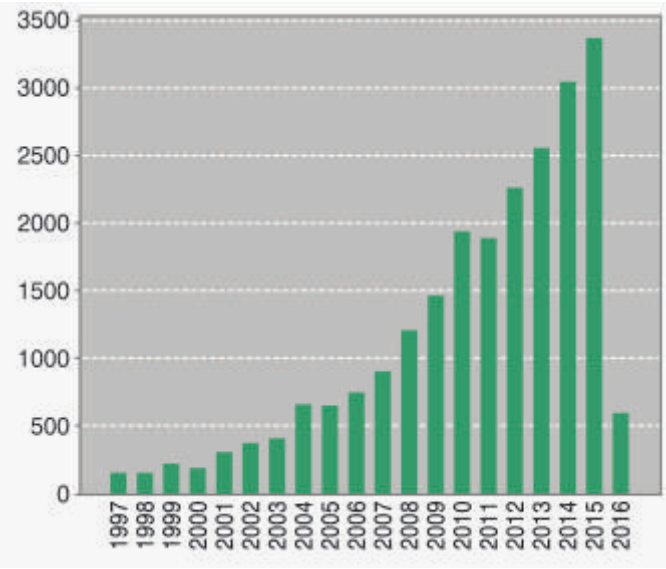
Time span = All years. Database = SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.

Published Items in Each Year



The latest 20 years are displayed.

Citations in Each Year



The latest 20 years are displayed.

Results found (No. of Publication)	:	2419
Sum of the Times Cited	:	23738
Sum of Times Cited without self-citations	:	18340
Citing Articles	:	15193
Citing Articles without self-citation	:	13578
Average Citations per Item	:	9.81
h-index	:	56

Total no. of Papers published	Total no. of Citation received	Citations per paper	Citation per year*	h-index
2419	23738	23738 / 2419 = 9.81	23738 / 29 = 818.55	56

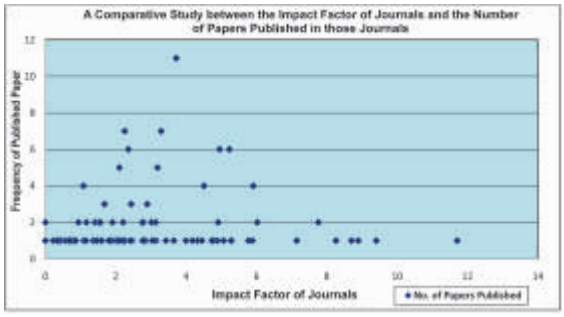
* Year of establishment of the Centre is 1986. Citations received from 1987 to 2016 = 29 years

Impact Factor for Publications in the Financial Year 2015-16

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
1	ACS Applied Materials & Interfaces	7.145	1	7.145
2	ACS Sensors	New Jr.	1	
3	ACS Sustainable Chemistry & Engineering	5.267	1	5.267
4	Advances in Space Research	1.409	2	2.818
5	AIP Advances	1.444	1	1.444
6	AIP conference proceedings	0.22	1	0.22
7	Analytical Chemistry	5.886	1	5.886
8	Angewandte Chemie International Edition	11.709	1	11.709
9	APL Materials	4.323	1	4.323
10	Asian Journal of Physics	-	1	
11	Astronomy Reports	0.805	1	0.805
12	Astrophysical Journal	5.909	4	23.636
13	Astrophysics and Space Science	1.678	3	5.034
14	Beilstein Journal of Nanotechnology	2.778	2	5.556
15	Biopolymers	2.248	1	2.248
16	Catalysis Science & Technology	5.287	1	5.287
17	Chaos, Solitons & Fractals	1.611	1	1.611
18	Channels	2.008	1	2.008
19	ChemBioChem	2.85	1	2.85
20	ChemPhysChem	3.138	2	6.276
21	Chemical Physics Letters	1.86	1	1.86
22	Chemistry: A European Journal	5.771	1	5.771
23	Chemistry of Materials	9.407	1	9.407
24	Classical and Quantum Gravity	2.837	1	2.837
25	Colloid and Polymer Science	1.89	1	1.89
26	Dalton Transactions	4.177	1	4.177
27	Electronic Materials Letters	2.057	1	2.057
28	European Physical Journal C	4.912	2	9.824
29	European Physical Journal Applied Physics	0.667	1	0.667
30	European Physical Journal Plus	1.521	2	3.042
31	Frontiers of Physics	2.462	1	2.462
32	Indian Journal of Physics	1.166	2	2.332
33	International Journal of Biological Macromolecules	3.138	1	3.138

