Celebrating 2018 BOSE 125th Birth Anniversary

Annual Report
2018 - 2019

CENTRE FOR BASIC SCIENCES 1986
S. N. BOSE NATIONAL
1894-1974
विज्ञानम् परमश्चायम् भोगः

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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SATYENDRA NATH BOSE
NATIONAL CENTRE FOR BASIC SCIENCES

Annual Report 2018 - 2019

Satyendra Nath Bose National Centre For Basic Sciences

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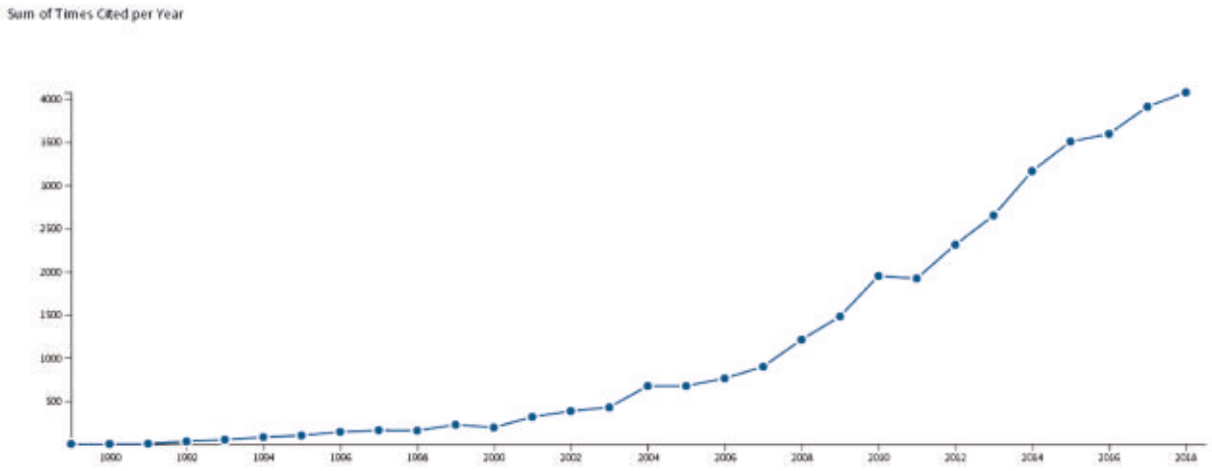
Academic Highlights

No. of Publications in refereed journal	**169**
No. of PhD Degree awarded	**23**
No. of PhD theses submitted	**21**
No. Ongoing Project	**31**
No. of Patent Applied/ Granted	**5 + 2**
No. of Awards/Recognitions (Student)	**11**
No. of Awards/Recognitions (Faculty/Scientist)	**7**
No. of Technology transfer	**1**



Source: web of science (On 1st April, 2019)

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 9th 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. This is the 3rd time the Annual Report is translated and typed in Hindi within the Centre. The Hindi Officer, Sadhana Tiwari has given sincere fatigueless effort to translate the Annual Report in Hindi and library staff - Gurudas Ghosh and Ananya Sarkar typed the Annual Report in Hindi within a very limited time period. Words won't be suffice to describe the painstaking labour of Hindi translation team. I would like to acknowledge the sincere efforts and labour of my Library staff - Gurudas Ghosh, Ananya Sarkar and 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

CONTENTS

Message from the Director	7
Dean, Faculty	8
Dean, Academic Programme	9
Celebration of 125th Birth Anniversary of Prof. Satyendra Nath Bose	21
Extended Visitors & Linkage Programme	25
Theoretical Physics Seminar Circuit	38
Registrar	39
Hindi (Rajbhasha) Implementation in the Centre	42
Committees	43
Academic Members	46
Administrative and Technical Staff Members	48
Department of Astrophysics & Cosmology	
HOD Report	54
Archan Subhra Majumdar	57
Manik Banik	61
Ramkrishna Das	63
Sandip Kumar Chakrabarti	66
Soumen Mondal	68
Department of Chemical Biological & Macro-Molecular Sciences	
HOD Report	74
Debashis Mukherjee	76
Gautam Gangopadhyay	78
Jaydeb Chakrabarti	80
Manik Pradhan	82
Rajib Kumar Mitra	86
Ranjit Biswas	89
Samir Kumar Pal	91
Subhra Jana	95
Suman Chakrabarty	98
Tatini Rakshit	101
Department of Condensed Matter Physics and Material Sciences	
HOD Report	104
Anjan Barman	106
Anup Ghosh	111
Arup Kumar Raychaudhuri	113
Atindra Nath Pal	117
Barnali Ghosh (Saha)	120
Dipanwita Majumdar	124

CONTENTS

Kalyan Mandal	125
Madhuri Mandal (Goswami)	128
Manoranjan Kumar	130
Milan Kumar Sanyal	133
Pratip Kumar Mukhopadhyay	135
Priya Mahadevan	138
Prosenjit Singha Deo	140
Ranjan Chaudhury	141
Samit Kumar Ray	144
Thirupathaiah Setti	147
Department of Theoretical Sciences	
HOD Report	152
Amitabha Lahiri	154
Biswajit Chakraborty	156
Makhtedar Sanjay Kumar	158
Manu Mathur	159
Partha Guha	160
Punyabrata Pradhan	163
Rabin Banerjee	165
Sakuntala Chatterjee	167
Subhrangshu Sekhar Manna	169
Sunandan Gangopadhyay	170
Facilities	
Library	174
Engineering Section	176
Computer Services Cell	180
Project and Patent Cell	185
Technical Research Centre	192
Technical Cell	195
Mechanical Workshop and Glass Blowing Unit	197
Guest House	198
Recreational and Cultural Programmes	199
Publications	
List of Publications 2018-19	202
Impact Factor for Publications	212
Accounts	
Accounts Budget Summary 20187-2019	218
Independent Auditors' Report	219
Financial Statements	220

MESSAGE FROM THE DIRECTOR

Annual report is a mirror of an institute to reflect it's progress and achievements over the last one year and I feel privileged to present the same. Keeping it's mandate in mind for undertaking cutting edge basic research, manpower training in advanced areas of research and networking globally to expand R&D base-human capacity, the Centre today stands as an institution with a balance of theory, computational physics and modern experimentation. The institute continued it's commendable efforts to take challenges in the niche areas of Quantum Science & Technology, emerging areas of Theoretical and Astro-physics, Computational Materials, Ultrafast Spectroscopy and Advanced Materials including soft and biomaterials. In line with the legacy of celebrating Bose's 125th birth anniversary starting from 1st January 2018, the Centre continued a plethora of pursuits in the year 2018-19 to mark the event as a memorable one. The Hon'ble Prime Minister had set the tune through an embracive inaugural address on Bose's birthday, 1st January 2018. In that spirit, the Centre set off the series of celebratory events, which achieved the peak during the period April - December 2018.

The year 2018-19 will be remembered for the significant progress and new feats the centre has achieved. In the last one year there have been 169 publications in referred journals and 17 other types of publications, 23 students were awarded PhD Degree and 21 others submitted their PhD theses. There are 165 PhD students and 29 post-doctoral research students associated with active and productive faculty strength of 32 during 2018-19. I feel proud to announce that several faculty members had received National / International laurels such as the Fellowship of the World Academy of Sciences, Abdul Kalam Technology Innovation fellowship, Top cited author award of Institute of Physics Publishing (IOP) etc. The students were equally competitive to bag several best paper awards in International & National conferences.

The TRC project supported by DST has reached a new milestone this year with the first Technology transfer in the annals of the Centre through NRDC for "Non-invasive quantitative estimation of Haemoglobin in blood". The prototype developed by the faculty member has also been selected for large scale clinical trial under National Anemia Mission for possible introduction in National Health Mission. It is laudable to note that the TRC could also earn contract research project & from private agencies (International &National) for the first time. In addition to prestigious TRC project, the Centre has 31 ongoing/new projects amounting an extramural annual funding of Rs. 4.63 crores, 7 no of patents have been granted and filed this year by the faculty of the Centre.

The Centre has been immensely vibrant in science networking and outreach activities in 2018-19 for mentoring junior researchers through Theoretical Physics Seminar Circuit (TPSC) and Extended Visitors & Linkage Program (EVLP) for making the BOSE-125 celebration a memorable one. It was our pleasant pledge to stud the 125th birth anniversary of legendary Scientist with distinguished programmes like organizing Public & Distinguished lectures, Conferences, Workshops and residential summer & winter schools. It is noteworthy to mention that the Centre organized more than 125 Science outreach programmes in 2018-19 across the nation to inspire the young generation in Science & Technology. It is worthwhile to note that a series of five lectures on History of Science by eminent scientists was organized on 1st January 2019 to celebrate the 126th birth annivedrsary of Bose.

Our sincere gratitude to the members of the statutory and advisory and internal administrative committees of the Centre for their cooperation and support. Sincere thanks to all faculty members including Emeritus/ Visiting faculties, staff members, administration and support services and students of the Centre for their sincere involvement towards profound growth of the Centre in the last year. Let me also thank the Annual Report Committee for compiling the report in time.

I wish more productive years ahead and hope our endeavour to mandated tasks will benefit the society to a greater extent.

Samit Kumar Ray
Director
S. N. Bose National Centre For Basic Sciences

DEAN, FACULTY

In the year 2018-19, celebrations on account of the 125th birth anniversary of Prof. S. N. Bose were concluded. The Centre was involved in several academic activities related to scientific collaborations, hosting national and international conferences, workshops, schools, and organizing outreach programmes, refurbishing of the Bose Archives, etc. Our faculty continued to publish in top quality international journals. In this fiscal year, the total number of publications was 169.

Throughout the year, we organized numerous seminars and distinguished lectures on various topics delivered by scientists ranging from young graduate students to well-established ones. Our ongoing collaborations with various institutions in India and abroad in terms of academic visits and exchange programmes including collaborations in conferences, as well as involvement in projects supported by extramural funding further bolstered the research activities at the Centre.

This year two new faculty members have joined in the Departments of CMP&MS and CBMS. Additionally, Prof. Debashis Mukherjee was appointed as S. N. Bose Chair Professor. Prof. Milan Kumar Sanyal joined the Centre as Emeritus Professor (Externally Funded). Thirteen Post Doctoral Research Associates have joined the Centre. Four of our faculty members were promoted to Senior Professor, one was promoted to Professor, and one was promoted to Scientist 'F'. Prof. Pratip Kumar Mukhopadhyay, Prof. Sandip Kumar Chakrabarti and Prof. Ranjan Chaudhury superannuated during this year.

The following faculty members received awards/recognitions:

Prof. Anjan Barman

- Program Committee Member of ICMFS-2018 Conference, University of California, Santa Cruz, USA, July 22-27, 2018.

Prof. Arup Kumar Raychaudhuri

- SERB Distinguished Fellowship

Prof. Kalyan Mandal

- "Alexander von Humboldt Foundation Fellowship" (September-October 2018)
- Cover Feature: Investigating the Role of Oxygen Vacancies and Lattice Strain Defects on the Enhanced Photoelectrochemical Property of Alkali Metal (Li, Na, and K) Doped ZnO Nanorod Photoanodes (ChemElectroChem 8/2018) K Karmakar, A Sarkar, K Mandal, GG Khan - ChemElectroChem, 2018

Dr. Manik Pradhan

- Guest of Honour Felicitation by Department of Physics, IITRAM, Ahmedabad on 6th October, 2018 for delivering invited lecture and chairing the session at the conference.

Prof. Partha Guha

- TUBITAK (The Scientific and Technological Research Council of Turkey) 2221 Fellowship.13.

Prof. Samir Kumar Pal

- Abdul Kalam Technology Innovation National Fellowship 2018
- Professor P. K. Bose Memorial Award 2016 (Indian Chemical Society)

Dr. Sunandan Gangopadhyay

- Top Cited Author Award 2018 for the paper titled "Constraints on the Generalized Uncertainty Principle from black-hole thermodynamics", Euro. Phys. Lett. 112, 20006, (2015), IOP Publishing Top 1% most-cited papers in Physics published over the period of 2015–2017.

Prof. Tanusri Saha-Dasgupta (on lien to IACS)

- Elected as a Fellow of The World Academy of Sciences (TWAS) for the advancement of science in developing countries, effective 1 January 2019.

Archan S. Majumdar
Dean (Faculty)

DEAN, ACADEMIC PROGRAMME

We are proud to present the Dean (AP)'s Annual Report on the Academic activities and the Visitors Linkage programme of the Centre during the period April 2018- March 19.

As one of the India's leading academic Institution in Basic Sciences, we, the members strive to provide all the necessary resources for carrying out the research work to our esteemed faculty members and their respective students and post doctoral fellows. The primary goal being creation of knowledge and related technologies. Serious efforts are made to see to it that the benefits of the created knowledge and technology can percolate down to the well being of the society at large. It is indeed quite inspiring to see the many of the deep ideas emanated from this Centre and eventually got translated into useful technology.

Besides, the year 2018 was of very important significance to all the members of the Centre as we celebrated 125th Birth Anniversary of Legendary Physicist, Professor Satyendra Nath Bose through out the year .The curtain raiser programme of this year long celebration was unveiled by the Honorable Prime Minister of India, Sri Narendra D. Modi on 1st January 2018,on the Birth date of Prof. S.N. Bose. Several international and national conferences were held where eminent physicists and mathematicians participated as speakers. Also several BOSE 125 Distinguished and Public Lectures were held to commemorate the contribution of Professor Satyendra Nath Bose.

This report highlights achievements in each of our programme conducted at the Centre i.e, Integrated Ph.D. Programme & PhD. Programme. In the academic year 2018-19, a total of 27 students joined the PhD Programme including students promoted as JRF from IPhD Programme. Of these, 01 joined Astrophysics & Cosmology, 11 joined Condensed Matter Physics and Material Science, 07 joined Chemical, Biological and Macromolecular Sciences and 08 joined Theoretical Sciences. While 13 students joined Integrated Ph.D. Programme (Post B.Sc.) of the Centre.

It is my privilege to work with this group of incredibly thoughtful, energetic and inspiring faculty members, teachers, administrative staff and students. The innovations and achievements highlighted in this report – as well as the many other successes not profiled – are the outcome of relentless efforts by countless individuals, whose dedication to the program and our students has been unwavering.

COURSES TAUGHT IN 2018-19

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

1st Semester:

- PHY 101, Classical Dynamics, Amitabha Lahiri;
- PHY 102, Mathematical Methods, Manu Mathur;
- PHY 103, Quantum Mechanics I, M Sanjay Kumar;
- PHY 104, Computational Methods in Physics I, Subhrangshu S Manna;
- PHY 191, Basic Laboratory I, Samir Kumar Pal & Soumen Mondal.

2nd Semester:

- PHY 201, Statistical Mechanics, Jaydeb Chakrabarti;
- PHY 202, Quantum Mechanics II, M Sanjay Kumar;
- HY 203, Electromagnetic Theory, Sunandan Gangopadhyay;
- PHY 204, Computational Methods in Physics II, Punyabrata Pradhan;
- PHY 291, Basic Laboratory II, Kalyan Mandal & Pratip Kumar Mukhopadhyay.

3rd Semester:

- PHY 301, Atomic & Molecular Physics, Anjan Barman & Rajib Kumar Mitra;
- PHY 302, Condensed Matter Physics, Kalyan Mandal & Manoranjan Kumar;
- PHY 303, Advanced Quantum Mechanics & Applications,

Sunandan Gangopadhyay;

- PHY 304, Project Research II, Faculty Supervisors;
- PHY 391, Methods of Experimental Physics, Kalyan Mandal (Coordinator), Rajib Kumar Mitra, Thirupathaiah Setti, Manik Pradhan, Ramkrishna Das & Madhuri Mandal.

4th Semester:

- PHY 401, Project Research III, Faculty Supervisors;
- PHY 402, Seminar Course, Faculty Experts;
- PHY 403, Astrophysics & Cosmology, Soumen Mondal & Ramkrishna Das;
- PHY 405, Biological Physics, Rajib Kumar Mitra;
- PHY 406, Advanced Mathematical Methods, Partha Guha & Samir Kumar Paul;
- PHY 412, Physics of Materials, Priya Mahadevan & Ranjan Chaudhury;
- PHY 413, Quantum Information Theory, Manik Banik.

Ph.D. Programme

Course Work Programme

- PHY 501, Research Methodology, Atindra Nath Pal & Sugata Mukherjee;
- PHY 502, Review of the Topical Research, Faculty Supervisors;
- PHY/CB 591, Project Research, Faculty Supervisors;
- CB 523, Advanced Equilibrium Statistical Mechanics, Jaydeb Chakrabarti & Gautam Gangopadhyay;
- •• CB 527, Molecular Physics & Spectroscopy, Rajib Mitra & Anjan Barman;
- •• PHY 503, Condensed Matter Physics, Kalyan Mandal & Manoranjan Kumar;
- PHY 504, Computational Methods in Physics, Subhrangshu S Manna;
- PHY 613, Quantum Information Theory, M Sanjay Kumar;
- PHY 616, Observational Techniques in Astronomy, Soumen Mondal & Ramkrishna Das;
- CB 521, Numerical Methods, Suman Chakrabarty;
- •• CB 526, Fundamentals of Biophysics, Rajib Kumar Mitra;
- •• PHY 507, Mathematical Methods, Partha Guha & Samir Kumar Paul;
- PHY 510, Astrophysics, Soumen Mondal & Ramkrishna Das
- PHY 601, Advanced Condensed Matter Physics I, Atindra Nath Pal & Thirupathaiah Setti;
- PHY 602, Advanced Condensed Matter Physics II Priya Mahadevan & Ranjan Chaudhury;
- PHY 613, Quantum Information Theory, Manik Banik.

Note: •• Conducted partially in combination with IPhD Programme.

Ph.D. THESIS WORK COMPLETED

1. **A Study of Geometry, Physics and Integrability of Geodesics on Curved Spaces**, Sumanto Chanda, Supervisor: Partha Guha, in University of Calcutta, in May 2018
2. **Field theories on curved spacetimes with boundaries**, Fernandes Karan Arthur, Supervisor: Amitabha Lahiri, in University of Calcutta, in July, 2018
3. **Effect of extra-cellular nutrient environment and intra-cellular biochemical conditions on the chemotactic performance of E. coli**, Subrata Dev, Supervisor: Sakuntala Chatterjee, in University of Calcutta, in July, 2018
4. **Electronic Structure of Ni-Mn Based Heusler Alloys**, Soumyadipta Pal, Supervisor: Chhayabrita Maji & Priya Mahadevan, in University of Calcutta, in July, 2018
5. **Studies of fluctuations in systems of self-propelled particles**, Subhadip Chakraborti, Supervisor: Punyabrata Pradhan, in University of Calcutta, in July, 2018
6. **Investigation On The Structure And Dynamics Of Water Molecules Around Electrolytes And Biologically Important Molecules**, Debasish Das Mahanta, Supervisor: Rajib Kumar Mitra, in University of Calcutta, in July, 2018
7. **Microscopic Insight To Protein Functions**, Sutapa Dutta, Supervisor: Jaydeb Chakrabarti & Mahua Ghosh, in University of Calcutta, in July, 2018
8. **Synthesis Of Inorganic-Organic Hybrid Nanocomposites For Environmental Application**, Sankar Das, Supervisor: Subhra Jana & Gautam Gangopadhyay, in University of Calcutta, in July, 2018
9. **Coarsening, Steady-State And Phase Transition In Self-Propelled Particles**, Rakesh Das, Supervisor: Manoranjan Kumar, in University of Calcutta, in July, 2018
10. **Information Theoretic Aspects of Some Non-**

Gaussian Classical and Quantum Optical Fields, Nirnay Samanta, Supervisor: Rajib Kumar Mitra, in University of Calcutta, in July, 2017

11. **Spontaneous Evolution of Long-range Correlations in Dynamical Systems**, Soumyakanti Bose, Supervisor: M Sanjay Kumar, in University of Calcutta, in August, 2018
12. **Studies on Superconducting Pairing Mechanism in Low Dimensional Materials**, Soumi Roy Chowdhury, Supervisor: Ranjan Chaudhury, in University of Calcutta, in September, 2018
13. **Synthesis And Study of Physical Property Of Binary Oxide Nanostructures, Thin Film And Devices**, Samik Roy Moulik, Supervisor: Barnali Ghosh (Saha), in University of Calcutta, in September, 2018
14. **Electronic Structure and Magnetic Properties of Graphene Derivatives and Graphene-based Composite Structures**, Dhani Nafday, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in September, 2018
15. **Theoretical Studies on Molecular Quantum Dynamics and Electron Transport**, Anirban Karmakar, Supervisor: Gautam Gangopadhyay, in University of Calcutta, in 2018
16. **Mechanical And Electronic Properties of Technologically Important Materials**, Poulami Chakraborty, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in October, 2018
17. **Surface Modified Transition Metal Oxide based Magnetic Nanostructures for Intrinsic Fluorescence, Catalytic Properties and Drug Delivery**, Souvanik Talukdar, Supervisor: Kalyan Mandal, in University of Calcutta, in January, 2019
18. **Aspects of Two Higgs Doublet Models**, Ambalika Biswas, Supervisor : Amitabha Lahiri, in University of Calcutta, in January, 2019.
19. **Some Studies of Percolation Phenomena in Disordered Systems**, Sumanta Kundu, Supervisor: Subhrangshu S Manna, in University of Calcutta, in February, 2019
20. **Force generation of actin filaments growing against a barrier**, Raj Kumar Sadhu, Supervisor: Sakuntala Chatterjee, in University of Calcutta, in February, 2019
21. **Studies of Cool And Evolved Stars**, Supriyo Ghosh, Supervisor: Soumen Mondal, in University of Calcutta, in March, 2019

Ph.D. AWARD RECEIVED

1. **Interlinking Fundamental Quantum Concepts with Inforamtion Theoretic Resources**, Shiladitya Mal, Supervisor: Archan S Majumdar, in University of Calcutta, in April, 2018
2. **Study on Entanglement and its Utility in Information Processing**, Sovik Roy, Supervisor: Archan S Majumdar, in University of Calcutta, in June, 2018
3. **Experimental and Theoretical Studies of Magnetic Alloys**, Tanmoy Ghosh, Supervisors: Pratip Kumar Mukhopadhyay, in University of Calcutta, in June, 2018
4. **Experimental Study of Spin Waves in Ferromagnetic Thin Films and Nanostructures**, Chandrima Banerjee, Supervisor: Anjan Barman, in Jadavpur University, in June, 2018
5. **Nonequilibrium Features of Voltage Gated Sodium Ion Channel**, Krishnendu Pal, Supervisor: Gautam Gangopadhyay, in University of Calcutta, in June, 2018
6. **Biophysical and Structural Characterization of Bacterial Protein STY3178**, Paramita Saha, Supervisor: Mahua Ghosh, in University of Calcutta, in July, 2018
7. **Study of Bipartite and Multipartite Quantum Nonlocality : Some Perspectives**, Subhadipa Das, Supervisors: Archan S Majumdar, in University of Calcutta, in July, 2018
8. **Cavity Enhanced Absorption Spectroscopy and its Application to Molecular Detection of Diabetes Mellitus**, Chiranjit Ghosh, Supervisors: Manik Pradhan, in University of Calcutta, in July 2018
9. **Integrated Cavity Output Spectroscopy And Its Non-Invasive Applications In Biomedical Diagnosis**, Suman Som, Supervisor Manik Pradhan, in University of Calcutta, in July, 2018
10. **Spectroscopic Studies On Nanomaterials For Solar Energy Harvesting Application**, Prasenjit Kar, Supervisor: Samir Kumar Pal, in University of Calcutta, in July, 2018
11. **Synthesis And Physical Properties Of Manganite Nanowires**, Subarna Datta, Supervisor: Barnali Ghosh (Saha), in University of Calcutta, in September, 2018
12. **Studying the Effects of Different Cosolutes on Protein Conformational Stability, Hydration Dynamics and Activity**, Nirnay Samanta, Supervisors: Rajib Kumar Mitra, in University of Calcutta, in September, 2018
13. **Microscopic Model For Spin, Orbital And Charge Ordering In Transition Metal Compounds**, Shishir Kumar Pandey, Supervisor Priya Mahadevan, in University of Calcutta, in September, 2018

14. **Role of structure in determining the properties of transition metal / post transition metal compounds**, Sagar Sarkar, Supervisor Priya Mahadevan, in University of Calcutta, in September, 2018
15. **Investigation of electronic conduction and magnetism in ferromagnetic Gd and ferrimagnetic GdCo alloy nanostructures**, Manotosh Chakravorty, Supervisor: Arup K Raychaudhuri, in University of Calcutta, in October, 2018
16. **Multi-wavelength Studies on Galactic H II regions**, Somnath Dutta, Supervisor: Soumen Mondal, in University of Calcutta, in October, 2018
17. **Thermodynamic characterisation of nonequilibrium steady states and study of phase transitions**, Arghya Das, Supervisor: Punyabrata Pradhan, in University of Calcutta, in November, 2018
18. **First Principles Study On Transition Metal Compounds Using Density Functional Theory**, Kartik Samanta, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in November, 2018
19. **Additivity Property and Mass Fluctuation in Conserved - Mass Transport Processess**, Sayani Chatterjee, Supervisor: Punyabrata Pradhan, in University of Calcutta, in January, 2019
20. **Exotic Phases in Frustrated Low Dimensional Spin Systems**, Aslam Parvej, Supervisor: Manoranjan Kumar, in University of Calcutta, in January, 2019
21. **Some Implications of Gauge Invariant Masses of Vector Bosons**, Ishita Dutta Choudhury, Supervisor: Amitabha Lahiri, in University of Calcutta, in February, 2019
22. **Study of Electronic Structure of Organic and Inorganic Complexes**, Hrishit Banerjee, Supervisor: Tanusri Saha Dasgupta & Manoranjan Kumar, in University of Calcutta, in March, 2019
23. **Electronic structure of Two-Dimensional Nanomaterials: Transport and Other Properties**, D'Souza Ransell Richard, Supervisor Sugata Mukherjee & Tanusri Saha Dasgupta, in University of Calcutta, in March, 2019

POST-DOC PLACEMENT

Sumanto Chanda - Postdoctoral Fellow, ICTS, Bangalore

Hrishit Banerjee - ICTP TRIL Fellowship, Chieti, Italy / Postdoc, ITPCP, TU Graz

Fernandes Karan Arthur – Post Doctoral Fellow, HRI, Allahabad

Subrata Dev - Postdoctoral Fellow, department of Biotechnology Processes at the Service of the Environment (PROSE), IRSTEA, Antony, France

Soumyadipta Pal - Assistant Professor, IEM, Kolkata

Debasish Das Mahanta – Post Doctoral Researcher, Ruhr University, Bochum, Germany

Sutapa Dutta - Postdoctoral Researcher, Dept. of Chemical Sciences, University of Padova, Italy

Sankar Das – PDRA, University of ULSAN, South Korea

Rakesh Das – PDRA, National University of Singapore, Singapore

Nirnay Samanta - Research Assistant, Technical University of Braunschweig, Germany

Soumyakanti Bose - PDRA, IISER, Mohali

Dhani Nafday – PDRA, Asia Pacific Centre for Theoretical Physics, South Korea

Anirban Karmakar – Asst . Professor, Calcutta Institute of Engineering and Management

Poulami Chakraborty - Post-doctoral Reaearch Fellow, Max Planck Institut fur Eisenforschung

Sumanta Kundu - Post-doctoral Reaearch Fellow, Osaka University, Japan

Subhadip Chakraborti – PDRA, International Centre for Theoretical Sciences, Bengaluru, India

Raj Kumar Sadhu - Project - SRF, SNBNCBS

Supriyo Ghosh - Visiting Fellow, TIFR, Mumbai

Shiladitya Mal - PDRA, HRI, Allahabad

Sovik Roy - Assistant Professor, Techno India

Tanmoy Ghosh - Research Associate, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)

Chandrima Banerjee –Post Doctoral Fellow ,Trinity College Dublin, Ireland.

Krishnendu Pal - Postdoctoral Researcher, IACS, under DBT-RA Fellowship

Paramita Saha - PDRA, University of Oklahoma

Subhadipa Das - Assistant Professor, Hari Mohan Ghosh College

Chiranjit Ghosh - Postdoctoral Fellow, University of Waterloo, Canada

Suman Som - PDF, Praque, Czech Republic

Prasenjit Kar - Postdoctoral Fellow, IIT, Kanpur

Subarna Datta - Research Associate, Saha Institute of Nuclear Physics

Nirnay Samanta - Research Assistant, Technical University

of Braunschweig, Germany

Shishir Kumar Pandey - Visiting Scholar, Dept. of Theoretical Condensed Matter Physics, IOP, Bhubaneshwar

Sagar Sarkar - Research Associate, APCTP inside POSTECH, Pohang, South Korea

Manotosh Chakravorty - High School Teacher, WB

Somnath Dutta - Postdoctoral Fellow, IIT, Tirupati

Arghya Das - Postdoctoral Fellow, International Centre for Theoretical Sciences, Bangalore

Kartik Samanta - Post-doctoral Researcher, Peter Grunberg Institut and Institute for Advanced Simulation, Forschungszentrum Julich GmbH, Germany

Sayani Chatterjee - Research Asssociate, JNCASR, Bangalore

Aslam Parvej - Post-doctoral Researcher, Ulsan National Institute of Science & Technology, Ulsan, South Korea

Hrishit Banerjee - ICTP TRIL Fellowship, Chieti, Italy / Postdoc, ITPCP, TU Graz

D'Souza Ransell Richard - Postdoctoral Researcher, Tyndall National Institute, UCC, Ireland

RESEARCH SCHOLARS - Ph.D. PROGRAMME
(by Year of Joining)

SENIOR RESEARCH FELLOW	Supervisor
2012-2013:	
1. Abhijit Maity (INSPIRE) till 01/05/2018	Manik Pradhan
2. Abhishek Roy (SNB) till 31.7.2018	Sandip Kumar Chakrabarti
3. Anindita Mondal (SNB) till31.7.2018	Ramkrishna Das & Soumen Mondal
4. Arnab Deb (SNB) till 31.7.2018	Sandip Kumar Chakrabarti
5. Arpita Mitra (SNB) till 31.7.2018	Rabin Banerjee
6. Chandrima Banerjee (CSIR) till 25/07/2018	Anjan Barman
7. Chiranjit Ghosh (SNB) till 16/04/2018	Manik Pradhan
8. Gourab Dutta Banik (INSPIRE) till 24/07/2018	Manik Pradhan
9. Hrishit Banerjee (SNB) till 12/06/2018	Tanusri Saha Dasgupta & Manoranjan Kumar
10. Karan Savio Fernandes (SNB) till 31/07/2018	Amitabha Lahiri
11. Krishnendu Pal (SNB) till 06/07/2018	Gautam Gangopadhyay
12. Nirnay Samanta (SNB) till 10/05/2018	Rajib Kumar Mitra
13. Poulami Chakraborty (SNB) till 11/10/2018	Tanusri Saha Dasgupta
14. Sagar Sarkar (CSIR) till 20/07/2018	Priya Mahadevan
15. Somnath Dutta (SNB) till 25/07/2018	Soumen Mondal
16. Subarna Datta (SNB) till 11/07/2018	Barnali Ghosh (Saha)
17. Subrata Dev (SNB) till 31/07/2018	Sakuntala Chatterjee
18. Suman Som (SNB) till 26/07/2018	Manik Pradhan
19. Sumanto Chanda (SNB) till 25/05/2018	Partha Guha
20. Supriyo Ghosh (SNB) till 31/07/2018	Soumen Mondal
2013-2014:	
21. Arindam Ghosh (SNB)	Sandip Kumar Chakrabarti
22. Poonam Kumari (SNB)	Priya Mahadevan
23. Raj Kumar Sadhu (SNB) till 31/01/2019	Sakuntala Chatterjee
24. Rakesh Das (SNB)	Manoranjan Kumar
25. Ransell Richard Dsouza (SNB)till 16/02/2019	Sugata Mukherjee & Tanusri Saha Dasgupta
26. Ravindra Singh Bisht (SNB)	Arup Kumar Raychaudhuri
27. Sankar Das (SNB)	Subhra Jana & Gautam Gangopadhyay
28. Shaili Sett (SNB)	Arup Kumar Raychaudhuri
29. Souvanik Talukdar (SNB) till 31/01/2019	Kalyan Mandal

30. Subhadip Chakraborti (SNB) till 31/10/2018 — Punyabrata Pradhan
31. Sutapa Dutta (INSPIRE) till 09/01/2019 — Jaydeb Chakrabarti & Mahua Ghosh

2014-2015:

32. Anuvab Banerjee (SNB) — Sandip Kumar Chakrabarti
33. Atanu Baksi(CSIR) — Ranjit Biswas
34. Debasmita Maiti (SNB) — Manoranjan Kumar
35. Ejaj Tarif (SNB) — Ranjit Biswas
36. Indranil Chakraborty (SNB) — Kalyan Mandal
37. Juriti Rajbangshi (SNB) — Ranjit Biswas
38. Priya Singh (SNB) — Samir Kumar Pal
39. Sudipta Pattanayak (SNB) — Manoranjan Kumar & M. Sanjay Kumar
40. Suraka Bhattacharjee (INSPIRE) — Ranjan Chaudhury
41. Joydeep Chatterjee (CSIR) — Priya Mahadevan
42. Sarowar Hossain (TWAS BOSE) — Pratip Kumar Mukhopadhyay
43. Anulekha De (INSPIRE) — Anjan Barman & Rajib Kumar Mitra
44. Damayanti Bagchi (INSPIRE) — Samir Kumar Pal
45. Debabrata Ghorai (INSPIRE) — Sunandan Gangopadhyay & Biswajit Chakraborty
46. Dhrimadri Khata (INSPIRE) — Soumen Mondal
47. Keshab Karmakar (INSPIRE) — Kalyan Mandal
48. Mahebub Alam (INSPIRE) — Kalyan Mandal
49. Mithun Pal (INSPIRE) — Manik Pradhan
50. Samrat Ghosh (INSPIRE) — Soumen Mondal
51. Sucheta Mondal (INSPIRE) — Anjan Barman
52. Sandip Saha (RGNF) — Gautam Gangopadhyay
53. Tuhin K Maji (INSPIRE) — Samir Kumar Pal

2015-2016:

54. Kajal Kumbhakar (CSIR) — Ranjit Biswas
55. Jayita Patwari (CSIR) — Samir Kumar Pal
56. Aniruddha Adhikari (SNB) — Samir Kumar Pal
57. Chandan Samanta (SNB) — Barnali Ghosh (Saha)
58. Avisek Maity (SNB) — Barnali Ghosh (Saha)
59. Rahul Bandyopadhyay (SNB) — Ramkrishna Das
60. Alik Panja (SNB) — Soumen Mondal
61. Arnab Sarkar (SNB) — Archan S Majumdar
62. Shounak Datta (INSPIRE) — Archan S Majumdar
63. Dipika Mandal (CSIR) — Kalyan Mandal
64. Subrata Ghosh (CSIR) — Kalyan Mandal
65. Sudip Kumar Saha (INSPIRE) — Manoranjan Kumar
66. Shreya Das (INSPIRE) — Tanusri Saha Dasgupta
67. Bihalan Bhattacharya (INSPIRE) from 09/06/2017 — Archan S Majumdar
68. Suchetana Goswami (SNB) from 13/06/2017 — Archan S Majumdar

2016-2017:

69. Piklu Santra (UGC) — Sandip Kumar Chakrabarti
70. Prantik Nandi (CSIR) — Sandip Kumar Chakrabarti
71. Sk Imadul Islam (UGC) — Rajib Kumar Mitra
72. Partha Nandi (SNB) — Biswajit Chakraborty
73. Subhamita Sengupta (UGC) — Arup Kumar Raychaudhuri
74. Sumanti Patra (SNB) — Priya Mahadevan
75. Sayan Kumar Pal (UGC) — Biswajit Chakraborty
76. Akash Das (UGC) — Manik Pradhan
77. Saikat Pal (CSIR) — Rajib Kumar Mitra
78. Ikbal Ahmed (INSPIRE) till 23.11.2018 — Manik Pradhan
79. Sasthi Charan Mandal (CSIR) — Manik Pradhan
80. Koushik Mandal (UGC) — Ranjan Chaudhury & Manoranjan Kumar
81. Priyanka Saha (INSPIRE) — Kalyan Mandal
82. Dipanjan Maity (CSIR) — Kalyan Mandal

JUNIOR RESEARCH FELLOW

2017-2018:

83. Arka Chatterjee(INSPIRE) — Samir Kumar Pal
84. Edwine Tendong (TWAS BOSE) — Tanusri Saha Dasgupta
85. Souma Mazumdar(SNB) — Partha Guha
86. Anirban Mukherjee(INSPIRE) — Punyabrata Pradhan
87. Shubhadip Moulik — Atindra Nath Pal
88. Vishal Kumar Aggarwal (SNB) — Arup Kumar Raychaudhuri & Manik Pradhan
89. Arundhati Adhikari(SNB) — Anjan Barman
90. Parushottam Maji (SNB) — Arup Kumar Raychaudhuri & Barnali Ghosh(Saha)

91.	Didhiti Bhattacharya(SNB)	Samit Kumar Ray & Rajib Kumar Mitra
92.	Koustav Dutta(INSPIRE)	Anjan Barman
93.	Amrit Kumar Mondal(SNB)	Anjan Barman
94.	Sayantan Adak(SNB) till 11.03.2019	Rajib Kumar Mitra
95.	Sk Saniur Rahaman(UGC)	Manoranjan Kumar & M. Sanjay Kumar
96.	Rituparna Mandal (INSPIRE)	Sunandan Gangopadhyay
97.	Abhik Ghosh Moulik(INSPIRE)	Jaydeb Chakrabarti
98.	Arpan Bera(CSIR)	Samir Kumar Pal
99.	Biswajit Pabi(INSPIRE)	Atindra Nath pal
100.	Dhrubajyoti Maji(INSPIRE)	Ranjit Biswas
101.	Indrani Kar(SNB)	Thirupathia Setti
102.	Jayanta Mondal(INSPIRE)	Ranjit Biswas
103.	Rafiqul Alam(INSPIRE)	Atindra Nath Pal
104.	Rahul Karmakar(INSPIRE)	Jaydeb Chakrabarti
105.	Shuvrasish Mukherjee (INSPIRE)	Samit Kumar Ray & Atindra Nath Pal
106.	Siddhartha Biswas(INSPIRE)	Soumen Mondal

2018-2019:

107.	Sumana Pyne	Rajib Kumar Mitra
108.	Dipanjan Mukherjee	Samir Kumar Pal
109.	Biswajit Panda	Manik Pradhan
110.	Narayan Chandra Maity	Ranjit Biswas
111.	Shobhan Dev Mandal	Sakuntala Chetterjee
112.	Premashis Kumar	Gautam Gangopadhyay
113.	Tribhuban Parida	Subhranshu Sekhar Manna
114.	Anish Das	Biswajit Chakraborty
115.	Md Nur Hasan	Samir Kumar Pal
116.	Tanmoy Chakraborty	Punyabrata Pradhan
117.	Susmita Mondal	Samir Kumar Pal
118.	Deepsikha Das	Sakuntala Chetterjee & Punyabrata Pradhan
119.	Prasun Boyal	Priya Mahadevan
120.	Debayan Mondal	Priya Mahadevan
121.	Jyotirmoy Sau	Manoranjan Kumar
122.	Monalisa Chatterjee	Manoranjan Kumar
123.	Siddharth Kumar Sahoo till Dec 2018	Thirupathaiah Setti
124.	Susmita Changdar	Thirupathaiah Setti
125.	Pratap Kumar Pal	Anjan Barman
126.	Shivam Mishra	Priya Mahadevan

RESEARCH SCHOLARS - INTEGRATED Ph.D. PROGRAMME

SENIOR RESEARCH FELLOW	Supervisor

2010–2011:

127.	Arpan Krishna Mitra (SNB) till 31.7.2018	Rabin Banerjee
128.	Soumyakanti Bose (SNB) till 31.07.2018	M. Sanjay Kumar
129.	Suman Dutta (SNB) till 31.01.2018	Jaydeb Chakrabarti

2011–2012:

130.	Anita Halder (SNB)	Tanusri Saha Dasgupta
131.	Chandreyee Roy (SNB) till 28.05.2019	Subhrangshu Sekhar Manna
132.	Debasish Das Mahanta (INSPIRE)	Rajib Kumar Mitra
133.	Shauri Chakrabarty (SNB)	Sakuntala Chatterjee
134.	Sumanta Kundu (SNB) till 06.02.2019	Subhrangshu Sekhar Manna

2013–2014:

135.	Ayan Bhattacharjee (SNB)	Sandip Kumar Chakrabarti
136.	Monalisa Singh Roy (SNB)	Manoranjan Kumar
137.	Samiran Choudhury (SNB)	Anjan Barman
138.	Vibhuti Narayan Rai (SNB) till 20.06.2017	Arup Kumar Raychaudhuri

2014–2015:

139.	Amal Garai (SNB) till 04.07.2017	Punyabrata Pradhan
140.	Ankan Pandey (SNB)	Partha Guha
141.	Avinash Kumar Chaurasiya (INSPIRE)	Anjan Barman
142.	Riddhi Chatterjee (SNB)	Archan S Majumdar
143.	Ritam Basu (SNB) till 27.06.2018	Amitabha Lahiri

144. Sanchi Maithani (INSPIRE) — Manik Pradhan
145. Santanu Mandal (SNB) till 23.04.2018 — Manik Pradhan

JUNIOR RESEARCH FELLOW

2015–2016:

146. Ananda Gopal Maity(SNB) — Archan S Majumdar
147. Arunava Adak (SNB) — Jaydeb Chakrabarti
148. Ruchi Pandey (SNB) — Ramkrishna Das
149. Sourav Sahoo (SNB) — Anjan Barman