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
34	International Jr. of Composite and Constituent Materials	-	1	
35	International Jr. of Geometric Methods in Modern Physics	0.82	1	0.82
36	International Journal of Modern Physics B	0.937	2	1.874
37	Journal of Alloys and Compounds	3.014	2	6.028
38	Journal of Applied Physics	2.101	5	10.505
39	Journal of Atmospheric and Solar-Terrestrial Physics	1.463	1	1.463
40	Journal of Chemical Physics	2.894	3	8.682
41	Journal of Chemical Sciences	1.085	1	1.085
42	Journal of Electron Spectroscopy and Related Phenomena	1.561	2	3.122
43	Journal of Generalized Lie theory and applications	0.429	1	0.429
44	Journal of Geometry and Physics	0.752	1	0.752
45	Journal of Geophysical Research : Space Physics	3.426	1	3.426
46	Journal of High Energy Physics	6.023	2	12.046
47	Journal of Magnetism and Magnetic Materials	2.357	6	14.142
48	Journal of Materials Chemistry A	8.262	1	8.262
49	Journal of Materials Chemistry C	5.066	1	5.066
50	Journal of Materials Science: Materials in Electronics	1.798	1	1.798
51	Journal of Mathematical Chemistry	3.648	1	3.648
52	Journal of Molecular Liquids	2.74	2	5.48
53	Journal of Nonlinear Mathematical Physics	0.58	1	0.58
54	Journal of Nuclear Materials	2.199	1	2.199
55	Journal of Photochemistry and Photobiology B: Biology	3.035	1	3.035
56	Journal of Physical Chemistry B	3.187	5	15.935
57	Journal of Physical Chemistry C	4.509	4	18.036
58	Journal of Physics: Condensed Matter	2.209	2	4.418
59	Journal of Physics: Conference Series	-	2	
60	"Journal of Physics D: Applied Physics"	2.772	2	5.544
61	Journal of Solid State Chemistry	2.265	1	2.265
62	Journal of the Physical Society of Japan	1.585	1	1.585
63	Langmuir	3.993	1	3.993
64	Materials Letters	2.437	3	7.311
65	Materials Today: Proceedings	-	1	
66	Mathematics	0.446	1	0.446
67	Modern Physics Letters A	1.08	4	4.32
68	Molecular BioSystems	2.829	1	2.829
69	Monthly Notices of the Royal Astronomical Society	4.952	6	29.712

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
70	Nano Research	8.893	1	8.893
71	Nanomedicine : Future Medicine	4.889	1	4.889
72	Nanoscale	7.76	2	15.52
73	Nanotechnology Reviews	2.044	1	2.044
74	New Astronomy	1.085	1	1.085
75	"Photochemical & Photobiological Sciences "	2.235	1	2.235
76	Physica B: Condensed Matter	1.352	1	1.352
77	Physica E	1.904	2	3.808
78	Physical Chemistry Chemical Physics	4.449	1	4.449
79	Physical Review A	2.765	1	2.765
80	Physical Review B	3.718	11	40.898
81	Physical Review D	4.506	4	18.024
82	Physical Review E	2.252	7	15.764
83	Physical Review X	8.701	1	8.701
84	Physics and Chemistry of Minerals	1.585	1	1.585
85	Physics Letters B	4.787	1	4.787
86	Physics of the Solid State	0.831	1	0.831
87	Polymer International	2.414	1	2.414
88	Pramana	0.692	1	0.692
89	Quantum Information Processing	1.15	1	1.15
90	Regular and Chaotic Dynamics	0.86	1	0.86
91	Reviews in Mathematical Physics	1.44	1	1.44
92	RSC Advances	3.289	7	23.023
93	Scientific Reports (Nature Publishing Group)	5.228	6	31.368
94	Solar Energy Materials and Solar Cells	4.732	1	4.732
95	Solid State Communications	1.458	1	1.458
96	SPIE Proceedings	0.37	1	0.37
97	Superlattices and Microstructures	2.117	1	2.117
98	Surveys in Mathematics and its Applications	0.33	1	0.33
	Total	**281.87**	**177**	**542.007**