2016–2017:

150. Anupam Garain(SNB) — Kalyan Mandal
151. Atul Rathod(SNB) — Manu Mathur
152. Shantonu Mukherjee(SNB) — Amitabha Lahiri
153. Shashank Gupta(SNB) — Archan S Majumdar
154. Sudip Majumder(SNB) — Anjan Barman & Rajib Kumar Mitra
155. Surya Narayan Panda(SNB) — Anjan Barman
156. Swarnali Hait(SNB) — Kalyan Mandal

2017-2018:

157. Achintya Low — Thirupathaiah Setti
158. Ankur Srivastav — Sunandan Gangopadhyay
159. Anuj K Dhiman till July 2019
160. Anwesha Chakraborty — Biswajit Chakraborty
161. Megha Dave — Ramkrishna Das
162. Raghvender — Jaydeb Chakrabarti and Tanusri Saha Dasgupta
163. Sayan Routh — Thirupathaiah Setti
164. Neeraj Kumar — Sunandan Gangopadhyay

PROJECT FELLOWS / ASSISTANTS / TRAINEES

2015-2016	**Project PI**
165. Dhiraj Tapader (Project JRF- till 8.9.2018)	Punyabrata Pradhan

2016-2017

166. Arnab Samanta (Project JRF) — Subhra Jana
167. Animesh Halder (Project SRF –till 10.5.2018) — Samir Kumar Pal

2017-2018

168. Sudipta Chatterjee (Project SRF) — Arup Kumar Raychaudhuri & Barnali Ghosh (Saha)
169. Anirban Goswami (Project SRF) — Arup Kumar Raychaudhuri & Barnali Ghosh (Saha)

2018-2019

170. Sourav Kanthal (Project JRF) — Anjan Barman & Tanusri saha DasGupta
171. Saikat Mitra (Project JRF) — Barnali Ghosh (saha) & Manik Pradhan
172. Suman Mondal — Tatini Rakshit

INTEGRATED Ph.D. PROGRAMME

2017-2018:

173. Harmit Jaysukhlal Joshi
174. Nivedita Pan
175. Parthapratim Mahapatra
176. Riju Pal
177. Samir Rom
178. Shubham purwar
179. Manjari Dutta

2018-2019:

180. Soham Saha
181. Patel Gauravkumar Ishwarbhai
182. Varsha Jangir
183. Ankita Rojaria
184. Animesh Hazra
185. Avik Sasmal
186. Ishita Jana
187. Shubham Shukla
188. Anirban Roy Chowdhury
189. Soumen Mandal
190. Rajdeep Biswas
191. Arnab Chakraborty
192. Vishwajeet Kumar

PART TIME RESEARCH SCHOLARS - Ph.D. PROGRAMME

1. Sourav Karar, Theoretical Sciences, under Sunandan Gangopadhyaya & Archan S. Majumdar, Current Affiliation: Muragacha Govt. College, Nadia.
2. Prosenjit Maity, Theoretical Sciences, Under M. Sanjay Kumar; Current Affiliation: RKM residential College, Narendrapur.
3. Abhishek Bagchi, Condensed Matter Physics and Material Sciences, under Pratip Kumar Mukhopadhyay
4. Piya Patra, Chemical, Biological & Macro-Molecular Sciences, under Jaydeb Chakrabarti
5. Putul Chakravorty (Malla Chowdhury), Condensed Matter Physics and Material Sciences, under Arup Kumar Raychaudhuri, Current Affiliation: School Service, WB
6. Samik Roy Moulik, Condensed Matter Physics & Material Sciences, under Barnali Ghosh (Saha), Current Affiliation: Icon Analytical Equipment Pvt. Ltd., Mumbai
7. Shirsendu Dey, Theoretical Sciences, under Rabin Banerjee, Current Affiliation: Kalyani Govt. Engineering College
8. Soumendra Singh, Chemical, Biological & Macro-Molecular Sciences, under Samir Kumar Pal, Current Affiliation: Bose Institute
9. Soumyadipta Pal, Condensed Matter Physics and Material Sciences, under Chhayabrita Biswas / Priya Mahadevan (Co-Supervisor), Current Affiliation: Calcutta Institute of Technology
10. Sovik Roy, Astrophysics & Cosmology, under Archan S. Majumdar, Current Affiliation: Techno India, Kolkata.
11. Probir Kumar Sarkar, Chemical, Biological & Macro-Molecular Sciences under Samir Kumar Pal ; Current Affiliation: Anandamohan College, Kolkata
12. Santanu Pan, Condensed Matter Physics and Material Sciences, under Anjan Barman, Current Affiliation: Netaji Nagar Day College,Kolkata
13. Kartik Adhikari, Condensed Matter Physics and Material Sciences, under Anjan Barman; Current Affiliation: New Alipore College
14. J.Wellington, Condensed Matter Physics and Material Sciences, under Samit Kumar Ray; Current Affiliation: , IIT Delhi

PROJECT RESEARCH

B.Tech. / M. Tech. / M. Sc. Projects

Name	Affiliation	Course of Study	Title of Project	Supervisor/Mentor
Surajit Basak	Jadavpur University	M.Sc.	Development of automated charging-discharging current unit & Applying it measure current relaxation in Barium Titanate"	Prof. Arup Kumar Raychaudhuri
Kankana Bhattacharjee	National Institute of Technology, Agartala	BS-MS	Molecular dynamics simulation study of water dynamics in a rhodopsin channel	Dr. Suman Chakrabarty

Name	Affiliation	Course of Study	Title of Project	Supervisor/Mentor
Surender Kumar	Central University of Haryana	M.Sc.	Origin of Almost Invariant Magnetic Ordering Temperature in Alkali Metal Oxoferrates AF eO2. (Where A= K, Rb, Cs).	Prof. Priya Mahadevan
Writasree Maitra	IIT Bombay	M.Sc.	Rotor –Router Model	Prof. Subhrangshu Sekhar Manna
Srestha Banik	IIT Bombay	M.Sc.	Spanning Trees in two dimension	Prof. Subhrangshu Sekhar Manna
Mouli Hazra	IIT Bombay	M.Sc.	Study of Critical height model of sand pile	Prof. Subhrangshu Sekhar Manna
Ritesh Bachhar	IIT Bombay	M.Sc.	Critical slope model of sandpile in two dimensional Lattice	Prof. Subhrangshu Sekhar Manna
Gaurav Kumar Arya	Central University of Haryana	M.Sc.	Synthesis and characterization of Silicon and Germanium nanowires and fabrication of an Optical Detector using nanowires.	Prof. Arup Kumar Raychaudhuri and Dr. Barnali Ghosh(Saha)
Tamanna Kumari	Central university of Haryana	M.Sc.	Synthesis of Palladium nanoparticles by Pulse Laser Ablation in liquid (PLAL) and their characterization	Prof. Arup Kumar Raychaudhuri and Dr. Barnali Ghosh(Saha)
Oindrila Sinha	Presidency University	B.Sc.	Investigation of antimicrobial effect of Ozonated Olive Oil	Prof. Samir Kumar Pal

SUMMER RESEARCH PROGRAMME:

Sl No	Candidate	Present University/ Institute	Supervisor
1.	Sk Asrap Murshed	IIT, Kanpur	Amitabha Lahiri
2.	Pankaj Gupta	College of Commerce, arts, and science Patna	Anjan Barman
3.	Vikramaditya Mondal	IISER, Mohali	Archan S Majumdar
4.	Swadhiti Maji	IIT, Kharagpur	Atindra Nath Pal
5.	Soumi Dey	University of Hyderabad	Biswajit Chakraborty
6.	Aditya Singha	Assam University	Gautam Gangopadhyay
7.	Arpan Chakraborty	University of Hyderabad	Gautam Gangopadhyay
8.	Ranajay Datta	University of Hyderabad	Jaydeb Chakrabarti
9.	Agneesh Pratim Das	Central University of South Bihar	Jaydeb Chakrabarti

Sl No	Candidate	Present University/ Institute	Supervisor
10.	Rupam Saha	University of Hyderabad	Kalyan Mandal
11.	Saurav Mahanta	Dibrugarh University	Madhuri Mandal
12.	Mallar Banerjee	Savitribai Phule Pune University	Manik Pradhan
13.	Gokul Arakkal	University of Madras	M Sanjay Kumar
14.	Ritwick Sarkar	Ramkrishna Mission Vivekananda Educational and Research Institute	Pratip Kumar Mukhopadhyay
15.	Pronay Dutta	University of Hyderabad	Pratip Kumar Mukhopadhyay
16.	Aathira, K.P.	Sree Kerala Varma College, Thrissur	Priya Mahadevan
	Candidate	**Present University/ Institute**	**Supervisor**
17	Saikat Sadhukhan	IIT, Madras	Ramkrishna Das
18	S.Devi Bala Saraswathi	Gandhigram Rural Institute	Ranjan Chaudhury
19	Nilasha Chakrabarty	St. Xaviers' College	Samir Kumar Pal
20	Sayan Das	University of Calcutta	Samir Kumar Pal
21	Ravi Raja Buddhaya	Osmania University	Soumen Mondal
22	Adreja Mondal	University of Calcutta	Subhrangshu Sekhar Manna
23	Arnab Mukherjee	Jadavpur University	Sunandan Gangopadhyay

Educational Visit:

1) St. Xavier's College, Kolkata, Date: 09-April-2018
2) University Of Kalyani, Date: 03-August-2018
3) Kendriya Vidyalaya II, 17- August-2018
4) S.S. College, Hailakandi, Assam; Date: 17-March-2019
5) Mizoram University,Mizoram, Date: 29.01.2019

National Science Day 2019:

The Centre observed National Science Day on 28th February, 2019. Students from the following colleges and universities participated in the programme:

1. Serampore College
2. Rammohan College
3. Barasat Government College
4. Raja Peary Mohan College
5. Scottish Church College
6. University of Calcutta
7. Jadavpur University

The programme schedule included popular scientific lectures by renowned speakers:

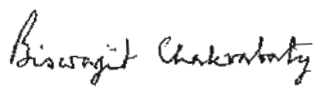
- Dr. S. P. Gon Chaudhuri, Chairman, N B Institute for Rural Technology, India
- Prof. Frederik Scolz, Director, National Institute for Theoretical Physics (NITheP) South Africa
- Prof. Kalyan Mandal, Senior Professor and In-charge, Technical Cell, S N Bose National Centre for Basic Sciences, Kolkata
- Prof. Samir Kumar Pal, Senior Professor, S N Bose National Centre for Basic Sciences, Kolkata

Students were also visited the research facilities of the Centre.

List of Awards received by Scholars:

- Sucheta Mondal, SRF, CMPMS Department, won the Best Poster Award in the "International Conference on Nanoscience and Technology (ICONSAT 2018), held during Mar. 21-23, 2018 at IISc Bangalore.
- Subrata Ghosh, SRF, CMPMS Department, awarded as Best Poster Presenter in the National Conference on 'Recent Trends in Condensed Matter Physics', held at Bose Institute, Kolkata.

- Avinash Kumar Chaurasiya, SRF, CMPMS Department, won the IEEE sponsored student-led group project with research grant of 5000 USD in "IEEE Magnetics Summer School 2018" held at Universidad San Francisco de Quito, Ecuador during 3rd - 8th June 2018.
- Anulekha De, SRF, CMPMS Department, won the First Prize for Poster Presentation in the Bose-Tagore National Advanced Workshop on "Recent Advances in Condensed Matter Physics: Theory and Experiment" held at Visva-Bharati, Shantiniketan during 3-4 August, 2018.
- Sucheta Mondal, SRF, CMPMS Department, won the Best Poster Award in the 3rd International Advanced School on Magnonics 2018 supported by IEEE Magnetics Society at Kyiv, Ukraine during September 17-21, 2018.
- Sanchi Maithani, SRF, CBMS Department, received the Best Poster Award in the "National Conference on Advances in Spectroscopy : Molecules to Materials-2018" held in Ahmedabad during 4-6 October, 2018.
- Avinash Kumar Chaurasiya, SRF, CMPMS Department, from Professor Anjan Barman's group has been selected for the 'Newton-Bhabha PhD Placement Program' Award by British Council, Department of Science and Technology and Department of Biotechnology, Govt. of India to work for 3 months in Imperial College London.
- Sanchi Maithani, SRF, CBMS Department, has received the "Best Oral Presentation Dayawati Rastogi Award" for her work on "High-resolution Cavity Ring-Down Spectroscopy" in ICOPVS-2018 held in BARC, Mumbai during 25-29 November, 2018
- Anita Halder, SRF, CMPMS Department, awarded "S.N.Bose Prize (Innovation in Theory)" for her poster in the "National Conferenece in Electronic Stuctures (NCES - 2018)" held during 17th -19th December 2018 at SRM Research Institute, Chennai.
- Vishal Kumar Aggarwal, JRF in CMPMS Department , awarded Best Presentation Award in 4th IEEE International Conference on Emerging Electronics (IEEE-ICEE) held at Bengaluru during 16th-19th December 2018.
- Sanchi Maithani, SRF, CBMS Department, received the DST-DFG award to participate in the 69th Lindau Nobel Laureate Meeting in Germany.
- Aniruddha Adhikari, SRF, CBMS Department received Gandhian Young technological Innovation Award(GYTI)2018 from Rastrapati Bhaban & SRISTI



Biswajit Chakraborty

Dean, Academic Programme

CELEBRATION OF 125th BIRTH ANNIVERSARY OF SATYENDRA NATH BOSE

Satyendra Nath Bose National Centre for Basic Science commemorated the 125th birth anniversary of Professor Satyendra Nath Bose throughout the year 2018 to pay homage to the legendary scientist. The hon'ble Prime Minister had set the tune through an embracive inaugural address on Bose's birthday, 1st January 2018 with the gracious visit of Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology, Earth Sciences and Environment, Forests and Climate Change, Government of India, Hon'ble Minister of State, Ministry of Science and Technology and Earth Sciences, the Secretary, Department of Science & Technology, Govt. of India. The Centre set off the series of celebratory events in that spirit and the period under review – April -December 2018 – witnessed the height of such programmes as catalogued seriatim:

Bose 125 Public Lecture – The Centre entitled such lectures to pay special homage to Professor S N Bose. Dr. Srikumar Banerjee, Homi Bhabha Chair Professor, BARC, Mumbai was the speaker of the 4th public lecture "New Energy Paradigm for Ensuring Energy Security and Mitigating Climate Change" on 13th November 2018. Prof. Wolfgang Ketterle, Nobel Laureate in Physics (2001) and Prof. C. N. R. Rao, Bharat Ratna were among the other speakers in this series, as reported in the review period 2017-18.

Bose 125 Public Lecture delivered by Dr. Srikumar Banerjee on 13th November 2018

BOSE-125 Memorial Lecture – Memorial Lectures are part of the endeavours that the Centre takes up annually in remembrance of the contributions that Professors S N Bose, C K Majumdar, S Chandrashekhar, and G N Ramachandran had made to Science at large. The Centre invited Prof. P. Balaram, Ex-Director Indian Institute of Science as the hon'ble speaker for the 4th G N Ramachandran Memorial Lecture "G. N. Ramachandran and his impact on the field of polypeptide and protein conformations" on 6th November, 2018.

BOSE-125 Distinguished Lectures – Scientists of renowned eminence world wide heartily responded to the invitation for Bose 125 distinguished lectures and visited the Centre during the period under review to deliver their talks of inestimable importance. All in all, there were fifteen distinguished lectures with nine of them delivered in the review period (details in EVLP report).

Distinguished Lecture by Prof. Lev Titarchuk on 9th November, 2018

BOSE-125 Conference/Symposium / Workshop - Several International & National Conferences / Symposiums were held throughout the year to celebrate the occasion. Out of total thirteen BOSE-125 Conference / Sumposium, nine were

organized during the reporting period (details in EVLP report)

International Conference on Complex and Functional Materials (ICCFM-2018) during 13- 16 December, 2018

BOSE – 125 Topical Workshop/Summer & Winter Schools : Topical Summer / Winter Schools and Workshops with lectures delivered by eminent academicians were organized for the students across India aspiring for higher studies and research, as outlined below.

i) 9th Vidyasagar Satyendranath Bose National Workshop: Science of Materials: Challenges and Prospects at Vidyasagar University during 17 – 19 January, 2018.

ii) C. K. Majumdar Memorial Summer Workshop in Physics during 23 May – 2 June, 2018.

iii) National Summer School on Statistical Physics during 4 – 15 June, 2018.

iv) Bose -Tagore National Workshop on "Recent Advances in Condensed Matter Physics" at Visva Bharati University during 3 – 4 August, 2018.

v) Winter School on Synchrotron Techniques in Materials Science during 25 – 31 October, 2018.

National Essay Competition among School Children on Contemporary Scientific Challenges – The event aimed at embracing the axiom catch them young and was triumphant as students of Classes IX to XII across the country heartily responded to the call. 30 no. of shortlisted students were invited with funding support to visit the Centre and participate in the competitions during 5 – 6 September, 2018.

BOSE – 125 Science Outreach Programmes in Schools and Colleges jointly with the host institutes – The Centre aspires to build up a symbiotic bond with teaching institutions, and thereby, reach out to the young talents. With this motivation the year saw twenty six outreach Workshop / Seminar programmes in different institutes across India (details in EVLP report). The move, the Centre believes, shall benefit both way enriching the quest for pursuing science.

Jagacha High School, Howrah, WB on Sept 25, 2018

Roychak High School, Purba Medinipur, W.B. on October 5, 2018

BOSE-125 Outreach Programmes in WB District Schools/Colleges jointly with Bangiya Bijnan Parishad – The collaborative initiative with the organization established by BOSE organized 110 lectures centering S N Bose and his work that earned him global fame. Out of the above, 101 programs were organized during the reporting period (details in EVLP report). The spontaneity among the teachers and students in remote districts in responding to the call to celebrate Bose 125 anniversary deserves high appreciations.

Jhapandanga Sabitri Debi Balika Vidyalaya on Oct 11, 2018 Purba Burdwan, W.B.

P P D High School on Oct 9, 2018 Panduk, Purba Burdwan, W.B.

BOSE-125 Outreach Lectures: Seven outreach lectures were delivered by the Faculty Members of the Centre during the reporting period – A great enthusiasm was noted among the members of the faculty to take part in visiting different institutes and deliver Bose 125 seminars.

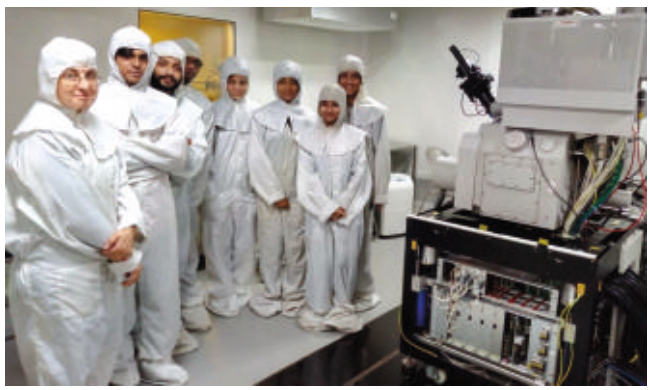
Jagadis Bose National Science Talent Search Camp on Sep 21, 2018 at Burdwan, W.B.

Science Orientation Programme on July 19, 2018 at Ranaghat, W.B.

Bose-125 Outreach: Students Visits (4)

1. Students from St. Xavier's College, Kolkata visited the Centre's Laboratories and facilities on April 9, 2018.
2. Students from University of Kalyani visited the Centre's Laboratories and facilities on August 3, 2018.

3. Outreach program on Science in Hindi for school students at the Centre on August 17, 2018.
4. Open day for school students at the Centre on 31st December, 2018.



Students from St. Xavier's College

Science outreach program in Hindi for students

Curtain raiser to India International Science Festival (IISF 2018) :

One day Public Outreach Program has been organized on 26th September, 2018 on Curtain Raiser Programme of India International Science Festival (IISF 2018) at S N Bose National Centre for Basic Sciences, Kolkata.

BOSE-125 Concluding Ceremony :

The Concluding Ceremony of 125th Birth Anniversary of S. N. Bose was held on 31st December, 2018 at S. N. Bose National Centre for Basic Sciences. A Marathon was organized by the students of the Centre in the early morning . Series of Lectures with Experimental Demonstrations were organized in the Open House for School Students in collaboration with Bangiya Bignan Parishad. Prof. Sourav Pal, Director, IISER Kolkata graced the occasion as the Chief Guest. A week long outreach program with Science Fair, Laboratory Experiments & Lectures was also organized jointly with Acharya Satyendra Nath Bose Shiksha Mancha, Midnapur College with 600 participants during the period Dec. 26, 2018 - Jan 1, 2019.

A Marathon was organized by the students of the Centre

Lectures with Experimental Demonstrations on 31st Dec,2018

EXTENDED VISITORS & LINKAGE PROGRAMME

Celebrating 125th Birth Anniversary of Prof. S.N. Bose

(1st April 2018 – 31st March 2019)

"BOSE 125" : Public Lecture

Date	Venue	Speaker & Affiliation	Title
13.11.2018	Auditorium, SINP	Dr. Srikumar Banerjee Homi Bhabha Chair Professor Bhabha Atomic Research Centre, Mumbai	New Energy Paradigm for Ensuring Energy Security and Mitigating Climate Change

Memorial Lecture:

Date	Event	Speaker & Affiliation	Title
06.11.2018	4th G. N. Ramachandran Memorial Lecture	Prof. Padmanabhan Balaram Indian Institute of Science, Bangalore	G. N. Ramachandran and his impact on the field of polypeptide and protein conformations

"BOSE 125" : Distinguished Lecture

Date	Speaker & Affiliation	Title
17.07.2018	Prof. Biman Bagchi IISC, Bangalore, Honorary Professor,SNBNCBS	Dynamics within Small Droplets: Dynamics of Water in Nano Spherical Confinement
27.07.2018	Prof. Supriyo Bandyopadhyay Virginia Commonwealth University, USA VAJRA Faculty, SNBNCBS	Straintronics: Extremely energy-efficient computing with strained nanomagnets
28.08.2018	Prof. Kankan Bhattacharyya Indian Institute of Science Education and Research, Bhopal	Live Cell Microscopy: A Physical Chemistry Approach
07.09.2018	Prof. D. D. Sarma Indian Institute of Science, Bangalore	A new generation of photovoltaic materials : Organic - inorganic hybrid perovskites
06.11.2018	Prof. Lev Titarchuk University of Ferrara and Moscow State University	Comptonization Problem and Its Solution in Application to the Spectra of the Neutron Star and Black Hole Source
22.11.2018	Prof. A. P. Balachandran Joel Dorman Steele Professor of Physics in Syracuse University	Algebraic Quantum Physics : Entanglement and Entropy
10.12.2018	Prof. Bela Mulder AMOLF, The Netherlands	Microtubules Dynamics: from Biology to physics and back

Date	Speaker & Affiliation	Title
11.12.2018	Prof. Yoshichika Otani IEEE Magnetics Society Distinguished Lecturers for 2018 University of Tokyo, Japan	Spin Conversion Phenomena in Spintronics
20.12.2018	Prof. Mustansir Barma Tata Institute of Fundamental Research, Hyderabad	Shared Histories and Correlations

Bose-125 : Conferences, Workshops and Extension Programme (CWEP)

Workshops/Seminars/Discussion/Meetings held during the period are as below:

(1) C.K. Majumdar Memorial Summer Workshop in Physics 2018.

Duration: 11 days (23.05.2018 to 02.06.2018). Convener: Dr. Saswati Dasgupta, Former Teacher-in-charge, Rammohan College, Kolkata and Member, Indian Association of Physics Teachers, Regional Council-15, Kolkata. Co-Convener: Prof. Kalyan Mandal, SNBNCBS. Total fund sanctioned from SNBNCBS: Rs.1,80,000/-. The objective of this workshop was to give an exposure of interesting and advanced scientific topics of physics to the participants so that they feel interested to study physics as their subject of higher study. The participating group in the workshop was comprised of about 30 students from the outgoing final year (3rd Year) of B.Sc. (Physics) from different Universities of India.

(2) National Summer School on Statistical Physics: Introducing Research Topics of Statistical Physics to Young Physicists. Duration: 12 days (04.06.2018 to 15.06.2018). Convener: Prof. S.S. Manna, Emeritus Professor, SNBNCBS. Co-conveners: Prof. Jaydeb Chakrabarti, SNBNCBS, Prof. Pradeep Mohanty, Saha Institute of Nuclear Physics (SINP), Prof. Sanat Karmakar, Jadavpur University, Prof. Tapati Dutta, St. Xavier's College. Total fund sanctioned from SNBNCBS: Rs. 6,32,000/-. The Summer School was jointly organized by S.N. Bose National Centre for Basic Sciences, Saha Institute of Nuclear Physics, Kolkata, Physics Department, Jadavpur University, Kolkata and Physics Department, St. Xavier's College, Kolkata.

(3) Winter School on "Synchrotron Techniques in Materials Science" held at SNBNCBS during 25-31 October, 2018. organized by Dr. Thirupathaiah Setti.

BOSE-125 Conferences

1. One-day Discussion Meeting on "Soft Matter and Chemical Physics" in Kolkata Region (SMCPK-2018) held at SNBNCBS on 15 September, 2018. Prof. Jaydeb Chakrabarti, Convener and Dr. Suman Chakrabarty, Co-Convener.
2. Four-days conference on "Exploring the Universe: Near Earth Space Science to Extragalactic Astronomy (EXPUNIV-18)" held at S. N. Bose National Centre for Basic Sciences and Science City, Kolkata during 14-17 Nov, 2018. Dr. Soumen Mondal, Convener.
3. Three-days meeting on "Young Investigator Meet On Quantum Condensed Matter Theory (YIMQCMT-2018)" held at S. N. Bose National Centre for Basic Sciences during 20-22 Nov, 2018. Dr. Manoranjan Kumar, Convener.
4. Four-days conference on "Noncommutative Geometry: Physical and Mathematical Aspects of Quantum Space Time and Matter (NCGQTM-18)" held at S. N. Bose National Centre for Basic Sciences during 27-30 Nov, 2018. Prof. Biswajit Chakraborty, Convener.
5. Five-days conference on "Current Developments in Quantum Field Theory and Gravity (CDQFTG-2018)" held at S. N. Bose National Centre for Basic Sciences during 3-7 Dec, 2018. Dr. Sunandan Gangopadhyay, Convener and Prof. Amitabha Lahiri, Co-Convener.
6. Four-days "International Conference on Complex and Functional Materials (ICCFM-2018)" at Biswa Bangla Convention Centre, New Town, Kolkata during 13-16 Dec, 2018. Prof. Kalyan Mandal, Prof. Anjan Barman, Prof. Jaydeb Chakrabarti and Dr. Rajib Mitra, Conveners.

BOSE-125 Outreach Programmes

a) Organized by the Centre jointly with the host institute

1. Workshop on Mathematica at S. N. Bose Centre on June 11, 2018
2. Kazi Nazrul University, Asansol, W.B. on June 21, 2018.
3. Jagacha High School, Howrah, West Bengal on September 25, 2018.
4. One Day Public Outreach Program at S. N. Bose Centre on September 26, 2018.
5. Durgapur Government College, Durgapur, Burdwan, West Bengal on September 27, 2018.
6. Pt. Ravishankar Shukla University, Raipur, Chattisgarh on September 28, 2018.
7. Prabhat Kumar College, Contai, Dist. Purba Medinipur, West Bengal on October 1, 2018.
8. Durgapur Women's College M. G. Road, Durgapur on October 5, 2018.
9. Roychak High School,Purba Medinipur on October 5, 2018.
10. Harmasra High School, West Bengal on October 11, 2018.
11. Government Arts College, Melur, Tamilnadu on October 23, 2018.
12. Gandhi Institute of Technology and Management, Visakhapatnam, on October 31, 2018.
13. Thiru Kolanjiappar Government Arts College, Tamilnadu during 1-2 November, 2018.
14. Digital Resource Managemnt Technology at S.N. Bose Centre during 2-3 November, 2018.
15. Nagaland University, Lumami, Nagaland during 9-10 November, 2018
16. Lady Brabourne College, Kolkata on November 12, 2018.
17. Pandit Deendayal Petroleum University, Gujarat on November 19, 2018.
18. North Eastern Hill University (NEHU) Campus, Shillong during 20-21 November, 2018.
19. J.R.N. Rajasthan Vidyapeeth (Deemed to be University), Udaipur on November 22, 2018.
20. Maharaja Sayajirao University of Baroda, Vadodara, Gujarat during 23-24 November, 2018.
21. Darjeeling Government College, Darjeeling, West Bengal on November 28, 2018.
22. The University of Burdwan, Burdwan, West Bengal on December 7, 2018
23. Indian Institute of Public Health-Delhi, Gurgaon, Haryana on 11th December, 2018.
24. National Institute of Technology Rourkela, Odisha during 14-15 December, 2018.
25. Deen Dayal Upadhaya Gorakhpur University during 15-16 December, 2018.
26. Acharya Satyendra Nath Basu Shiksha Mancha, Colonelgola, Paschim Medinipur, West Bengal during Dec 26, 2018 - January 1, 2019.

b) Organized in Collaboration with Bangiya Bigyan Parishad

1) Kalna College, Purba Bardhaman on April 3, 2018
2) Sodepur High School, N. 24 Parganas on May 11, 2018
3) Jogesh Chandra Balika Vidyalaya, Howrah on July 10, 2018
4) Ranaghat Brojobala Girls' High School, Nadia on July 12, 2018
5) Bakhrabad Bharati Bidyapith, Paschim Medinipur on July 17, 2018
6) Bhagabati Devi PTTI (B.Ed & DELED) College, Paschim Medinipur on July 17, 2018
7) Rajnagar Srinathgram Bani Vidyapith, Kakdwip, Dakshin 24 Parganas on July 18, 2018
8) Balarampur Lalmati Girls' H S School, Purulia on July 20, 2018
9) Balarampur Fool Chand High School, Purulia on July 20, 2018
10) Malti Shyamnagar Jilplaya H S School, Purulia on July 21, 2018
11) Lakshya High School, Purba Medinipur on July 26, 2018
12) Ramkrishna Mission Vidyalaya, Narendrapur, South 24 Parganas on July 28, 2018.
13) School level competition of Quiz, Essay, Extempore, Documentary, Film Making etc. at Bangiya Bijnan Parishad Bhavan during 1-30 August, 2018.
14) Ramgopal Saraf Vidyapith, Ballavpur, Paschim Burdwan on August 2, 2018.
15) Searsolr Raj High School, Paschim Burdwan on August 2, 2018
16) Asansol Arunodoy High School, Paschim Burdwan on August 10, 2019

17) Srirampur Mission Girls' High School, Hooghly on August 10, 2018
18) Kanyapur High school, Asansol, Paschim Burdwan on August 10, 2018
19) Malda Town High School (H. S.), Malda on August 13, 2018
20) C. C. Girls' High School (H. S.), Malda on August 13, 2018
21) Ramkrishna Mission Vivekananda Vidyamandir, Malda on August 13, 2018
22) Kanyapur High school, Asansol, Paschim Burdwan on August 16, 2018
23) Asansol Ramkrishna Mission High School, Paschim Burdwan on August 16, 2018
24) Sanskrit Collegiate School, Kolkata on August 27, 2018
25) Palashi ADP High School, N24 Pgs on August 30, 2018
26) University BT & Evening College, Cooch Behar on August 31, 2018
27) A B N Seal College, Coochbehar on August 31, 2018
28) Alipurduar High School, Alipurduar on September 1, 2018
29) Falakata High school, Alipurduar on September 1, 2018
30) Madarhat Popular Academy, S24 Pgs on September 1, 2018
31) Zenkins School, Coochbehar on September 1, 2018
32) D N Memorial High School, S24 Pgs on September 1, 2018
33) Global Institute of Management and Technology on September 5, 2018
34) Lalbag M M C Girls' High School, Murshidabad on September 7, 2018
35) Kalyani Pannalal Institution, Nadia on September 7, 2018
36) Bedibhavan Rabitirtha Vidyalaya, Nadia on September 7, 2018
37) Howrah Vivekananda Institution, Howrah on September 7, 2018
38) Gorabazar Iswar chandra Institution, Baharampur, Murshidabad on September 7, 2018
39) Kandi Raj High School, Murshidabad on September 8, 2018
40) Naihati Narendra Niketan, N 24 Pgs on September 8, 2018
41) Baidyabati Surendranath Roy Balika Vidyalyay on September 8, 2018
42) Hoogly Womens' College, Hoogly on September 11, 2018
43) Krishnanagar Collegiate School, Nadia on September 11, 2018
44) Bishnupur High School, Bankura on September 11, 2018
45) Bishnupur Sri Ramkrishna Vidyalaya, Paschim Medinipur on September 13, 2018
46) Siliguri Girls' High School, Darjeeling on September 13, 2018
47) Bolpur High School, Birbhum on September 13, 2018
48) Krishnapur chanchal Kumari Balika Vidyalaya, N 24 Pgs on September 13, 2018
49) Siliguri College, Darjeeling on September 14, 2018
50) Malpar Vivekananda Siksha Niketan, Paschim Mednipur on September 14, 2018
51) Tilantapara U M M High school, Paschim Medinipur on September 14, 2018
52) Bolpur College, Birbhum on September 14, 2018
53) Bolpur Nichupally Nirod Baran High School, Birbhum on September 14, 2018
54) Jalpaiguri Zilla School, Jalpaiguri on September 15, 2018
55) Gopalganj R N High School, Dakshin Dinajpur on September 18, 2018
56) Taki House, Kolkata on September 18, 2018
57) Hare School, Kolkata on September 18, 2018
58) Balurghat Khadimpur High School, Dakshin Dinajpur on September 19, 2018
59) Balurghat Girls' High School, Dakshin Dinajpur on September 19, 2018
60) Rudrapur Sikshsa Sadan, Howrah on September 19, 2018
61) Gangajalghati High School, Bankura on September 19, 2018
62) Bankura Kenduadihi Girls' High School, Bankura on September 19, 2018
63) Ananda Chandra College, Jalpaiguri on September 19, 2018
64) Bethune Collegiate School, Kolkata on September

19, 2018

65) Banpass Sikshaniketan, Purba Bardhaman on September 20, 2018

66) Howrah Zilla School, Howrah on September 20, 2018

67) Naktala High School, Kolkata on September 20, 2018

68) Gangarampur B. Ed. College, Dakshin Dinajpur on September 20, 2018

69) Gangarampur High School, Dakshin Dinajpur on September 20, 2018

70) Srirampur Union Institution, Hooghly on September 22, 2018

71) Sakhwat Memorial Govt. Girls' School, Kolkata on September 22, 2018

72) Ultadanga Govt. Sponsored H. S. School for Girls, Kolkata on September 24, 2018

73) Makardah Girls' High School, Howrah on September 27, 2018

74) Begri High School, Domjur, Howrah on September 27, 2018

75) Kashiram Das Institution, Katwa, Purba Burdwan on September 27, 2018

76) Greater Calcutta Eng. and Mng College, S. 24 Pgs on September 28, 2018

77) Purulia Zilla School, Purulia on September 28, 2018

78) Govt. Girls' H.S. School, Purulia on September 28, 2018

79) Raiganj University, Uttar Dinajpur on September 28, 2018

80) Kaliyaganj College, Uttar Dinajpur, September 28, 2018

81) Jadavpur Vidyapith, Kolkata on October 3, 2018

82) Burdwan Municipal High School, Burdwan on October 3, 2018

83) Kanchrapara Indian Girls' High School, N 24 Pgs on October 3, 2018

84) Contai High School, Purba Medinipur on October 4, 2018

85) Satmile High School, Purba Medinipur on October 4, 2018

86) Prabhu Jagabandhu College, Andul, Howrah on October 4, 2018

87) New Andul Higher Class School, Howrah on October 4, 2018

88) Sailendra Sarkar Vidyalaya, Kolkata on October 4, 2018

89) Fatepur High School, Nadia on October 4, 2018

90) Lighthouse For The Blind, Kolkata on October 4, 2018

91) Battala Anandamoyee High School, Ramnagar Purba Medinipur on October 5, 2018

92) Paniparul Mukteswar High School, Purba Medinipur on October 5, 2018

93) Ashokgarh Adarsha Vidyalaya for Boys, North 24 Parganas on October 9, 2018

94) Sri Ramkrishna Boys' High School, Coochbehar. On October 9, 2018

95) P P D High School, Panduk, Purba Burdwan on October 9, 2018

96) Sir Ramesh Mitter Girls' School, Kolkata on October 9, 2018

97) Khasmora High School, Howrah on October 10, 2018

98) Ballygunge Govt. High School, Kolkata on October 10, 2018

99) Kolorah High School, Howrah on October 10, 2018

100) Jhapandanga Sabitri Debi Balika Vidyalaya, Purba Burdwan on October 11, 2018

101) Hindu High School, Kolkata on October 12, 2018

BOSE-125 Outreach Lectures by the Faculty Members of the Centre:

1. An outreach lecture on "Ultrafast Spin Dynamics" by Prof. Anjan Barman was held at New Alipore College, Kolkata on April 6, 2018.

2. An outreach lecture on "Nanotechnology for Quantum Devices" by Prof. Samit Kumar Ray was held at Rahara Ramkrishna Mission, Kolkata on April 7, 2018.

3. A one-day outreach programme was organized at IIT Mandi on the occasion of BOSE-125 outreach programmes on 12 May, 2018 sponsored by S. N. Bose National Centre for Basic Sciences. Dr. Manoranjan Kumar, Associate Professor and Dr. Thirupathaiah Setti, Assistant Professor of the Centre participated in this programme and discussed about the 125th birth celebration of Prof. Satyendra Nath Bose.

4. An outreach programme on "Research trends in Multifunctional and Hybrid Nanomaterials (CRMN 2018)" was organized at Kazi Nazrul University, Asansol, West Bengal on 21 June, 2018. Prof. Samit

Kr. Ray, Director of the Centre participated as Guest of Honour in this programme and delivered his speech.

5. A Science Orientation Programme was jointly organized by St. John Ambulance and JBNSTS at Nazrul Mancha, Ranaghat, Kolkata on July 19, 2018. Prof. Samir Kumar Pal participated in this programme.

6. An outreach lecture on "Science, Society and Acharya Satyendra Nath Bose" by Prof. Samit Kumar Ray was held at National Library, Kolkata on July 24, 2018.

7. An outreach lecture on "Science Towards Sustainable Development" by Prof. Samir Kumar Pal was held at Acharya Prafulla Chandra College, Kolkata on August 6, 2018.

8. A programme on "Commemoration of 157th Birthday Celebration of Acharya Prafulla Chandra Ray" participated by Prof. Samir Kumar Pal at Lady Brabourne College on August 7, 2018.

9. An outreach lecture on "Bose 125 Event in Condensed Matter Days 2018" by Prof. Pratip Kumar Mukhopadhyay was held at Burdwan University on August 30, 2018.

10. Department of Science & Technology Science Camp held at Jagadis Bose National Science Talent Search participated by Prof. Samir Kumar Pal at Burdwan University on September 21, 2018.

11. Teacher Training program at University of Burdwan participated by Prof. Samir Kumar Pal on September 25, 2018.

12. State (GoWB) Science Fair participated by Prof. Samir Kumar Pal at Netaji Indoor Stadium, Kolkata held 26-28 September, 2018.

13. As a part of BOSE-125 outreach programme, a one-day discussion meeting on "Current Research on Chemistry of Biomolecules: Theory and Experiment" was organized at Durgapur Government College, Durgapur on 27 September, 2018. Prof. Rajib Kr. Mitra, Professor and Dr. Suman Chakrabarty, Assistant Professor participated in the programme and delivered lecture.

14. As part of 125th birth anniversary of Prof. S. N. Bose, a one-day conference on "Recent Advances in Functional Nanomaterials" was organized by School of Studies in Chemistry, Pt. Ravishankar Shukla University, Raipur, Chattisgarh . The conference was held on 28 September, 2018. Prof. Samir Kumar Pal, Senior Professor participated in this programme as Chief Guest and delivered his lecture to the gathering.

15. As a part of BOSE-125 programme, a one-day state level discussion meeting on "Relevance of Prof. S. N. Bose in Modern Perspective" was organized at Prabhat Kumar College, Contai, Purba Medinipur, West Bengal on 01 October, 2018. Prof. Samit Kr. Ray, Director of the Centre participated as a Guest of Honour and delivered lecture.

16. As a part of BOSE-125 programme, a one-day conference was organized at Durgapur Women's College, Durgapur titled "Prof. S. N. Bose : A Role Model for Indian Academicians and Scientists" held on 5 October, 2018 . Prof. Jaydeb Chakrabarti, Senior Professor attended the programme as Chief Guest and delivered the key note address.

17. As a part of 125th birth anniversary of Prof. S. N. Bose, a two-days conference on "New Energy Materials for a Secure and Sustainable Future (NEMSS-18)" was organized at Thiru Kolanjiappar Government Arts College, Vridhachalam, Cuddalore District, Tamilnadu during 01-02 November, 2018. Dr. Vinodh Kumar Shanmugam, Post Doctoral Research Associate (PDRA) of CMPMS Department of the Centre participated in this programme and delivered lecture.

18. As a part of BOSE-125 outreach programme, a two-days national seminar on "Chemistry in Interdisciplinary Research" was held at Nagaland University during 09 – 10 November, 2018 at Lumami, Zunheboto District, Nagaland. Prof. Samir Kumar Pal, Senior Professor participated as Centre's nominee and delivered speech in this programme.

19. As a part of BOSE-125 outreach programme, a one-day conference on "Macromolecular Characterization of Coal and Hydrocarbon Components for Future" was organized at School of Petroleum Technology, PDPU, Gandhinagar, Gujarat on 19 November, 2018. Prof. Samir Kumar Pal, Senior Professor delivered an invited lecture on "Interdisciplinary Approach in Optical Spectroscopy for the Development of Indigenous Technology".

20. As a part of BOSE-125 outreach activities, a national seminar on "Contemporary Challenges in Chemistry (NSC3-2018) was organized at North Eastern Hill University (NEHU), Shillong, Meghalaya during 20 – 21 November, 2018. Prof. Samit Kumar Ray, Director participated in this programme and delivered his invited lecture on "Life and Works of

Prof. S. N. Bose".

21. A one-day national conference on "Frontiers of Chemical Sciences in New Millennium" on the occasion of BOSE-125 outreach activities was held at Department of Chemistry, Faculty of Sciences, M.V. Shramjeevi College, J.R.N. Rajasthan Vidyapeeth, Udaipur, Rajasthan on 22 November, 2018 in collaboration with the Centre. Dr. Atindra Nath Pal, Assistant Professor of the Centre participated as Centre's nominee and delivered his invited lecture on "Electronic Transport in 2D Graphene to Single Molecule".
22. As a part of BOSE-125 outreach programmes, a national conference at the Maharaja Sayajirao University (MS University), Baroda, Vadodara, Gujarat was organized during 23 – 24 November, 2018 titled "Recent Advances in Material Sciences". Prof. Ranjit Biswas, Senior Professor of the Centre participated as Centre's nominee and presented his invited lecture.
23. As a part of BOSE-125 outreach activities, a one-day outreach programme was organized at Darjeeling Govt. College, Darjeeling on "Recent Trends in Physics" on 28 November, 2018. Prof. Archan S. Majumder, Senior Professor and Dean (Faculty) participated in this programme and gave his invited lecture on "Recent Trends in Quantum Information".
24. As a part of 125th birth anniversary celebration of Prof. S. N. Bose, a one day scientific workshop titled "Come, Fall in Love with Science" was organized at Don Bosco School, Bandel, Hooghly, West Bengal. Prof. Samir Kumar Pal, Senior Professor of the Centre participated and delivered his lecture in this workshop.
25. As a part of 125th birth anniversary celebration of Prof. S. N. Bose, a one-day seminar on "Advances in Physical Sciences" was organized on 07 December, 2018 at Department of Physics, The University of Burdwan, Golapbag, Burdwan, West Bengal. Prof. Samir Kumar Pal participated as Centre's nominee and delivered his speech on "Recent Advances on the Field of Applications of Various Diagnostic Tools developed at S. N. Bose National Centre for Basic Sciences" and thereafter on the application of various drug delivery systems followed by interaction with students.
26. As a part of BOSE-125 outreach activity, a one-day symposium on "Bridging the Gap Between Basic Sciences and Public Health Research" was organized on 11 December, 2018 at Indian Institute of Public Health-Delhi, Public Health Foundation of India, Gurgaon. Prof. Samir Kumar Pal, Senior Professor participated in this symposium and delivered his speech titled "An Interdisciplinary Approach in Optical Spectroscopy for Development of Indigenous (Swadeshi) Technology".
27. As a part of 125th Birth Anniversary celebration of Prof. S. N. Bose, a two-days conference on "Bioengineering-2018" was organized at Department of Biotechnology and Medical Engineering, National Institute of Technology, Rourkela, Odisha during 14-15 December, 2018. Prof. Samir Kumar Pal, Senior Professor participated as Centre's nominee and delivered his key-note address.
28. On the occasion of 125th Birth Anniversary of Prof. S. N. Bose, a one-day outreach programme on "Trends in Chemistry, Education and Opportunities" was organized by the Department of Chemistry, Gandhi Institute of Technology and Management (GITAM), Visakhapatnam on 20 December, 2018. Dr. Thirupathaiah Setti, Assistant Professor, participated in the programme as Guest of Honour.
29. As a part of BOSE-125 outreach activity, a one-day state level conference on the "Life and Works of Prof. S. N. Bose" was organized by Department of Physics, S.B.S.S. Mahavidyalaya, Goaltore, Paschim Medinipur, West Bengal on 21 December, 2018. Prof. Jaydeb Chakrabarti, Senior Professor of the Centre participated as Centre's nominee and delivered an invited talk on "Life and Works of Prof. S. N. Bose".
30. To commemorate the 125th Birth Anniversary of Prof. S. N. Bose, a seven-days "Science Festival" celebration programme from 26 December, 2018 to 01 January, 2019 was organized by Acharya Satyendra Nath Basu Shikshamancha, Colonegola, Paschim Medinipur, West Bengal. Prof. Samir Kumar Pal, Senior Professor inaugurated the Science Festival on 26 December, 2018 and delivered the inaugural lecture. Also, he inaugurated the Educational Science Exhibition on this occasion.

National Essay Competition on School Children on Contemporary Scientific Challenges

National Essay Competition 2018 at S. N. Bose National Centre for Basic Sciences was held during 5-6 September, 2018. Students across the nation of class IX to XII participated in the competition.

Bose-125 Outreach: Students Visits

1) Student from St. Xavier's College, Kolkata visited the Centre's Laboratories and facilities on April 9, 2018
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3) Outreach program on Science in Hindi for school students at the Centre on August 17, 2018
4) Open day for School students at the Centre on 31st December, 2018

Curtain raiser to IISF Festival

One Day Public Outreach Program on 26th September, 2018 on Curtain raiser programme of 'India International Science Festival' (IISF 2018) at S. N. Bose National Centre for Basic Sciences, Kolkata.

SEMINAR AND COLLOQUIA PROGRAMME

Institute Seminar/ BOSE Colloquium

Date	Speaker & Affiliation	Title
19.04.2018/ Special Colloquium	Dr. Yashawant Dev Panwar Head PFC, Patent Facilitating Centre (PFC) Technology Information Forecasting and Assessment Council (TIFAC), New Delhi	Intellectual Property Rights Eco System in India and their Management in Government R&D Institutes
02.07.2018 /Institute Colloquium	Prof. Amalendu Chandra Department of Chemistry Indian Institute of Technology, Kanpur	Nonlinear Vibrational Spectroscopy of Aqueous Surfaces from Molecular Dynamics Simulations
13.07.2018/ Bose Colloquium	Prof. Dwarka Nath Bose Department of Physics, St. Xavier's College	Reminiscences and Reflections on Semiconductors
08.08.2018/ Institute Seminar	Dr. Sibasish Ghosh, Institute of Mathematical Sciences, Chennai	Evolution of Photon Beams through a Nested Mach-Zehnder Interferometer using Classical States of Light
06.09.2018/ Bose Colloquium	Prof. Wen Ping Chen Graduate Institute of Astronomy, National Central University, Taiwan	Dwindle, Dwindle Little Stars – Hunting for Substellar Objects Young and Old Rich and Poor
16.11.2018 / Bose Colloquium	Prof. Alok K. Ray Bhabha Atomic Research Centre, Mumbai	Functionalized graphene - highly effective multipurpose smart materials

Date	Speaker & Affiliation	Title
13.12.2018 / Institute Seminar	Dr. Amit Kumar Pal Department of Physics Swansea University, UK	Entanglement in topological codes under noise
16.1.2019/ Institute Seminar	Prof. Sarbarish Chakravarty University of Colorado at Colorado Springs, USA	Nonlinear ODEs whose solutions are modular functions
20.2.2019/ Institute Seminar	Prof. Sachindeo Vaidya, CHEP, IISc., Bangalore	Light Hadron Masses from QCD Matrix Model
22.2.2019/ Bose Colloquium	Prof. Frederik G. Scholtz, National Institute of Theoretical Physics (NIThep), Stellenbosch, South Africa	Classical Dynamics on Three-dimensional Fuzzy Space
27.2.2019/ Bose Colloquium	Prof. K. L. Chopra, Former Professor and Dean, IIT Delhi, Former Director, IIT Kharagpur & President, Society for Scientific Values	Ethical Conduct of Scientific Research
28.2.2019 / Bose Colloquium	Prof. S. Ramasesha, Indian Institute of Science, Bangalore, India	Modeling magnetic anisotropy in molecular magnets

Lecture Series on " Introduction to Spintronics"

by **Professor Supriyo Bandyopadhyay**

Electrical and Computer Engineering Virginia Commonwealth University Richmond, VA 23284,

1. The semi-classical concept of an electron's spin a. Kronig Uhlenbeck model b. Stern-Gerlach experiment 2. Quantum mechanical operator for "spin": Pauli matrices and "spinors" 3. Dirac and Pauli equations.
2. Rotations on the Bloch sphere 5. Evolution of a spinor on the Bloch sphere a. Spin flip 12 b. Rabi oscillations
3. Spin-orbit interaction a. Atomic b. Rashba c. Dresselhaus 7. Spin Hall effect 8. Spin relaxation in a solid a. D'yakonov-Perel' b. Elliott-Yafet c. Bir-Aronov-Pikus d. Hyperfine interactions with nuclear spins
4. Spin transistors a. Datta-Das transistor b. Other types of SPINFETs c. Spin bipolar junction transistors
5. Spin based quantum computing

Lecture Series on "Noncom mutative Geometry and Particle Physics" Date: 20-23 Nov, 2018

By **Professor. Fedele Lizzi**

Universita di Napoli Federico II, Napoli, Italy.

1. Noncommutative spaces, physical origins, mathematical foundations
2. Almost commutative geometry and the standard model
3. Noncommutative geometry and "real" physics
4. Next steps?

Lecture Series on "An Introduction to Non-commutative Quantum Mechanics" Date:

by **Professor Frederik G. Scholtz**

Director National Institute of Theoretical Physics (NIThep) Stellenbosch South Africa

1. Quantum mechanics on the Moyal plane
2. Quantum mechanics on 3-dimensional fuzzy space
3. Advanced applications

VISITOR, ASSOCIATES AND STUDENTS PROGRAMME

Associates and Short Term Visitors

Name of the Visitor	Affiliation	Period of stay		Host Faculty/ Department
		Date From	Date to	
Dr. Pradip Mukherjee (VASP Associate)	Barasat Govt. College, Barasat	14.5.2018	30.5.2018	Prof. Rabin Bannerjee
Dr. Kumar Abhinav (Short term visitor)	PDRA, Bilkent University , Ankara, Turkey	28.5.2018	02.06.2018	Prof. Partha Guha
Dr. Saikat Debnath (Short term visitor)	Assistant professor, M.V. College, Buxer,Bihar	04.06.2018	18.06.2018	Prof. Priya Mahadevan
Dr. Md. Manirul Ali (Short term visitor)	National Centre for Theoretical Sciences, TIWAN	18.6.2018	22.06.2018	Prof. Archan S Majumdar
Dr. Sekhar Bhattacharyya (VASP Associate)	KAUST,UAE	15.6.2018	29.06.2018	Dr. Barnali Ghosh Saha
Mr. Sagnik Chakraborty (Short term Visitor)	SRF, IMSc. Chennai	02.07.2019	10.07.2019	Prof. Archan S Majumdar
Prof.Wen Ping Chen (Short term visitor)	Graduate Institute of Astronomy National Central University, Taiwan.	03.09.2018	8.09.2018	Dr Soumen Mondal
Prof. Sibashish Ghosh (Short term visitor)	The Institute of Mathematical Sciences, Chennai	06.08.2018	10.08.2018	Prof. Archan S. Majumdar
Dr. Sohail Ahmed (Short term visitor)	Assistant Professor, King Khalid University , Abha, Saudi Arabia	06.08.2018	18.08.2018	Dr. Sugata Mukherjee
Dr. Avijit Misra (Short term visitor)	The Institute of Mathematical Sciences ,Chennai	07.08.2018	14.08.2019	Prof. Archan S. Majumdar
Dr. Sudip Kumar Garain (Short term visitor)	Post Doctoral fellow, University of Norte Dam,USA	18.8.2018	22.8.2018	Prof. S.K Chakrabarti
Dr. Shaon Sahoo (Visiting Scientist)	Post Doctoral Fellow, University of Kaiserslautern, Germany	01.06.2018	30.8.2018	Dr. Manoranjan Kumar
Dr. B. Rajinikanth (Short term visitor)	Professor & Head , TKR college of Engineering and Technology	25.09.2018	01.10.2018	Prof. P.K.Mukhopadhyay
Dr. Amit Mukherjee (Short term visitor)	Post Doctoral fellow, The Institute of Mathematical Sciences, Chennai	01.10.2018	05.10.2018	Dr. Manik Banik
Professor Lev Titarchuk (Short term visitor)	University of Ferrara, Italy	05.11.2018	17.11.2018	Prof. S.K Chakrabarti
Prof. A.P. Balachandran (Short term visitor)	Syracuse University, USA	19.11.2018	26.11.2018	Prof. Biswajit Chakraborty
Dr. Shaon Sahoo (Visiting Scientist-Post Doc)	Post Doctoral Fellow, University of Kaiserslautern, Germany	01.09.2018	30.11.2018	Dr. Manoranjan Kumar

Name of the Visitor	Affiliation	Period of stay		Host Faculty/ Department
		Date From	Date to	
Dr. Anirban Polley (visiting Associate - Post Doc)	Columbia University, New York, USA	24.09.2018	23.12.2018	Dr. Sakuntala Chatterjee
Dr. Ramit Dey (Visiting Associate - Post Doc)	University of Western Ontario, Canada	24.09.2018	24.12.2018	Prof. Rabin Banerjee
Mr. Sagnik Chakraborty	Seniuor Research Fellow, The Institute of Mathematical Sciences, Chennai	13.11.2018	30.11.2018	Prof. Archan S. Majumdar
Prof. M.P Das (Short Term Visitor)	Research School of Physics and Engineering, The Australian National University ,Canberra	24.11.2018	27.11.2018	Dr. Ranjan Choudhury/ CMPMS
Dr. Broja Gopal Dutta (Short term visitor)	Associate Professor, Rishi Bankim Chandra College, Naihati	18.12.2018	24.12.2018	Dr. Soumen Mondal
Dr. Somnath Dutta (Short term visitor)	Post Doctoral Fellow, IISER ,Tirupati	26.12.2018	01.01.2019	Dr. Soumen Mondal
Dr. Shiladitya Mal (Short term visitor)	Post Doctoral Fellow, HRI, Allahabad	24.12.2018	04.01.2019	Prof. Archan S. Majumdar
Professor Dirk Wulferding (Short term visitor)	Institute for Condensed Matter Physics, TU Braunschweig , Mendelssohnstr. 3 38106 Braunschweig, Germany	03.02.2019	17.2.2019	Prof. Samir Kumar Pal
Dr Dmitri G. Fedorov (Short term visitor)	Senior Researcher, Research Center for Computational Design of Advanced Functional Materials (CD-FMAT); National Institute of Advanced and Industrial Science and Technology (AIST), Central 2, Umezono 1-1-1; Tsukuba, 305-8568 Japan	19.02.2019 28.02.2019	24.02.2019 01.03.2019	Prof. Debashish Mukherjee
Professor Frederik G. Scholtz (Short term visitor)	Director,National Institute for Theoretical Physics (NITheP) Stellenbosch 7600 ,South Africa	18.02.2019	09.03.2019	Prof. Biswajit Chakraborty
Professor N.D Hari Dass (Short term visitor)	TIPR-TCIS,Hyderabad	01.03.2019	08.03.2019	Prof. Manu Mathur
Mr. Soumya Kanti Bose (Short term visitor)	PDRA, IISER ,Mohali	01.03.2019	07.03.2019	Dr. M. Sanjay Kumar

Centres Students participated at India International Science Festival (IISF 2018), Lucknow.

One Day Public Outreach Program organized at the Centre on 26th September 2018 in association with Vivekananda Vijnan Mission, West Bengal chapter of Vijnana Bharati.

The Center Celebrated **the BOSE FEST 2019 --The Annual Science Celebration & Alumni Day** of the Center during 07-08 March 2019 with great enthusiasm.The invited artist Mr. Raghab Chatterjee has performed with his musical troupe followed by in-house cultural programme by the students and staff members of the Centre, coordinated by Muktangan Performing Arts Group.

Advanced Postdoctoral Manpower Programme (APMP)

Sl. No.	Name	Status	Mentor / Department
1	Arka Chatterjee (from 20.08.2018)	PDRA-I	Prof. Sandip K. Chakrabarti & Dr. Soumen Mondal / A&C
2	Arka Dey (from 01.01.2019)	PDRA-I	Prof. Samit Kumar Ray / CMPMS
3	Arnab Ghosh (from 18.02.2019)	PDRA-II	Dr. Barnali Ghosh (Saha) / CMPMS
4	Arun Bera (from 03.01.2019)	PDRA-I	Prof. Arup Kumar Raychaudhuri & Dr. Manik Pradhan / CMPMS
5	Aurab Chakraborty (till 31.10.2018)	PDRA-III	Prof. Tanusri Saha-Dasgupta & Prof. Pratip Kr. Mukhopadhyay/ CMPMS
6	C. Jebarathinam (till 23.02.2019)	PDRA-I	Prof. Archan S. Majumdar / A&C
7	Chaitrali Sengupta (from 01.08.2017)	PDRA-I	Prof. Rajib Kumar Mitra / CBMS
8	Deepika Kumari (till 31.05.2018)	PDRA-I	Prof. Partha Guha / TS
9	Deepika Shrivastava (from 01.10.2018)	PDRA-I	Prof. Priya Mahadevan / CMPMS
10	Dipak Kumar Das (from 16.07.2018)	PDRA-II	Prof. Anjan Barman / CMPMS
11	Gulmi Chakraborty (from 10.09.2018)	PDRA-I	Prof. Samir Kumar Pal / CBMS
12	Kumar Das (from 24.08.2018)	PDRA-I	Prof. Biswajit Chakraborty / TS
13	Mantu Santra (from 27.12.2018)	PDRA-III	Dr. Suman Chakrabarty / CBMS
14	Mausumi Ray	PDRA-III	Prof. Jaydeb Chakrabarti / CBMS
15	Prasanta Kundu	PDRA-I	Prof. Gautam Gangopadhyay / CBMS
16	Sandeep Agarwal (from 20.12.2018)	PDRA-III	Prof. Anjan Barman / CMPMS
17	Shamik Chakrabarti (till 14.09.2018)	PDRA-I	Prof. Tanusri Saha-Dasgupta / CMPMS
18	Sirshendu Dinda (from 19.09.2018)	PDRA-I	Prof. Ranjit Biswas / CBMS
19	Srabantika Ghose	PDRA-I	Prof. Kalyan Mandal / CMPMS
20	Suman Chakraborty	PDRA-I	Prof. Sandip K. Chakrabarti & Dr. Ramkrishna Das / A&C
21	Supriyo Dutta (from 30.08.2018)	PDRA-I	Prof. Partha Guha / TS
22	Vinodh Kr. Shanmugam (till 15.02.2019)	PDRA-I	Prof. Pratip Kumar Mukhopadhyay / CMPMS

Sl. No.	Name	Status	Mentor / Department
1	Ankita Ghatak (till 31.05.2018)	NPDF	Dr. Barnali Ghosh (Saha) / CMPMS
2	Jashashree Ray (till 31.05.2018)	NPDF	Prof. Arup Kumar Raychaudhuri / CMPMS
3	Samyadeb Bhattacharya (from 30.10.2017)	NPDF	Prof. Archan S. Majumdar / A&C
4	Shubhashis Rana	NPDF	Dr. Punyabrata Pradhan / TS
5	Sumona Sinha	NPDF	Prof. Anjan Barman / CMPMS
6	Tanushree Dutta	NPDF	Prof. Samir Kumar Pal / CBMS

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

Nibedita Konar | Debashish Bhattacharjee | Rupam Porel

THEORETICAL PHYSICS SEMINAR CIRCUIT

Academic visits

Sl No	Seminar Date	Speaker	Affiliation	Duration of Visit	Title of the Talk
1.	28-11-2018	Dr. Tapas Singha	Postdoctoral Fellow, TIFR Centre for Interdisciplinary Sciences, TIFR-Hyderabad	November 25 - December 9, 2018	Clustering, intermittency and scaling for passive particles on fluctuating surfaces
2.	20-02-2019	Professor Sachindeo Vaidya	Professor, CHEP, IISc., Bangalore	February 19 - 22, 2019	Light Hadron Masses from QCD Matrix Model

Grant released to TPSC Centres in the Country

Bharathidarsan University (50,000 INR)	Punjab University (50,000 INR)
Institute of Physics, Bhubaneswar (80,000 INR)	Visva-Bharati, Santiniketan (2,00,000 INR)
Indian Institute of Technology, Roorkee (35,000 INR)	Benaras Hindu University (35,000 INR)
Indian Institute of Technology, Kanpur (1,00,,000 INR)	Cochin Univ. of Science & Technology, Cochin (50,000 INR)

Advanced Research Workshop

- 2,00,000 INR TPSC grant released to Vidyasagar University for organizing the 10th Vidyasagar-Satyendranath Bose National Workshop on "Expanding Horizon in Physics (EHP 2019)" by Department of Physics & Technophysics, Vidyasagar University during 16th to 22nd January 2019 at Vidyasagar University Campus, Midnapore.
- 2,00,000 INR TPSC Grant released to Visva-Bharati University for organizing the Bose Tagore National Advanced Workshop on "Recent Advances in Condensed Matter Physics: Theory & Experiment (NAWCMP 2018)" by Department of Physics, Visva-Bharati, Santiniketan during 3rd August to 4th August 2018 at Lipica Auditorium, Visva-Bharati, Santiniketan.
- 1,00,000 INR TPSC Grant released to the University of Burdwan for organizing 26th Annual National Conference on "Condensed Matter Physics (CMDAYS 2018)" by Department of Physics, University of Burdwan during 29th August to 31st August 2018 at University Campus, Burdwan.
- 1,00,000 INR TPSC grant released to Birla Institute of Technology & Science, Pilani for organizing the 30th meeting of the Indian Association for General Relativity and Gravitation in BITS Pilani Hyderabad Campus during 3rd to 5th January 2019.
- 15,000 INR TPSC Grant released to Materials Research Society of India for holding Young Scientists' Colloquium (YSC 2018) on 21st September 2018 at Indian Association for the Cultivation of Sciences.
- 25,000 INR TPSC Grant released to the Indian Physical Society for holding Young Physicists' Colloquium.
- 12,000 INR TPSC grant released to Presidency University for organizing public lecture on the occassion of 125th Birth Anniversary of Prof. S. N. Bose.

Sakuntala Chatterjee

Sakuntala Chatterjee
Convener, Theoretical Physics Seminar Circuit

Registrar

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 2018-2019 successful. Staff comprising of strength of approximately 20 in permanent, 11 in temporary and 37 in contractual category as on 31st March 2019, 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 2018-2019. The Centre has also adhered to the norms of the Right to Information Act and so far has received 19 (nineteen) cases under the said Act in the last financial year all of which has been successfully disposed off.

As part of Vigilance Awareness Week 2018 during 29th October 2018 to 3rd November 2018, the Centre organised an Essay Competition (Topic: "Eradicate Corruption – Build a New India"). The essay competition carried a cash award of Rs.5,000/- (1st prize), Rs.3,000/- (2nd prize) and Rs.1,000/- (3rd prize) with winners as :

- 1st Prize – Ms. Sonali Sen, Office Assistant.
- 2nd Prize – Mr. Siddhartha Chatterjee, Upper Division Clerk.
- 3rd Prize – Mr. Swarup Dutta – Project Assistant.

A lecture on "Administrative Vigilance" delivered by Sri Banibrata Basu, Vigilance Commissioner, West Bengal was organised 30th November 2018 as a part of celebration of 125th Birth Anniversary of Prof. S. N. Bose.

The Centre celebrated 'Swachhta Pakhwada' from 1st May 2018 to 15th May 2018. As a part of the Pakhwada on 01.05.2018 the Centre observed 'Swachh Day' and mass cleaning of Main Office Building, Guest House, Students' Hostels etc., was carried out. Posters titled "Zero Plastic, Green Campus" was pasted in all notice boards and all prominent places of the Centre. A motivational talk/lecture titled "The Best out of Waste" delivered by Prof. S.K.Pal, Senior Professor of the Centre was organised. An Essay Competition on "Waste Management" was organised. The essay competition carried a cash award of Rs.3,000/- (1st prize), Rs.2,000/- (2nd prize) and Rs.1,000/- (3rd prize) with winners as:

- 1st Prize – Mr. Supriyo Ganguly, Jr. Engineer (Electrical).
- 2nd Prize – Ms. Sadhana Tiwari, Hindi Officer.
- 3rd Prize – Ms. Sudipta Das – Office Assistant.

A short drama titled "Swachhta in Workplace" was also organised by the staff and students of the Centre.

The Centre also organised an interactive yoga session conducted by Yoga Instructor, Shri Lokesh Mishra on the occasion of the International Yoga Day on 21st June 2018. The staff and students participated enthusiastically in the session.

Study Visit of Parliamentary Committee On Science and Technology, Environment and Forests.

A study visit of the Parliamentary Committee on Science and Technology, Environment and Forests led by Shri Anand Sharma, Chairman to Kolkata was organised under the aegis of S.N.Bose National Centre for Basic Sciences on 6th & 7th December 2018. The event comprised of visit of the Parliamentary Committee to River Hooghly and discussion with the representative of Ministry of Environment, Forest and Climate, Ministry of Water Resources at Hotel Taj Bengal on 6th December 2018 followed by visit of the said Committee to S.N.Bose National Centre for Basic Sciences, Kolkata and discussion with the representative of Department of Science & Technology, New Delhi on functioning of the Centre on 7th December 2018. The Department of Science and Technology entrusted S.N.Bose National for Basic Sciences to make all logistic arrangements regarding the visit of the Parliamentary Committee and officers of the Rajya Sabha Secretariat including their stay and transportation. In total 7 (Seven) Parliamentarians and 5 (five) Rajya Sabha Secretariat officers visited. The visit of the Parliamentary Committee to the Centre on 7th December 2018 was very successful as they enquired into the research activities undertaken by the Centre and the challenges / difficulties faced by the Centre for smooth discharge of its mandates. The meeting was also attended by the representatives of DST.

The administration of the Centre actively participated in organising various Conferences, Workshops and Outreach Programmes as part of the 125th Birth Anniversary celebrations of Prof. Satyendra Nath Bose. The Centre also organised the concluding ceremony of 125th Birth Anniversary & celebration of 126th Birth Anniversary of Prof. S.N.Bose in collaboration with Bangiya Bijnan Parishad on 31st December 2018 & 1st January 2019 respectively. The following Events & Lectures were organised on the occasions:

31st December 2018: Concluding Ceremony of 125th Birth Anniversary of Prof. S. N. Bose :

- BOSE-125 Marathon organized by the S. N. Bose National Centre for staff and students of the Centre.
- Welcome Address by the Director, SNBNCBS, Kolkata.
- Address by the Chief Guest, Prof. Sourav Pal, Director, IISER, Kolkata.
- Lecture by Prof. Samir Kumar Pal, Senior Professor, SNBNCBS, Kolkata.
- Lecture with Experimental Demonstration - Dr. Dirtha Sanyal, VECC, Kolkata.
- Lecture with Experimental Demonstration - Dr. Bhupati Chakrabarti, General Secretary, IAPT.
- Felicitation by the Centre to the Speakers on Outreach Lectures organized jointly with Bangiya Bijnan Parishad, Kolkata.
- Screening of the documentary film "An Iconic Genius".

1st January 2019: Celebration of 126th Birth Anniversary of Prof. S. N. Bose :

- Garlanding the bust of Prof. S. N. Bose.
- Prof. Ajoy Ghatak, Ex-Professor of Physics, IIT, Delhi; Title: Development of Science in India: A Brief Historical Perspective.
- Prof. Kankan Bhattacharyya, Ex-Director, IACS, Kolkata; Visiting Professor, IISER-Bhopal; Title: 125 years of S N Bose and his Friends: Makers of Modern India.
- Prof. Partha Ghose, NASI distinguished Scientist, Former Professor, SNBNCBS; Title: Bose, Einstein and their Physics
- Prof. Suprakash C Roy, Editor-in-Chief, Science and Culture, Member, National Commission of History of Science, INSA; Title: History of X-ray Research in Colonial India.
- Prof. Rabin Banerjee, Emeritus Professor, SNBNCBS, Kolkata; Title: Bidhubhusan Ray, the forgotten man of Indian science

Meetings of the Statutory Committees of the Centre :

(i) The 56th, 57th & 58th Governing Body (GB) meetings of the Centre were held on 18.05.2018, 18.09.2018 and 03.01.2019 .

(ii) The 36th & 37th Finance Committee (FC) meeting of the Centre was held on 16.05.2018 and 11.09.2018.

(iii) The 26th Academic & Research Programme Advisory Committee (ARPAC) meeting of the Centre was held on 26.04.2018.

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. B.M. Birla Heart Research Centre, Medica Superspeciality Hospital, Peerless Hospitex Hospital and Research Centre Limited, Desun Hospital & Heart Institute, AMRI Hospitals, Charnock Hospitals Pvt. Ltd. etc who provide cash less indoor hospitalisation facility. Outdoor treatments are also available as per CGHS rates.

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

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. Subarnarekha also provides 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 provides accommodation to Post Doctoral Fellows, on request. The newly constructed Integrated Hostel Building and Transit Quarter (by the name 'Basundhara') is being moderately put into use through its dining hall facilities and housing of summer students.

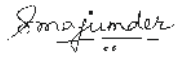
The Centre has modernly equipped Lecture Halls / Seminar Halls namely : Silver Jubilee Hall (120 sitting capacity), BOSON (60 sitting capacity) and FERMION (80 sitting capacity) with latest lecture facilities to cater to the various events organised viz. Lectures, Seminars, Colloquiums, Symposiums, Training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

'Muktangan' has been successfully organising various recreational activities within the Centre in Performing Arts, Literary Arts, Visual Arts, Sports Activities and Social Outreach. 'Muktangan' organised several programmes under its aegis during the year 2018-19.

The Centre also successfully organised a number of conferences during this period, namely ICCFM-2018, WSSTMS-18, SMCPK-18, NGPMAQSTM-2018 & CDQFTG-18 with full support from the administration.

I express my sincere condolences on the untimely death of Mr. Sukamal Das, Staff on Temporary Status on 7th April 2018.

While concluding, I express my sincere thanks to the three Deputy Registrars of Administration, Finance and Academic sections, all Section Incharges and all the administrative and academic staff members of the Centre for their unfailing dedication and cooperation in successfully organising the programmes held in the Centre and for day to day functioning of the administration. I am also grateful to Prof. Samit Kumar Ray, Director for his valuable guidance and advice on administrative matters.



Shohini Majumder
Registrar

HINDI (RAJBHASHA) IMPLEMENTATION IN THE CENTRE

The Centre paid emphasis on implementation of the Official Language in the year 2018-19. According to Rajbhasha Rule 5, 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 Town Official Language Implementation Committee (Office-2), Kolkata and has a Hindi Implementation Committee which meets regularly. All the administrative staff and many of the academic staff members possess working knowledge of Hindi and the administrative staff have been successfully trained in the 'Praveen' and 'Pragya' courses of the Department of Official Language, Government of India. The Centre has also initiated the training of staff in the 'Parangat' course.

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, in the month of September with 'Hindi Mahina' from 01.09.2018 to 30.09.2018. The mahina commenced with Hindi Extempore & Hindi Essay Competition. The essay competition carried a cash award of Rs.6,000/- (1st prize), Rs.4,000/- (2nd prize) and Rs.3,000/- (3rd prize). The winners were:

- 1st Prize - Ms.Urmi Chakraborty, Technical Assistant
- 2nd Prize – Mr. Amit Roy, Technical Assistant (Library).
- 3rd Prize – Mr. Debashish Mitra, Telephone Operator.

On 14th September 2018 "Hindi Diwas Samaroh" was organised in the presence of Prof. Arup Hota, Professor & HOD, Hindi Dept, West Bengal State University, Smt. Manju Sirin, Assistant Director & Office President, Hindi Shikshan Yojana, Department of Official Language, Home Ministry, Government of India and Shri. Vipati, Hindi Teacher, Hindi Teaching Scheme, Dept. of OL, MHA, Govt. of India. On the said day a cultural programme by staff members of the Centre was organised. Hindi Debate Competition, Hindi Quiz and a Hindi Play "Yamraaj Ki Dhaarti Yatra" by the Centre's staff were also organised.

A Science outreach programme for school students comprising of special lecture, documentary and quiz competition was organised by the Hindi Cell as a part of celebration of 125th Birth Anniversary of Prof. S.N.Bose. In this programme 40 students from 4 (four) schools of Salt Lake viz. Kendriya Vidyalaya 1, Kendriya Vidyalaya 2, Bharatiya Vidya Bhavan & Hariyana Vidya Mandir took active part. The special lectures were delivered by faculties of the Centre viz. Prof. Manu Mathur, Professor & Dr. Manoranjan Kumar, Associate Professor. The documentary on Prof. S.N.Bose -"An Iconic Genius" was exhibited in the programme. A quiz programme based on science was held amongst the children in which Hariyana Vidya Mandir, Bharatiya Vidya Bhavan and Kendriya Vidyalaya 1 came first, second and third respectively.

The Centre organised quarterly 'Hindi Workshops' on i) 08.06.2018 organised by Hindi Cell of the Centre on "Constitutional Provisions of the Official Language" ; ii) 27.08.2018 where Dr. Rishikesh Roy, Joint Director (Official Language), Tea Board, Kolkata spoke on "Problems and their solutions in Hindi use in office" ; iii) 28.12.2018 where Dr. J. P. Singh, Hindi Teacher, Hindi Shiksha Yojna, Home Ministry spoke on "Work in Hindi on Computer – Problems and their Solutions" ; iv) 18.03.2018 organised by Hindi Cell of the Centre on "Implementation of Official Language Hindi in Office".

Shohini Majumder
Registrar

COMMITTEES (As on 31.03.2019)

Governing Body

Dr. Srikumar Banerjee Homi Bhabha Chair Professor Department of Atomic Energy Bhabha Atomic Research Centre, Mumbai	Chairman
Prof. Ashutosh Sharma Secretary Department of Science & Technology Government of India, New Delhi	Member
Prof. Archana Bhattacharyya, Emeritus Scientist Former Director, IIG, Mumbai	Member
Dr. D.K. Aswal Director CSIR-National Physical Laboratory, New Delhi	Member
Prof. Debashish Chowdhury Professor Dept. of Physics IIT, Kanpur	Member
Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. (Dr.) Uday Bandopadhyay Director Bose Institute, Kolkata	Member
Prof. Santanu Bhattacharya Director Indian Association for Cultivation of Science Kolkata	Member
Shri B. Anand Additional Secretary & Finance Advisor Department of Science & Technology Government of India, New Delhi	Member
Shri Malay Kumar De, IAS Chief Secretary, Government of West Bengal Kolkata	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Non-member Secretary

Finance Committee

Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Chairman
Dr. Praveen Chaddah Former Director UGC-DAE Consortium for Scientific Research Indore	Member
Shri B. Anand Additional Secretary & Finance Advisor Department of Science & Technology New Delhi	Member
Prof. Biswajit Mahanty Dean, Planning & Coordination & Professor Department of Industrial and System Engineering IIT, Kharagpur	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Member Secretary

Academic & Research Programme Advisory Committee

Prof. Praveen Chaddah Former Director UGC-DAE Consortium for Scientific Research Indore	Chairman

Prof. Sanjay Puri Professor, JNU, New Delhi	Member
Prof. Amitabha Raychaudhuri Professor Emeritus, Calcutta University, Kolkata	Member
Prof. Satrajit Adhikari Professor, IACS, Kolkata	Member
Prof. Gautam Basu Senior Professor, Bose Institute, Kolkata	Member
Prof. S.M.Yusuf Scientific Officer (H+), BARC, Mumbai	Member
Prof. Somak Raychaudhury Director, IUCAA, Puna	Member
Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Archan S Majumdar Dean (Faculty) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Biswajit Chakraborty Dean (Academic Programme) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Non–Member Secretary
Dr. Saumen Mondal Head, Department of Astrophysics and Cosmology S. N. Bose National Centre for Basic Sciences Kolkata	Permanent Invitee
Dr. M. Sanjay Kumar Head, Department of Theoretical Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Permanent Invitee
Prof. Kalyan Mandal Head, Department of Condensed Matter Physics and Material Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Permanent Invitee
Prof. Jaydeb Chakrabarti Head, Department of Chemical, Biological and Macromolecular Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Permanent Invitee

Building Committee

Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Chairman
Retd. Engineer of CPWD (Not below the rank of Superintending Engineer)	Member
Mr. Chirantan Debdas Superintending Engineer (Electrical) Indian Institute of Chemical Biology (CSIR) 4, Raja S.C.Mullick Road Kolkata – 700 032	Member
Prof. Sriman Kumar Bhattacharyya Deputy Director and Professor Civil Engineering Indian Institute of Technology Kharagpur A-193, IIT Campus Kharagpur 721 302 (WB)	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Member Secretary
Mr. Sujit Kr. Dasgupta Superintending Engineer S. N. Bose National Centre for Basic Sciences Kolkata	Special Invitee
Mr. Apurba Kanti Sarkar Deputy Registrar (Finance) S. N. Bose National Centre for Basic Sciences Kolkata	Special Invitee

Consultative Advisory Committee

Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Chairman
Prof. Archan S Majumdar Dean (Faculty) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Biswajit Chakraborty Dean (Academic Programme) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Dr. M. Sanjay Kumar Head, Department of Theoretical Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Member
Dr. Saumen Mondal Head, Department of Astrophysics and Cosmology S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Jaydeb Chakrabarti Head, Department of Chemical, Biological and Macromolecular Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Kalyan Mandal Head, Department of Condensed Matter Physics and Material Sciences S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Apurba Kanti Sarkar Deputy Registrar (Finance) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Nibedita Konar Deputy Registrar (Academic) S. N. Bose National Centre for Basic Sciences Kolkata	Member Secretary

Official Language Implementation Committee

Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Chairman
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Manu Mathur Professor S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Apurba Kanti Sarkar Deputy Registrar (Finance) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Sirsendu Ghosh In-charge, Hindi Cell S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Debashish Bhattacharjee Deputy Registrar (Administration) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Sadhana Tiwari Hindi Officer S. N. Bose National Centre for Basic Sciences Kolkata	Member

ACADEMIC MEMBERS

Faculty Members

1	Samit Kumar Ray	Senior Professor & Director
2	Amitabha Lahiri	Senior Professor, TS
3	Anjan Barman	Senior Professor, CMPMS & Associate Dean (Faculty)
4	Archan S. Majumdar	Senior Professor, A&C & Dean (Faculty)
5	Atindra Nath Pal	Assistant Professor, CMPMS
6	Barnali Ghosh (Saha)	Scientist-F, CMPMS
7	Biswajit Chakraborty	Senior Professor, TS & Dean (AP)
8	Gautam Gangopadhyay	Professor, CBMS
9	Jaydeb Chakrabarti	Senior Professor & HOD, CBMS
10	Kalyan Mandal	Senior Professor & HOD, CMPMS
11	Manik Pradhan	Associate Professor, CBMS
12	Manoranjan Kumar	Associate Professor, CMPMS
13	Manu Mathur	Professor, TS
14	M. Sanjay Kumar	Associate Professor & HOD, TS
15	Partha Guha	Senior Professor, TS
16	Pratip Kr. Mukhopadhyay (till 30.09.2018)	Senior Professor, CMPMS
17	Priya Mahadevan	Senior Professor, CMPMS & Associate Dean (AP)
18	Prosenjit Singha Deo	Professor, CMPMS
19	Punyabrata Pradhan	Associate Professor, TS
20	Rajib Kumar Mitra	Professor, CBMS
21	Ramkrishna Das	Assistant Professor, A&C
22	Ranjan Chaudhury (till 31.12.2018)	Professor, CMPMS
23	Ranjit Biswas	Senior Professor, CBMS
24	Sakuntala Chatterjee	Associate Professor, TS
25	Samir K. Pal	Senior Professor, CBMS
26	Sandip K. Chakrabarti (till 30.11.2018)	Senior Professor, A&C
27	Sanjoy Choudhury	Scientist-D (Computer Services Cell)
28	Soumen Mondal	Associate Professor & HOD, A&C
29	Suman Chakrabarty (from 24.05.2019)	Assistant Professor, CBMS
30	Sunandan Gangopadhyay	Assistant Professor, TS
31	Tanusri Saha Dasgupta (on lien to IACS)	Senior Professor, CMPMS
32	Thirupathaiah Setti (from 02.04.2019)	Assistant Professor, CMPMS

S. N. Bose Chair Professor

1	Debashis Mukherjee (from 01.01.2019)	CBMS

Distinguished Professor (Emeritus)

1	Arup Kumar Raychaudhuri	CMPMS

Emeritus Professors

1	Bikash K. Chakrabarti	TS
2	Milan Kumar Sanyal (from 01.05.2018)	CMPMS
3	Rabin Banerjee	TS
4	Subhrangshu Sekhar Manna	TS
5	Subodh Kumar Sharma (till 02.11.2018)	TS

Academic Visitor

1	Abhijit Mookerjee (till 30.06.2018)	CMPMS

Honorary Fellow

1	Pratip Kr. Mukhopadhyay (from 01.10.2018)	CMPMS
2	Ranjan Chaudhury (from 01.01.2019)	CMPMS
3	Samir Kumar Paul	TS
4	Sugata Mukherjee	CMPMS

DST INSPIRE Faculty

1	Anup Ghosh (from 01.01.2019)	CMPMS
2	Dipanwita Majumdar (from 03.01.2019)	CMPMS
3	Manik Banik (from 18.04.2018)	A&C
4	Soumendu Datta (till 21.01.2019)	CMPMS
5	Subhra Jana (till 30.10.2018)	CBMS
6	Tatini Rakshit (from 01.11.2018)	CBMS