£ million
Income
PBT
2 841
980
3 516
1 142
4 505
1 431
6 267
2 216
7 119
2 335
5 231
1 302
3 411
524
6 089
1 047
03
04
05
06
07
08
H1 08
H1 09
£ million
Income
PBT
4.215
JAN FEB MAR APR MAY JUN
25%
75%
84
65
58
96
68
62
Passive market share
First
Second
FEW
BGY
RDW
HRT
RTG
TRG
JAN FEB MAR APR MAY JUN JUL AUG SEP NOV DEC
AU GAS PL SIB
TYU division
FRT division
DAT BID ASK PRO
JAN € 241,00 € 558,00 € 104,00
FEB € 955,00 € 348,00 € 374,00
MAR € 116,00 € 415,00 € 930,00
APR € 262,00 € 146,00 € 107,00
MAY € 839,00 € 890,00 € 801,00
JUN € 706,00 € 579,00 € 691,00
JUL € 622,00 € 870,00 € 933,00
AUG € 557,00 € 775,00 € 934,00
SEP € 50,00 € 300,00 € 437,00
OCT € 817,00 € 518,00 € 269,00
NOV € 173,00 € 331,00 € 223,00
DEC € 608,00 € 599,00 € 339,00
RDW 650 320 754 273
TRG 241 450 144 364
RTG 654 650 874 657
WEF 784 145 124 752
HRT 453 784 954 241
DAT BID ASK PRO
JAN € 598,00 € 391,00 € 820,00
FEB € 891,00 € 958,00 € 784,00
MAR € 748,00 € 627,00 € 934,00
APR € 589,00 € 335,00 € 555,00
MAY € 949,00 € 885,00 € 386,00
JUN € 843,00 € 256,00 € 974,00
JUL € 836,00 € 628,00 € 575,00
AUG € 349,00 € 341,00 € 645,00
SEP € 221,00 € 441,00 € 941,00
OCT € 886,00 € 943,00 € 802,00
NOV € 661,00 € 949,00 € 715,00
DEC € 297,00 € 440,00 € 557,00

Accounts

INDEPENDENT AUDITORS' REPORT

To the Governing Body of Satyendra Nath Bose National Centre for Basic Sciences

BUDGET SUMMARY 2015-2016

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the year 2015-2016.

Figure in La khs (₹.)

	Actuals 2014-2015	Budget Estimate 2015-2016	Revised Estimate 2015-2016
Non-Plan	12.76	12.50	13.42*
Plan	2927.25	3024.00	3099.48*
TOTAL	**2940.01**	**3036.50**	**3112.90**

* Sanctioned by DST Plan 2950.00 lakhs, Non-Plan 50.00 lakhs and released as under:

Non-Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/NP/003/2015/1	26.06.2015	6.38lakhs
2	AI/SNB/NP/003/2015/2	12.02.2016	43.62.lakhs
	TOTAL (A)		**50.00 lakhs**

Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/GEN/003/2015/1	17.04.2015	209.84 lakhs
2	AI/SNB/CAP/003/2015/1	17.04.2015	153.04 lakhs
3	AI/SNB/SAL/003/2015/1	10.04.2015	127.83 lakhs
4	AI/SNB/SAL/003/2015/2	22.06.2015	255.65 lakhs
5	AI/SNB/CAP/003/2015/2	22.06.2015	306.08 lakhs
6	AI/SNB/GEN/003/2015/2	26.06.2015	420.00lakhs
7	AI/SNB/SC/003/2015/1	26.06.2015	26.58 lakhs
8	AI/SNB/SC/003/2015/2	30.09.2015	13.5 lakhs
9	AI/SNB/SAL/003/2015/3	30.09.2015	700.00 lakhs
10	AI/SNB/SC/003/2015/3	12.02.2016	18.92 lakhs
11	AI/SNB/GEN/003/2015/4	12.02.2016	121.32 lakhs
12	AI/SNB/SAL/003/2015/4	12.02.2016	597.24 lakhs
	TOTAL (B)		**2950.00 lakhs**
	TOTAL (A + B)		**3000.00 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, 2016, 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, 2016.

(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 matter

Without qualifying our opinion we draw attention to Note No.2.5 of schedule 25 regarding interest earned on Fixed Deposits and Savings Bank Deposits.

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: August 24, 2016

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

BALANCE SHEET AS AT 31ST MARCH 2016			Amount (Rs.)
	Schedule	Current Year	Previous Year
FUNDS AND LIABILITIES		₹	₹
CAPITAL / CORPUS FUND	1	958290018.36	1043226974.35
RESERVES AND SURPLUS	2	-	
EARMARKED/ENDOWMENT FUNDS	3	379800108.79	190436956.05
SECURED LOANS AND BORROWINGS	4		
UNSECURED LOANS AND BORROWINGS	5		
DEFERRED CREDIT LIABILITIES	6		
CURRENT LIABILITIES AND PROVISIONS	7	42545812.31	39585083.31
TOTAL		**1380635939.46**	**1273249013.71**
ASSETS			
FIXED ASSETS	8	758132456.80	804922255.75
INVESTMENTS-FROM EARMARKED/ENDOWMENT FUNDS	9	126371330.38	110575849.38
INVESTMENTS - OTHERS	10	362531415.00	210248304.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	133600737.28	147502604.58
MISCELLANEOUS EXPENDITURE (to the extent not written off or adjusted)			
TOTAL		**1380635939.46**	**1273249013.71**
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: 24.08.2016
Place: Kolkata

(Amit Mitra)
Partner
Membership no:060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2016 Amount (Rs.)

INCOME	Schedule ₹	Current Year ₹	Previous Year
Income from Sales/Services	12	6722569.00	6032006.86
Grants/Subsidies	13	254088000.00	225357894.00
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 on fixed deposit(including interest on loan to employees)	17	11617691.00	20074784.00
Other Income	18	407331.00	720013.00
Increase/(decrease) in stock of finished goods and works-in-progress	19		
TOTAL (A)		**272835591.00**	**252184697.86**
EXPENDITURE			
Establishment Expenses	20	94194800.00	92925287.00
Other Administrative Expenses etc.	21	150485526.14	150594693.15
Expenditure on Grants, Subsidies etc.	22		
Interest earned on fixed deposit and savings bank (payable)		11455120.00	
TOTAL (B)		**256135446.14**	**243519980.15**
Balance being excess of Income over Expenditure(A-B)		16700144.86	8664717.71
Prior period adjustments (Credit)		3374419.10	451254.00
Transfer to/from Capital Fund			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/CAPITAL FUND		**20074563.96**	**9115971.71**
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: 24.08.2016
Place: Kolkata

(Amit Mitra)
Partner
Membership no:060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

RECEIPTS AND PAYMENTS ACCOUNTS

For the year ended 31st March 2016

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. **Opening Balances**			I. **Expenses :**		
a) Cash in hand	12001.00	31393.00	a) Establishment Expenses	114936354.00	108736853.8
b) Bank Balances :			b) Administrative Expenses	100945389.77	104106046.41
i. In current accounts(Schd 11A)	18469564.66	26707922.69	c) Maintenance	31766605.00	35711813.00
ii. In deposit accounts			II. **Payments made against funds for**		
Schedule - 10	210248304.00	183743956.00	**various Projects**		
Schedule - 11A	54651909.00	129128239.00			
iii. Savings accounts (Schd 11A)	13907339.37	13554280.98			
iv. Remittance-in-Transit					
II. **Grants Received**			III. **Investments and deposits made**		
a) From Government of India			a) Out of Earmarked/Endowment	213114234.00	28529527.00
-For the year	553501889.00	294445254.00	b) CPWD Deposit and NBCC Deposit		0.00
-For the previous year			c) Bank Gurantee & LC A/C	1060000.00	1200000.00
b) From State Government			d) Out of Own Fund	68918450.00	13351683.00
c) From Other sources (details)			e) Bridge&Roof Deposit Account	0.00	0.00
(Grants for capital & revenue exp.					
To be shown separately)			IV. **Expenditure on Fixed Assets &**		
			Capital Work-in-Progress		
			a) Purchase of Fixed Assets	82775238.93	125061026.00
			b) Expenditure on Capital		
III. **Income on Investments from**			Work-in-Progress	69011595.00	2,100,233.00
a) Earmarked/Endow Funds		-			
b) Own Funds (Oth. Investment)			V. **Refund of surplus money/Loans**		
			a) To the Government of India		
IV. **Interest Received**			b) To the State Government		
a) On Bank deposits	8160947.00	7632274.00	c) To other providers of funds		