Visiting Fellow/Scientist

1	Madhuri Mandal Goswami	CMPMS
2	Mausumi Ray (from 10.10.2018)	CBMS

Young Scientist

1	Alo Dutta (till 01.08.2018)	CMPMS

Post Doctoral Research Associates

1	Arka Chatterjee (from 20.08.2018)	A&C
2	Arka Dey (from 01.01.2019)	
3	Arnab Ghosh (from 18.02.2019)	CMPMS
4	Arun Bera (from 03.01.2019)	CMPMS
5	Aurab Chakraborty (till 31.10.2018)	CMPMS
6	C. Jebarathinam (till 23.02.2019)	A&C
7	Chaitrali Sengupta (from 01.08.2017)	CBMS
8	Deepika Kumari (till 31.05.2018)	TS
9	Deepika Shrivastava (from 01.10.2018)	CMPMS
10	Dipak Kumar Das (from 16.07.2018)	CMPMS
11	Gulmi Chakraborty (from 10.09.2018)	CBMS
12	Kumar Das (from 24.08.2018)	TS
13	Mantu Santra (from 27.12.2018)	CBMS
14	Mausumi Ray	CBMS
15	Prasanta Kundu	CBMS
16	Sandeep Agarwal (from 20.12.2018)	CMPMS
17	Shamik Chakrabarti (till 14.09.2018)	CMPMS
18	Sirshendu Dinda (from 19.09.2018)	CBMS
19	Srabantika Ghose	CMPMS
20	Suman Chakraborty	A&C
21	Supriyo Dutta (from 30.08.2018)	TS
22	Vinodh Kumar Shanmugam (till 15.02.2019)	CMPMS

Senior Research Associate

1	Sayan Bayan (from 18.07.2018)	CMPMS

National Post Doctoral Fellow

1	Ankita Ghatak (till 31.05.2018)	CMPMS
2	Jashashree Ray (till 31.05.2018)	CMPMS
3	Samyadeb Bhattacharya (from 30.10.2017)	A&C
4	Shubhashis Rana	TS
5	Sumona Sinha	CMPMS
6	Tanushree Dutta	CBMS

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
Jaydeb Chakrabarti	Vigilance Officer
Saumen Adhikari	Central Public Information Officer

Other Members

Nibedita Konar	Deputy Registrar (Academic)
Debashish Bhattacharjee	Deputy Registrar (Administration)
Saumen Adhikari	Librarian cum Information Officer
Shiladitya Chatterjee	Deputy Registrar (Finance) [joined on 30.11.2018]
Sukanta Mukherjee	Sr. Assistant Registrar (Projects) [superannuated on 30.04.2018]
Santosh Kumar Singh	Assistant Registrar (Purchase)
Sirsendu Ghosh	Programme Coordinating Officer
Achyut Saha	Personal Assistant to Director
Swapnamoy Datta	Stenographer [joined on 06.12.2018]
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
Siddhartha Chatterjee	Upper Division Clerk [joined on 07.09.2018]
Sushanta Kumar Biswas	Driver
Pradip Kumar Bose	Tradesman 'A' [superannuated on 31.07.2018]
Partha Mitra	Attendant
Ratan Acharya	Attendant
Swapan Ghosh	Attendant
Swarup Dutta	Project Assistant [joined on 07.09.2018]

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) [Expired on 07.04.2018]
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

Sunish Kumar Deb	Advisor (Liaison)
A.K.Sarkar	Advisor (Finance) [joined on 11.06.2018]
Sujit Kr. Dasgupta	Superintending Engineer
Amitabha Haldar	Executive Engineer [joined on 01.08.2018]
Ayan Deb	Assistant Engineer (Electrical)
Sutapa Basu	PS to Registrar
Sadhana Tiwari	Hindi Officer
Abhijit Ghosh	Junior Computer Engineer
Sagar Samrat De	Junior Computer Engineer

Somasree Mal	Junior Computer Engineer
Deblina Mukherjee	Junior Computer Engineer
Amit Roy	Technical Assistant (Library)
Gurudas Ghosh	Technical Assistant (Library)
Ananya Sarkar	Technical Assistant (Library)
Shakti Nath Das	Technical Assistant
Urmi Chakraborty	Technical Assistant
Amit Kumar Chanda	Technical Assistant
Joy Bandopadhyay	Technical Assistant
Dipayan Banerjee	Technical Assistant [till 13.03.2019]
Ganesh Gupta	Junior Engineer (Electrical)
Supriyo Ganguly	Junior Engineer (Electrical)
Amitava Palit	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 [till 06.09.2018]
Moumita Banik	Office Assistant
Suvendu Dutta	Office Assistant
Siddhartha Chatterjee	Office Assistant [till 06.09.2018]
Sonali Sen	Office Assistant
Sudipta Das	Office Assistant
Lina Mukherjee	Jr. Office Assistant
Debasish Mitra	Telephone Operator
Amit Kumar Ghosh	Mechanic
Sani Amed Ali Molla	Technician (AC & Refrigeration)
Kalyani Ghosh	Caretaker (Creche)
Suranjan Deb	Telephone Technician
Harishikesh Nandi	Glass Blower (Part-time)

MEDICAL CELL (CONSULTANT PHYSICIANS)

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

Staff members of Academic Section, SNBNCBS

Staff members of Administrative Section, SNBNCBS

Staff members of Purchase Section, SNBNCBS

HINDI (RAJBHASHA) IMPLEMENTATION IN THE CENTRE

Hindi Mahina 2018

Hindi Essay writing competition

Hindi Extempore

Hindi Diwas

Hindi Quiz

Hindi Play


Department of
ASTROPHYSICS
& COSMOLOGY

Department of Astrophysics & Cosmology

Soumen Mondal

Department profile indicators

Table A : Manpower and resources

Number of faculties	05
Number of Post –doctoral research associate (centre+project)	04
Number of Ph.D students	24
Number of other project staff	0
Number of summer students	05
Projects (ongoing)	02

Table B: Research Activities indicators

Number of research papers in Journals	32
Number of Book-chapters/books	0
Number of other publications	01
Number of Ph.D students graduated (submitted+degree awarded)	05
Number of M.Tech/M.Sc projects	02

Table C: Academic activities and likeage

Number of courses taught by faculties	08	
Number of Visitors (non –associates)	12	
Number of associates	0	
Number of Seminars organized	18	
Number of Conference/Symposia/Advanced Schools organized	04	
Number of talks delivered by members of department in conferences/Symposia	National	10
	International	14

Most important research highlights

- Masses of black holes in active galactic nuclei were obtained using TCAF solution and these masses agree with those obtained from other techniques.
- Any change in accretion rate of the Keplerian disk at the outer edge, low mass and high mass X-ray binaries show a change in X-rays after a few days and few hours respectively because of viscous time delay in the different size of disk in those binaries.
- The quantumness of certain unsteerable correlations can be pointed out by the notion of superunsteerability.
- Quantum mechanics puts a restriction on the number of observers who can simultaneously steer another observer's system, known as the monogamy of steering.
- A problem of one-sided device-independent self-testing of any pure entangled two-qubit state based on steering inequalities is addressed.
- Star-formation in a Planck Cold Clump G108.37-01.06 is studied using multiwavelength data from National and International facilities.
- Spectral calibration of K–M giants from medium-resolution near-infrared HK-band spectra using the TIFR Near-Infrared spectragraph on the 2-m Himalyan Chandra Telescope (HCT).
- A construction of novae grid model using photoionization

code CLOUDY is successfully implemented to estimate physical parameters of novae.

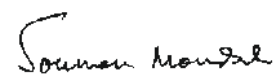
- Optical/Near-IR spectra of several planetary nebulae are analyszed to estimate their physical parameters.
- The variability properties in very low mass stars and brown dwarfs in star-formating regions are studied.
- Building of Astronomical Observing facilities at Panchet hill, Purulia, West Bengal is planned and it is under progress.
- Multipartite Quantum Entanglement: Entanglement is one of the most intriguing features of multipartite quantum systems.
- Enhanced Quantum Communication: Quantum mechanics is compatible with scenarios where the relative order between two events is indefinite.
- Quantum Foundations: Obtaining a physical perspective of the abstract mathematical description of quantum theory is a long-standing aspiration in quantum foundations.

Summary of research activities

- Neutron stars are compact objects with a normal boundary layer. However, centrifugal pressure supported boundary layers may also form around them just as in the case of black holes. The net spectra must include the radiations from the Keplerian disk, boundary layer, and the Comptonized radiations. Masses of black holes in active galactic nuclei were obtained using TCAF solution and these masses agree well with those obtained from other techniques. Any change in accretion rate of the Keplerian disk at the outer edge in low mass X-ray binaries is manifested in a change in X-rays after a few days due to viscous time scale. While in high mass X-ray binaries, this delay is found to be a few hours. delay. Such delay due to viscous time scale gives an idea of the size of the disk. This is expected from a system where the companion supplies a huge amount of winds.
- The quantumness of unsteerable correlations in the context of a given steering scenario is investigated here. In particular, the quantumness of certain unsteerable correlations can be pointed out by the notion of superunsteerability, the requirement for a larger dimension of the classical variable that the steering party has to preshare with the trusted party for simulating the correlations than that of the quantum states which reproduce them.
- Quantum mechanics puts a restriction on the number of observers who can simultaneously steer another observer's system, known as the monogamy of steering. Invoking a scenario where half of an entangled pair is shared between a single Alice in one wing and several Bobs on the other wing, we find that two Bobs can steer Alice's system. We next show that three Bobs can steer Alice's system, considering a three-settings linear steering inequality.
- The problem of one-sided device-independent self-testing of any pure entangled two-qubit state based on steering inequalities is investigated. In particular, we note that in the 2-2-2 steering scenario (involving two parties, two measurement settings per party, and two outcomes per measurement setting), the maximal violation of a fine-grained steering inequality can be used to witness certain extremal steerable correlations, which certify all pure two-qubit entangled states.
- The problem of detection of entanglement of an unknown two-qubit state using minimal resources is revisited. Using weak values and just two copies of an arbitrary two-qubit state, we present a protocol where a post-selection measurement in the computational basis provides enough information to identify if the state is entangled or not.
- The Planck Galactic Cold Clumps (PGCCs) are possible representations of the initial conditions and very early stages of star formation. To understand better the star and star cluster formation, we probe the molecular cloud associated with PGCC G108.37-01.06 to understand the star-formation activities. A careful inspection of James Clerk Maxwell Telescope 13CO (3–2) molecular data exhibits that the massive cluster is associated with several filamentary structures. Several embedded young stellar objects (YSOs) are also identified in PG108.3 along the length and junction of filaments. Along with kinematics of the filaments and the distribution of ionized, molecular gas and YSOs, we suggest that the cluster formation is most likely due to the longitudinal collapse of the most massive filament in PG108.3 (Dutta S., et al. APJ, 2018).
- Stellar spectral libraries have a particularly important role to understand and classify the stellar population as well as an evolutionary synthesis for the individual sources in our Galaxy. The new medium-resolution spectra (?/? ~ 1200)

of K–M giants covering wavelength ranges 1.50–1.80 and 1.95–2.45 μm are presented here. We have calibrated here the empirical relations between fundamental parameters (e.g. effective temperature and surface gravity) and equivalent widths of some important spectral features like Si I, Na I, Ca I, and 12CO molecular bands in the near-Infrared regions (Ghosh S., et al., MNRAS, 2018).

- The photometric variability in brown dwarfs help us to understand their atmospheric properties and binary nature. Such studies of an L3.5 brown dwarf 2MASS J00361617+1821104 (2M0036+18) in the field and of four young brown dwarfs in the star-forming region IC 348 are studied here. From muti-epoch observations, we found significant periodic variability in 2M0036+18 with a period of 2.66 ± 0.55 hours on one occasion while it seemed to be non-variable on three other occasions. An evolving dust cloud might cause such a scenario. Among the four young brown dwarfs of IC 348 in the spectral range M7.25 - M8, one brown dwarf 2MASS J03443921+3208138 shows significant variability (Mondal S., et al. 2018, BLRSS, 87)
- A novae grid model using photoionization code CLOUDY is constructed to estimate physical parameters of novae, as it is very difficult to obtain them directly from observations. Grid model provides a wide range of parameters, for example, the total hydrogen density (n), source temperature (T) and luminosity (L), inner radius (Rin) and thickness (dR) of the ejecta, keeping other elements other than hydrogen at solar values. We show that the physical parameters associated with nova systems can be estimated by comparing these line ratios with those obtained from observed spectra. We have applied this method to a few novae and illustrated the idea and estimated the parameter values for a few other novae (Mondal A., et al., 2019, MNRAS).
- Spectra of several planetary nebulae (VV28, PB1, M1-11, etc) are obtained using HFOSC, TIRSPEC and HESP installed on the 2-m HCT. We have analyzed and modeled those observed spectra and estimated physical parameters.
- Multipartite Quantum Entanglement: Entanglement is one of the most intriguing features of multipartite quantum systems. We classify genuinely nonlocal product bases into different categories. Our classification is based on state elimination property of the set via orthogonality-preserving measurements when all the parties are spatially separated or different subsets of the parties come together.
- Enhanced Quantum Communication: Quantum mechanics is compatible with scenarios where the relative order between two events is indefinite. In recent work, we show that two instances of a noisy process, used in a superposition of two alternative orders, can behave as a perfect quantum communication channel.
- Quantum Foundations: Obtaining a physical perspective of the abstract mathematical description of quantum theory is a long-standing aspiration in quantum foundations. We propose a profound consequence of symmetry towards the axiomatic derivation of Hilbert space quantum theory.



Soumen Mondal

Head, Department of Astrophysics and Cosmology

ARCHAN SUBHRA MAJUMDAR
SENIOR PROFESSOR
Astrophysics & Cosmology
archan@bose.res.in

Supervision of Research / Students

a) Ph.D. Students

1. Subhadipa Das; Quantum foundations; Awarded
2. Shiladitya Mal; Quantum foundations; Awarded
3. Sovik Roy; Quantum Information; Awarded
4. Suchetana Goswami; Quantum Information; Under progress
5. Shounak Datta; Quantum Information; Under progress
6. Riddhi Chatterjee; Relativistic Quantum Mechanics; Under progress
7. Arnab Sarkar; Gravitation & Cosmology; Under progress
8. Bihalan Bhattacharya; Quantum Information; Under progress
9. Ananda Gopal Maity; Quantum Information; Under progress
10. Shashank Gupta; Quantum Information; Under progress

b) Post Doctoral Research Scientist/s

1. C. Jebaratnam; Quantum Information
2. Samyadeb Bhattacharya; Quantum thermodynamics

Teaching activities at the Centre

1. Autumn semester; Relativity and Cosmology (PHY 509); PhD; 4 students; with 1 (Prof. Biswajit Chakraborty,) co-teacher
2. Spring semester; Project Research-Part II (PHY 691); PhD; 1 student

Publications

a) In Journals

1. D. Das, B. Bhattacharya, C. Datta, A. Roy, C. Jebaratnam, **A. S. Majumdar**, R. Srikanth, Operational characterization of quantumness of unsteerable bipartite states, Phys. Rev. A 97, 062335 (2018).
2. S. Sasmal, D. Das, S. Mal, **A. S. Majumdar**, Steering a single system sequentially by multiple observers, Phys. Rev. A 98, 012305 (2018).
3. C. Jebaratnam, D. Das, S. Goswami, R. Srikanth, **A. S. Majumdar**, Operational nonclassicality of local multipartite correlations in the limited-dimensional simulation scenario, J. Phys. A: Math. Theor. 51, 365304 (2018).
4. S. Goswami, B. Bhattacharya, D. Das, S. Sasmal, C. Jebaratnam, **A. S. Majumdar**, One-sided device-independent self-testing of any pure two-qubit entangled state, Phys. Rev. A 98, 022311 (2018).
5. S.Datta, **A. S. Majumdar**, Sharing of nonlocal advantage of quantum coherence by sequential observers, Phys. Rev. A 98, 042311 (2018).
6. S. Gupta, S. Datta, **A. S. Majumdar**, Preservation of quantum nonbilocal correlations in noisy entanglement-swapping experiments using weak measurements, Phys. Rev. A 98, 042322 (2018).
7. **S. Gangopadhyay**, S. Karar, **A. S. Majumdar**, Holographic complexity of "black" non-SUSY D3-brane and the high temperature limit, Int. J. Mod. Phys. A 34, 1950003 (2019).
8. S. Goswami, S. Chakraborty, S. Ghosh, **A. S. Majumdar**, Universal detection of entanglement in two-qubit states using only two copies, Phys. Rev. A 99, 012327 (2019).
9. S. Goswami, S. Adhikari, **A. S. Majumdar**, Coherence and entanglement under three-qubit cloning operations, Quant. Inf. Proc. 18, 36 (2019).
10. D. Das, A. Ghosal, S. Sasmal, S. Mal, **A. S. Majumdar**, Facets of bipartite nonlocality sharing by multiple observers via sequential measurements, Phys. Rev. A 99, 022305 (2019).

b) Independent publications of student/s

11. C. Jebaratnam, Debarshi Das, A. Roy, A. Mukherjee, S. S. Bhattacharya, B. Bhattacharya, A. Riccardi, and D. Sarkar, Tripartite-entanglement detection through tripartite quantum steering in one-sided and two-sided device-independent scenarios, Phys. Rev. A 98, 022101 (2018).
12. D.Das, C. Jebaratnam, B. Bhattacharya, A. Mukherjee, S. S. Bhattacharya, A. Roy, Characterization of the quantumness of unsteerable tripartite correlations, Annals of Physics 398, 55 (2018).
13. C. Jebarathinam, A. Khan, S. Kanjilal, and D. Home, Revealing the quantitative relation between simultaneous correlations in complementary bases and quantum steering for two-qubit Bell diagonal states, Phys. Rev. A 98, 042306 (2018).
14. S. Kanjilal, A. Khan, C. Jebarathinam, and D. Home, Remote state preparation using correlations beyond discord, Phys. Rev. A 98, 062320 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. International Iran Conference on Quantum information; Sep 10, 2018; Sharief University of Science & Technology, Tehran, Iran; 4 days
2. National Workshop on Quantum Information & Information Security; Oct 9, 2018; IIIT, Hyderabad; 5 days
3. Quantum Computing and Knowledge Workshop; Oct 12, 2018; Biswa-Bangla Convention Centre, Kolkata; 1 day
4. International Conference on Quantum and Atomic Optics; Dec 17, 2018; IIT, Patna; 2 days
5. Asia-Pacific Conference and Workshop on Quantum Information Sciences; Dec 19, 2018; IISER, Kolkata; 4 days
6. UGC-DSA-SAP Invited Lecture Series; Feb 15, 2019; Deptt. Applied Maths, CU; 1 day
7. Conference on Quantum Information and Many-body theory; Mar 2, 2019; IIT- BHU; 3 days
8. Symposium on Recent Trends in Applied Mathematics; Mar 12, 2019; Deptt. Applied Maths, CU; 3 days

Conference / Symposia / Workshops / Seminars etc. organized

1. Discussion meeting on Kolkata Knowledge City Cluster; Jan 18, 2019; SNBNCBS; One-day

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators):

1. Bose Institute; Joint publication serial number-1, 4, 10, 12, 13, 14; National
2. ISI Kolkata; Joint publication serial number-1, 11, 12; National
3. Calcutta University; Joint publication serial number-1, 11, 12; National
4. PPISR Bangalore; Joint publication serial number-1, 3; National
5. IMSc Chennai; Joint publication serial number-8; National
6. DTU, Delhi; Joint publication serial number-9; National
7. HRI Allahabad; Joint publication serial number-2, 10; National
8. Dipartimento di Fisica and INFN Pavia, Italy; Joint publication serial number-1, 11, 12; International

Participation in Science Outreach program

1. Bose-125 Outreach Program on Recent Trends in Physics, held at Darjeeling Govt. College, W.B., on 28th November, 2018.
2. 13th Nalanda Dialog Forum, on Philosophy of Relation & Modern Science, held at Nava Nalanda Mahavihara, Nalanda, January 21-23, 2019.

Societal impact of Research

1. My research in basic science attempts to address fundamental questions regarding the physical world. It hence fulfils one of the most crucial needs for advance of cultured society, i.e., pure knowledge creation that has been recognized as important since the beginning of human civilization. Progress in basic science is the key attractor for young minds into subsequent applied science research. All technology development of the future is based upon and motivated by current advance in basic science.

Significant research output / development during last one year

a) General research areas and problems worked on

Quantum Information Science; Gravitation & Cosmology

b) Interesting results obtained

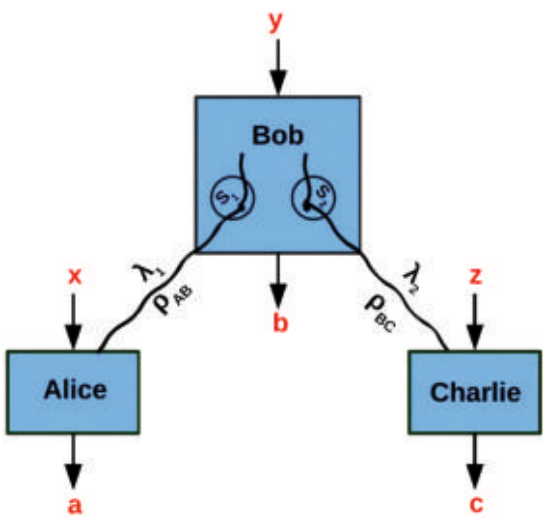
We investigate the quantumness of unsteerable

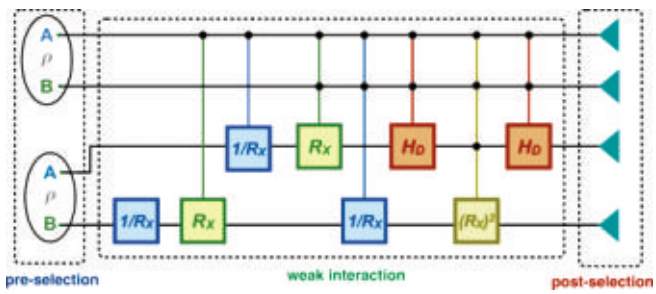
correlations in the context of a given steering scenario. In particular, the quantumness of certain unsteerable correlations can be pointed out by the notion of superunsteerability, the requirement for a larger dimension of the classical variable that the steering party has to preshare with the trusted party for simulating the correlations than that of the quantum states which reproduce them. We further present specific examples of genuine superlocality for tripartite correlations derived from three-qubit states. It is argued that genuine quantumness as captured by the notion of genuine discord is necessary for demonstrating genuine superlocality. Finally, the notions of absolute and genuine superlocality are also defined for multipartite correlations.

Quantum mechanics puts a restriction on the number of observers who can simultaneously steer another observer's system, known as the monogamy of steering. Invoking a scenario where half of an entangled pair is shared between a single Alice in one wing and several Bobs on the other wing, we find that two Bobs can steer Alice's system. We next show that three Bobs can steer Alice's system, considering a three-settings linear steering inequality. We further investigate the above scenario when the number of measurement settings per observer is increased. It is shown that at most two Bobs can exhibit bipartite nonlocality with a single Alice using local realist inequalities with three as well as four dichotomic measurements per observer. Nonlocal advantage of quantum coherence (NAQC) or steerability of local quantum coherence is a strong nonlocal resource based on coherence complementarity relations. We show that only one Alice can reveal NAQC within the same framework.

We consider the problem of one-sided device-independent self-testing of any pure entangled two-qubit state based on steering inequalities. In particular, we note that in the 2-2-2 steering scenario (involving two parties, two measurement settings per party, and two outcomes per measurement setting), the maximal violation of a fine-grained steering inequality can be used to witness certain extremal steerable correlations, which certify all pure two-qubit entangled states. We demonstrate that the violation of the analogous Clauser-Horne-Shimony-Holt inequality of steering can be used to self-test any pure entangled two-qubit state in a one-sided device-independent way.

We revisit the problem of detection of entanglement of an unknown two-qubit state using minimal resources. Using weak values and just two copies of an arbitrary two-qubit state, we present a protocol where a post-selection measurement in the computational basis provides enough information to identify if the state is entangled or not. A tripartite quantum network is said to be bilocal if two independent sources produce a pair of bipartite entangled states. Here we show that decoherence by the amplitude damping can be slowed down by employing the technique of weak measurements and reversals.





c) Proposed research activities for the coming year

1. We establish a convex resource theory of non-Markovianity under the constraint of small time

intervals within the temporal evolution. We construct the free operations, free states and a generalized bona-fide measure of non-Markovianity. The framework satisfies the basic properties of a consistent resource theory. We establish a connection between non-Markovianity and negative entropy production rate. We present a formalism for detection of non-Markovianity through uncertainty relations. We further show that non-Markovianity is necessary in order to decrease the uncertainty of the states undergoing unital dynamics for qubits. This provides another method of certifying non-Markovianity.

We investigate the stochastic gravitational wave background produced by primordial black hole binaries during their early inspiral stage while accreting high-density radiation surrounding them in the early universe. We first show that the gravitational wave amplitude produced from a primordial black hole binary has correction terms because of the rapid rate of increase in masses of the primordial black holes. These correction terms arise due to non-vanishing first and second time derivatives of the masses and their contribution to the overall second time derivative of quadrupole-moment tensor. We find that some of these correction terms are not only significant in comparison with the main term but may be even dominant over the main term for certain ranges of time in the early Universe. We show that the spectral density produced from such accreting primordial black hole binaries lie within the detectability range of present and future gravitational wave detectors.

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Supervision of Research / Students

a) Ph.D. Students

1. Sutapa Saha; Quantum Foundations; Under progress
2. Ananda Gopal Maity; Quantum Information; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Sristy Agrawal; Study on multipartite quantum entanglement; IISER Kolkata
2. Sumit Rout; Genuine quantum nonlocality without entanglement; Vivsa Bharati University

c) Post Doctoral Research Scientist/s

1. Arup Roy; Quantum Foundations and Quantum Information

Teaching activities at the Centre

1. Spring, 2019; Quantum Information Theory [PHY413]; IPhD; 2 students; Full Course
2. Spring, 2019; Quantum Information Theory [PHY613]; PhD; 2 students; Full Course

Publications

a) In journals

1. S. Agrawal, S. Halder and **M. Banik**; Genuinely entangled subspace with all-encompassing distillable entanglement across every bipartition, Physical Review A 99, 032335 (2019).
2. A. Ambainis, **M. Banik**, A. Chaturvedi, D. Kravchenko, and A.Rai; Parity Oblivious d- Level Random Access Codes and Class of Noncontextuality Inequalities, Quantum Information Process 18, 111 (2019).
3. S. Halder, **M. Banik**, S. Agrawal, and S. Bandyopadhyay; Strong quantum nonlocality without entanglement, Physical Review Letters 122, 040403 (2019).
4. P. J Cherian, A. Mukherjee, A. Roy, S. S. Bhattacharya, and **M. Banik**; Uncertainty principle as a postquantum nonlocality witness for the continuous-variable multimode scenario, Physical Review A 99, 012105 (2019).
5. S. Aravinda, Amit Mukherjee, and **M. Banik**; Exclusivity principle and unphysicality of the Garg-Mermin correlation, Physical Review A 98, 012116 (2018).
6. S. Halder, **M. Banik**, and S. Ghosh; Family of bound entangled states on the boundary of Peres set, Physical Review A, 99, 062329 (2019).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Conference Name: QIPA-2018; Date: December 02-08, 2018; Organized at: HRI, Allahabad; Participation: Present Talk
2. Conference Name: Recent Trends in Applied Mathematics 2019; Date: March 12-14, 2019; Organized at: University of Calcutta; Participation: Present Talk

Significant research output / development during last one year

a) General research areas and problems worked on

Quantum Information and Quantum Foundations

b) Interesting results obtained

(i) Multipartite Quantum Entanglement: Entanglement is one of the most intriguing features of multipartite quantum systems. One of my research interests during the recent past is focused on studying this peculiar phenomenon for quantum systems involving more than two spatially separated subsystems. In another works we classify genuinely nonlocal product bases into different categories. Our classification is based on state elimination property of the set via

orthogonality-preserving measurements when all the parties are spatially separated or different subsets of the parties come together. We then study local state discrimination protocols for several such bases with additional entangled resources shared among the parties. Apart from consuming less entanglement than teleportation based schemes our protocols indicate operational significance of the proposed classification and exhibit nontrivial use of genuine entanglement in local state discrimination problem.

(ii) Enhanced Quantum Communication: Quantum mechanics is compatible with scenarios where the relative order between two events is indefinite. In a recent works we show that two instances of a noisy process, used in a superposition of two alternative orders, can behave as a perfect quantum communication channel. This phenomenon occurs even if the original processes have zero capacity to transmit quantum information. In contrast, perfect quantum communication does not occur when the message is sent along a superposition of paths, with independent noise processes acting on each path.

(iii) Quantum Foundations: Obtaining a physical perspective of the abstract mathematical description of quantum theory is a long-standing aspiration in quantum foundations. In one of our works we propose a profound consequence of symmetry towards the axiomatic derivation of Hilbert space quantum theory. In another work we study a very naive question that goes back to the origin of the relation between mathematics and a physical theory. In particular, we focus on the question whether an arbitrary probability distribution satisfying Kolmogorov's axioms can always be realized in some physical experiment.

c) Proposed research activities for the coming year

In the coming future my research will mainly be focused on exploring several new aspects of multipartite quantum entanglement. In particular I am interested in finding the necessary and sufficient amount of quantum entanglement required to perfectly distinguish a genuinely nonlocal entangled basis under local operation and classical communications. I am also interested to come up with new primitives of 'indefinite causal order' and study their implications in reliable transferring of quantum information. My other research plan is to explore different nonlocal computation tasks and to establish supremacy of quantum theory over several post quantum generalized probabilistic theoretic models.

RAMKRISHNA DAS
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Supervision of Research / Students

a) Ph.D. Students

1. Anindita Mondal; Multi-wavelength Study of Novae; Under progress
2. Dhrimadri Khata; Understanding Physical Properties of M-Dwarfs; Under progress
3. Rahul Bandyopadhyay; Multi Wavelegth Study of Planetary Novae; Under progress
4. Ruchie Pandey; Study of Novae Properties; Under progress
5. Megha Dave; Massive Stars; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s

1. Saikat Sadhukhan; Astronomical Spectroscopy; IIT Madras

Teaching activities at the Centre

1. Spring semester; Methods of Experimental Physics (PHY 391); Integrated PhD; 7 students; with 5 co-teachers
2. Autumn semester; Observational Techniques in Astronomy (PHY 616); PhD; 2 students; with 1 (Soumen Mondal,) co-teacher

Publications

a) In journals

1. Anindita Mondal, **Ramkrishna Das**, Gargi Shaw, Soumen Mondal, A photoionization model grid for novae: estimation of physical parameters, MNRAS, 483, 4884, 2019.
2. Supriyo Ghosh, Soumen Mondal, **Ramkrishna Das**, Dhrimadri Khata, Spectral calibration of K-M giants from medium-resolution near-infrared HK-band spectra, MNRAS, 484, 4619, 2019.

b) Other Publications (including conferences)

1. Soumen Mondal, Supriyo Ghosh, Dhrimadri Khata, Santosh Joshi, Ramkrishna Das, "Understanding of variability properties in very low mass stars and brown dwarfs", BSRSL, 87, 242, 2018

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. 'Grid Model of Novae' at 'Exploring the Universe: Near Earth Space Science to Galactic Astronomy"; Nov 14, 2018; SNBNCBS; 15 Minutes
2. "Understanding the Universe through Invisible Lights' at C K Majumdar Memorial Summer Workshop; May 24, 2017; SNBNCBS; 60 Minutes

Membership of Committees

a) Internal Committee

Member of the following internal committees: i. Seminar, Colloquium Programme (SCOLP) ii. Newsletter Committee iii. Selection Committee for the post of Upper Division Clerk iv. Committee to fix the Technical Specifications of Bio-metric based attendance system v. Faculty Search Committee vi. Conference, Workshop and Extension Programme (CWEP)

Conference / Symposia / Workshops / Seminars etc. organized

1. Exploring the Universe: Near Earth Space Science to Extra-galactic Astronomy Nov 14, 2018; S N Bose Centre for Basic Sciences; 4 Days
2. Bose Fest 2019; Mar 7, 2019; S N Bose Centre for Basic Sciences; 2 Days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Dr Gargi Shaw, TIFR, Mumbai; 1; National

Participation in Science Outreach program

1. Participated in C K M Memorial Summer Workshop at S N Bose National Centre for Basic Sciences, Kolkata, May 23 - June 02, 2018. Delivered a talk on "Understanding the Universe through Invisible Lights" and organized a sky-watching program for the participants.

Societal impact of Research

1. Progress in the basic sciences helps in solving the problems and understanding the world around us.
2. Solving the basic scientific questions improves and enriches the basic knowledge.
3. Development of human resource (through teaching and supervising PhD students) helps to build the Nation.
4. Generation of manpower for worldwide astronomical projects.

Significant research output / development during last one year

a) General research areas and problems worked on

Novae, Planetary Nebulae, Modeling of spectra, Developing observational facility

b) Interesting results obtained

In the previous year, I along with my students, have observed different types of astronomical objects viz. novae, planetary nebulae, etc. using the national facilities, e.g., 2m Himalaya Chandra Telescope (HCT), in optical and infrared region. Additionally, we are using archived and published data also. Part of the observed data has been analyzed, interpreted, modeled where applicable, and results have been published.

One of the important works we completed is construction of novae grid model using photoionization code CLOUDY. Our aim was to find a method that could help to estimate physical parameters of novae, as it is very difficult to obtain them directly from observations. Thus, we constructed the grid covering a wide range of parameters, for example the total hydrogen density (n), source temperature (T) and luminosity (L), inner radius (Rin) and thickness (dR) of the ejecta, keeping other elements other than hydrogen at solar values. In this way, a total of 1792 models were generated. From the model-generated spectra, which cover a wide wavelength region from the ultraviolet to the infrared, we calculate the ratios of hydrogen and helium emission-line fluxes, which are generally strong in nova spectra. We show that the physical parameters associated with nova systems can be estimated by comparing these line ratios with those obtained from observed

spectra (see the figures). We have applied this method to few novae and illustrated the idea and estimated the parameter values for a few other novae. The results of the grid model are available online. (Mondal A., et al., 2019, MNRAS).

We illustrate the idea with

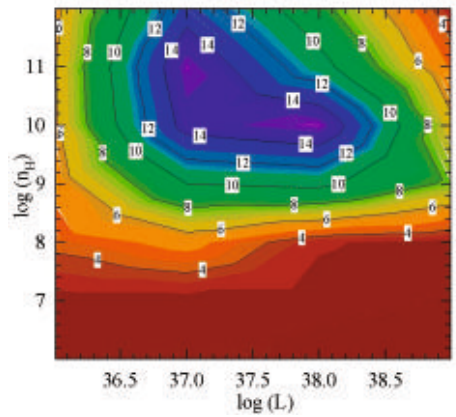

Figure 1: Contour plot of the Ha line flux ratio with respect to Hß for log (Rin) =15.0 (in cm), log(dR) = 14.0 (in cm) and log(TBB) = 5.5 (in K); log(L) (in erg s-1) and log(nH) (in cm-3), corresponding to tables 217 - 220 in the database, are plotted along the x- and y-axis respectively. The values of Ha/Hß are marked on each contour.

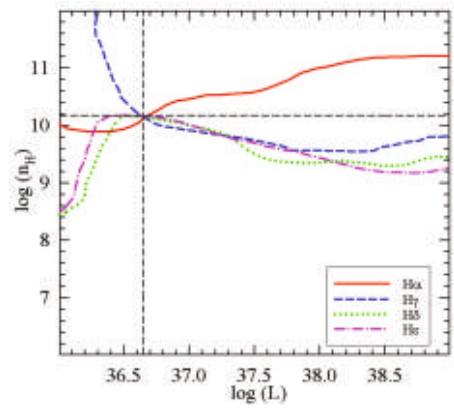

Figure 2: Plots of various extracted contour lines for nova RS Oph, 12 days after outburst. The red solid,

blue short-dashed, green dotted, and pink dot–dashed lines represent the extracted plots of line flux ratios of Ha, H? , Hd and He respectively with respect to Hß. The lines intersect at log(L) = 36.65 (in erg s-1) and log(nH) = 10.2 (in cm-3).]

From NIR spectra of about seventy K0-M8 giants, using TIRSPEC (R~1200) at HCT and spectra of 35 giants from IRTF spectral library, we have calibrated empirical relations between fundamental parameters (e.g. effective temperature and surface gravity) and equivalent widths of some important spectral features like Si I, Na I, Ca I, and ^{12}CO. It has been showed that the 2.29 µm and 1.62 µm bands of ^{12}CO are a reasonably good indicator of temperature above 3400 K and surface gravity. (Ghosh S. et. al., 2019, MNRAS)

We have are also observed spectra of several planetary nebulae (VV28, PB1, M1-11 etc) which have not been studied in details earlier, using HFOSC, TIRSPEC and HESP installed at 2m HCT. We have analyzed and modeled observed spectra of PB1& VV28 and estimated physical parameters. Using the information obtained from observed spectra we constructed a 3-D model of the planetary nebula and show how the density profile obtained from 3-D modeling could be used in photoionization modeling (paper under preparation).

c) Proposed research activities for the coming year

1. We hope to complete analysis and interpretation of remaining observed data. We are also planning to observe and study more astronomical objects using the national facilities. We aim to investigate several problems like understanding the chemical composition, geometry (morphology) and velocity (kinematics) of the material in ejecta of novae, to understand the properties of novae, dust formation process in novae, details analysis of planetary nebulae etc.
2. We are also working to establish S N Bose Centre's Astronomical Observatory at Panchet hill, Purulia. We have received stage-II approval for land and demarcation of the land has been completed. We shall work to complete the next level jobs required to establish the facility.

Any other matter

I am acting as officiating 'Supervisor' of Mr Ayan Bhattacharyya and Mr Arindam Ghosh, 'Co-supervisor' of Prantik Nandi, Piklu Santra and Anuvab Banerjee, and Menrtor of Post Doctoral Fellow, Dr Suman Chakrabarty.

SANDIP KUMAR CHAKRABARTI
SENIOR PROFESSOR (Till 30.11.2018)
Astrophysics and Cosmology
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Supervision of Research / Students

a) Ph.D. Students

1. Arnab Deb; Black Hole Astrophysics; Thesis written. To be submitted
2. Abhishek Roy; Black Hole Astrophysics; Thesis to be written
3. Ayan Bhattacharjee; Black Hole Astrophysics; Thesis being written
4. Anubhab Banerjee; Black Hole Astrophysics; Under progress
5. Arindam Ghosh; Black Hole Astrophysics; Thesis written. To be submitted
6. Prantik Nandi; Black Hole Astrophysics; Under progress
7. Piklu Santra; Black Hole Astrophysics; Under progress

b) Post Doctoral Research Scientist/s

1. Suman Chakraborty; Ionospheric Science

Publications

a) In Journals

1. Broja G. Dutta, Partha Sarathi Pal, **Sandip K Chakrabarti**, Evolution of accretion disc geometry of GRS 1915+105 during its chi state as revealed by TCAF solution, MNRAS, 479, 2183, 2018.
2. Arindam Ghosh, **Sandip K. Chakrabarti**, Signature of Two-Component Advective Flow in several Black Hole candidates obtained through time-of-arrival analysis of RXTE/ASM Data, MNRAS, 479, 1210, 2018.
3. Arka Chatterjee, **Sandip K. Chakrabarti**, Himadri Ghosh, Sudip K. Garain, Images and spectra of time-dependent two-component advective flow in presence of outflows, MNRAS, 478, 3356, 2018.
4. **Sandip K. Chakrabarti**, Sudipta Sasmal, Suman Chakraborty, Tamal Basak, Robert L. Tucker, Modeling D-region ionospheric response of the Great American TSE of August 21, 2017 from VLF signal perturbation, AdSpR, 62, 651, 2018.
5. Ankan Das, Milan Sil, Prasanta Gorai, **Sandip K. Chakrabarti**, J. C. Loison, An Approach to Estimate the Binding Energy of Interstellar Species, ApJS, 237, 9, 2018.
6. Emmanuel E. Etim, Prasanta Gorai, Ankan Das, **Sandip K. Chakrabarti**, Elangannan Arunan, Interstellar hydrogen bonding, AdSpR, 61, 2870, 2018.
7. Dipen Sahu, Y. C. Minh, Chin-Fei Lee, Sheng-Yuan Liu, Ankan Das, **S. K. Chakrabarti**, Bhala Sivaraman, Deuterated formaldehyde in the low-mass protostar HH212, MNRAS, 475, 5322, 2018.
8. Victor U. J. Nwankwo, **Sandip K. Chakrabarti**, Effects of space weather on the ionosphere and LEO satellites' orbital trajectory in equatorial, low and middle latitude, AdSpR, 61, 1880, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited Talk at 15th Marcel Grossman Meeting on Black Holes; July 3, 2018; Rome; July 1-7, 2018.
2. Invited Talks at 42nd COSPAR Assembly at Caltech; July 15, 2018; Pasaden, July 14-22 , 2018.
3. A Set of 6 lectures (9 hours) on Black Hole Astrophyics, at National Tsing Hua University, Taiwan; Sept. 3rd-8th, 2018; Hsinchu, NTHU; 3/9-9/9/2018.
4. An Invited Talk at Exploring the Universe conference at SNBNCBS on black holes; 13/11/2018 SNBNCBS; 13/11-18/11/2018.

Significant research output / development during last one year

a) General research areas and problems worked on

The TCAF solution which was useful to interpret black hole spectra was used to study Neutron star spectra with the inclusion of a normal

boundary layer. Size of the disk around high and low mass X-ray binaries are distinguished. Mass of black holes in AGNs and ULX objects are determined using TCAF solution.

b) Interesting results obtained

Neutron stars are compact objects with a normal boundary layer. However, centrifugal pressure supported boundary layers may also form around them just as in the case of black holes. The net spectra must include the radiations from the Keplerian disk, boundary layer, and the Comptonized radiations. Masses of black holes in active galactic nuclei were obtained using TCAF solution and these masses agree with those obtained from other techniques. In seems that the matter is accreted through the Roche loab in low mass X-ray binaries and any change in accretion rate of the Keplerian disk at the outer edge is manifested in change in X-rays after a few days due to viscous time delay. The viscous time scale gives an idea of the size of the disk. In high mass X-ray binaries, this delay is found to be a few hours only indicating the disk size is very small. This is expected from a system where the companion supplies huge amount of winds.

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Supervision of Research / Students

a) Ph.D. Students

1. Somnath Dutta; Multi-wavelength studies on Galactic H II regions; Awarded
2. Supriyo Dutta; Studies on Cool and Evolved stars; Thesis submitted
3. Anindita Mondal; Multi-wavelength studies of Novae; Thesis submitted
4. Samrat Ghosh; Understanding the Atmosphere of Brown Dwarfs and Low Mass Stars; Under progress
5. Dhrimadri Khata; Understanding of Physical Properties of M-dwarfs : Optical and Near-IR Spectroscopic Studies; Under progress
6. Alik Panja; A Multiwavelength Study of Galactic Star-forming Regions; Under progress
7. Siddhartha Biswas; Studies of Pre-main Sequence stars in the Galactic Star-forrmation processes; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s

1. Mr. P. Ravi Rjaja; Study of Exo-planet transit light curves and their different analysis methods; Osmania University

Teaching activities at the Centre

1. Autumn semester; Basic Laboratory -I (PHY 191); Integrated PhD; 7 students; with 1 (Prof. Samir Pal) co-teacher
2. Spring semester; Astrophysics and Astronomy (PHY 403); Integrated PhD; 6 students; with 1 (Dr. Ramkrishna Das) co-teacher

Publications

a) In journals

1. Supriyo Ghosh, **Soumen Mondal**, Ramkrishna Das, Dhrimadri Khata, Spectral calibration of K-M giants from medium-resolution near-infrared HK-band spectra, Monthly Notices of the Royal Astronomical Society, Volume 484, Issue 4, p.4619-4634, 2019.
2. A. Mondal, R. Das, G. Shaw, **Soumen Mondal**, A photoionization model grid for novae: estimation of physical parameters, Monthly Notices of the Royal Astronomical Society, Vol. 483, p. 4884-4892, 2019.
3. Somnath Dutta, **Soumen Mondal**, Manash R. Samal, Jessy Jose, The Planck Cold Clump G108.37-01.06: A Site of Complex Interplay between H II Regions, Young Clusters, and Filaments, The Astrophysical Journal, Volume 864, 2018.

b) Other Publications

1. Mondal, Soumen; Ghosh, Samrat; Khata, Dhrimadri; Joshi, Santosh; Das, Ramkrishna, "Understanding of variability properties in very low mass stars and brown dwarfs", Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the First Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, November 2016, held in Nainital, India, Vol. 87, pp. 242-252, April 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. A contributory talk on "Rotation rates of pre-main sequence stars" in an International conference "BINA as an International Collaboration" held at Brussels, Belgium during 09 - 12 October 2018; Oct 11, 2018; Royal Observatory of Belgium, Brussels, Belgium; 20 minutes
2. An invited talk on "Rotational Evolution of Young Stellar Objects in Star-forming Regions" in an International conference "Exploring the Universe: Near Earth Space Science to Extra-Galactic Astronomy (EXPUNIV2018)" held at SNBNCBS during 14 - 17 November 2018; Nov 14, 2018; S. N. Bose National Centre for Basic Sciences Kolkata, India; 20 minutes

Membership of Committees

a) Internal Committee

1. Member secretary, Local Management Committee of Technical Research Centre

Sponsored Projects

1. Technical Research Centre; DST; 5 years; Co-PI

Conference / Symposia / Workshops / Seminars etc. organized

1. An International conference "Exploring the Universe: Near Earth space science to extragalactic astronomy" (EXPUNIV2018)"; Nov 14, 2018; S. N. Bose National Centre for Basic Sciences; 14 - 17 November 2018

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Dr. Jessy Jose, Indian Institute of Science Education and Research Tirupati, Rami Reddy Nagar, Karakambadi Road, Mangalam (P.O.), Tirupati 517507, India; 03; National
2. Dr. Manash R. Samal, Physical Research Laboratory, Navrangpura, Ahmedabad, Gujarat 380009, India; 03; National
3. Dr. Gargi Shaw, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Homi Bhabha Road, Navy Nagar, Colaba, Mumbai 400005, India; 02; National

Societal impact of Research

1. A spectroscopic based low-cost instrument "Mil-Q-Way" is being developed under Technical Reseach Centre for the detection of adulteration of milk. A prototype instrument is already developed at the Centre, which is under trial run.

Significant research output / development during last one year

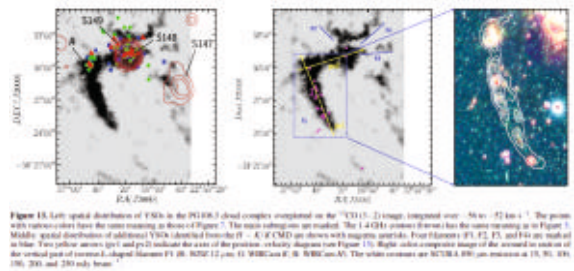
a) General research areas and problems worked on

Star-formation, Extra-solar planets, Brown dwarfs, and low-mass stars, Evolved AGB stars, Small solar system objects, Astronomical Instrumentation

b) Interesting results obtained

A. Star-formation in a Planck Cold Clump G108.37-01.06

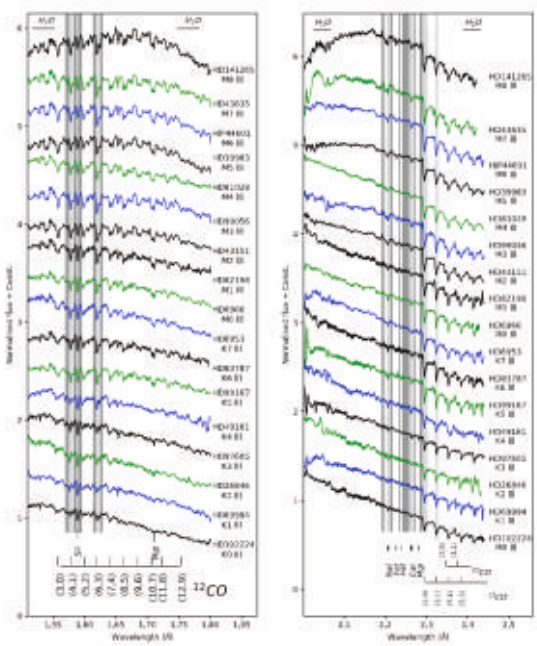
The Planck Galactic Cold Clumps (PGCCs) are possible representations of the initial conditions and very early stages of star formation. With the objective of understanding better the star and star cluster formation, we probe the molecular cloud associated with PGCC G108.37-01.06 (hereafter PG108.3), which can be traced in a velocity range of -57 to -51 km/s. The INT Photometric Ha Survey images reveal Ha emission at various locations around PG108.3, and optical spectroscopy of the bright sources in those zones of Ha emission discloses two massive ionizing sources with spectral type O8-O9V and B1V. Using the radio continuum, we estimate ionizing gas parameters and find the dynamical ages of H II regions associated with the massive stars in the range of 0.5–0.75 Myr. Based on the stellar surface density map constructed from deep near-infrared Canada–France–Hawaii Telescope observations, we find two prominent star clusters in PG108.3; of these, the cluster associated with H II region S148 is moderately massive (~240 M_Sun). A careful inspection of James Clerk Maxwell Telescope 13CO (3–2) molecular data exhibits that the massive cluster is associated with a number of filamentary structures. Several embedded young stellar objects (YSOs) are also identified in PG108.3 along the length and junction of filaments. We find evidence of a velocity gradient along the length of the filaments. Along with kinematics of the filaments and the distribution of ionized, molecular gas and YSOs, we suggest that the cluster formation is most likely due to the longitudinal collapse of the most massive filament in PG108.3 **(Dutta et al. APJ, 2018)**.



B. Spectral calibration of K–M giants from medium-resolution near-infrared HK-band spectra

Stellar spectral libraries have a particularly important role to understand and classify the stellar population as well as an evolutionary synthesis for the individual sources in the field, star clusters of our Galaxy, and integrated stellar lights in the extragalactic sources. The new medium resolution spectra (?/ ? ~ 1200) of K–M giants covering wavelength ranges 1.50–1.80 and 1.95–2.45 μm are presented here. The sample

includes 72 K0-M8 giants from our TIRSPEC observations and all available 35 giants in that spectral range from archival IRTF spectral library. We have calibrated here the empirical relations between fundamental parameters (e.g. effective temperature and surface gravity) and equivalent widths of some important spectral features like Si I, Na I, Ca I, and 12CO molecular bands in the near-Infrared regions. We find that the CO first-overtone band at 2.29 μm and second-overtone band at 1.62 μm are a reasonably good indicator of temperature above 3400 K and surface gravity. We show that the dispersion of empirical relations between CO-bands and Teff significantly improves considering the effect of surface gravity **(Ghosh et al., MNRAS, 2018)**.

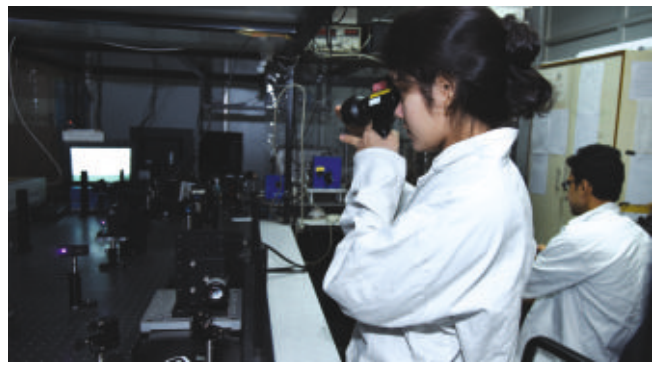


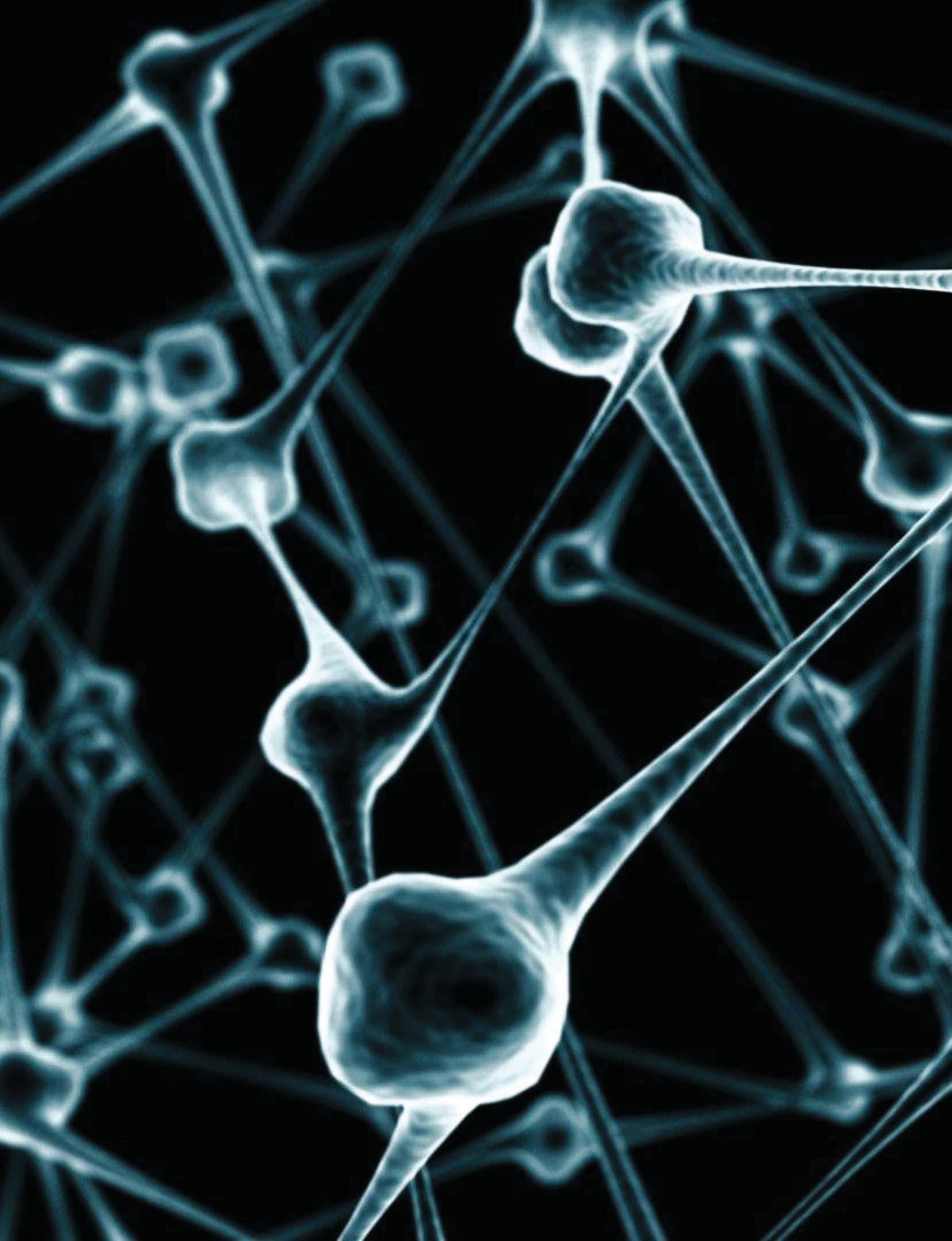
c) Proposed research activities for the coming year

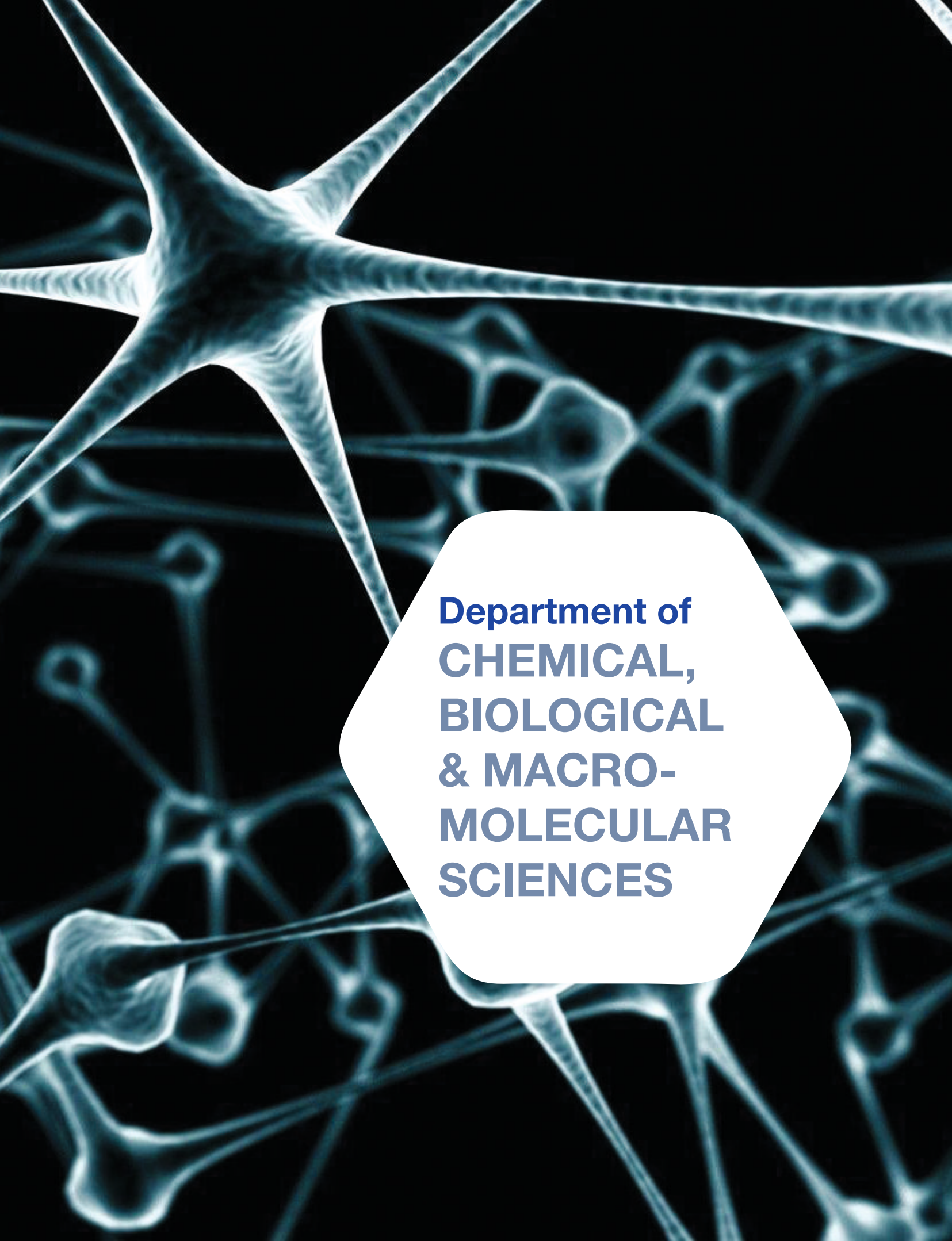
1. S. N. Bose Centre Telescope project at Panchet Hill: At S. N. Bose Centre, we have initiated to establish a World-class Astronomical observing facility at Panchet hill, Purulia, India. This project envisages establishing initially a small one-meter-class relatively wide-field telescope, which will be first in the eastern part of the country. Scientific motivations for our telescope program encompass forefront problems in Astronomy and Astrophysics ranging from Extra-solar planets to Black-hole Astrophysics. The 2-hectares land on the Panchet hill-top, Purulia for the said Astronomical Observatory site had been approved by the Forest department of Govt. Of India and state Govt. Of West Bengal, and the land hand-over to the Centre is under process now.
2. On-going scientific programs in the observational Astronomy: I Spectrophotometric studies of late M-type stars (dwarfs and giants) and Miras : Spectrophotometric studies of low-to-intermediate mass stars represent a vital test of theoretical models of stellar evolution, structure, and atmospheres. In stellar evolution. 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: Multi-wavelength studies of such regions provide a census of Young Stellar Objects, their fundamental parameters e.g., masses, ages, effective temperatures, circumstellar disks around them (if any), etc. We are studying these regions in optical, near-infrared (near-IR) and mid-infrared (mid-IR) wavelengths from the ground and space-based national/international facilities. To provide comprehensive observations and in-depth study of the physical properties of Very Low Mass (VLM) objects and brown dwarfs in the galactic field as well as in young star-forming regions, we have started an observational program on "Photometric variability studies and characterization of very-low-mass (VLM) stars and brown dwarfs " using the National telescope facilities. iii). Astronomical Instrumentation: With our expertise in the Optical/IR instrument design and development, we are working to establish an Astronomical Instrumentation Laboratory at the Centre for building the state-of-art backend instruments for the telescopes. We have planned one fiber-fed low-intermediate resolution spectrograph for our own telescope and other national facility telescopes as a visitor instrument.

Any other matter

1. Advanced manpower generation through training of IPh.D./Ph.D. students for National needs in educational sectors as well as the need for National/ International mega projects of Govt. of India (e.g., TMT, LIGO, etc.).







Department of CHEMICAL, BIOLOGICAL & MACRO-MOLECULAR SCIENCES

Department of Chemical, Biological & Macro-Molecular Sciences

Jaydeb Chakrabarti

Department profile indicators

Table A : Manpower and resources

Number of faculties	10
Number of Post –doctoral research associate (centre+project)	06
Number of Ph.D students	39
Number of other project staff	12
Number of summer students	08
Projects (ongoing)	13

Table B: Research Activities indicators

Number of research papers in Journals	57
Number of Book-chapters/books	01
Number of other publications	02
Number of Ph.D students graduated (submitted+degree awarded)	12
Number of M.Tech/M.Sc projects	03

Table C: Academic activities and likeage

Number of courses taught by faculties	08	
Number of Visitors (non –associates)	03	
Number of associates	01	
Number of Seminars organized	12	
Number of Conference/Symposia/Advanced Schools organized	09	
Number of talks delivered by members of department in conferences/Symposia	National	45
	International	07

Most important research highlights

The department makes constant endeavor of research both in fundamental science and technology oriented research. Highlights on some of the key achievements are:

- Reports on (1) dielectric relaxation measurements of Acetamide+Urea deep eutectic solvent (J. Chem. Phys. **149**, 2018, 124501) and (2) relaxation dynamics measurements of lithium battery electrolytes (J. Mol. Liq. **290**, 2019, 111225) for the first time of their kind.
- Theoretical understanding on (1)experimental observations on rapid isotopic exchange in nano-meter sized clusters (Sciences Advances, (DOI: 10.1126/Sciadv.aau7555, 2019); (2) anion specificity of CaNN motif in functional proteins (Journal of computer-aided molecular design, 32, 929, 2018) and (3) transient responses of a charged binary colloid (Soft matter, 14, 4477, 2018).
- Stability enhancement of DNA molecules by amino acid based ionic liquids (ACS Central Science 4, 1642-1651 (2018)).
- Developed home-built optical rectification (OR) based THz radiation facility; one-color and two-color optical pump-probe transient absorption set up.
- Technology transfer through NRDC for the noninvasive detection of anemia to an Indian company.

Summary of research activities

Prof. Ranjit Biswas and his group work for an integrated understanding of chemical events in complex systems. This includes dielectric relaxation and measurement of relaxation dynamics in deep eutectic mixture and lithium battery electrolytes, reported for the first time in the literature.

Prof. Jaydeb Chakrabarti and his group are involved in research area of soft condensed matter physics. This group has investigated dynamics of colloids in external perturbation, anion selectivity by peptide motif and exchange of atoms between clusters.

Dr. Suman Chakrabarti and his co-workers work in the area of computational biophysical chemistry. They have investigated stability of DNA molecules in amino-acid based ionic liquids. Using combination of experimental and computational methods they demonstrated that such ionic liquids tend to enhance the structural stability of DNA molecules through multi-modal binding modes.

Prof Gautam Gangopadhyay and his group focus on: Molecular quantum Dynamics and Quantum transport; Multiscale nonlinear dynamics in open Chemical and Biological Systems; and Nonequilibrium Features Of Voltage Gated Sodium Ion Channel

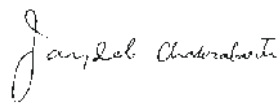
Prof Rajib Kumar Mitra and his group are involved in primarily THz spectroscopic technique. They explored the microstructure and collective dynamics of the membrane interfacial hydration shell in zwitterionic and negatively charged phospholipid membrane bilayers using terahertz time-domain spectroscopy. Their THz studies established the key role of hydrophobicity to determine the effect of complex ionic salts on protein hydration.

Prof. Samir Kumar Pal and his coworkers focus on Experimental nano-physics and bio-nano interfaces which encompasses both the fundamental science and development of indigenous technology for immediate health applications. Last academic year their primary achievement was technology development which includes AJO technologies transfer to NRDC for potential commercialization. **This is first ever technology transfer from our Centre.**

Dr Manik Pradhan and his group are involved in research area using cavity ring down spectroscopy as a major tool. They achieved in the last academic year: (1) simultaneous monitoring of three stable isotopes of hydrogen sulphide (H2S), i.e. H232S, H233S, and H234S, within a single laser scan of 0.4 cm-1 by means of an external-cavity quantum cascade laser (EC-QCL) coupled to high-resolution cavity ring-down spectroscopy (CRDS) near 7.5 μm. (2) A high-resolution external cavity-quantum cascade laser at ~6.2?μm coupled with high-sensitive cavity ring-down spectroscopy (CRDS). They provide a spectroscopic window that may enable selective and high-sensitive sensing of 1,3-butadiene in the future.

Dr Subhra Jana and her group developed: (1) porous materials with high efficiency in removing mercury from aqueous solution; and (2) inorganic-organic hybrid nanocomposites for the extraction of toxic inorganic contaminants from aqueous solution.

Dr. Tatini Rakshit reported a rational design and optimization of fluorescence-Raman bimodal nanoparticles (FRNPs) by DNA-enabled molecular engineering. FRNPs enable highly efficient image-guided photo-thermal ablation of tumors, widening the scope of the NPs into the therapeutic realm.



Jaydeb Chakrabarti

Head, Department of Chemical, Biological and Macromolecular Sciences

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Supervision of Research / Students

a) Ph.D. Students

1. R Kayal, SRF (IACS)
2. K Hazra, SRF (IACS)
3. D Chakravarti, SRF (IACS)

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. S N Bose Memorial Lecture, Bangiya Bijnan Parishad: Science, Faith and Human Values: Some reflections; January 25, 2019.
2. Annual Alumni Talk: German Consulate, Kolkata: Emergence of Modern Research in Physics and Chemistry in Colonial India: the German Connection; February 8, 2019.
3. Science Day Lecture, IISER, Kolkata: An Eternal Quest: Some Less-known Researches of Raman; February 29, 2019.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

I. (1) A Shee, Univ of Michigan, Ann Arbor, USA; (2) S. Sen, Hylleraas Centre, Univ. of OSLO,Norway (3) T Saue, Paul Sabatier University, Toulouse, France; (4) B P Das, Tokyo Institute of Technology, Japan; (5) A Sen, previously at MPI, Muelheim, Germany; (6) T Helgaker, Hylleraas Centre, Univ. of Oslo, Norway; (7) L Cheng, Johns Hopkins University, USA;

II. Professor Yvon Maday, Universite Pierre et Marie Curie, Sorbonne, Paris: ERC funded collaborator

Significant research output / development during last one year

a) General research areas and problems worked on

Development and Validation of Many-Body Theories for Electronic Structure

b) Interesting results obtained

Interplay of correlation, relativity and orbital relaxation in electronic properties

Theoretical prediction of the inner valence processes such as core ionization potential (IP) poses a special challenge to any high level correlation theory. As an example, an accurate description of the core ionization phenomenon requires proper quantitative modeling of not only the differential correlation attendant on ionization, but also of the orbital relaxation which is huge. For molecules containing one medium-heavy atom, the scalar relativistic effect tends to become important In the series of example molecules of the generic formula [XHn] with X as the non-hydrogen atom, our continued research using our recently developed relativistic coupled cluster theory in both non-relativistic (NR) and spin-free Dirac-Coulomb (DC) Hamiltonian regime clearly establishes this with quantitative accuracy. Since spin-orbit coupling is relatively small up to medium heavy atoms, the spin-free DC Hamiltonian has been studied in both a four-component and a two-component framework. The most widely accepted approach for the two component theories is the exact two-component one-electron (X2C-1e) Hamiltonian, and we have invoked its spin-free version in our numerical implementation.

The effects of correlation and relativity are not additive, and non-perturbative theories are ideally suited for handling them together. We have now embarked on the study of excitation energy of molecules with up to medium heave atoms in the spin-free formalisms. We will also assess the lowest order Quantum Electrodynamic (QED) correction to the core excitation energies. We estimated the importance of the spin-free part of the Gaunt term at the mean field level, i.e., the ?SCF level, which contains the current-current interaction. We have also assessed the contribution of the spin-dependent part of the Gaunt term at the ?SCF level and found it to be much smaller than the spin-free part.

Use of self-consistent propagator theories to study excitation energies

Using the self-consistent propagator formalism of Prasad and Mukherjee, which allows one to form a seamless carry over of an effective Hamiltonian theory to a propagator theory, we have studied the accuracy of the valence excitation energies of a series of closed shell molecules using the newly developed self-consistent propagator theory up to third order. We show that the strictly third order theory is equivalent to the so-called third order Algebrain Diagrammatic Construction (ADC(3)), while a unitary coupled cluster representation of the ground state which embodies all the terms upto third order, but having all other terms upto the commutator needed to incorporate the third order terms, perform very well, indicating the high potentiality of the method. More work dealing with core ionization potentials is in progress.

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Supervision of Research / Students

a) Ph.D. Students

1. Sandip Saha; Nonlinear Dynamics in open systems; Under progress
2. Premasish Kumar; Nonlinear nonequilibrium dynamics; Under progress
3. Anirban Karmakar; Quantum transport through molecular systems; Thesis submitted

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Arpan Chakrabarty; Graph Theory in moleular network dynamics; University of Hyderabad

c) Post Doctoral Research Scientist/s

1. Prasanta Kundu; Electron transfer dynamics in heregeneous systems

Teaching activities at the Centre

1. Autumn semester; Equilibrium Statistical Mechanics; PhD; 8 students; with 1 (Jaydeb Chakrabarti,) co-teacher

Publications

a) In Journals

1. Sandip Saha and **Gautam Gangopadhyay**, When an oscillating center in an open system undergoes power law decay, Journal of Mathematical Chemistry (2019) 57:750–768.
2. S Saha, **G Gangopadhyay** and D S Ray, Reduction of Kinetic Equations to Liénard–Levinson–Smith Form: Counting Limit Cycles, Int. J. Appl. Comput. Math (2019) 5: 46
3. Biswajit Das and **G Gangopadhyay**, Diffusion Influenced Non-equilibrium Gating Processes of a Voltage-gated Potassium Ion Channel, The Pharmaceutical and Chemical Journal, 2018, 5(2):144-166
4. S Das, A Samanta, **G Gangopadhyay**, and S Jana, Clay-Based Nanocomposites as Recyclable Adsorbent toward Hg(II) Capture: Experimental and Theoretical Understanding, ACS Omega 2018, 3, 6283-6292

b) Books / Book Chapter / Monographs Published / Edited

1. Abstract Book of Multiscale Simulation and Mathematical Modelling of Complex Biological Systems(MSMM'19) 30thJan--1st Feb' 2019, at Jawarharlal Nehru University, New Delhi

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Talk on Large deviation theory in turn over of enzyme catalysis on (MSMM) 30thJan--1st Feb' 2019, at Jawarharlal Nehru University, New Delhi; Jan 30, 2019; Abstract Book of Multiscale Simulation and Mathematical Modelling of Complex Biological Systems(MSMM'19) 30thJan--1st Feb' 2019, at Jawarharlal Nehru University, New Delhi; 3 days

Membership of Committees

a) Internal Committee

1. Project and Patent Cell
2. Vigilance Officer upto October'2018

Conference / Symposia / Workshops / Seminars etc. organized

1. Co-oranizer of International Conference on Functional Materials(ICCFM); Dec 13, 2018; Biswa Bangla Convention Centre; 4-days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. IACS, Kolkata; Sl No. 2, International

Significant research output / development during last one year

a) Interesting results obtained

Our recent activity is to look into the physical properties of open nonlinear dynamical systems containing periodic orbits by adopting multiscale perturbation analysis to cover single to multi-limit cycles which can arise in various practical situations. In order to understand the response properties of limit cycle under external perturbation we have investigated subharmonic resonances. As the multiple limit cycles in a given system is an important issue, we have explored on the counting of limit cycles and its application in systematic construction of birhythmic and tri-rhythmic oscillators from a simple limit cycle system. As the diffusion is an integral part of the most spatially heterogeneous dynamical systems in Chemistry and Biology we have studied reaction-diffusion systems. In presence of a slow diffusion time scale in a system of limit cycle through the construction of amplitude equation we need to investigate the diffusion driven instability in spatio-temporal pattern.

b) Proposed research activities for the coming year

1. We are recently interested to work on Nonequilibrium thermodynamics in nonlinear dynamical systems. Thermodynamic cost in pattern formation in nonlinear dynamics will be estimated. Thermodynamics of small systems will also be emphasized in this project.

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Supervision of Research / Students

a) Ph.D. Students

1. Rahul Karmakar; Soft matter physics; Under progress
2. Abhik GhoshMoulick; Biomolecular systems; Under progress
3. Edwine tendons; Soft matter physics; Under progress
4. Raghavendra; Soft matter physics; Under progress
5. Arunava Adak; Biomolecular systems; Under progress
6. Sashthi Charan Mandal; Biomolecular systems; Under progress
7. Piya Patra; Biomolecular system; Under progress

Teaching activities at the Centre

1. Spring semester; Phy201 Statistical mechanics; Integrated PhD; 13 students

Publications

a) In Journals

1. P. Chakraborty, A. Nag, G. Natarajan, N. Bandyopadhyay, G. Paramasivam, M. K. Panwar, **J. Chakrabarti** and T Pradeep, Rapid isotopic exchange in nanoparticles, Science Advances, 5, no. 1, eaau7555, 2019 (DOI: 10.1126/sciadv.aau7555).
2. P Patra, M Ghosh, R Banerjee, **J Chakrabarti**, Quantum chemical studies on anion specificity of $C^{\alpha}NN$ motif in functional proteins, Journal of computer-aided molecular design, 32, 929, 2018.
3. S. Dutta and **J. Chakrabarti**, Transient dynamical responses of a charged binary colloid in an electric field, Soft matter, 14, 4477, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Model for aggregation of misfolded proteins, ISPC meeting, Bangalore, 2018; February 14, 2019; ICTS, Bangalore.
2. Mean field description of protein function; December 30, 2018; New Delhi.
3. Mean field description of protein function; March 22, 2019; IIT Kanpur.

Fellow / Member of Professional Body

1. Biophysical Society, US

Conference / Symposia / Workshops / Seminars etc. organized

1. International conference on functional materials; Dec 12, 2018; Kolkata

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Sl No. 1, National

Significant research output / development during last one year

a) Interesting results obtained

1. Attempts have been made to explore the interplay between dynamics and structural changes in a simple system of a binary mixture of oppositely charged colloidal particles driven by a constant electric field using Brownian Dynamics Simulations. This system is widely regarded as a generic model of pattern forming non-equilibrium systems. The system is known to form microscopic lanes of like charges along the field. We investigate the growth in structural heterogeneity as electric field is turned on equilibrium system in transient condition. The aging persists till the system reaches steady states. We show that the lifetime of anomaly in dynamical responses depends upon the time of observations after the field is turned on. The formation of heterogeneous structures shows signature of aging. The aging is not present when the steady states relax back to

equilibrium in absence of the field.

2. Anion binding CaNN motif is found in functionally important regions of protein structures. This motif based only on backbone atoms from three adjacent residues, recognizes free sulphate or phosphate ion as well as phosphate groups in nucleotides and in a variety of cofactors. The mode of anion recognition and microscopic picture of binding interaction remains unclear. Here we perform self-consistent quantum chemical calculations considering sulphate and phosphate bound CaNN motif fragments from crystal structures of functional proteins in order to figure out microscopic basis of anion recognition. Our calculations indicate that stability and preference of the anion in the motif depends on the sequence of the motif. The stabilization energy is larger in case of polar residue containing motif fragment. Nitrogen atom of the polar residue of motif mainly participates in the coordination at the lowest energy levels. Anion replacement decreases stabilization energy along with coordination between motif atoms and oxygen atoms of anion shifted to higher energies, suggesting preference of the motif residues to specific anion. Our analysis may be helpful to understand microscopic basis of interaction between proteins and ionic species.

b) Proposed research activities for the coming year

1. Theoretical description of thermophoretic self-assembly
2. Dynamics of colloids in external perturbation
3. Model studies for disordered/partially structures protein functions

Any other matter

1. Training students

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Supervision of Research / Students

a) Ph.D. Students

1. Sanchi Maithani; Cavity ring-down spectroscopy and Evanescent Wave; Under progress
2. Biswajit Panda; High-resolution gas-phase molecular spectroscopy; Under progress
3. Mithun Pal; Quantum Cascade Laser Spectroscopy; Under progress
4. Akash Das; Optical properties in 2D materials; Under progress
5. Vishal Agarwal; Nanomaterials and Spectroscopy; Under progress
6. Chiranjit Ghosh; Cavity enhanced absorption spectroscopy and diabetes detection; Awarded
7. Sumon Som; Spectroscopy and Biomedical Diagnostics; Awarded

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Saikat Ghosh; Isotopic Fractionation and Spectroscopy; SERB Project (Co-PI) at SN Bose Centre
2. Sayoni Bhattacharya; Breath Analysis and Analyzer Calibration; TRC (Project Student)
3. Swarnava Biswas; Breath Analysis and patient management; TRC (Project Student)
4. Mallar Banerjee; Isotope analysis; Summer Project Student

c) Post Doctoral Research Scientist/s

1. Arun Bera (Joint); Nano Materials

Teaching activities at the Centre

1. Spring semester; Methods in Experimental Physics (PHY 391); Integrated PhD; 8 students

Publications

a) In Journals

1. Sanchi Maithani, Abhijit Maity, Mithun Pal, Sayoni Bhattacharya, Gourab Dutta Banik, Chiranjit Ghosh, Sujit Chaudhuri, **Manik Pradhan**, Isotopic evidences of the preferential coordination between ^{12}CO2 and urease enzyme, Chemical Physics 520, 21-26, 2019.
2. Sanchi Maithani, Abhijit Maity, **Manik Pradhan**, High-resolution spectral analysis of hybrid A/B-type band of 1, 3-butadiene at 6.2 µm using an EC-QCL coupled with cavity ring-down spectroscopy, Chemical Physics 522, 123-128, 2019.
3. Mithun Pal, Sanchi Maithani, Abhijit Maity, **Manik Pradhan**, Simultaneous monitoring of ^{32}S, ^{33}S and ^{34}S isotopes of H_2S using cavity ring-down spectroscopy with a mid-infrared external-cavity quantum cascade laser, Journal of Analytical Atomic Spectrometry 34, 860-866, 2019.
4. Samik Roy Moulik, Abhijit Maity, Prasenjit Chakraborty, **Manik Pradhan**, Barnali Ghosh, Evidence of Isotope Selective Diffusion of Ambient CO_2 Gas in WO_3 Nanostructures, J. Phys. Chem. C 123,4, 2573-2578, 2019.
5. Mithun Pal, Sanchi Maithani, Abhijit Maity, Sujit Chaudhuri, **Manik Pradhan**, Exploring the physiological link of breath N_2O through nitrification and denitrification processes in human gastric juice, Journal of breath research 13, 016002, 2018.
6. Mithun Pal, Abhijit Maity, **Manik Pradhan**, A continuous-wave quantum cascade laser near 7.5 µm combined with 2f-wavelength modulation spectroscopy for trace monitoring of ambient CH_4 concentrations, Laser Physics 28, 105702, 2018.
7. Akash Das, **Manik Pradhan**, Goos–Hänchen shift for Gaussian beams impinging on monolayer-MoS_2-coated surfaces, Journal of the Optical Society of America B 35 (8), 1956-1962, 2018.

8. Akash Das, **Manik Pradhan**, Exploring the optical beam shifts in monolayers of transition metal dichalcogenides using Gaussian beams, Optics Communications 437, 312-320, 2019.
9. Suman Som, Gourab Dutta Banik, Abhijit Maity, Chiranjit Ghosh, Sujit Chaudhuri, **Manik Pradhan**, Non-invasive diagnosis of type 2 diabetes in Helicobacter pylori infected patients using isotope-specific infrared absorption measurements, Isotopes in environmental and health studies 54 (4), 435-445, 2018.

b) Other Publications (including conferences)

1. Sanchi Maithani, Abhijit Maity, Mithun Pal, Manik Pradhan, "Ro-vibrational analysis of ammonia at 6.2 µm using high-precision cavity ring-down spectroscopy", Optics and Photonics for Energy and the Environment (Optical Society of America) EW3A. 1, 2018.
2. Mithun Pal, Abhijit Maity, Sanchi Maithani and Manik Pradhan, "Spectroscopic analysis of Nitrous Oxide (N2O) using Wavelength Modulation technique coupled with a mid-IR Quantum Cascade Laser", PHOTONICS-2018: International Conference on Fibre Optics and Photonics, December, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited Speaker: "Spectroscopy and Dynamics of Molecules and Clusters (SDMC)" Feb 21, 2019; Shimla, India; 21-24th February, 2019.
2. Invited Speaker: "25th Indian Society for Chemistry and Biology International Conference, ISCBC-2019"; Jan 12, 2019; Lucknow, India; 12-14th January, 2019.
3. Invited Speaker: "6th World Congress on Nanomedical Sciences, ISNSCON-2018" Apr 7, 2019; Vigyan Bhawan, New Delhi, India; 7-9th January, 2019.
4. Invited Speaker: "One Day Discussion Meeting on Atmospheric Chemistry by ISRAPS"; Nov 24, 2018; IACS, Kolkata India; 24th November, 2018.
5. Invited Speaker: "Nanobioteck-2018, 3rd Annual Conference of ISNM"; Oct 25, 2018; AIIMS, New Delhi, India; 25-27th October, 2018.
6. Invited Speaker: "National Conference on Advances in Spectroscopy: Molecules to Materials, NCASMM-2018"; Oct 4, 2018; IITRAM, Ahmedabad, India; 4-6th October, 2018.
7. Invited Speaker: "Innovations in Frontier Chemistry, IFC-2018"; May 8, 2018; IISER Pune, India; 8-9th May, 2018.
8. Invited Speaker: "7th International Conference on Perpectives in Vibrational Spectroscopy, ICOPVS-2018"; Nov 25, 2018; BARC, Mumbai, India; 25-29th November, 2018.