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
			VI. **Finance Charges (Interest)**		
V. **Other Income**	5282542.00	5442520.86			
`			VII. **Other Payments**	66082801.27	35853077.23
			VIII. **Amount transferred from Fixed**		-
			Deposit account to Savings Account Account/Current Account	85857589.00	74476330.00
VI. **Amount Borrowed**	–	–			
			IX. **Closing Balances**		
VII. **Any other receipts**	25203154.10	29629189.00	a) Cash in hand	53541.00	12001.00
			b) Bank Balances :		
VIII. **Amount transferred from Current Account/ Savings Account to Deposit Account.**	375943892	136100678.00	i. In current accounts(Schd 11A)	11003610.72	18469564.66
			ii. In deposit accounts		
			Schedule - 10	362531415.00	210248304.00
			Schedule - 11A	22589916.00	54651909.00
			iii. Savings accounts(Schd.11A)	34734802.44	13907339.37
			iv. Remittance-in-Transit		
	1265381542.13	**826415707.53**		**1265381542.13**	**826415707.53**

Date 22.08.2016
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, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

	Current Year		Previous Year	
	₹	₹	₹	₹
SCHEDULE 1 -CAPITAL FUND:				
Balance as at the beginning of the year	1043226974.35		1012218107.76	
Add : Contributions towards Corpus/ Capital Fund	45912000.00		49541106.00	
Less: Depreciation for the year	150923519.95		41073252.48	
Add : Surplus during the year	20074563.96		9115971.71	
Add : Adjustment for Depreciation (Overcharged)			13425041.36	
				1043226974.35
		958290018.36		
BALANCE AS AT THE YEAR - END		**958290018.36**		**1043226974.35**

	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				

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

	FUND-WISE BREAK UP					TOTAL	
	Project Fund	Technical Research Centre	Medical fund	Retirement Benefits Fund	Corpus Fund	Current Year	Prev. Year
SCHEDULE 3 - EARMARKED/ ENDOWMENT FUNDS							
a) **Opening balance of the funds**	111189158.67	0.00	4483627.00	66410349.00	8353821.38	190436956.05	217030481.32
b) **Additions to the Funds**							
i) Donations/grants/ Contributions	47150347.00	222114000.00	505345.00	1218713.00	760000.00		51301010.00
ii) Income from investments made on account of funds	6060493.00	1423972.00	331486.00	5977199.00	638377.00	14431527.00	8981988.00
iii) Other additions -Provision during the year						–	0.00
TOTAL (a + b)	**164399998.67**	**223537972.00**	**5320458.00**	**73606261.00**	**9752198.38**	**204868483.05**	**277313479.32**
c) **Utilisation/Expenditure towards objectives of funds**							
i) Capital Expenditure							
Fixed Assets	56665735.93			-		56665735.93	52845367.00
Others							
Total							
ii) Revenue Expenditure							
Salaries, Wages and allowances etc.	25484114.00			-		25484114.00	19579823.86
Rent							
Other Administrative expenses							
Other Payments	12629505.33	227222.00	331486.00	1478716.00		14666929.33	14451332.41
iii) Adjustment (Interest)							
TOTAL (c)	**94779355.26**	**227222.00**	**331486.00**	**1478716.00**	**-**	**96816779.26**	**86876523.27**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**69620643.41**	**223310750.00**	**4988972.00**	**72127545.00**	**9752198.38**	**379800108.79**	**190436956.05**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