Membership of Committees

a) Internal Committee

1. Member of SCOLP Committee
2. Member of Works Committee
3. Member of Reservation Cell Committee
4. Member in Various Interview, Thesis Committee and Purchase committee

Patent/s submitted / granted

1. Dioxo vanadium (v) complex as carbonic anhydrase inhibito (First examination report submitted); E-91/708/2019/KOL; Applied

Awards / Recognitions

1. Guest of Honour Felicitation by Department of Physics, IITRAM, Ahmadabad on 6th October, 2018 for delivering invited lecture and chairing the session at the conference.

Fellow / Member of Professional Body

1. Chemical Research Society of India (CRSI)
2. Indian Society of Chemists and Biologists (ISCB)
3. Research Society for the Study of Diabetes in India (RSSDI)
4. Indian Spectroscopy Society

Sponsored Projects

1. New-frontiers in quantitative mid-IR high-resolution cavity ring-down spectroscopy using quantum cascade laser; DST; 2015-2018; PI
2. Understanding of growth of vertically aligned nanowires or nanotubes of binary oxides and physics of isotopic fractionation of gases by them; DST; 2017-2020; Co-PI

Conference / Symposia / Workshops / Seminars etc. organized

1. International Conference on Complex and Functional Materials (ICCFM-2018) Dec 13, 2018; Biswa Bangla Convention Centre, Kolkata; 13-16, December, 2018

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Collaborator: Dr. Sujit Chaudhuri at Department of Gastroenterology, AMRI Hospital, Salt Lake, Kolkata, India; Sl.No. 1; National
2. Collaborator: Dr. Sujit Chaudhuri at Department of Gastroenterology, AMRI Hospital, Salt Lake, Kolkata, India; Sl. No. 9; National

Participation in Science Outreach program

1. Innovation Bazaar at AIIMS, New Delhi (25-27th October, 2018) Given lecture and interacted with stockholders, industry people, innovators, entrepreneurs, doctors, policy makers, scientists etc.
2. "The Scientist's Role in Technology Commercialization", India Habitat Centre, New Delhi, 16-18 January, 2019

Societal impact of Research

1. Currently few prototype breath analyzers have been developed for the detection of stomach infection and ulcer diseases. They are under the clinical trials as a prelude to technology transfer and subsequent commercialization.
2. We are also working for the development a prototype analyzer for non-invasive detection of diabetes.

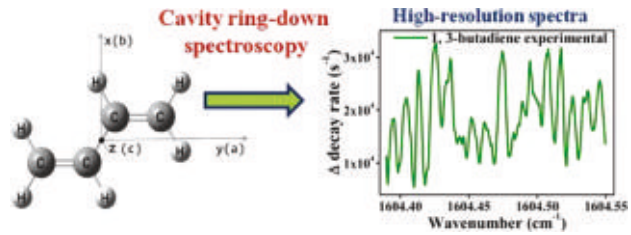
Significant research output / development during last one year

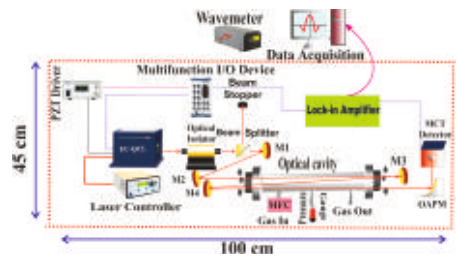
a) General research areas and problems worked on

Cavity Ring-Down Spectroscopy, Quantum Cascade Laser & Applied Spectroscopy, High-Resolution Gas-phase Molecular Spectroscopy, Applications in Laser spectroscopy in Medical Diagnostics and Environmental Sensing, Applied Optics and Optical Properties of Nanomaterials

b) Interesting results obtained

(A) The simultaneous monitoring of three stable isotopes of hydrogen sulphide (H^2S), i.e. $H_2{}^{32}S$, $H_2{}^{33}S$, and $H_2{}^{34}S$, within a single laser scan of 0.4 cm-1 has been achieved by means of a continuous-wave (cw) external-cavity quantum cascade laser (EC-QCL) coupled to high-resolution cavity ring-down spectroscopy (CRDS) near 7.5 µm. Moreover, simultaneous monitoring of multiple trace species such as CH_4, N_2O, and H_2S in a single laser scan of 0.05 cm-1 was demonstrated with high sensitivity and molecular specificity. The present study may lead to several potential future applications ranging from understanding of sulphur isotope geochemistry and fractionations to environmental sensing.





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Supervision of Research / Students

a) Ph.D. Students

1. Debasish Das Mahanta; Investigation of the Collective H-bonded network and Hydration Dynamics around Electrolytes and Bio-molecules; Awarded
2. Sk. Imadul Islam; Studies on ultrafast dynamics and spectroscopic investigations on fluorescent probes in bimolecular and biomimetic recognition; Under progress
3. Saikat Pal; Studies on the Effects of Different Crowding agents on Protein Folding-Unfolding Process and its Kinetics as well as Activity; Under progress
4. Partha Pyne; Studies of Some Biophysical Processes Using Ultrafast Spectroscopic Techniques; Under progress
5. Anulekha De; Nanomagnetism; Under progress
6. Didhiti Bhattacharya; 2D materials, synthesis, characterization and applications; Under progress
7. Sumana Pyne; Application of Ultrafast Spectroscopy in Biological Systems; Under progress
8. Sudip Majumder; Nanomagnetism; Under progress

b) Post Doctoral Research Scientist/s

1. Chaitrali Sengupta; Fluorescence Characteristics of Quantum dots

Teaching activities at the Centre

1. Autumn semester; PHY 301 (Atomic and Molecular Physics); Integrated PhD; 7 students; with 1 (Prof. Anjan Barman,) co-teacher
2. Autumn semester; CB 527 (Molecular Physics & Spectroscopy); PhD; 7 students; with 1 (Prof. Anjan Barman,) co-teacher
3. Spring semester; PHY 405 (Biological Physics); Integrated PhD; 5 students
4. Spring semester; CB 526 (Fundamentals of Biophysics); PhD; 10 students

Publications

a) In journals

1. S. Pal, N. Samanta, D. Das Mahanta, **R.K. Mitra**, and A. Chattopadhyay, Effect of Phospholipid Headgroup Charge on the Structure and Dynamics of Water at the Membrane Interface: A Terahertz Spectroscopic Study, J. Phys. Chem. B 122, 5066–5074, 2018.
2. Anulekha De, Sucheta Mondal, Sourav Sahoo, Saswati Barman, Yoshichika Otani, **Rajib Kumar Mitra** and Anjan Barman, Field-controlled ultrafast magnetization dynamics in two-dimensional nanoscale ferromagnetic antidot arrays, Beilstein J. Nanotech., 9, 1123–1134, 2018.
3. Arindam Das, Sk Imadul Islam, Dipak Kumar Das, **Rajib Kumar Mitra**, Modulation of the Excited-State Proton Transfer Rate of d-luciferin in Mixed Reverse Micellar Systems, ACS Omega 3, 5715-5724, 2018.
4. D. Das Mahanta, A. Patra, D. Rana, B. Mukherjee, and **R.K. Mitra**, Heterogeneous structure and solvation dynamics of DME/water binary mixtures: A combined spectroscopic and simulation investigation, Chem. Phys. Lett. 700, 50–56, 2018.
5. Sonali Mondal, Animesh Pan, Animesh Patra, **Rajib Kumar Mitra** and Soumen Ghosh, Ionic liquid mediated micelle to vesicle transition of a cationic gemini surfactant: a spectroscopic investigation, Soft Metter 14, 4185-4193, 2018.
6. Dipak Kumar Das, Sk Imadul Islam, Nirnay Samanta, Yogendra Yadav, Debabrata Goswami, **Rajib Kumar Mitra**, Two Photon Spectroscopy Can Serve as a Marker of Protein Denaturation

Pathway, J. Fluorescence. 28, 855-862, 2018.

7. Nirnay Samanta, Debasish Das Mahanta, Animesh Patra, **Rajib Kumar Mitra**, Soft interaction and excluded volume effect compete as polyethylene glycols modulate enzyme activity, Int. J. Biol. Macromol. 118, 209-215, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. "Current Research on Chemistry of Biomolecules: Experiment" at Discussion Meeting on Current Research on Chemistry of Biomolecules: Theory and Experiment Sep 27, 2018; Durgapur Govt. College, West Bengal
2. "Investigation of Collective Vibrational Dynamics of Water in Presence of Solutes: A THz Spectroscopic Approach" One-Day Symposium on Spectroscopic and computational studies of complex chemical systems at different time and length scales; Dec 22, 2018; IIT, Kanpur
3. "Terahertz: A New Spectroscopic Window to Investigate Collective Vibrational Dynamics"; Aug 27, 2018; BARC, Mumbai
4. "Far-infrared and Terahertz Spectroscopy in Chemistry and Biology"; Aug 28, 2018; Centre for Excellence in Basic Sciences, Mumbai
5. "Far-infrared and Terahertz: A New Spectroscopic Window to Investigate Collective Vibrational Dynamics"; Nov 13, 2018; TU Braunschweig, Germany,
6. "Interaction of small molecules with proteins: Is it direct or through water structure alteration or both?" at SOFT MATTER AND CHEMICAL PHYSICS IN KOLKATA REGION; Sep 15, 2018; SNBNCBS, Kolkata

Membership of Committees

a) Internal Committee

1. Faculty in-charge, students affairs
2. Member, Admission committee
3. Member, Students' Curriculum & Research Evaluation (SCREC) Committee
4. Member, Visitor, Associates and Students' Programme (VASP) Committee
5. Warden, Students hostel

Conference / Symposia / Workshops / Seminars etc. organized

1. International Conference on Condensed and Functional Materials; Dec 13, 2018; Biswa Bangla Convention Centre, Kolkata; 13-16 December, 2018

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Collaboration with Prof. Amitabha Chattopadhyay, CCMB, Hyderabad; Sl. No. 1; National
2. Collaboration with Prof. Soumen Ghosh, Department of Chemistry, Jadavpur University; Sl. No. 5; National

Participation in Science Outreach program

1. Delivered a talk at Durgapur Govt. College, West Bengal as a part of the outreach activity of the SNBNCBS.

Significant research output / development during last one year

a) General research areas and problems worked on

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

b) Interesting results obtained

One of the main focuses of our group is to study ultrafast dynamics of chemically and biologically important phenomenon, with special reference to hydration dynamics, using a combination of various experimental techniques viz. THz time domain spectroscopy, pump-probe transient absorption spectroscopy and fluorescence spectroscopy. We have developed both antenna based and optical rectification based THz facilities at the SNBNCBS. In the THz frequency we study the collective vibrational modes of water which are otherwise wiped off in conventional spectroscopic techniques and thus provides with a label free global dynamic information of water around solute molecules. Transient absorption and time-resolved fluorescence, on the other had, provides information on the probe specific local dynamics of water. Combination of these two approaches apprehends the overall hydration dynamics to a larger extend.

Our recent results on the effect of various complex salts on protein stability has unambiguously established the pivotal role of hydrophobicity in protein stability despite their specific ability of being either water structure breaker or maker. A combined THz and one color pump-probe study in solvent

mixture has further strengthened this conclusion.

Our recent study has explored the microstructure and collective dynamics of the membrane interfacial hydration shell in zwitterionic and negatively charged phospholipid membrane bilayers using terahertz time-domain spectroscopy. These results constitute one of the first experimental evidences of the modulation of the dielectric relaxation response of membrane interfacial water by membrane lipid composition in a concentration-dependent manner.

Our group is also interested in studying the effect of externally added molecular crowders in stability and functionality of proteins. Our recent studies on the enzymatic activity of lysozyme in presence of PEGs enzyme activity increases at low osmolyte concentrations (~2%) beyond which it decreases. The maximum in the enzyme efficiency has been explained on the basis of an optimization between excluded volume effect and soft interaction among the protein and the cosolutes. We also investigated the effect of amino acids on the thermal stability of a model protein with a through thermodynamic investigation using differential scanning calorimetry. We observe systematic changes depending upon the property of the amino acid.

We have developed a two-photon absorption measurement system and found it to be an alternative marker to tracking its conformational transformations in proteins using biologically transparent NIR radiation window.

We also have studied excited state electron transfer process of a biologically relevant dye luciferin in reverse micelles at different temperature and found that the associated kinetics could be modulated by changing the parameters of Rms.

We have synthesized different sized (10-70 nm), crystalline, hexagonal 2H-MoS_2 nanoparticles (NPs) dispersed in DMF solvent using a simple exfoliation technique and observe their size dependent emission characteristics. We also found noticeble photocatalytic activity of these materials.

c) Proposed research activities for the coming year

1. We plan to combine two experimental approaches namely THz time domain spectroscopy (which probes the low frequency collective vibration models of water, and therefore very sensitive to the global network dynamics of water around hydrophobic surfaces) and optical pump-probe (transient absorption) spectroscopy (which is extremely sensitive to the local environment of a chromophore) to monitor the expected change in overall hydration of a protein during their self-aggregation. The results of this proposed work would render positive impetus for advancement in the research on the protein-aggregation based neurodegenerative diseases.
2. We plan to explore the effect of cholesterol and its biosynthetic precursors on hydration dynamics in membranes of different phases and its implications in the complex, evolutionarily fine-tuned biology of cholesterol in membranes using THz spectroscopy complemented by time resolved fluorescence approaches. Insights obtained from the proposed experiments would provide with fundamental knowledge in membrane hydration dynamics that could be relevant in the context of various membrane phenomena such as membrane fusion and regulation of lipid-protein interactions in a membrane milieu.
3. We would continue our study to understanding how molecular crowders interact with biomolecules and affect their biological activity. Such molecular crowders often mimic the real cellular environments. We pay special reference to the effect of various ionic liquids on protein stability. We will make a detailed thermodynamic analysis of the processes involved using differential scanning calorimetry measurements. This study will include both experimental as well as simulation measurements.
4. We plan to apply transient absorption measurements (with a possible extension towards optical pump-THz probe measurements) to monitor the ultra-fast hydration dynamics around light harvesting complexes (LHC). Also binding of small molecules (drugs or ligands) to proteins, DNA and membranes will be studied using two-photon absorption measurements.
5. We plan to synthesize and characterize various optical and mechanical proprieties of MoS_2 and other dichalcogenite materials in their two-dimensional layered as well as in nanoparticle forms. We also plan to dope these materials with suitable dopants to enhance their optical and mechanical properties.

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Supervision of Research / Students

a) Ph.D. Students

1. Ejaj Tarif; Experimental studies of deep eutectics; Under progress
2. Atanu Bakshi; Simulation studies of bulk liquids and confined systems; Under progress
3. Juriti Rajbanshi; Simulation studies of ionic liquids and its binary mixtures with common solvents; Under progress
4. Kajal Kumbhakar; Experimental studies of energy materials; Under progress
5. Jayanta Mondal; Dielectri Relaxation and Spectroscopic studies of ionic systems; Under progress
6. Dhrubajyoti Majhi; Simulations studies of dielectric relaxation in deep eutectics; Under progress
7. Narayan Maity; Spectroscopic studies of binary mixtures and other complex systems; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s

1. Arnab Sil; TRC project on food adulteration
2. Indrajit Manna; TRC project on water pollution
3. Soumita Bera; TRC project on biodegradation of xenobiotics

c) Post Doctoral Research Scientist/s

1. Sirshendu Dinda; Experimental studies of complex chemical systems

Publications

a) In Journals

1. H. Srinivasan, V. K. Sharma, S. Mitra, **R. Biswas**, and R. Mukhopadhyay, Dynamics in Acetamide+$LiNO_3$ Deep Eutectic Solvents, Physica B: Condensed Matter 2019, 562, 13-16.
2. Ejaj Tarif, Biswajit Saha, Kallol Mukherjee, Priyadarsi De, and **Ranjit Biswas**, Exploring Aqueous Solution Dynamics of Amphiphilic Diblock Copolymer: Dielectric Relaxation and Time-resolved Fluorescence Measurements, Journal of Physical Chemistry, B 2019, cover article; DOI: 10.1021/acs.jpcb.9b00889.
3. Sukanya Konar, Anirban Sharma, Pradip Kr. Ghorai, and **Ranjit Biswas**, Water-mediated Weakening of Inter-ionic Interactions in Aqueous Mixtures of Ionic Liquid: An Investigation Combining Quantum Chemical Calculations and Molecular Dynamics Simulations, Chemical Physics, 524, 31-39, 2019.
4. Ejaj Tarif, Kallol Mukherjee, Anjan Barman and **Ranjit Biswas**, Are Water-Xylitol Mixtures Heterogeneous? An Investigation Employing Composition and Temperature Dependent Dielectric Relaxation and Time-Resolved Fluorescence Measurements, Journal of Chemical Sciences, 131, 43, 2019.
5. Kallol Mukherjee, Suman Das, Ejaj Tarif, Anjan Barman and **Ranjit Biswas**, Dielectric Relaxation in Acetamide+Urea Deep Eutectics and Neat Molten Urea: Origin of Time scales Via Temperature Dependent Measurements and Computer Simulations, Journal of Chemical Physics, 149, 124501, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited talk at the International Conference on Dynamics at the Interface of Chemistry and Biology" (DICB-2019) IISc, Bangalore during Feb 18-20, 2019, entitled "Ethanol and Water Azeotrope: A Combined Fluorescence Spectroscopic and Computer Simulation Study"; Feb 19, 2019; IISc, Bangalore; 3 days
2. Invited talk in the meeting by National Society for the Radiation and Photochemistry (NSRP) at the Visva Bharati University, Santiniketan during February 07-09, 2019, entitled "Temperature Dependent Dielectric Relaxation in Ionic Deep Eutectics: Role of H-bonding Fluctuation Dynamics and Reorientational Relaxations";

Feb 9, 2019; Shantiniketan; 3 days

3. Invited talk in "National Workshop on Fluorescence and Raman Spectroscopy" at the Jawaharlal Nehru University, New Delhi, during Nov 12-17, 2018 entitled "Frictional Response and Viscosity Decoupling in Deep Eutectics: Experiments and Theory"; Nov 17, 2018; JNU Delhi; 6 days
4. Invited talk in the conference "Inter-Disciplinary Explorations in Chemistry" at the IISER Bhopal during Dec 06-08, 2018, entitled "Dielectric Relaxation in Acetamide+Urea Deep Eutectics: Possible Origin of the Multi-Step Relaxations"; Dec 8, 2018; IISER Bhopal; 3 days
5. Invited talk in the Indo-Japan mini conference at the SSCU, IISC Bangalore on Dec 19-20, 2018, entitled "Dielectric Relaxation in Ionic and Non-Ionic Acetamide Deep Eutectics: Role of Inter and Intra-Species Hydrogen Bonding"; Dec 20, 2018; IISc Bangalore; 3 days
6. Invited Talk at the Department of Physical Chemistry, IACS, Jadavpur, on June 29, 2018, entitled "Viscosity Coupling and Heterogeneity in Deep Eutectics"; Jun 29, 2018; IACS, Jadavpur; 1 day

Significant research output / development during last one year

a) General research areas and problems worked on

Physical Chemistry: Experiments, Theory and Computer Simulations

b) Interesting results obtained

Our focus is to develop a molecular level understanding of relaxation processes in condensed phases and complex media by using experiment, theory and molecular dynamics simulations. The sub-topics that we are interested in are Deep Eutectics, Ionic Liquids, Electrolyte solutions, Binary and Multi-component Mixtures. We employ pico-second resolved fluorescence spectroscopy, molecular dynamics simulation, and time dependent statistical mechanics.

c) Proposed research activities for the coming year

1. Our goal is to explore the structure dynamics relationship of complex chemical systems through experiments, theory and simulations. We use time-resolved fluorescence spectroscopy, dielectric relaxation spectroscopy, and molecular dynamics simulations. In addition, we develop molecular and semi-molecular theories using the framework of equilibrium and time-dependent statistical mechanics.

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Supervision of Research / Students

a) Ph.D. Students

1. Damayanti Bagchi; Spectroscopic Studies On Hybrid-Materials Of Medicinally Important Molecules For Enhanced Biological Activity; Thesis submitted
2. Probir Sarkar; Spectroscopic Studies on Molecules and Nanomaterials for Potential Applications in Medical Diagnosis and Environmental Pollution Monitoring; Thesis submitted
3. Priya Singh; Spectroscopic Studies on Structure, Function and Dynamics of Biological Macromolecules in Physiologically Relevant and Engineered Environments; Under progress
4. Tuhin Maji; Combined experimental and computational investigation on optical and catalytic properties of functionalized metal oxides; Under progress
5. Aniruddha Adhikari; Studies on Therapeutic Potential of Various Nanomaterials and Ethnobotanical Ingredients in Preclinical Disease Model; Under progress
6. Jayita Patwari; Photophysical Studies on Light Harvesting Nanomaterials for Improved Solar Energy Conversion; Under progress
7. Soumendra Singh; Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications; Under progress
8. Arka Chatterjee; Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis; Under progress
9. Arpan Bera; Spectroscopic Studies on Functional Nanohybrids and their Potential Biological Application; Under progress
10. Dipanjan Mukherjee; Experimental Biophysics; Under progress
11. Susmita Mondal; Nanomedicines; Under progress
12. Nur Hasan; Experimental and computational studies on nanohybrids; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Sayan Das; Nanomaterial in agricultural use; University of Calcutta, 2016
2. Anindita Bhattacharya; MOF, Nano-Bio Interface, Nanofertilizers; St. Xaviers College, Kolkata
3. Harmit Joshi; Light Harvesting Materials; SNBNCBS
4. Nibedita Pan; Nano Sensor; SNBNCBS
5. Oiendrila Sinha; Biomedical Instrumentation; Presidency University, Kolkata
6. Nilasha Chakrabarty; Experimental Biophysics; St. Xaviers College, Kolkata

c) Post Doctoral Research Scientist/s

1. Tanushree Dutta; MOF, Nano-Bio Interface, Nanofertilizers; External funding
2. Gulmi Chakraborty; Experimental Biophysics; Centre PDRA

Teaching activities at the Centre

1. Spring semester; PHY191; Integrated PhD; 10 students; with 1 (Dr. Soumen Mondal,) co-teachers

Publications

a) In journals

1. D. Bagchi, A. Halder, S. Debnath, P. Saha, and **S. K. Pal**, Exploration of Interfacial Dynamics in Squaraine Based Nanohybrids for Potential Photodynamic Action, J. Photochem. Photobiol. A 380 (2019) 111842.
2. J. Patwari, H. Joshi, H. Mandal, L. Roy, C. Bhattacharya, P. Lemmens and **S. K. Pal**, Exciton Dissociation in an NIR-Active Triohybrid Nanocrystal Leading to Efficient Generation of Reactive Oxygen Species, Phys. Chem. Chem. Phys. 21 (2019) 10667.
3. A. Chatterjee, D. Das, J. Patwari, B. Tongbram, D. Panda, S. Chakrabarti and **S. K. Pal**, Ultrafast Electronic Spectroscopy on the Coupling of Stranski-Krastanov and Submonolayer Quantum Dots for Potential Application in Near Infrared Light Harvesting, Materials Research Express 6 (2019) 085903.
4. J. Patwari, A. Chatterjee, H. Ghadi, H. Sharma, S. Chakrabarti and **S. K. Pal**, In Situ Measurement of Temperature Dependent Picosecond Resolved Carrier Dynamics in Near Infrared (NIR) Sensitive Device on Action, Rev. Scintific Instruments 90 (2019) 043909.
5. P. K. Sarkar, P. Kar, A. Halder, P. Lemmens, and **S. K. Pal**, Development of Highly Efficient Dual Sensor Based on Carbon Dots for Direct Estimation of Iron and Fluoride Ions in Drinking Water, Chem. Select 4 (2019) 4462.
6. D. Bagchi, A. Bhattacharya, T. Dutta, S. Nag, Sudip; D. Wulferding, P. Lemmens, and **S. K. Pal**, Nano MOF entrapping Hydrophobic Photosensitizer for Dual-stimuli-Responsive Unprecedented Therapeutic Action against Drug-resistant Bacteria, ACS Applied Bio Materials 2 (2019) 1772.
7. P. Singh, V. K. Sharma, S. Singha, V. G. Sakai, R. Mukhopadhyay, R. Das and and **S. K. Pal**, Unraveling the Role of Monoolein in Fluidity and Dynamical Response of a Mixed Cationic Lipid Bilayer, Langmuir 35 (2019) 4682.
8. J. Patwari, S. Shyamal, T. Khan, H. Ghadi, C. Bhattacharya, S. Chakrabarti and **S. K. Pal**, Inversion of activity in DSSC for TiO2 and ZnO photo-anodes depending on the choice of sensitizer and carrier dynamics, J. Luminescence 207 (2019) 169.
9. A. Adhikari, S. Darbar, T. Chatterjee, M. Das, N. Polley, M. Bhattacharyya, S. Bhattacharya, D. Pal, and **S. K. Pal**, Spectroscopic Studies on Dual Role of Natural Flavonoids in Detoxification of Lead Poisoning: Bench to Bedside-Preclinical Trial, ACS Omega 3 (2018) 15975.
10. T. Dutta, D. Bagchi and **S. K. Pal**, Bimetallic zeolitic imidazolate framework as an active excipient of curcumin under physiological condition, Biomed. Phys. Eng. Express 4 (2018) 055004.
11. P. Singh, S. Choudhury, V. K. Sharma, S. Mitra, R. Mukhopadhyay, Ranjan Das and **S. K. Pal**, Modulation of Solvation and Molecular Recognition of a Lipid Bilayer under Dynamical Phase Transition, Chem. Phys. Chem. 19 (2018) 2709.
12. D. Bagchi, V.S.S. Rathnam, P. Lemmens, I. Banerjee and **S. K. Pal**, NIR-Light-Active ZnO-Based Nanohybrids for Bacterial Biofilm Treatment, ACS Omega 3 (2018) 10877.
13. P. Singh, D. Bagchi and **S. K. Pal**, Ultrafast Dynamics Driven Biomolecular Recognition where Fast Activities Dictate Slow Events, J. Biosci. 43 (2018) 485.
14. T. K. Maji, P. Kar, H. Mandal, C. Bhattacharya, D. Karmakar and **S. K. Pal**, Halide-Modulated Functionality of Wide Band Gap Zinc Oxide Semiconductor Nanoparticle, Chemistry Select 3 (2018) 6382.

b) Books / Book Chapter / Monographs Published / Edited

1. D. Bagchi and S. K. Pal "Probing Crucial Interfacial Dynamics of Nanohybrids for Emerging Functionalities", (Book Chapter) in "Nanohybrids in Environmental & Biomedical Applications" Edited by Surender Kumar Sharma, DEANTA, DUBLIN, IRELAND, 2019.
2. A. Halder, S. Singh, A. Adhikari, P. K. Sarkar and and S. K. Pal "Development of Spectroscopy-based Medical Devices for Disease Diagnosis in Low Resource Point of Care Setting", (Book Chapter) in "Bioelectronics and Medical Devices" Edited by Kunal Pal, ELSEVIER, LONDON 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Key Electronic Spectroscopy for Understanding Molecular Recognition and Development of Theranostic Strategies; May 21, 2018; NTU, Singapore; Conference in Memory of the Nobel Laureate Ahmed H. Zewail
2. 5th National Conference on NEMS/MEMS and

Theranostic Devices; Feb 21, 2019; IIT Guwahati; Speaker

3. National Seminar on Chemistry in Interdisciplinary Research NSCIR 2018; Nov 9, 2018; Nagaland University; Speaker
4. ICCFM 2018; Dec 13, 2018; Biswa Bangla Centre; SNBNCBS
5. National Conference on BIOENGINEERING 2018; Dec 14, 2018; NIT Rourkela; Guest of Honour
6. Recent Developments in Chemistry; Dec 17, 2018; NIT Durgapur; Speaker
7. DAE Solid State Physics Symposium; Dec 18, 2018; Haryana; Speaker
8. Industry Academia Meet 2018; Oct 6, 2019; SNBNCBS; Speaker

Membership of Committees

a) Internal Committee

1. Chairman Pest Control
2. Chairman BOSE125 Outreach Committee

Patent/s submitted / granted

1. A NON INV HYPERBILIRUBINEMIA ASIVE SCREENING SYSTEM FOR NEONATAL; Indian Pat. Appl. (2018), TEMP/E-1/ 32366/2018-KOL dated 7th August 2018; Applied
2. Technology: A method and system for non-invasive quantitative estimation of Hemoglobin in human blood, Pat: 466/KOL/2009. Transfer to: EZERX HEALTH TECH PRIVATE LIMITED (Facilitated by National Research Development Corporation (NRDC), 2018); Pat: 466/KOL/2009; Granted
3. Technology: A method and system for non-invasive quantitative estimation of Billirubin in human body, Pat: 467/KOL/2009. Transfer to: EZERX HEALTH TECH PRIVATE LIMITED (Facilitated by National Research Development Corporation (NRDC), 2019); Pat: 467/KOL/2009; Granted
4. Technology: A method and system for non-invasive quantitative estimation of Oxygen content in human blood, Pat: 465/KOL/2009. Transfer to: EZERX HEALTH TECH PRIVATE LIMITED (Facilitated by National Research Development Corporation (NRDC), 2019); Pat: 465/KOL/2009; Granted

Awards / Recognitions

1. Abdul Kalam Technology Innovation National Fellowship 2018
2. Professor P. K. Bose Memorial Award 2016 (Indian Chemical Society)

Fellow / Member of Professional Body

1. American Chemical Society
2. Indian Association for the Cultivation of Science, Life Member
3. Indian Physical Society

Sponsored Projects

1. Exploration of key photoinduced dynamics in inorganic nanohybrids for enhanced biological activities; Department of Science and Technology (DST); PI
2. Fabrication of a Spectroscopy based Prototype for Detection of VOC in Human Urine to Diagnose Bladder Cancer; Agency: University of Dundee, Scotland, UK and EzeRx Health Tech Pvt Ltd, India; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. One Day Public Outreach Program; Sep 26, 2018; SNBNCBS; Bose125

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. U. K. Bhui, S. Sanyal, R. Saha, S. Rakshit and S. K. Pal "Steady-state and time-resolved fluorescence spectroscopic study of petroleum crudes in aqueous-surfactant solutions: Its implications for enhanced oil recovery (EOR) during surfactant flooding", Fuel 222 (2018) 561; National
2. B. Ghosh, L. Boila, S. Choudhury, P. Mondal, S. Bhattacharjee, S. K. Pal, A. Sengupta, and S. Roy "A Potent Conformation-Constrained Synthetic Peptide Mimic of a Homeodomain Selectively Regulates Target Genes in Cells ", ACS Chemical Biology 13 (2018) 2003; National
3. E. Khatun, A. Ghosh, P. Chakraborty, P. Singh, M. Bodiuzzaman, P. Ganesan, G. Nataranjan, J. Ghosh, S. K. Pal and T. Pradeep "A thirty-fold photoluminescence enhancement induced by secondary ligands in monolayer protected silver clusters", Nanoscale 10 (2018) 20033; National
4. Sl. No. 7; National
5. Sl. No. 6; International

Participation in Science Outreach program

1. A National Conference on Condensed Matter Physics Bose 125 Events, August 29-31, 2018, University of Burdwan (Speaker)
2. Science Festival, Midnapore College, 1st January 2019 (Speaker)
3. Recent Advances in Functional Nanomaterials, Pt. Ravishankar Shukla University, Raipur
4. Recent trends in Science towards sustainable development, APC College, New Barrackpore (Speaker)
5. Teaching and Invited lecture in Jagadis Bose National Science Talent Search (JBNSTS), Kolkata

Societal impact of Research

1. We have developed a technology which would detect maternal and neonatal jaundice and anemia in a noncontact and non-invasive way. The prototype is under use in NRS hospital on a trial.
2. We have developed an instrument (FeFFlu) for the detection of fluoride ions
3. We have also developed a minimally invasive low cost digital camera-based instrument for the detection of sodium, potassium ions.
4. We have also developed a minimally invasive low cost digital camera-based instrument for the detection urinary bladder cancer.

Significant research output / development during last one year

a) General research areas and problems worked on

Ultrafast Spectroscopy of Biomolecules and Nanomaterials, Bio-Nano Interface, Light Harvesting for Potential Environmental Application, Biomedical Instrumentation

b) Interesting results obtained

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 nanoparticles to medicinally important organic molecules is the key feature of the nano-conjugates, which leads synthesis of nanomedicines .

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. The systems are also used to prepare various drug delivery vehicles.

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.

c) Proposed research activities for the coming year

1. Development of biomedical instruments
2. Development of point of care diagnosis
3. Basic studies on energy harvesting materials
4. Development of nanomedicines and nanohybrids for treating different diseases
5. Basic experimental photophysical studies on bio-mimetic systems

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Supervision of Research / Students

a) Ph.D. Students

1. Sankar Das; Synthesis of Inorganic-Organic Hybrid Nanocomposites for Environmental Application; Thesis submitted
2. Arnab Samanta; Solution Phase Synthesis and Catalytic Application of Alloys and Metal Oxides; Under progress
3. Kanika Kole; Synthesis, Characterization and Application of Hybrid Nanocomposites; Under progress

Publications

a) In Journals

1. A. Modak and **S. Jana**, Advancement in Porous Adsorbents for Post-Combustion CO2 Capture, Microporous and Mesoporous Materials 276, 107–132, 2019.
2. A. Modak, S. Das, D. K. Chanda, A. Samanta and **S. Jana**, Thiophene Containing Microporous and Mesoporous Nanoplates for Separation of Mercury from Aqueous Solution, New Journal of Chemistry, 43, 3341–3349, 2019.
3. A. V. Kornilova, M. V. Gorbachevskii, G. A. Kuralbaeva, **S. Jana**, A. A. Novikov, A. A. Eliseev, A. N. Vasiliev and V. U. Timoshenko, Plasmonic Properties of Halloysite Nanotubes with Immobilized Silver Nanoparticles for Applications in Surface-Enhanced Raman Scattering, Physica Status Solidi A,1800886, 2019.
4. Kiran Bharadwaj, Somnath Koley, **Subhra Jana**, Subhadip Ghosh, Model-Free Estimation of Energy-Transfer Timescales in a Closely Emitting CdSe/ZnS Quantum Dot and Rhodamine 6G FRET Couple, Chemistry-An Asian Journal, 13, 3296-3303, 2018.
5. S. Das, A. Samanta, G. Gangopadhyay and **S. Jana**, Clay-Based Nanocomposites as Recyclable Adsorbent toward Hg(II) Capture: Experimental and Theoretical Understanding, ACS Omega, 3, 6283-6292, 2018.

Patent/s submitted / granted

1. A Method Of Fabricating Monodispersed Silica Nanoflowers For Carbon Dioxide Adsorption; File No.: 201831048458; Indian Patent Applied; (2018)

Fellow / Member of Professional Body

1. Life Member of Chemical Research Society of India (CRSI)
2. Life Member of Materials Research Society of India (MRSI)
3. Young Associate of Indian Academy of Sciences, Bangalore

Sponsored Projects

1. SERB Women Excellence Award; Department of Science and Technology (DST), India; Ongoing; PI
2. Nano Mission Grant; Nano Mission, Department of Science and Technology (DST), India; Ongoing; PI
3. INSPIRE Research Grant; Department of Science and Technology (DST), India; Completed; PI
4. Technical Research Centre (TRC); Department of Science and Technology (DST), India; Ongoing; One of the PIs

Conference / Symposia / Workshops / Seminars etc. organized

1. Organizing Committee Member of International Conference on Complex and Functional Materials (ICCFM 2018); 13-16 December, 2018; Biswa Bangla Convention Centre, Kolkata; 04 days
2. Organizing Committee Member of Industry-Academia Meet 2018; 6th October, 2018; S. N. Bose National Centre for Basic Sciences; 01 day

3. Organize seminars as a Seminar Cordinator of Department of CBMS.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Moscow State University, Russia; Sl. No. 3; International
2. National Institute of Science Education and Research, HBNI, Odisha; Sl. No. 4; National

Societal impact of Research

1. Novel hybrid nanocomposites were developed for the adsorption of contaminants from aqueous solution.
2. Developed metal oxide based nanocomposites for the degradation of refractory pollutant under solar light irradiation.
3. Working on the development of a technology for the detection of carbon dioxide present in human breath.

Significant research output / development during last one year

a) General research areas and problems worked on

Experimental Inorganic Chemistry

b) Interesting results obtained

Acute toxicity of mercury in food is a challenging problem in health and environmental sector which could be addressed by designing robust organic porous materials containing strong mercury chelating sites with high affinity and rapid uptake capacity towards mercury contaminants. Taking the intrinsic advantages of hypercrosslinked polymers, we have developed porous materials having chelating thiophene units in the pore wall. As a proof-of-concept, the bottom-up synthesis approach is used for Friedel-Craft polymerization of thiophene in making Th-1, Th-2 and Th-3 as the representative materials (Figure 1A). Among these porous materials, Th-2 exhibits high efficiency in removing mercury from aqueous solution, affording Hg(II) uptake capacity of 145 mg g-1. The high adsorption capacity renders rapid separation of Hg(II) from aqueous solution, resulting in the concentration well below to the acceptable value in drinking water. The impressive performance might be because of the synergistic action between densely packed thiophene sites and rapid diffusion throughout the well-defined micropores and interparticle mesopores. The interaction mechanism between Hg(II) and Th-2 has been established through XPS and FT-IR studies. Overall, we have explored the potential of hypercrosslinked thiophene polymers as scavenger of mercury for the first time and may be extended for the treatment of mercury contaminated waste water in future.

Likewise, several inorganic-organic hybrid nanocomposites were developed through the selective modification of the negative outer surfaces of halloysite nanoclays with two different organosilanes having primary or secondary amine sites to be explored them as novel and costeffective adsorbents for the extraction of toxic inorganic contaminants from aqueous solution. They possess excellent selectivity for the adsorption of mercury which shows monolayer molecular adsorption over the nanocomposites (Figure 1B). The adsorption kinetics of Hg(II) is very fast and follows pseudo-second-order as compared to pseudo-first-order model. A combined experimental and theoretical study demonstrated that Hg(II) uptake by these nanocomposites is highly favorable and spontaneous up to 40 °C, beyond this temperature uptake capacity gradually reduced. Temperature dependent adsorption study exhibits the endothermicity at low temperature (= 40 °C) and exothermicity beyond 40 °C. pH dependent adsorption study ascribed their high uptake capacity until pH 7 and reduced at alkaline pH. All the nanocomposites hold excellent adsorption capacity even at low concentration of adsorbate, along with multi-cycle sorption capability. The outstanding adsorption capacity as well as the easy synthetic route to achieve these nanocomposites may attract to the researcher for developing low-cost adsorbents to capture toxic metals, which in turn regulate the permissible limit of these toxic metals in drinking water.

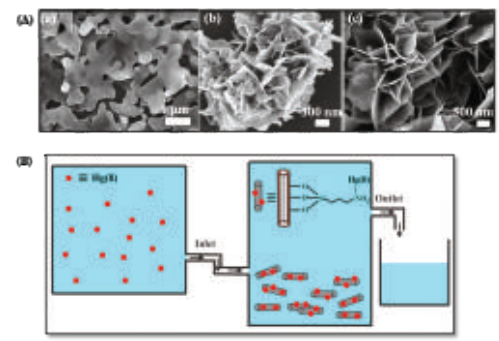

Figure 1. (A) FESEM images of (a) Th-1, (b) Th-2 and (c) Th-3. (B) Schematic presentation of the sorption of Hg(II) ions by these clay based nanocomposites leaving behind clean water free from toxic metal ions.

One of the foremost environmental concerns of our age is the growing concentration of atmospheric CO_2 owing to the fossil fuel, power plants, chemical processing and deforestation. High CO_2 level in atmosphere induces global warming which is considered as one of the major long lasting problems in the twenty-first century and thus intensive efforts are necessary to curb CO_2 from entering into carbon cycle. To address this issue, several promising porous adsorbents are developed to partially mitigate the global climate problems. With increasing substantial interest on high surface area metal-organic frameworks (MOFs), porous organic polymers (POPs), covalent organic frameworks (COFs) and nanoporous oxides, we believe, they could be promising for carbon capture due to their high porosity, presence of ultra-small pores, structural diversity, high stability and excellent recyclability (Figure 2). This review highlights the recent progresses on MOFs, POPs, COFs and mesoporous oxides as CO_2 adsorbent and illustrates their CO_2 separation selectivity and enthalpy of interaction etc. Finally, we conclude with the viewpoint on the future developments in the context of promising adsorbents for CO_2 capture, followed by its transformation to value added products and the potential drawbacks which are associated with them.

Figure 2. A comprehensive discussion on the development and prospect of several advanced porous materials for CO_2 capture and storage together with technical feasibility and efficacy was demonstrated.

c) Proposed research activities for the coming year

Proposed research plan has been summarized below:

- Synthesis of solid nanocomposites for environmental application.
- Fabrication of chromogenic nanocomposites using solution chemistry route for the detection of carbon dioxide.
- Design and fabrication of noble metal free nanostructures for catalysis.
- Synthesis of size- and shape-tunable alloys and intermetallics for several chemical and photochemical reactions.

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Supervision of Research / Students

a) Ph.D. Students

1. Amit Kumawat; Molecular mechanism of allostery and signalling in biomolecules; Under progress
2. Vrushali Hande; Structure and dynamics of water molecules in heterogenous environment; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Kankana Bhattacharjee; Master's thesis project: Molecular dynamics simulation study of water dynamics in a rhodopsin channel; NIT Agartala
2. Aniruddha Seal; Winter project: Basic Monte Carlo simulation methods; NISER Bhubaneswar

c) Post Doctoral Research Scientist/s

1. Dr. Mantu Santra; Mechanism of photoactivation and ion transport in KR2 rhodopsin

Teaching activities at the Centre

1. Spring semester; Numerical Methods (CB 521); PhD; 9 students

Publications

a) In Journals

1. Dipak K. Sahoo, Subhrakant Jena, Juhi Dutta, **Suman Chakrabarty** and Himansu S. Biswal, Critical Assessment of the Interaction between DNA and Choline Amino Acid Ionic Liquids: Evidences of Multimodal Binding and Stability Enhancement, ACS Central Science 4, 1642-1651 (2018).

b) Other Publications (including conferences)

1. Amit Kumawat and Suman Chakrabarty, "A Thermodynamic View of Dynamic Allostery in a PDZ Domain Protein", Biophysical Journal, 116, 163A (2019)

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Kaleidoscope: A Discussion Meeting in Chemistry organised by IIT Bombay and TIFR; Jul 5, 2018; The International Center Goa; 4 days
2. Annual meeting of Indian Biophysical Society (2019); Mar 15, 2019; IISER Kolkata; 3 days
3. Recent Advances in Dynamics at the Interface of Chemistry and Biology (DICB-2019); Feb 18, 2019; IISc Bangalore; 3 days
4. Annual meeting of Biophysical Society, USA (2019); Mar 2, 2019; Baltimore, Maryland, USA; 5 days

Membership of Committees

a) Internal Committee

1. Served in the interview committee for incoming integrated PhD and PhD students

Awards / Recognitions

1. Travel award from Biophysical Society, USA for attending the 63rd Annual Meeting of the Biophysical Society, USA (02 March, 2019 to 06 March, 2019)" in Baltimore, Maryland, USA
2. Financial support from International Travel Support (ITS) scheme of SERB, DST, India for attending the 63rd Annual Meeting of the Biophysical Society, USA (02 March, 2019 to 06 March, 2019) in Baltimore, Maryland, USA

Fellow / Member of Professional Body

1. Biophysical Society, USA
2. American Chemical Society (ACS), USA

Sponsored Projects

1. Molecular mechanism of regulation of Rho GTPases through phosphorylation of RhoGDI: Towards unraveling the "phosphorylation code"; SERB, DST, India; 3 years; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. SMCPK-2018: A discussion meeting on Soft Matter and Chemical Physics; Sep 15, 2018; Silver Jubilee Hall, SNBNCBS, Kolkata; 1 day
2. ICCFM-2018: International conference on complex and functional materials; Dec 13, 2018; Biswa Bangla Convention Centre, Kolkata; 4 days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Collaboration with Dr. Himansu S. Biswal from NISER Bhubaneswar on studying stability and dynamics of biomolecules (DNA, protein) in various ionic liquids; Sl. No. 1; National

Participation in Science Outreach program

1. Conducted a computational chemistry workshop for the JBNSTS Junior Scholars at IISER Kolkata on 6th June, 2018.
2. Conducted a computational chemistry workshop for the JBNSTS Science Camp at JBNSTS Campus on 17th March, 2019.
3. Delivered lecture in the Bose-125 Outreach Activity: "Discussion Meeting on Current Research on Chemistry of Biomolecules: Theory and Experiment", organised by Department of Chemistry, Durgapur Government College in association with SNBNCBS, Kolkata on 27th September, 2018.

Significant research output / development during last one year

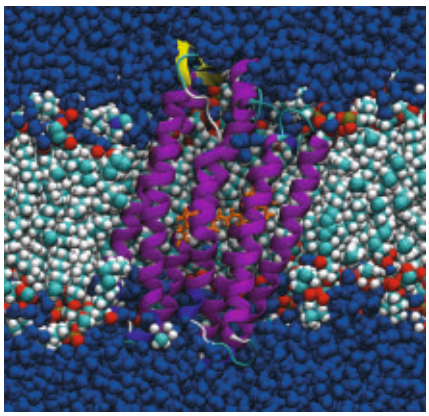
a) General research areas and problems worked on

Theoretical and computational chemistry; Computational molecular biophysics

b) Interesting results obtained

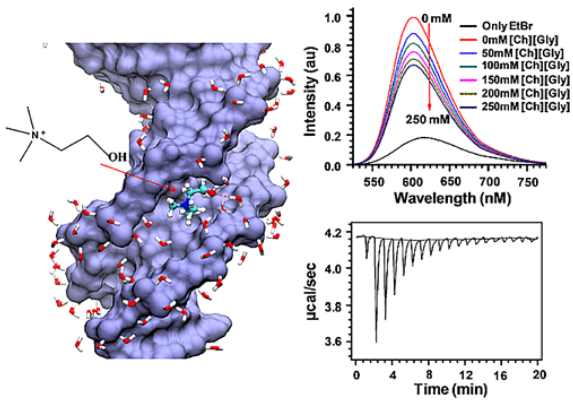
We use a combination of large scale atomistic molecular dynamics (classical) simulation and enhanced sampling methods to understand the connection between structure, interaction, dynamics and function of complex biomolecular systems. A few representative examples where we have made significant progress recently are:

1. Phosphorylation code in RhoGDI regulation: Phosphorylation of specific sites of RhoGDI protein can selectively control the release of its binding partner Rac/Rho protein. We have used several microsecond long simulations and free energy calculations using metadynamics to demonstrate how rearrangement of hydrogen bonded network leads to long range control (allosteric) over protein-protein interaction in this system.
2. Mechanism of photoactivation and role of water in the function of various rhodopsin proteins: Vision in mammals and light sensing in bacteria involve a photo-induced cis-trans isomerization of retinal moiety in trans-membrane rhodopsin proteins. This conformational change triggers further conformational changes in the protein that finally leads to opening of a channel and selective passage of ions. It has been suggested that movement of water in this process plays a crucial role in lubrication of the channel and modulates the ion transport. Through molecular dynamics simulation in the resting state we have identified several hydration sites with exceptionally long residence time and slow orientational relaxation of water. We are further exploring the effect of these strongly bound water molecules on the energetics of the conformational fluctuations of the protein (channel residues). A representative snapshot of this system follow:



3. In collaboration with the group of Dr. Himansu Biswal of NISER Bhubaneswar, we have studied the effect of various amino acid based ionic liquids (in aqueous solution) on the stability and dynamics of DNA. We have demonstrated that the cholinium cation of the ionic liquid has multi-modal binding with the DNA, where it can interact with the DNA surface phosphate groups through electrostatic interaction and also bind to the minor groove (with high residence time) using a

combination of hydrophobic interaction and hydrogen bonding. The addition of ionic liquid tends to make the DNA more rigid without altering the helical structure. Hence such ionic liquids are promising for long term preservation of genetic materials. This work is being extended to enzymes as well.



c) Proposed research activities for the coming year

1. Industry sponsored project from Sarfez Cure India has been approved and to be initiated very soon. They are sponsoring one postdoc (RA-II) for this project. This project will be within the scope of TRC activities of the centre.
2. The above mentioned project on "Phosphorylation code in RhoGDI regulation" has generated interest from Prof. Ruth Nussinov, NCI, USA. A long term international collaboration with their group is being planned.
3. A project proposal on "Molecular mechanism of photoactivation and role of water in the function of various rhodopsins" is being prepared and to be submitted to DBT for funding.

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Supervision of Research / Students

a) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Suman Mondal (DST inspire faculty grant); Biophysical Characterization of exosomes

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited speaker at Soft Matter Young Investigators' Meet (SMYIM) 2019; May 12-14, 2019; Shillong, Meghalaya; 3 days
2. Invited oral presentation at Amity University, Raipur Campus; May 27-30, 2019; Raipur, Chhattisgarh; 4 days

Sponsored Projects

1. DST inspire faculty project; DST; 2018-2023 (5 years); PI

Significant research output / development during last one year

a) Interesting results obtained

Photophysics of a non-activated spiropyran viz., 1,3,3-Trimethylindolinobenzopyrylospiran (SP) in response to UV exposure has been explored in bulk solvent media (water and acetic acid), micelles (cetyltrimethylammonium bromide (CTAB), sodium dodecyl sulfate (SDS) and Triton-X 100) and protein (Histone, H1). The experimental results are corroborated by calculations based on density functional theory (DFT) and molecular dynamics (MD) simulations. Upon UV irradiation, a barrierless spontaneous ring opening of SP occurs in bulk aqueous media and acetic acid giving rise to an energetically favourable protonated merocyanine (E-MCH^+) form stabilized via hydrogen bonding with the bulk solvent molecules. As for micelles, UV irradiation results in the formation of a zwitterionic ring-open orthogonal isomer 'X' which is preferentially located in the micellar interface depending on the surfactant headgroup charge. In histone (H1) the ring-open merocyanine (MC) form of the non-activated spiropyran is obtained at room temperature. Thus, at room temperature, significant structural changes in the non-substituted spiropyran occur depending on its microenvironment which may be exploited for potential use in drug delivery vehicles.

b) Proposed research activities for the coming year

Developing protocols for isolation and fractionation of exosomes from colon and breast cancer cell media and immobilization techniques to visualize them by Atomic Force Microscopy. Once we would be able to firmly anchor them with the substrate, we will start our single- molecule AFM force spectroscopy experiments to identify different proteins on the exosome surface.

Department of CONDENSED MATTER PHYSICS AND MATERIAL SCIENCES

Department of Condensed Matter Physics and Material Sciences

Kalyan Mandal

Department profile indicators

Table_A : Manpower and resources

Number of faculties	12
Number of Post –doctoral research associate (centre+project)	14
Number of Ph.D students	64
Number of other project staff	04
Number of summer students	08
Projects (ongoing)	15

Table B: Research Activities indicators

Number of research papers in Journals	55
Number of Book-chapters/books	0
Number of other publications	11
Number of Ph.D students graduated (submitted+degree awarded)	7+10=17
Number of M.Tech/M.Sc projects	04

Table C: Academic activities and likeage

Number of courses taught by faculties	08	
Number of Visitors (non –associates)	07	
Number of associates	02	
Number of Seminars organized	09	
Number of Conference/Symposia/Advanced Schools organized	05	
Number of talks delivered by members of department in conferences/Symposia	National	18
	International	7

Most important research highlights

- Demonstrated that simultaneous and controlled excitation of both direct and indirect mechanisms of demagnetization are possible with control gained in modulating the demagnetization time by external parameters.
- Fabricated self-powered photodetectors from a single Germanium nanowire with a high photoresponse.
- Made a ZnO/Silicon nanowires heterojunction array based NO gas sensor operating at room temperature with high response.
- An easy and scalable route of n-n architecture engineering with ZnO-MoO_3 core-shell nanorods, for hydrogen energy generation demonstrated.
- Implemented a new numerical method based on density matrix group method and exact diagonalization to handle thermodynamics of many body model systems.
- Demonstrated a route to reduction of the band gap in ferroelectrics which would aid their application in photovoltaics.
- Generalized charge stiffness constant was determined for strongly correlated doped quantum antiferromagnets in both 1D and 2D.
- Demonstrated that the excitons in layers of WSe2 behave like Wannier-Mott excitons.
- Topological transitions were examined in P doped Cd3As2 using ARPES.

Summary of research activities

The research activities of the department have focussed on functional materials with applications based research in aspects ranging from photovoltaics, gas sensor applications as well as on photochemical cells. Additionally there has been a strong emphasis on magnetism, exploring demagnetization as well effects on topological phases; strongly correlated electron systems exploring phenomena as well as theoretical modeling and experimental studies of topological phases.

The group of Anjan Barman has demonstrated for the first time that simultaneous and controlled excitation of both direct and indirect mechanisms of demagnetization is possible. They were also able to modulate the demagnetization time (from ~350 fs to ~750 fs) by fluence and thickness dependent indirect excitation due to heat current. Finally, by regulating the pump wavelength they were able to effectively control the contribution of indirect process, thereby providing insights into the ultrafast demagnetization process. The group of A.K. Raychaudhuri have recently examined metal-insulator transitions (MIT) using conductivity and magnetoconductance (MC) measurements down to 0.3 K in $Nd_{0.7}La_{0.3}NiO_3$ films. Although the nicklelates are known to exhibit first-order Mott type transitions, the doped nickelates are found to undergo a continuous transition anaolgous to systems undergoing disorder/composition driven Anderson transition. The group of Barnali Ghosh has been working on design of gas sensors. Recently they have developed a ZnO/Silicon nanowires heterojunction array based NO gas sensor operating at room temperature and have shown that it has extremely high response (noise limited response ~ 10 ppb). The group of Kalyan Mandal has found an easy and scalable route with ZnO-MoO_3 core-shell nanorods, for hydrogen energy generation in a photoelectrochemical (PEC) cell. The group of Manoranjan Kumar has recently implemented a new numerical method based on of density matrix group method (DMRG) and exact (ED) to handle thermodynamics of many body model systems. The group of Milan Sanyal has carried out resonant coherent X-ray scattering measurements on a Fe/Gd thin-film heterostructure that exhibits highly tunable magnetic phases to understand the effect of topological order in skyrmion phase on the domain-fluctuations through statistical measurements of speckle patterns. They observed different critical behaviour for avalanches in the stripe and skyrmion phases of the Fe/Gd heterostructure, suggesting that these represent different universality classes. The group of Priya Mahadevan has been involved in understanding how to reduce the band gap of ferroelectric oxides to a value that is optimal for use in photovoltaics. The group of Ranjan Chaudhury has been examining the generalized charge stiffness constant in strongly correlated doped quantum antiferromagnets in both 1D and 2D. The group of S.K. Ray has examined the nature of excitons in few layers of Wse2. The group of T. Setti has examined the modifications in the topological properties of Cd3As2 upon P doping via angle resolved photoemission experiments.

Kalyan Mandal

Head, Department of Condensed Matter Physics and Material Sciences

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Supervision of Research / Students

a) Ph.D. Students

1. Sucheta Mondal; Ultrafast Spin Dynamics and Spin Orbitronics; Under progress
2. Samiran Choudhury; Electrical and Optically Controlled Magnonic Crystals; Under progress
3. Chandrima Banerjee; Spin Waves in Magnetic Thin Films and Nanostructures; Awarded
4. Anulekha De; Ultrafast Spin Dynamics in Magnetic Nanostructures; Under progress
5. Avinash Kumar Chaurasiya; Interface Magnetism; Under progress
6. Sourav Kumar Sahoo; Spin Waves in 2D and 3D Magnetic Nanostructures; Under progress
7. Suryanarayan Panda; Ultrafast Spin Dynamics in magnetic Thin Films and Heterostructures; Under progress
8. Koustuv Dutta; Spin Dynamics in Ferromagnetic Thin films and Artificial Structures; Under progress
9. Amrit Kumar Mondal; Spin waves in Ferromagnetics Thin Films and Magnonic Crystals; Under progress
10. Arundhati Adhikari; Spin Dynamics in Magnetic Nanostructures; Under progress
11. Sudip Majumdar; Magnonics; Under progress
12. Pratap Kumar Pal; Magneto-optical Measurements of Spin-Orbit Effects; Under progress
13. Santanu Pan; Ultrafast Demagnetization, Precession and Damping in Magnetic Thin Films and Multilayers; Under progress
14. Kartik Adhikari; Magnetization Dynamics in Ferromagnetic Thin Films and Nanostructures; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer training

1. Pankaj Gupta; Magneto-optical Studies of Ferromagnetic Thin Films; College of Commerce Arts and Science Patna
2. Gyandeep Pradhan; Brillouin Light Scattering Study of Propagating Spin Waves; NISER, Bubneswar

c) Post Doctoral Research Scientist/s

1. Dipak Das; Ultrafast and THz Spectroscopy
2. Sumona Sinha; 2D Material Spintronics
3. Sandeep Agarwal; Interface Magnetism

Teaching activities at the Centre

1. Autumn semester; PHY301: Atomic & Molecular Physics; Integrated PhD; 7 students; with 1 (Prof. Rajib Kumar Mitra,) co-teacher
2. Autumn semester; CB527: Molecular Physics and Spectroscopy; PhD; 7 students; with 1 (Prof. Rajib Kumar Mitra,) co-teacher
3. Spring semester; PHY401: Project Research III; Integrated PhD; 1 student

Publications

a) In journals

1. S. Sahoo, S. Barman, G. Williams, A. May, S. Ladak and **A. Barman**, Ultrafast Magnetization Dynamics in a Nanoscale Three-dimensional Cobalt Tetrapod Structure, Nanoscale 10, 9981 (2018).
2. R. K. Upadhyay, T. Thundat, S. Naicker, **A. Barman**, S. S Roy, and P. Waghmare, Fabrication of Free-standing Graphene Oxide Films using a Facile Approach Toluene Swollen Paraffin Peeling and Green Reduction of These Films into Highly Conductive Reduced Graphene Oxide films, Chemical Engineering Journal 354, 149-161 (2018).

3. K. Mukherjee, S. Das, E. Tarif, **A. Barman** and **R. Biswas**, Dielectric Relaxation in Acetamide+Urea Deep Eutectics and Neat Molten Urea: Origin of Time scales Via Temperature Dependent Measurements and Computer Simulations, The Journal of Chemical Physics 149, 124501 (2018).
4. K. Adhikari, S. Barman, Y. Otani and **A. Barman**, Tunable Angle-Dependent Magnetization Dynamics in Ni80Fe20 Nanocross Structures of Varying Size, Physical Review Applied 10, 044010 (2018).
5. S. Mondal and **A. Barman**, Laser Controlled Spin Dynamics of Ferromagnetic Thin Film from Femtosecond to Nanosecond Timescale, Physical Review Applied 10, 054037 (2018).
6. S. Mondal, M. A. Abeed, K. Dutta, A. De, S. Sahoo, **A. Barman** and S. Bandyopadhyay, Hybrid Magnetodynamical Modes in a Single Magnetostrictive Nanomagnet on a Piezoelectric Substrate Arising from Magnetoelastic Modulation of Precessional Dynamics, ACS Applied Materials & Interfaces 10, 43970 (2018).
7. S. Choudhury, S. Majumder, S. Barman, Y. Otani, and **A. Barman**, Active Control of Mode Crossover and Mode Hopping of Spin Waves in a Ferromagnetic Antidot Lattice, Physical Review Applied 10, 064044 (2018).
8. S. Pan, O. Hellwig and **A. Barman**, Controlled coexcitation of direct and indirect ultrafast demagnetization in Co/Pd multilayers with large perpendicular magnetic anisotropy, Physical Review B 98, 214436 (2018).
9. S. Husain, N. Sisodia, P. K. Muduli, S. Chaudhary, A. K. Chaurasiya, **A. Barman**, A. Kumar. P. Svedlindh, Observation of Skyrmions at Room Temperature in Co2FeAl Heusler Alloy Ultrathin Films, Scientific Reports 9, 1085 (2019).
10. A. K. Chaurasiya, A. Kumar, R. Gupta, S. Chaudhary, P. K. Muduli, and **A. Barman**, Direct Observation of Unusual Interfacial Dzyaloshinskii-Moriya Interaction in Graphene/NiFe/Ta Heterostructures, Physical Review B 99, 035402 (2019).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. A. Barman, Ultrafast Spin-Orbit Effects in ferromagnet/Nonmagnet Thin Film Heterostructures, ICMAGMA 2018, 9-13 Dec., 2018; Dec 10, 2018; NISER Bhubneswar; 30 min
2. A. Barman, Ultrafast Spin Dynamics: from Theory to Experiment, Recent Development in Physics: Theory and Experiment, 19th Nov., 2018; Nov 19, 2018; Jadavpur University, Kolkata; 90 min
3. A. Barman, Ultrafast Spin-Orbitronics, Ultrafast Science 2018, 22-24 Oct., 2018. Oct 23, 2018; RRCAT, Indore; 30 min
4. A. Barman, Ultrafast Spin Dynamics in Artificially Structured Ferromagnetic Nanomaterials for Applications in Spintronics and Magnonics, Bose Tagore Workshop, NAWCMP-2018, 3-4 Aug., 2018; Aug 4, 2018; Visva-Bharati, Shantiniketan; 30 min
5. A. Barman, Ultrafast Spin Dynamics in Artificially Structured Ferromagnets for Applications in Spintronics and Magnonics, Department of Physics Seminar, Indian Institute of Science Bangalore, 1st June, 2018; Jun 1, 2018; Indian Institute of Science, Bangalore; 60 min
6. A. Barman, Introduction to Optical Methods for Investigation of Ultrafast Magnetism, C. K. Majumdar Memorial Summer Workshop 2018, May 23 to June 02, 2018; May 29, 2018; S. N. Bose National Centre for Basic Sciences; 75 min

Membership of Committees

a) Internal Committee

1. Associate Dean Faculty
2. Member of the Faculty Search Committee
3. Convener of Advanced Post Doctoral Manpower Programme (APMP)
4. Member of the Technical Cell Advisory Committee and Technical Cell Working Group

Awards / Recognitions

1. Program Committee Member of ICMFS-2018 Conference, University of California, Santa Cruz, USA, July 22-27, 2018.

Fellow / Member of Professional Body

1. Member of American Physical Society.
2. Member of IEEE
3. Life Member of MRSI

Sponsored Projects

1. Nanoscale Modifications and Active Control of Magnonic Crystals for On-Chip Microwave Communication; DST (Indo-Poland Project); 2015-18; PI
2. Time resolved measurements of spin dynamics in magneto-elastic systems VAJRA Faculty Scheme, SERB; 2018; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. International Conference on Complex and Functional Materials (ICCFM 2018), Dec 13, 2018; Biswa Bangla Convention Centre, Kolkata; 13-16 Dec., 2018.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Prof. Yoshichika Otani, RIKEN and ISSP, University of Tokyo Japan; Sl. No. 4, 7; International
2. Dr. Sam Ladak, Cardiff University, UK; Sl. No. 1; International
3. Prof. Olav Hellwig, Institute of Physics, Chemnitz University of Technology and Helmholtz-Zentrum Dresden-Rossendorf, Germany; Sl. No. 8; International
4. Prof. Supriyo Bandyopadhyay, Virginia Commonwealth University, USA; Sl. No. 6; International
5. Prof. S. Chaudhary and Dr. P. K. Muduli, IIT Delhi; Sl. No. 9, 10; National
6. Dr. S. S. Roy, Shiv Nadar University; Sl. No. 2; National

Participation in Science Outreach program

1. A. Barman, Ultrafast Spin Dynamics, One Day Seminar, New Alipore College, Kolkata, 6th Apr., 2018.

Societal impact of Research

1. Initiated new and emerging research fields such as magnonics and spin-orbitronics for enabling India to compete at the international level.
2. Developed novel research facilities such as Time-resolved Magneto-optical Kerr Effect Microscopy, Micro-focused Brillouin Light Scattering and spin-torque FMR for the first time in India for the experimental studies of magnonics and spintronics.
3. Played advisory role to several young scientists in India for developing the above research fields and facilities.
4. Generated knowledge base for applications in magnetic data storage, memory, logic and communication devices.
5. Trained Masters and PhD students and Postdoctoral scientists for the development of future science and technology in India.

Significant research output / development during last one year

a) General research areas and problems worked on

Experimental Condensed Matter Physics, Magnetism, Spintronics, Spin Dynamics

b) Interesting results obtained

Unification and Control of Ultrafast Spin Dynamics Over Femtosecond to Nanosecond Timescale: Ever since its discovery in 1996, ultrafast demagnetization has ignited immense research interest due to its scientific rigor and technological potential. However, it still lacks a unified mechanism and remains highly debatable. We, for the first time, demonstrated that simultaneous and controlled excitation of both direct and indirect mechanisms of demagnetization are possible. Moreover, we were able to modulate demagnetization time (from ~350 fs to ~750 fs) by fluence and thickness dependent indirect excitation due to heat current flowing vertically downward from top layers (Fig. 1). Finally, by regulating the pump wavelength we could effectively control the contribution of indirect process, which gives a confirmation to our understanding of the ultrafast demagnetization process.

We have further demonstrated laser fluence controlled spin dynamics from femtosecond to nanosecond time scale. The weak correlation between demagnetization time and pump fluence with substantial enhancement in remagnetization time is demonstrated using three-temperature model considering the temperatures of electron, spin and lattice. With increasing pump fluence the Gilbert damping parameter shows significant enhancement from its intrinsic value due to increment in the ratio of electronic temperature to Curie temperature within very short time scale. The changes in the local magnetic properties due to accumulation and dissipation of thermal energy within the probed volume are described by the evolution of temporal chirp parameter in a comprehensive manner.

Ultrafast Magnetization Dynamics in a Three-dimensional Nanomagnet: We have investigated ultrafast magnetization dynamics of a complex three-dimensional magnetic nanostructure fabricated using the combination of two-photon lithography and electrodeposition. Time-resolved magneto-optical Kerr microscopy was exploited to probe the spin-wave modes from the junction of a single tetrapod structure. Micromagnetic simulations reveal the nature of these modes originates from the intricate three-dimensional

tetrapod structure (Fig. 2). Our findings enhance the basic knowledge about the dynamic control of spin waves in complex three-dimensional magnetic elements.

Hybrid Magneto-dynamical Modes in a Single Magnetostrictive Nanomagnet: Magneto-elastic (or "straintronic") switching is an extremely energy-efficient mechanism for switching the magnetization in magnetic memory, logic and non-Boolean circuits. We demonstrated, for the first time, ultrafast magneto-dynamics associated with straintronic switching in a single magnetostrictive Co nanomagnet deposited on a piezoelectric substrate using time-resolved magneto-optical Kerr effect measurements. The pulsed laser causes precession of the magnetization and also generates surface acoustic waves which modulates the precessional dynamics. This modulation gives rise to intriguing hybrid magneto-dynamical modes in the nanomagnet, with rich spin-wave texture in 5-15 GHz frequency, indicating that strain can affect magnetization of a nanomagnet in time scales of ~100 ps.

Direct Observation of Unusual Interfacial Dzyaloshinskii-Moriya Interaction (iDMI) in Graphene/NiFe/Ta Heterostructure: We have directly observed iDMI in graphene/$Ni_{80}Fe_{20}$/Ta heterostructure from non-reciprocity in spin-wave dispersion using Brillouin light scattering. Linear scaling of iDMI with the inverse of $Ni_{80}Fe_{20}$ thicknesses suggests primarily interfacial origin of iDMI. Both iDMI and spin-mixing conductance increase with the increase in defect density of graphene. This suggests that the observed iDMI originates from defect-induced extrinsic spin-orbit coupling at the interface.

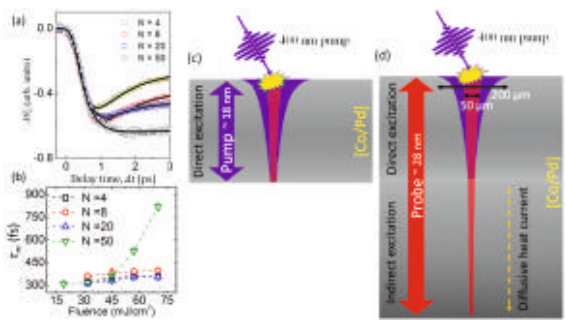

Fig. 1 (a) Kerr rotation traces at a fixed pump (70 mJ/cm^2) and probe fluence, (b) demagnetization time (tm) versus pump fluence, for all the samples. Penetration of both pump (blue) and probe (red) laser in the sample; (c) only direct excitation in thinner sample where pump beam (~400 nm) and probe beam (~800 nm) both reaches to the bottom of the sample, (d) both direct and indirect excitation in thicker sample where pump (~400 nm) does not reach to bottom most part of the sample but probe beam (~800 nm) reaches.

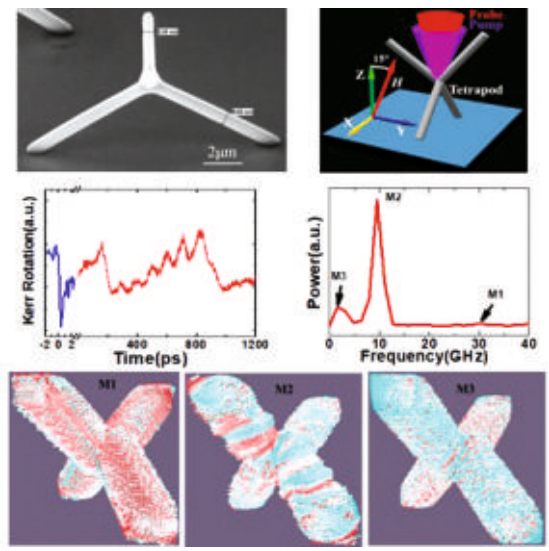

Fig. 2. Ultrafast magnetization dynamics of a 3D complex magnetic nanostructure explored using time-resolved magneto-optical Kerr effect technique.

c) Proposed research activities for the coming year

1. We will investigate spin-pumping in heavy metal/ferromagnet heterostructures by all-optical technique. From variation of Gilbert damping with heavy metal and ferromagnet thicknesses, we will extract the spin-diffusion length, spin-mixing conductances and interfacial spin transparency of these heterostructures.
2. We will further study the anisotropy in spin pumping efficiency in heavy metal/ferromagnet heterostructures formed in different stacking order. The possible origin of this anisotropy in the precessional angle of magnetization and interfacial spin transparency will be investigated.
3. Voltage-controlled magnetic anisotropy (VCMA) may significantly reduce power consumption of future magnonic devices. We will investigate modulations of ferromagnetic resonance and propagating spin waves by VCMA in ultrathin Co20Fe60B20 films with varying thickness. UFMR and SWs will be excited by microwave antenna and detected by spin pumping and

inverse spin Hall effect. We will also investigate if the spin waves can be guided through virtual nanochannels formed by VCMA.

4. We will study the spin-wave non-reciprocity induced by dipolar interactions in a coupled bilayer consisting of two ferromagnetic layers separated by a non-magnetic spacer showing synthetic antiferromagnetic state. The scaling of non-reciprocity with wave number will be studied by experiment, analytical models and micromagnetic simulations.
5. We will develop a new type of magnetic logic gate based upon asymmetric vortex transistor. Depending upon magnetic vortex chirality and polarity the network will behave like a tri-state buffer. Considering the asymmetric magnetic vortex transistor as unit, the logic gate will be formed where two such transistors will be placed parallel and another one is placed at the output.

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Supervision of Research / Students

a) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer training

1. P. Gayathri; Surface Enhanced Infrared Absorption on gold nano-star/nano-sphere/Nano-rod. A study by 2D IR spectroscopy; Bharathidasan University

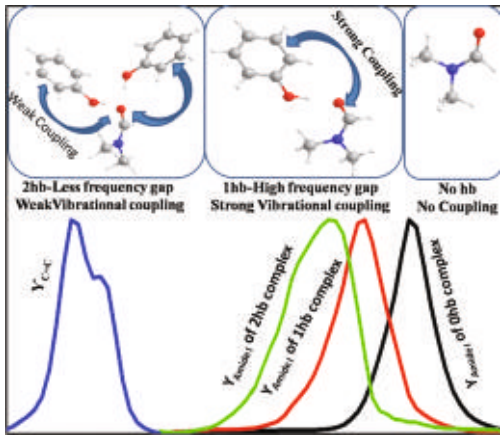
Significant research output / development during last one year

a) General research areas and problems worked on

Vibration coupling on stepwise hydrogen Bond formation constant of amide I

b) Interesting results obtained

Despite the key roles of proteins and nucleic acids in biology, understanding their labile structures and hydrogen bond interactions with guest molecules has posed a critical challenge to the scientific community. In this report, I have used dimethylformamide as a model amide to account for amide hydrogen bond interactions in relation to the protein structural properties. To quantify hydrogen bond conformation and the structural change, I have monitored the amide I IR stretching frequencies while varying the pKa of the guest molecules (phenol derivatives). It has been observed that the formation constant for one hydrogen bond is higher than that of two hydrogen bonds for all phenol derivatives. Enhancement of the infrared absorbance of the C=C transition of the guest molecules indicates hydrogen bond assisted vibrational coupling between the host and the guest molecules. The relative coupling constant is estimated to be higher for single hydrogen bonded conformer than the double hydrogen bonded conformer. This is an intriguing result as the frequency difference between the two coupled transitions predict otherwise. Using IR absorption spectroscopy, a delicate interplay between hydrogen bonding conformations and intermolecular vibrational coupling between amide I and H-bond donor guest molecules has been shown. This study will act as a benchmark for understanding the structural information of proteins, peptides, and nucleosides having hydrogen bond interaction with any drug or ligand molecules. My results as well provide an insight into the vibrational coupling of carbonyl and C=C transition of nucleobases.



c) Proposed research activities for the coming year

Nucleic acids, DNA can adopt various secondary structures through hydrogen-bond interactions between the nucleic acid bases. These base-paired secondary structures form double helices, and G-quadruplexes. The ability to predict, manipulate, and monitor the atomic structures of these biomolecules is a focus in drug delivery and other DNA engineering applications. In addition to being the carrier of genetic information, DNA nanotechnology has utilized artificial DNA strands to design molecular self-assemblies for a wide variety of technological purposes. Therefore, understanding the

interactions between the nucleic acid bases and the DNA secondary structural dynamics will be essential to study the interplay of these biomolecules, as well as improve the design of DNA nanoconstructs. The challenge with these problems is the need for experimental tools that can watch molecular structures change in real time. Ultrafast infrared light sources for structure-sensitive vibrational spectroscopies, such as 2D IR spectroscopic, methods can be apply to characterize molecular dynamics on time scales varying from femto to micro second scales.

It has been found that change in local hydration/solvation state drastically induces structural polymorphism in G-quadruplexes, thereby strongly affecting ligand binding to these structures; however, despite the availability of large sum of structural data, it is still unknown how dynamics of water and ions solvate ligand inside G-quadruplexes.

This proposal aims to fulfill several of the research needs concerning the interaction and dynamics of DNA/G quadruplexes in water.

This research project has the following main objectives:

- The ultrafast vibrational spectroscopy can be used to study chemical dynamics of DNA in water. I am interested in understanding how the dynamical nature of water's hydrogen bond network influences it's physical properties, aqueous chemical reactions, hydrophobicity, and how water influences the structure and dynamics of DNA absence and presence of ligands (drugs).
- We can establish a method and model system for characterization of G- quadruplexes and aggregating G-repeat DNA, and use FTIR spectroscopy to characterize the vibrational frequency and line shape shifts that occur under varying salt conditions. Infrared spectroscopy is appealing for such systems because it can be used to study insoluble aggregates and disordered systems. It can also report structural changes based on its sensitivity to vibrational coupling, local electrostatics and solvent exposure. I will focus on the in-plane vibrational modes of guanine between 1500 cm^{-1} and 1750 cm^{-1}, which are sensitive to the K+/Na+/Li+ binding and Hoogsteen base pairing in G-quaduplex. Upon investigating different lengths of repeat sequences, the resulting blue shift trend in the FTIR spectra indicate a preference for three to four layers in the most stable G-quadruplex structures, which corresponds to typical repeat lengths observed in naturally occurring G-quadruplex in non-aggregating structures. Based on this information we conclude that a model involving the introduction of disorder in longer repeat sequences is probably thermodynamically favored. Future studies using two dimensional infrared (2D IR) spectroscopy will further our understanding of the structural changes associated with the introduction of disorder in G-quadruplex.

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Supervision of Research / Students

a) Ph.D. Students

1. Shaili Seth; Physics with Single Ge nanowire; To be submitted by July 2019
2. Rabindra Singh Bisht; Metal-Insulator Transition in correlated oxide; To be submitted by August 2019
3. Subhamita Sengupta; Electron doped Ferroelectric Oxides and its interfaces; Under Progress
4. Vishal Aggarwal; Opto-thermal properties of Ge; Under Progress
5. Parushottam Majhi; Strained Oxide Multilayers; Under Progress
6. Putul Mall Chowdhury; Nanoscopic Control of Stoichiometry; To be submitted by July 2019
7. Sudipta Chatterjee; Metal-Insulator Transition in correlated oxide; Under Progress
8. Anirban Goswami; Metal-Insulator Transition in correlated oxide; Under Progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Anagha Kamath; Si nanowire photo detectors; NIT, Surat
2. Gaurav Arya; Semiconductor nanowire growth; Central University, Haryana

c) Post Doctoral Research Scientist/s

1. Arun Bera; Oxide -Polymer composite

Publications

a) In journals

1. Manotosh Chakravorty, **A. K. Raychaudhuri**, Size induced large upward shift of magnetic transition temperatures in nanowires of rare-earth transition metal alloy Gd_xCo1_{-x} (x = 0.4), Journal of Alloys and Compounds 155, 764 (2018).
2. Shaili Sett, Subhamita Sengupta, N. Ganesh, K. S. Narayan and **A. K. Raychaudhuri**, Self-powered single semiconductor nanowire photodetector, Nanotechnology 29, 445202 (2018).
3. Ravindra Singh Bisht, Gopi Nath Daptary, Aveek Bid, and **A. K. Raychaudhuri**, Continuous transition from weakly localized regime to strong localization regime in $Nd_{0.7}La_{0.3}Ni_{O3}$ films, J. Phys.: Condens. Matter 31, 145603 (2019).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Experimenting with single nanowires: A New paradigm to do Materials Physics; March 6, 2019; IIT, Mumbai; March 5-6, 2019
2. Single nanowire electronics: A new paradigm of ultrasensitive devices; February 23, 2019; International Conference on Functional Nanomaterials; IIT, Varanasi; February 22-25, 2019
3. Noise spectroscopy: Theory, practice and its application in physics; February 12, 2019; Jawaharlal University , New Delhi; February 11-13, 2019
4. Physics of Tunnelling and Scanning Tunnelling Microscopy and Spectroscopy; February 11, 2019; Jawaharlal University, New Delhi; February 11-13, 2019
5. Tunneling States in Glasses and disordered solids: 49 years after its observation, February 3, 2019, Celebrating the Physics of Anthony Leggett, RRI Bangalore; February 3-4, 2019
6. Experimenting with single nanowires: A New paradigm to do Materials Science; January 31, 2019; IISER, Trivandrum; January 31, 2019
7. Translational Research in solid state physics and materials science; December 18, 2018; 63rd DAE Symposium on Solid State Physics; University of Science & Technology, Hisar; December 18, 2018

8. Physics of Photoconduction and single semiconductor nanowire photodetectors; November 13, 2018; South East University, Nanjing, China; November 12-16 , 2018
9. Different methods to make nanostructures- Chemistry to Ion Beams; November 12, 2018; South East University, Nanjing, China; November 12-16 , 2018
10. Synthesis of metal nanoparticles and nanochains by laser ablation in liquids and their applications in thermal transport and opto-electronics; October 22, 2018; 14th IUPAC –NMS, Guangzhao, China; October 21-26, 2018
11. Substrate and substitution tuned metal insulator transition in rare-earth nickelate $NdNiO_3$ films grown on single crystalline substrates: some emerging issues; September 11, 2018; EMN Barcelona ,Spain; Sept 10-14, 2018
12. High responsivity single nanowire photo-detectors for UV-Vis-NIR applications; September 3, 2018; 3rd Assembly of Sensors & Actuators Congress; Stockholm; Sept 3-6, 2018
13. 80 years of Verwey transition: Retrospective and Prospective views of Metal Insulator Transition in context of oxides; July 25, 2018; Quantum Matter; IISER, Mohali; July 25-28, 2018
14. Ultra high response broad band optical detector from single semiconductor nanowires: Enabling effect of surface states; Nanowires with diameter < 100nm; July 18, 2018; EMN Berlin 2018; July 17-18 , 2018
15. Innovations with Nanowires Science and Applications; July, 2018; Amity University, Noida; July 2018
16. Electric field as an enabling tool to fabricate and control properties of materials; June 13, 2018; BARC, SSPD Colloquium, Mumbai; June 13, 2018

Membership of Committees

a) Internal Committee

Nodal Officer, TRC project

Patent/s submitted / granted

1. A rot resistant jute comprising silver nanoparticles; 306194; Granted

Awards / Recognitions

1. SERB Distinguished Fellowship

Fellow / Member of Professional Body

1. Fellow , Indian National Science Academy, New Delhi
2. Fellow, Indian Academy of Sciences, Bangalore
3. Fellow, National Science Academy of India, Prayagraj
4. Fellow, Asia Pacific academy of materials
5. Fellow, West Bengal State Academy of Science and Technology
6. Life member, Materials Society of India
7. Life member, Indian Physics Association
8. Life Member, Indian Association of Physics Teachers.
9. Member, American Physical Society
10. Member, Materials Research Society, USA

Sponsored Projects

1. An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films; SERB; Till March 2021; PI
2. J.C. Bose National Fellowship; SERB; Till February 2020; PI

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Prof. K.S.Narayan, JNCASR, Bangalore; Sl. No. 2; National
2. Dr. Avik Bid, IISc, Bangalore, Sl. No. 3; National

Significant research output / development during last one year

a) General research areas and problems worked on

Condensed matter Physics at low temperatures: Metal-Insulator transition in correlated oxides, Transport through Oxide heterostructures and interfaces.

Nanoscience and Nanotechnology: Magnetic, Electronics and Opto-electronics properties of single nanowires and arrays

b) Interesting results obtained

1. Rare-earth Transition metal alloy magnetic nanowires-enhanced magnetism:

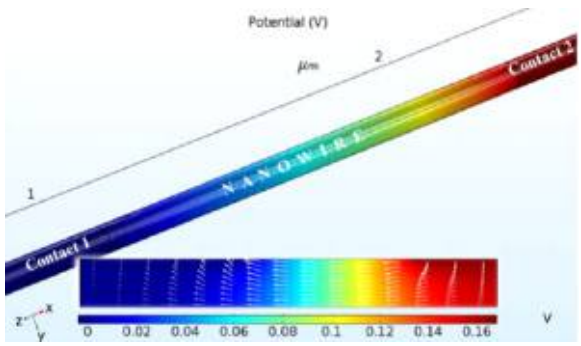
We have observed size induced large upward shift of magnetic transition temperatures in nanowires (diameter ~ 100 nm) of rare-earth transition metal alloy Gd_xCo1_{-x} (x = 0.4). The magnetic transition temperatures like the magnetization compensation temperatures (T_{cm}) shifts upward by nearly 350 K compared to that of the bulk. The saturation magnetization (M_S) remains high over the whole temperature range compared to that the bulk and at room temperature the enhancement in MS is 33 %.