	Current Year		Previous Year	
	₹	₹	₹	₹
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS				
A. CURRENT LIABILITIES				
1. Acceptances				
2. Sundry Creditors:				
a) For Capital expenditure	3516855.00			10980162.00
b) Others - Revenue expend. (including Project Rs.30000.00)	10112138.00			11936424.00
3. Othert Liabilities	2599419.00			2751815.00
4. Deposit from Contractors	7017928.88			6745308.88
5. Deposit from Students	1242100.00			1122700.00
6. Deposit from Contractual Employees	1572265.00			1434967.00
7. Provident Fund Account (Payable)	0.00			0.00
8. Project Overhead Fund	4974330.43			4547688.43
9. Interest earned on fixed deposit and savings bank (payable)	11455120.00			0.00
TOTAL (A)	**42490156.31**			**39519065.31**
B. PROVISIONS				
1. For Taxation				
2. Gratuity				
3. Superannuation/Pension				
4. Accumulated Leave Encashment				
5. Trade Warranties/Claims				
6. Others - Adhoc Bonus	55656.00			66018.00
TOTAL (B)	**55656.00**	**-**		**66018.00**
TOTAL (A+B)	**42545812.31**	**-**		**39585083.31**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

SCHEDULE 8 - FIXED ASSETS

DESCRIPTION	GROSS BLOCK			
	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		10950654.60
2. BUILDINGS:				
a) On Leasehold Land	291601874.86	14849574.00		306451448.86
b) On Freehold Land				
c) Ownership Flats/Premises				
d) Superstructures on Land not belonging to the entity				
3. PLANT MACHIENRY & EQUIPMENT	433821095.22	14362928.00		448184023.22
4. VEHICLES	321013.00	0.00		321013.00
5. FURNITURE, FIXTURES	38450817.22	387578.00		38838395.22
6. OFFICE EQUIPMENT	4267589.29	149561.00		4417150.29
7. COMPUTER & LAN INSTALLATION	67232547.44	2343553.00		69576100.44
8. ELECTRIC INSTALLATIONS	11699040.00	0.00		11699040.00
9. LIBRARY BOOKS	205772315.11	9908328.00		215680643.11
10. TUBEWELLS & W.SUPPLY	-	-		0.00
11. OTHER FIXED ASSETS	84225.55	0.00		84225.55
TOTAL OF CURRENT YEAR	**1064201172.29**	**42001522.00**	**0.00**	**1106202694.29**
PREVIOUS YEAR	**976401302.29**	**87799870.00**	**-**	**1064201172.29**
B. CAPITAL WORK IN PROGRESS	**12992443.00**	**70841534.00**	**-8709335.00**	**75124642.00**
TOTAL (A + B)	**1077193615.29**	**112843056.00**	**-8709335.00**	**1181327336.29**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

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	10950654.60	10950654.60
38826895.28	4542195.21		43369090.49	263082358.37	252774979.58
90029427.56	134921322.46		224950750.02	223233273.20	343791667.66
321011.00	0.00		321011.00	2.00	2.00
18718875.80	4217815.34		22936691.14	15901704.08	19731941.42
968835.44	1170804.43		2139639.87	2277510.42	3298753.85
51529054.43	4742008.65		56271063.08	13305037.36	15703493.01
2244119.14	1296022.44		3540141.58	8158898.42	9454920.86
69586478.05	0.00		69586478.05	146094165.06	136185837.06
-	-		0.00	0.00	
46662.84	33351.42		80014.26	4211.29	37562.71
272271359.54	**150923519.95**	**0.00**	**423194879.49**	**683007814.80**	**791929812.75**
244623148.42	**41073252.48**	**(13,425,041.36)**	**272271359.54**	**797929812.75**	**731778153.87**
				75124642.00	**12992443.00**
272271359.54	**150923519.95**	**0.00**	**423194879.49**	**758132456.80**	**804922255.75**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016 Amount (Rs.)

SCHEDULE 9 - INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS

	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	51013440.00	37070690.00
Retirement Benefit Fund Investment	64553448.00	62700717.00
Staff Medical Fund Investment	3694778.00	3694778.00
Corpus Fund Investment (Project Overhead)	7109664.38	7109664.38
TOTAL	**126371330.38**	**110575849.38**

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.)	104045250.00	33525945.00
Fixed Deposit with Union Bank of India including fixed deposits of TRC	258486165.00	176722359.00
TOTAL	**362531415.00**	**210248304.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC

	Current Year		Previous Year	
	₹	₹	₹	₹
A. CURRENT ASSETS:				
1. Inventories:				
a) Stores and Spares		73921.12		106431.55
2. Cash balances in hand		53541.00		12001.00
3. Bank Balances:				
a) With Scheduled Banks:				
On Current Accoutns:				
Indian Overseas Bank (CA-089302000000220)	2884451.34		10669197.86	
Indian Overseas Bank (CA-089302000000273)	4311277.65		6830065.30	
Union Bank of India (CA-460901010034252)	3807881.73	11003610.72	970301.50	18469564.66
On Deposit Accounts for LC&BG:				
Indian Overseas Bank (CA-089302000000220)	17410616.00		9331909.00	
Indian Overseas Bank (CA-089302000000273)	5179300.00	22589916.00	45320000.00	54651909.00
On Savings Accounts:				
Indian Overseas Bank(SB-089301000010662 UNAST)	919995.62		2414336.62	
Indian Overseas Bank(SB-089301000012029 SYNC.)	662796.00		1630826.00	
Indian Overseas Bank(SB-089301000011479 NANO TECH)	469983.000		3433035.00	
Union Bank of India (SB-460901110050013)	8281346.82		5943821.75	
Axis Bank (SB-775010100024408)	511885.00		449931.00	
Axis Bank (SB-775010100017860)	1506.00		35389.00	
Union Bank of India(SB-460902010097273 TRC)	23887290.00	34734802.44		13907339.37
5. Remittance - in - Transit				
6. Post Office-Savings Accounts				
TOTAL (A)		**68455791.28**		**87147245.58**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.(Contd.)

	Current Year		Previous Year	
	₹	₹	₹	₹
B. LOANS, ADVACNES AND OTHER ASSETS				
1. *Loans:*				
a) Staff including HBA, Vehicle &PC Advance (includes Project A/c Rs.16073.00)		1204625.00		2828467.00
b) Other Entitites engaged in activities/objectives similar to that of the Entity				
c) Other - Advance to Project A/c		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		40438840.00
b) Prepayments				
c) Others (Security Deposits)		126130.00		107218.00
d) Contractors & Suppliers		91941.00		91941.00
3. *Income Accrued:*				
a) On Investments from Earmarked/Endowment Funds(Including Project Rs.645970.00)		20922215.00		15366230.00
b) On investmetns - Others		937223.00		1522663.00
c) On Loans and Advances				
d) On investment on funds (Technical Research Centre)		1423972		
4. Claims Receivable - Grant -in- Aid Receivable		-		-
TOTAL (B)		**65144946.00**		**60355359.00**
TOTAL (A + B)		**133600737.28**		**147502604.58**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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	3753640.00	2537200.00
b) Hostel Charges (Recovery of HRA)	265537.00	633053.86
c) Equipment Utilisation Fees	752100.00	588200.00
d) Hostel Maintenance Fees	1454942.00	1881153.00
e) Project Overhead	304000.00	276000.00
f) Others	0.00	0.00
g) Income from BSNL	60500.00	66000.00
h) Course Fees	10000.00	0.00
I) Seminer Room Rent	121100.00	47000.00
j) Dining Hall Rent	750.00	3400.00
TOTAL	**6722569.00**	**6032006.86**

SCHEDULE 13 - GRANTS/SUBSIDIES

(Irrevocable Grants & Subsidies Received)

	Current Year ₹	Previous Year ₹
1) Central Government	254088000.00	225357894.00
2) State Government(s)		
3) Government Agencies		
4) Institutions/Welfare Bodies		
5) International Organsations		
6) Others		
TOTAL	**254088000.00**	**225357894.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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		

SCHEDULE 15 - INCOME FROM INVESTMENTS

(Income on Invest. From Earmarked/ Endowment Funds transferred to Funds)	Investment from Earmarked Fund		Investment - Others	
	Current Year	Previous Year	Currnent 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 - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016 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	11433983.00	19855159.00
b) With Institutions		
c) Others		
2) On Savings Accounts:		
a) With Scheduled Banks	21137.00	23521.00
b) Post Office Savings Accounts		
c) Others		
3) On Loans:		
a) Employees/Staff (Interest on HBA etc.)	162571.00	196104.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	**11617691.00**	**20074784.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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	407331.00	720013.00
TOTAL	**407331.00**	**720013.00**

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	86664563.00	83708487.00
b) Other Allowances and Bonus	55656.00	66018.00
c) Contribution to Provident Fund	1975132.00	2084806.00
d) Contribution to Retirement Benefits Fund	1218713.00	2040076.00
e) Staff Welfare Expenses (Medical)	1540129.00	1591112.00
f) Contribution to NPS	1367721.00	1302737.00
f) Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	1372886.00	2132051.00
TOTAL	**94194800.00**	**92925287.00**

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SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

Amount (Rs.)

SCHEDULE 21 -OTHER ADMINISTRATIVE EXPENSES ETC.

	Current Year ₹	Previous Year ₹
a) Extended Visitors Programme. (Including Seminars & Workshops)	10703764.00	7153228.00
b) Meeting Expenses	1164353.00	1431534.00
c) Library General Expenses	130128.00	123177.00
d) Electricity and Power	36633061.77	34969686.00
e) Laboratory Expenses	11365113.00	21511839.00
f) Insurance	10945.00	9910.00
g) Repairs and Maintenance	36186941.43	44281630.00
h) TPSC Programme	576149.00	680000.00
I) Student Hostel Rent	412985.00	390278.00
j) Vehicles Hire Charges	1451550.00	1396943.00
k) Postage, Telephone and Communication Charges	1525738.00	2381694.00
l) Printing and Stationary	1094078.00	1004011.00
m) Travelling and Conveyance Expenses	2118904.00	3580115.00
n) Contingency to Faculty	41868.00	121259.00
o) Auditors' Remuneration	46000.00	45600.00
p) Bank Charges	336122.94	863648.15
q) Professional Charges (Legal Charges)	914907.00	223425.00
r) Staff Training & Welfare	196648.00	370250.00
s) Patent & Trademark	156950.00	37350.00
t) Integrated Ph.D.	41121919.00	27080927.00
u) Hindi Programme	366799.00	296496.00
v) Advertisement and Publicity	2505977.00	1174612.00
w) Others	1277657.00	1300843.00
x) Municipal Tax	146968.00	146968.00
y) Entry Tax		19270.00
TOTAL	**150485526.14**	**150594693.15**

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BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2016

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		
TOTAL	**Nil**	**Nil**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

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, 2013.

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 No depreciation has been provided on Books and Journals for the year since it is not mentioned in the Companies Act, 2013.

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 - 700 106

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 - ₹ 81,09,409.00 against 100% margin money by way of fixed deposit (Previous year ₹ 70,49,409.00).
- Letters of Credit opened by Bank on behalf of the Centre and Project- ₹ 1,44,80,507.00 (Previous year ₹ 4,76,02,500.00) 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 ₹ 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, 2015 was ₹ 1,29,92,443/- addition during the year is ₹ 6,90,11,595/-, totaling to ₹ 8,20,04,038/- an amount of ₹ 68,79,396/- has been capitalized, leaving balance of ₹ 7,51,24,642/-00 which has been carried forward.

2.2.3 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.

2.3 Taxation

In view of there being no taxable income under Income-tax Act 1961, no provision for Income tax has been considered necessary.

2.4 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

2.5 We have examined the Finance Committee's observations/recommendations regarding accounting treatment of interest earned on Fixed Deposits and Savings Bank Deposits with relevant Accounting Standards of the Institute of Chartered Accounts of India (ICAI) and notes and instructions as issued by the Department of Science & Technology (DST), New Delhi for compilation of Financial Statements of the Autonomous Institute and terms and conditions as mentioned in the grant sanction letters as issued by the DST. In our opinion, the said recommendations as recorded under the Agenda Item No.23.3 of the Minutes of the 32nd meeting of the Finance Committee held on 09.10.2015 regarding accounting treatment of Interest earned on Fixed Deposits and Savings Deposits are not in conformity of general practice of accounting and also not supported by specific instruction/ orders in the grant memo on the instruction manual issued by The Department of Science and Technology (DST). However, disclosures of Interest Earned on Fixed Deposits and Savings Bank Deposits in Income and Expenditure Account and Balance Sheet for the financial year 2015-16 are made as per the recommendations of the Finance Committee.

2.6 Corresponding figures for the previous year have been re-grouped/re-arranged, wherever necessary.

Kolkata
Dated: August 24, 2016

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

Para-wise replies to the audit observations

SL	Audit Observations	Para-wise replies
	Without qualifying our opinion we draw attention to Note No.2.5 of schedule 25 regarding interest earned on Fixed Deposits and Savings Bank Deposits.	The matter will be placed before the Finance Committee of the Centre for further consideration.

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