This enhances the applicability of the RE-TM alloy to well above the room temperature. The magnetic experiments were carried out in the temperature range 80 K to 1100 K on the alloy nanowires grown by electrochemical synthesis in the nanopores of Anodic Aluminium Oxide (AAO) templates. It has been established that the large shift in the T_{cm} is linked to qualitative change in the nature of the anisotropy energy E_A on size reduction, in particular in the temperature derivative dE_A/dT.

2. Self-powered single semiconductor nanowire photodetector:

Self-powered photodetectors have been fabricated from a single Germanium nanowire (NW) in the metal-semiconductor-metal (MSM) device configuration. The self-powered devices show high photoresponse (Responsivity~ 10^3-105^A/W) in the wavelength range 300-1100 nm. It has been established that the asymmetry in Schottky Barrier Height (SBH) at the two MS contacts leads to a "built-in" axial field that in turn leads to separation of light generated electron-hole pair in the absence of an applied bias. Thus, the photogenerated carriers can be separated at zero bias , which then diffuse to the appropriate electrodes driven by the "built-in" axial field. We also point out the physical origins that can lead to unequal barrier heights in seemingly identical NW/metal junctions in a MSM device.

Figure 1. Simulation of electric field developed in a nanowire (without applied bias) due to existence of Asymmetric Schottky barriers at contact that leads to self-powered photodetectors.



3. Continuous transition from weakly localized regime to strong localization regime in $Nd_{0.7}La_{0.3}NiO_3$ films undergoing insulator-metal transition.

We investigated Metal-Insulator Transition (MIT) using conductivity and magnetoconductance (MC) measurements down to 0.3 K in $Nd_{0.7}La_{0.3}NiO_3$ films grown on crystalline substrates of LaAlO3 (LAO), $SrTiO_3$ (STO) and $NdGaO_3$ (NGO) by pulsed laser deposition. The film grown on LAO experience a compressive strain and shows metallic behavior with the onset of a weak localization contribution. Films grown on STO and NGO show a cross-over from a Positive Temperature Coefficient (PTC) resistance regime to Negative Temperature Coefficient (NTC) resistance regime at definite temperature with the extrapolated conductivity at zero temperature though small (<10 S/cm) is finite, signalling the existence of a bad metallic state and absence of an activated transport. We show that a combination of certain physical factors makes substituted nickelates (that are known to exhibit first-order Mott type transition) , undergo a continuous transition as seen in systems undergoing disorder/composition driven Anderson transition. The MC measurements also support the above observation. Interestingly, the film grown on LAO shows onset of Non-Fermi liquid behavior for T > 100K, although higher resistivity films with tensile strain show Fermi-Liquid behavior.

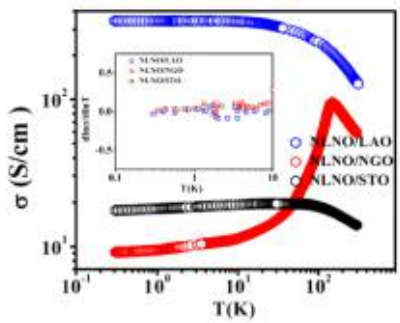


Figure 2. Conductivity (s) as a function of temperature T in the three films of NLNO grown on LAO, STO, and NGO single crystal substrates. The inset shows the derivative W= dln s/ dlnT as a function of temperature for 0.3K< T < 10 K.

c) Proposed research activities for the coming year

The group of AKR will continue to focus on Mott transition in $NdNiO_3$ as per the objective of the SERB project. In particular, in next year following issues will be addressed to : (a) Effect of disorder, created by swift heavy ions of inert gas, on the Mott transition. (b) Nature of phase transition in very thin $NdNiO_3$ films (few unit cells). (c) Effect of reversible strain when such films are grown on Piezo-electric substrates and the strain tuned in a reversible way by a bias.

The research will also start a new activity on interfaces of Ferro-electric and Ferromagnetic interfaces as realized in a heterostructure of $BaTiO_3$ (FE) /$SrRuO_3$ (FM). The experiments carried down to 3K will reveal the effect of magnetic order in SrRuO3 (FM at 150K) on the nature of potential barrier at the interface.

The research on nanowires will be strengthened by such measurements as thermal conductivity in single nanowires using a novel non-contact opto-thermal spectroscopy based on Raman Spectroscopy. The work is being carried out in collaboration with Bose Institute, Kolkata. In addition a comprehensive model will be developed to explain the ultra-high sensitivity in nanowire photo-detectors that have been a main contribution of the AKR group in recent years.

The above two activities are being carried out with support of J.C. Bose National Fellowship.

The collaborative work with Dr. Barnali Ghosh and Dr. Manik Pradhan on gas sensors will continue as part of TRC activity.

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Supervision of Research / Students

a) Ph.D. Students

1. Shubhadip Moulick; Charge and spin transport in hybrid two dimensional nanodevices; Under progress
2. Biswajit Pabi; An investigation of mechanical tunability in single molecular junction; Under progress
3. Rafiqul Alam; An investigation of transport phenomena in topological materials; Under progress
4. Shubhrasish Mukherjee; An investigation of electronic and optical properties in 2D semiconductors and their heterostructures; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Riju Pal; Fabrication and Characterization of Few-layer Graphene Field Effect Devices; SNBNCBS

Teaching activities at the Centre

1. Autumn semester; PHY 501- Research Methodology; PhD; 45 students; with 1 (Prof. Sugata Mukherjee,) co-teacher
2. Spring semester; PHY 601 - Advanced Condensed Matter Physics 2; PhD; 25 students; with 1 (Dr. T. Setti,) co-teacher

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited talk at ICCFM 2018; Dec 18, 2018; Kolkata; 30 min
2. Invited talk at Vidyasagar University, Midnapore; Mar 15, 2018; Midnapore, WB; 1 hour
3. Invited talk at J. R. N. Rajasthan Vidyapeeth (Deemed to be University) Udaipur; Nov 22, 2018; Udaipur, Rajasthan; 35 min

Membership of Committees

a) Internal Committee

1. Joint in-charge of clean room and Helios-FIB system
2. In charge of Helium plant
3. In charge of 3K measurement system under Technical Research Cell

Conference / Symposia / Workshops / Seminars etc. organized

1. ICCFM 2018; Dec 13, 2018; Biswa Bangla Convention Center, Kolkata; 4 days

Participation in Science Outreach program

1. Went to J. R. N. Rajasthan Vidyapeeth (Deemed to be University) Udaipur, Rajasthan during 21-22nd November, 2019 for the Bose 125 outreach program. I have given a talk on my research work after showing them the documentary on Prof. S N Bose. Also I have interacted with the students and faculty members present there.

Significant research output / development during last one year

a) General research areas and problems worked on

Experimental condensed matter physics

b) Interesting results obtained

Our research mainly focuses on studies of the mechanisms of charge transport, spin transport nano-scale down to single atom. In the past one year the activities were mainly developmental. As the laboratory space was not available, we were mainly focusing on the common facilities. The research activities are listed below:

1. Single molecular break junction set up: We have successfully created a room temperature mechanically controllable break junction set up to study atomic and molecular junction. The set was completely built at SNBNCBS. First gold atomic junction was characterized,

showing characteristics quantum of conductance at room temperature. Introduction of molecule shows conductance features below than the quantum of conductance (2e^2/h). We are trying to understand the formation and breaking mechanism of certain molecular junction of different functional molecules. My research scholar, Biswajit Pabi won the best poster prize on this work in last December at the ICCFM 2018.

2. Fabrication of 2D device: We have optimized the device fabrication of 2D mesoscopic device like graphene and MoS2. Multiterminal field effect devices were successfully fabricated and characterized using Raman spectroscopy and transport measurement. The main hurdle in this part was to develop the optical lithography with the existing mask aligner.
3. Heterostructure set up: Another important development of our group is to create the optical microscope based set up using which we can hybrid 2D heterostructure of graphene/hBn/Mos2 etc. We have also created graphene and Mos2 devices by transferring them directly on the predefined contacts. This will help us to create resist free clean interface for studying particularly hybrid molecular device.
4. Transport and noise measurement set up: We have prepared a customized transport measurement set up for measurement of transport and noise down to low temperature (77K). Moreover, a versatile high vacuum (1E-6 mbar), room temperature set up is developed with a optical window for optoelectronic measurements.

c) Proposed research activities for the coming year

1. Single molecular junction: A single organic molecule suspended between two metallic electrodes is an attractive electronic device since it allows using the rich structural possibilities of organic molecules to manipulate electronic conductance at the nano-scale. Up to date, most of the research concerning single-molecule conductance, focused on systems where the molecule is attached to the metal electrodes (mostly with gold) via anchoring groups, which act as a potential barrier and suppress the conductance to the tunneling regime. Recent experiments reveal that metal-molecule hybridization plays a key role in determining the electronic properties of a molecular junction. In this project, we intend to study both electric and thermoelectric properties of single molecular junction by changing the functionality of both the electrode and molecule by mechanically controllable break junction technique. Both s-metal (Au, Ag, Cu etc.) and d-metal (Pt, Pd, Fe, Ni etc.) will be used as electrodes, whereas, different molecular functionalities will be explored. Here we intend to identify the effect of the asymmetry of the molecule and the presence of a dipole moment along the molecule on the electronic transport properties of this highly conductive molecular junction. We will compare the conductance of two isomeric molecules, the symmetric and asymmetric molecules by attaching the molecules directly to metallic electrodes with no anchoring side groups. Understanding the dependence between structure and conductance will help us to learn how to control conductance in the atomic scale.
2. 2D and hybrid materials: We intend to investigate some of the key issues in solid-state physics and materials science: (1) Hybrid nanodevices combined with organic molecules, and (2) Electrical transport in novel topological materials. Novelty of the research lies in the design and fabrication of the innovative device structure combined with unique experimental probe comprising of simultaneous measurements of fluctuations, or “noise”, in direct electrical transport. The primary objectives are summarized below: - Fabricating high quality two-dimensional devices (graphene, transition metal dichalcognides (TMDCs) etc.) in combination with various functional molecules. - Investigation of spin and charge based switching in these devices through electrical transport, magneto-transport and noise measurements. -Address the effect of strain in nanomaterials and possibility of mechanical tunability in devices. -Investigations of charge and spin transport through single molecular junction through hybridization with metal molecule interface. - Understanding electronic and magnetic transport in new topological materials like Weyl semimetal and nodal line semimetals.
3. 2D spintronics: A promising direction for exceptionally efficient and low-power information processing involves manipulations of electron-spin rather than its charge at the nanoscale. Due to the presence of weak spin orbit coupling, graphene promises to have long spin coherence length up to ~100 µm, creating a possibility of having a spin-based logic device at room temperature. Moreover, after the successful production of large-scale graphene or by chemical vapor deposition (CVD) based techniques, created a huge prospect for their practical usage. Recently, a pure spin transport and precession over long channel lengths extending up to 16 µm was

observed in a CVD graphene device at room temperature. In line with these observations, we would like to enter in this fascinating field of research, which should not be limited to graphene, but other 2D materials as well. There are several aspects needs to be addressed to improve the device performance at ambient condition. Particularly, interface between the contact and 2D materials is an important issue. As these 2D materials, particularly graphene can adsorb any foreign molecule, the specific effect of these foreign impurities need to be seen. Apart from that, new electrodes and dielectric materials need to be investigated.

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Supervision of Research / Students

a) Ph.D. Students

1. Subarna Datta; Synthesis And Physical Properties Of Manganite Nanowires; Awarded
2. Samik Roy Moulik; Synthesis and study of physical properties of binary oxide thin films and nanostructures and devices; Thesis submitted
3. Avisek Maity; Synthesis, Characterization, Physical Property Studies & Applications of Perovskite Halide; Under progress
4. Chandan Samanta; Synthesis, Physical Properties And Application Of Metal Oxide Semiconductor Nanostructures And Thin Film; Under progress
5. Parushottam Majhi; Structure And Physical Properties Of Strained Metal Oxide Films; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Saikat Mitra, SERB project student; Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; S.N Bose National Centre For Basic Sciences
2. Prasenjit Chakraborty, TRC Project student; Fabrication of hazards gas sensor; S.N Bose National Centre For Basic Sciences
3. Shehamoyee Hazra, TRC Project student; Growth of piezoelectric nanowires and fabrication of nano generator; S.N Bose National Centre For Basic Sciences
4. Ayan Ghosh, TRC project student (shared); Growth of gas sensor material and prototype development; S.N Bose National Centre For Basic Sciences
5. Tamanna Kumari , M.Sc. Project student (six months); Synthesis of Palladium nanoparticles by pulsed laser ablation in liquid (PLAL) and their characterization; Central University Haryana

c) Post Doctoral Research Scientist/s

1. Arnab Ghosh; Synthesis of graphene and transition metal dichalcogenide based two dimensional nanostructures for applications in supercapacitor, gas sensor and piezoelectric nanogenerator devices
2. Dr. Ankita Ghatak, NPDF, SERB, Project completed on 31st May 2018; Interface Physics in multilayer oxide thin films

Publications

a) In journals

1. Samik Roy Moulik, Abhijit Maity, Prasenjit Chakraborty, Manik Pradhan**, Barnali Ghosh**, Evidence of Isotope Selective Diffusion of Ambient CO_2 Gas in WO_3 Nanostructures, J. Phys. Chem. C 123,4, 2573-2578, 2019.
2. Avisek Maity and **Barnali Ghosh**, Fast response paper based visual color change gas sensor for efficient ammonia detection at room temperature, Scientific Reports 8:16851 2018.
3. S. Leela, GV. Rohini, K. Saranya, Sekhar Bhattacharya, Nafis Ahmed, Shaili Sett, and **Barnali Ghosh**, Tunable growth of semiconductor nanostructures by Plasma Enhanced Chemical Vapor Deposition - Synthesis, morphological and Raman studies, Superlattices and Microstructures, 122 510–515 2018.
4. Chandan Samanta , Rishi Ram Ghimire, and **Barnali Ghosh**, Fabrication of Amorphous Indium–Gallium– Zinc–Oxide Thin-Film Transistor on Flexible Substrate Using a Polymer Electrolyte as Gate Dielectric, IEEE Transactions on Electron Devices, 65, 2827-2832 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited speaker and organizing committee member of 21st International conference on Advanced Materials & Nanotechnology" (Advanced Materials -2018) held during September 04-06, 2018 in Zürich, Switzerland; Sep 4, 2018; Zurich, Switzerland; three days,04-06 September
2. Invited talk in Users' meeting of Indian Beamline, Photon Factory, KEK, Japan held in JNCASR on 25th-26th September, 2018; Sep 25, 2018; JNCASR; two days, 25-26 Sept
3. Invited Speaker of the "International Conference on Quantum & Atom Optics (ICQAO-2018)" held on December 16-18, 2018 at Indian Institute of Technology ; Patna; Dec 16, 2018; IIT Patna; three days, 06-08 Dec
4. Invited speaker in One day seminar at CGCRI held on on Feb 20, 2019 Jadavpur, Kolkata; Feb 20, 2019; CGCRI, Kolkata; one day 20 Feb
5. KEK Research Proposal No: 2018-IB-25 , accepted for Synchrotron X-Ray diffraction experiment at Bl-18B, Indian Beamline, KEK , Photon factory, Japan visit during Dec 07 – 10, 2018; Dec 7, 2018; Photon factory, KEK Japan; four days, 07-10 Dec

Membership of Committees

a) Internal Committee

1. Various thesis committee
2. Purchase committee,
3. Committees related to TRC
4. Scientist - in charge of few Central equipment facilities under Technical Cell
5. Various evaluation committees
6. Interview committee

Fellow / Member of Professional Body

1. Life member Indian Physics Association,
2. Life member Indian Association for the Cultivation of Science
3. American Physical Society

Sponsored Projects

1. Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; SERB-DST; 06/07/2018-05/07/2021; PI
2. An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films; SERB-DST; 24/3/2017-23/03/2020; Co-PI
3. Technical Research Centre, Centre project, one among other PI s.; DST; 01/01/2016 to 31/ 12/2020; PI

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. SSN Research Centre, Chennai, India; Sl. No. 3; National

Participation in Science Outreach program

1. Invited lecture on hazardas gases in environment and their detection using simple technique in 5th meeting of Vidyasagar Bigyan chakra, Paschimbanga Bigyan Mancha, 22nd September, 2018, Community Hall, North 24 Parganas.

Societal impact of Research

1. One of the activity leader in Technical Research Centre (TRC) project: Main area of work: i) Environment related issue: Making of sensor for Hazardas gas detection ii) Health Care Sector: Technology development for making device for detection of disease

2. A) Development of ultra-sensitive sensor for hazards gas detection: Ammonia gas sensor : a)"Visual color change based ammonia gas sensor (<10ppm)for stand - alone use for hazards " i) Hazards Gas detection in an open atmosphere down to 10ppm level/based on ammonia gas sensing, patent filed). ii) The technology developed is to be used for Ammonia gas detection without any other peripherals like a pH paper. "Prototype is ready for use which can sense ammonia <10ppm level by visual effect (just by colour change)" (one Indian patent filed(Patent no: 201731000270) and one paper published in Scientific reports(2018) 8:16851)

3. b)" High sensitivity NH3 gas (500 ppb) solid state sensor with electrical readout" High sensnitive sensor can be used as markers for renal disease and chronic kidney diseases (CKD). Even during dialysis of a patient exhaled NH3 can used to check the efficacy of the dialysis. Making of prototype is under process, Indian Patent filed (patent no: 201831001993), and one paper published in Scientific reports.

4. B) Development of Nitric oxide (NO) gas sensor: Fabrication of solid state sensor , detecting NO gas (sensitivity: 500ppm). Exhaled NO can be used as the

markers for Asthma and Chronic obstructive pulmonary disease (COPD). Making of prototype is under process.

Significant research output / development during last one year

a) General research areas and problems worked on

i) Growth of high performance thin film transistors (TFT) and physical property study ii) Growth and physical property study of perovskite lead hallide iii)Crystallographic strcutural study using Synchrotron X-ray and Neutron diffraction study in complex oxides. iv)Growth of binary and complex oxide nanowires and thin films by using different techniques like; wet chemistry and pulsed laser deposition methods. v)Fabrication of single nanowire device of complex oxide systems by using different lithographic techniques and transport measurement on single nanowire. vi)Interface physics using cross-sectional transmission electron microscope (TEM) study on thin films and devices vii)Study of Photoresponse and gas sensing property in binary oxide systems.

b) Interesting results obtained

a) Ultra high sensitive nitric oxide (NO) gas sensor using Si nanowires heterojunction array based deice with noise limited detectivity approaching 10 ppb

A ZnO/Silicon nanowires (ZnO/Si NWs) heterojunction array based NO gas sensor operating at room temperature shows extremely high response (noise limited response ~ 10 ppb). The sensor shows very high selectivity towards NO gas sensing and limited perturbation in response due to presence of moisture. The sensor has been fabricated by using cost effective chemical processing that is compatible with wafer level processing. Extensive cross-sectional electron microscopy and composition analysis by line EDS allowed us to make a physical model. The electrical characteristic of the model was to fit the I-V data before and after exposure to gas and essential changes in electrical parameters were obtained. This was then explained based on a proposal for mechanism of gas sensing. We observe that the heterostructure leads to a synergetic effect where the sensing response is more than the sum total of the individual components, namely the ZnO and the Si NWs. The response is much enhanced in the p-n junction when the n-ZnO nanostructure interfaces with p-Si NW compared to that in the n-n junction formed by ZnO on n-Si NW.

a) A proof of concept has already been established and a patent has been filed, patent no: 201731038036, filed on: 26/10/2017, published on: 10/11/2017 ,b) A paper has been published I Nanotechnology, in 2019.

Evidence of isotope selective diffusion of ambient CO2 Gas in WO3 Nanostructures:

It has been observed that the isotope selective diffusion of carbon dioxide (CO_2) gas occurs through large aspect ratio (length/ diameter = 20:1) and porous one-dimensional nanostructure of tungsten oxide (WO_3). This novel effect was demonstrated in an ensemble of binary oxide, WO_3 nanostructures with large surface area. When atmospheric CO_2, which has two major stable isotopes ($12CO_2$ and $13CO_2$), flows through such an ensemble of nanotubes, it allows only the $12CO_2$ isotopes to diffuse through it and hinders diffusion of the $13CO_2$ isotopes. The selective diffusion leads to different isotopic fractionations of ambient CO_2 (12C:13C), in other words, generating different isotope-enriched CO_2 gases as established through high-precision cavity-enhanced absorption spectroscopy technique. The phenomena are strongly dependent on the surface morphology of nanostructures of binary oxide, and the surface-induced diffusion process is most likely to be the effects of physical processes enabling the Knudsen diffusion, but is not related to any chemical activities.

a) A proof of concept has been established and a patent has been filed, patent no: 201731017087, Filed on 16/05/2017, published on 16/06/17 and b) a paper has been published, mentioned in "Publications in Journals" section.

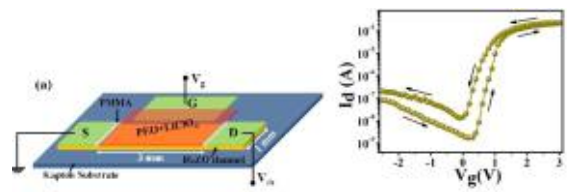

Fig1: a)A schematic of Flexible TFT composed of a kapton substrate, source, drain and gate Cr/Au electrode patterns, an amorphous IGZO semiconducting channel , b) Transfer characteristic curve (I_d vs V_g) at V_{ds} = 1V.

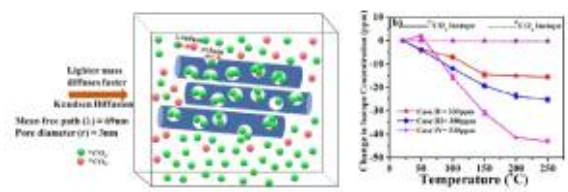

Fig2. Variation of concentration of CO_2 isotopes $^{12}CO_2$ and $^{13}CO_2$ during diffusion through WO_3 nanotubes

c) Proposed research activities for the coming year

1. Basic research: 1) i) Physical Property study on Single nanowire based devices ii) Growth to Physical Properties on thin film transistors (TFT) iii) Study of interface physics of complex and binary Oxide thin films and multilayers: iv) Synthesis & optical properties, crystallographic structure microstructural study on Perovskite halide systems
2. Work under Project SERB ref no: EMR-2016/002855 dated 20/3/2017 i) Synchrotron and Neutron Diffraction study on perovskite oxides

3. 3) Work under project SERB ref no: EMR/2017/001990 dated July 2018 Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them: one paper has been published: J. Phys. Chem. C 2019, 123, 2573-2578. Further work is under study.

4. 3) Technology development related work (under TRC project): i) Development of Hazards Gas Detection Sensor based devices and prototypes : (see details given in serial no 13) ii) Development of nano-generator using piezoelectric nanostructures:

5. Piezo-electric nanowires for energy harvesting and sensitive motion. Work is being done on self-powered nanosystems combine the nanogenerator with functional nanodevices in order to harvest mechanical energy from the environment into electricity to power nano devices. (Indian patent filed)

DIPANWITA MAJUMDAR
INSPIRE FACULTY
CMPMS

Awards / Recognitions

1. DST Inspire Faculty Award

Significant research output / development during last one year

a) General research areas and problems worked on

Structural, vibrational, optical and electronic properties of hybrid systems of 2D layered materials

b) Interesting results obtained

Inspired by the isolation of graphene, a great deal of attention has been focused on the other two-dimensional (2D) materials which led to the emergence of a new era of flatland with great potential for a range of applications in optoelectronics and sensors. To further potentially extend the functionalities of such materials by modifying them with 0D materials is of great and widespread interest. The systematic study of structural and electronic properties and the understanding of the optical and vibrational responses are essential to realize the impact of hybridization and to explore the role of these hybrid systems for practical applications.

c) Proposed research activities for the coming year

- Synthesis and study of structural and electronic properties of hybrid systems of 2D materials
- Understanding the optical and vibrational responses
- Study the role of these systems for practical applications.

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Supervision of Research / Students

a) Ph.D. Students

1. Souvanik Talukdar; Biomedical applications of magnetic nanomaterials; Thesis submitted
2. Indranil Chakraborty; Biomedical applications of magnetic nanomaterials; Under progress
3. Mahebub Alam; Multiferroic materials; Under progress
4. Keshab Karmakar; Photoelectro-chemical water splitting; Under progress
5. Dipika Mandal; Transition metal Oxides at high frequency; Under progress
6. Subrata Ghosh; Magnetocaloric materials; Under progress
7. Priyanka Saha; Magnetorheology; Under progress
8. Dipanjan Maity; Photoelectrochemical water splitting; Under progress
9. Swarnali Hait; Multiferroic materials; Under progress
10. Anupam Garai; Transition metal Oxides at high frequency; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Suchandra Mukherjee; Comparative study of magnetorheological fluids prepared with Fe_3O_4 nanoparticles and nanohollow spheres; Dimond Harbour Women's University
2. Rupam Saha; Incorporation of Multifunctionality in surface modified ferrite nano-hollowspheres; University of Hyderabad

c) Post Doctoral Research Scientist/s

1. Srabantika Ghosh; Multiferroic materials

Teaching activities at the Centre

1. Autumn semester; Condensed Matter Physics; Integrated PhD; 7 students; with 1 (Professor Manoranjan Kumar,) co-teacher
2. Autumn semester; Condensed Matter Physics; PhD; 15 students; with 1 (Professor Manoranjan Kumar,) co-teacher
3. Autumn semester; Advanced Laboratory; Integrated PhD; 7 students; with 4 (Tirupaythya Setti, Rajib Mitra, and Madhuri MandalManik Pradhan) co-teacher
4. Spring semester; Basic Laboratory; Integrated PhD; with 1 (P. K. Mukhopadhyay) co-teacher

Publications

a) In journals

1. M. Alam, S. Talukdar, **K. Mandal**, Multiferroic properties of bilayered $BiFeO_3/CoFe_2O_4$ Nano-hollowspheres, Materials Letters, 210 (2018) 80–83.
2. M. Alam, I. Chakraborty, **K. Mandal**, Microwave synthesis of surface functionalized $ErFeO_3$ nanoparticles for photoluminescence and excellent photocatalytic activity, Journal of Luminescence, 196, (2018), 387-391.
3. S. Talukdar, R. Rakshit, A. Kramer, F. A. Muller, **K. Mandal**, Facile surface modification of nickel ferrite nanoparticles for inherent multiple fluorescence & catalytic activities, RSC Advances, 8 (2018), 38.
4. K. Karmakar, A. Sarkar, **K. Mandal** and G. G. Khan, Investigating the Role of Oxygen Vacancies and Lattice Strain Defects on the Enhanced Photoelectrochemical Property of Alkali Metal (Li, Na, and K) Doped ZnO Nanorod Photoanodes, ChemElectroChem, 5, (2018), 1147.
5. R Rakshit, S. K Kadakuntla, P Agarwal, S Sardar, P Saha, **K Mandal**, Surface Electronic States Induced High Terahertz Conductivity of Co_3O_4 Microhollow Structure, ACS Applied

Materials & Interfaces 10, (2018), 19189.

6. D. Mandal, M. Mandal Goswami and **K. Mandal**, Magnetic Properties of AOT Functionalized Cobalt-FerriteNanoparticles in Search of Hard-Soft Marginal Magnet, IEEE Transaction on Magnetics, 54, (2018), 6000406.
7. S Ghosh, A Ghosh, **K Mandal**, Reversible magnetocaloric effect and critical exponent analysis in Mn-Fe-Ni-Sn Heusler alloys, Journal of Alloys and Compounds 746, (2018), 200.
8. S Ghosh, P Sen, **K Mandal**, Effect of Si Doping on Magnetic and Magnetocaloric Properties of Ni-Co-Mn-Sn Alloys, IEEE Transactions on Magnetics 54, (2018), 2501405.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Magnetism: Bulk to Nano; May 30, 2018; S. N. Bose National Centre for Basic Sciences; 1hr 30 min
2. Transition metal oxides nanostructures: Novel properties; Oct 24, 2018; Johannes Gutenberg University Mainz, Germany; 1hr

Academic Visits

a) International

1. Exchange Visit; I visited Johannes Guttenburg University Mainz, Germany during 01 September - 31 October 2018 for collaborative research work.

Membership of Committees

a) Internal Committee

1. Head of the Department, Condensed Matter Physics and Materials Sciences
2. Technical Committee (Purchase)
3. Purchase Committee
4. Students' Curriculum and Research Evaluation Committee
5. Security Committee
6. Library Committee
7. Technical Cell

Awards / Recognitions

1. Funding for renewed research stay (September-October 2018) in Germany from Alexander von Humboldt Foundation.
2. Cover Feature: Investigating the Role of Oxygen Vacancies and Lattice Strain Defects on the Enhanced Photoelectrochemical Property of Alkali Metal (Li, Na, and K) Doped ZnO Nanorod Photoanodes (ChemElectroChem 8/2018) K Karmakar, A Sarkar, K Mandal, GG Khan - ChemElectroChem, 2018.
3. Our paper, "The role of oxygen vacancies and lattice strain defects in photoelectrochemical properties of Li, Na, and K Doped ZnO nanorod" presented by Keshab Karmakar in the Fall Meeting of European Materials Research Society, held in Warshow University Poland during 17-21 September 2018, received the best poster award.

Fellow / Member of Professional Body

1. Indian Society for Non-destructive Testing
2. Materials Society of India
3. Indian Physics Teachers' Association
4. Indian Physical Society
5. IEEE Magnetic Society

Conference / Symposia / Workshops / Seminars etc. organized

1. C. K. Majumdar Memorial Summer Workshop in Physics; May 22, 2018; S. N. Bose National Centre for Basic Sciences; 11 days
2. International Conference on Complexes and Functional Materials; Dec 13, 2018; Biswa-Banga Convension Centre; 4 days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Professor F. A. Muller, Friedrich Schiller University Jena, Funded by Humboldt Foundation, collaborative research on biomedical applications of magnetic nanostructures; Sl. No. 3; International
2. Professor G. G. Khan, Tripura Central University, collaborative research on electrochemical water splitting; Sl. No. 4; National

Societal impact of Research

1. Magnetic nanomaterials have tremendous possibilities to be used in biomedical applications such as in drug delivery, hyperthermia treatment, imaging etc. They can also be used in magnetic memory, high frequency (microwave) communication. Magnetocaloric materials, being more energy efficient and environment friendly, can be used in domestic refrigeration system. Semiconducting materials with efficient photo-electrochemical water-splitting capability can be used as energy materials for hydrogen evaluation.

Significant research output / development during last one year

a) General research areas and problems worked on

Magnetism and magnetic materials, Energy materials

b) Interesting results obtained

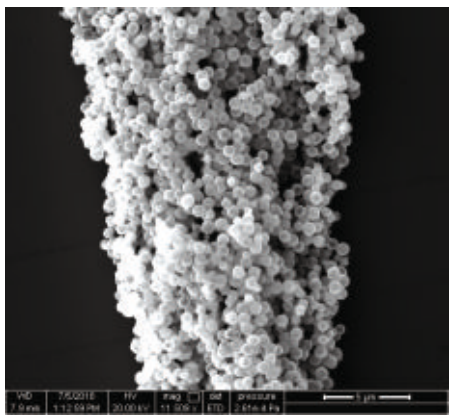
1. Improved Magnetorheological Effect with Ferrite Nano-Hollow Spheres

Micron or nano-sized particles with low-density and high saturation magnetization are desirable for magnetorheological applications. Zn0.2Fe2.8O4 nano hollow spheres with higher saturation magnetization can be an interesting candidate for magnetorheology.

We prepared silicon oil based MR fluids by dispersing $Zn_{0.2}Fe_{2.8}O_4$ and Fe_3O_4 NHSs of diameter 700 nm, each with 50 wt. % and studied their magnetorheological response in flow mode. Fig. 1 shows the FESEM image of chain formation of $Zn_{0.2}Fe_{2.8}O_4$ NHSs under applied magnetic field. $Zn_{0.2}Fe_{2.8}O_4$ shows much better MR response than Fe_3O_4.

2. Investigation of Efficient Microwave Absorber

In search of lightweight, broadband and stable microwave absorbing material, we investigated a



morphology dependent study on Nickel Ferrite (NFO) nano hollow spheres. A comparative study of NFO NHS with its nano particles (NPs) and bulk counterpart on permittivity (e), permeability (μ), Reflection Loss (RL) and Shielding efficiency (SE) has been performed for widely used X-Band (8-12 GHz) on composites filled (25 wt% and thickness of 2 mm) with each sample. Interestingly, NFO nano hollow spheres (NHS) are found to be highly efficient material towards microwave attenuation. A optimal RL of ~ -59.2 dB is obtained for frequency ~ 11.7 GHz with a band width (W) of ~ (9.18 – 12) GHz with RL < -10 dB (absorption > 90%). Hollow cavity of NHS leads to a lower density (~ 3.9 g/cc) as well as multiple internal reflections in the core of NHS enhances wave absorption. Excellent impedance matching with free space, with proper dielectric and magnetic loss contributes towards maximization of RL for NHS. These properties enhance the potentiality of NFO NHS as an efficient microwave absorbing material applicable in various microwave devices.

3. N-N type heterojunction engineering with ZnO-MoO3 core-shell nanorods for solar energy conversion

We observed an easy and scalable route of n-n architecture engineering with ZnO-MoO_3 core-shell nanorods, which indeed is the first time demonstration of this nano-heterojunction for hydrogen energy generation in a photoelectrochemical (PEC) cell. We found the n-n hetero-architecture to provide a suitable solution to maximize solar light absorption along with enhanced charge carrier separation which also boosts the charge transportation and mobility in the junction region due to suitable core-shell interfacial band alignment and modulation of interfacial electronic structure. Again, the MoO_3 shell was found to provide a potential solution to get more catalytically active sites which transfer hole to the electrolyte for easy oxidation of water. An average thickness ~150nm of MoO_3 shell significantly improved the photocurrent and a 7.5 fold increase of applied bias photon to current conversion efficiency (ABPE) value is achieved upon visible light illumination (?>420 nm, 10 mWcm-2) with a maximum value of 0.15% . Hydrogen gas was evolved even at no external potential applied to the PEC cell.

c) Proposed research activities for the coming year

1. To work on magnetic nanostructures in bio-medical applications, magnetic rheology, imaging, high frequency communication
2. To work on multiferroic materials
3. Magnetocaloric effect
4. Photoelectrochemical water splitting

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Supervision of Research / Students

a) Ph.D. Students

1. Chaitali Dey; Synthesis and Characterization of Transition Metal Based Magnetic Nanoparticles for Applications in Drug Delivery and Catalysis; Awarded
2. Debarati De; Under progress
3. Arpita Das; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Muruganandham Hariram; Cell imaging by magnetic particles

Teaching activities at the Centre

1. Fall; Spectroscopy related practical (PHY-391); I.Ph.D; 10 students

Publications

a) In Journals

1. Chaitali Dey, Arup Ghosh, Manisha Ahir, Ajay Ghosh, **Madhuri Mandal Goswami**, Improvement of anticancer drug release by cobalt ferrite magnetic nanoparticles through combined pH and temperature responsive technique, ChemPhysChem 19, 2872-2878 (2018).
2. **Madhuri Mandal Goswami**, Arpita Das, Debarati De, Wetchemical synthesis of FePt nanoparticles: Tuning of magnetic properties and biofunctionalization for hyperthermia therapy, Journal of Magnetism and Magnetic Materials, 475, 93-97 (2019).
3. Arpita Das, Debarati De, Ajay Ghosh, **Madhuri Mandal Goswami**, DNA engineered magnetically tuned cobalt ferrite for hyperthermia application, Journal of Magnetism and Magnetic Materials, 475, 787-793 (2019).

b) Other Publications (including conferences)

1. Chaitali Dey, Arka Chaudhuri, Madhuri Mandal Goswami 'Synthesis of MnFe2O4 magnetic nano hollow spheres by a facile solvothermal route and its characterization' AIP Conference Proceedings 1942 (1), 050099, 2018

Sponsored Projects

1. DST, WOS-A; DST, New Delhi; 3 years; PI

Significant research output / development during last one year

a) General research areas and problems worked on

Fluorescent magnetic nano-materials, Cell imaging, Hyperthermia therapy, Catalysis, Energy materials

b) Interesting results obtained

First the Co-ferrite particles were synthesized by wet chemical method then characterized to check the suitability of these particles for their use in magnetic hyperthermic drug release. For this following experiments were done on the particles.

We have seen the power loss (PL ~ 1 W/g = 1 J/s.g) of the sample as obtained under 60 kA/m field of 600 Hz. Here, from DTA data we have the heat flow (HF) of MNPs at 30 oC ~1 mW = 0.001 J/s, the heating rate (HR) ~10 oC/min = 10/60 = 1/6 oC/s and the sample's mass (m) ~10 mg = 0.01 g. So, the heat required to increase the temperature 1 oC for 1 g sample is HF/(HR×m) = 0.001×6/0.01 J = 0.6 J, which is the specific heat of the sample. Finally, the change in temperature due to ac field heating = 1/0.6 oC/s ~ 1.67 oC/s. So, the temperature will increase at a rate of 1.67 oC per second if the sample is kept under an ac magnetic field of amplitude ~ 60 kA/m and frequency ~ 600 Hz. Then the temperature and pH triggered drug release study was done on this particles. The drug release spectra were measured under different time interval with UV-visible spectrometer. It is clear from the graph (Figure1) that drug release spectra is no doubt better at elevated temperature than our normal

body temperature. At higher temperature due to increase of thermal agitation, the drug molecules start to detach from the surface of the MNPs, by which drug release rate increases. It is seen that above 95% of loaded drug was released at higher temperature within 6h.

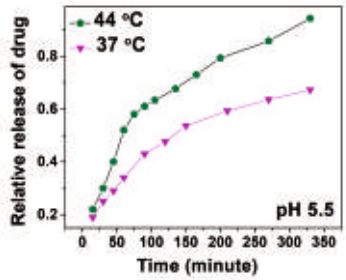

Figure 1. Time dependent anticancer drug release (DOX) spectra from $CoFe_2O_4$ MNPs at lower pH as a function of time under two different temperatures.

We are using these MNPs as drug delivery agent. So, we are interested in studying the behavior of the MNPs within the cell system. The evidence from MTT assay showed that there was no effect of MNPs on cell survival of cancer cells (MDA MB 231), depicting the fact that there was no significant cell death due to MNPs within cells (around 75% cells are alive. Further, it was used to study its effect on normal cells and we observed that the nanoparticle caused no such significant cell death in normal cells also.

To confirm its possible use in hyperthermia, we have tried to check the effect of heat with the drug loaded MNPs in cancer cells. Around 10^6 cells were seeded in 6-well plates and incubated for 24 h followed by addition of MTT by triplicate experiment manner, which are shown in figure 2.

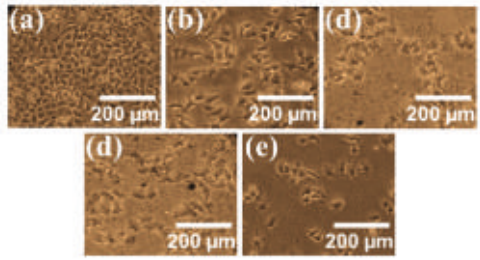

Figure 2. MDA MB-231 cells incubated with (a) control, (b) 100µg/ml at 37 °C, (c) 100µg/ml at 44 °C, (d) 150µg/ml at 37 °C, (e) 150µg/ml at 44 oC drug loaded $CoFe_2O_4$ MNPs.

After cells were treated and incubated at two different temperatures (i.e 37 °C and 44 °C), it was observed that there was a remarkable cell death at two respective doses with a significant more number of cell death at 44 °C. In control sets, the cells were found to be adherent and with intact morphology whereas on the other hand, in treated sets the adherent property of cells was not so prominent and thus started floating in the media signifying the fact that it may be due to cell death. The reason behind is that the nanoparticle loaded with drug was more internalized by the cells thereby causing more number of cell death at higher temperature.

c) Proposed research activities for the coming year

Our future plan is prepare the magnetic nanomaterials for hyperthermia and cell imaging. We achieved the success upto cell culture level. Our next goal is to apply those materials on mice model and see how it works.

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Supervision of Research / Students

a) Ph.D. Students

1. Aslam Parvej; Exotic Phases in Frustrated Low Dimensional Spin Systems; Awarded
2. Hrishit Banerjee; Study of Electronic Structure of Organic and Inorganic Complexes; Awarded
3. Rakesh Das; Coarsening, Steady-State And Phase Transition in Self-Propelled Particles; Thesis submitted
4. Debasmita Maiti; Frustrated Magnetic Ladders : A DMRG Study; Under progress
5. Sudipta Pattanayak; Ordering Kinetics, Steady State and Phase Transition in Active Particle Systems : Role of Noise and Boundary; Under progress
6. Monalisa Singh Roy; Edge Modes in 1D Chains of Correlated Electrons and Their Junctions; Under progress
7. Sudip Kumar Saha; Topology and Thermodynamics in Low-dimensional Systems; Under progress
8. Sk. Saniur Rahaman; Strongly correlated systems; Under progress
9. Jyotirmoy Sau; Strongly correlated systems; Under progress
10. Monalisa Chatterjee; Strongly correlated systems; Under progress

c) Post Doctoral Research Scientist/s

1. Dayasindhu Dey; Magnetic properties of Frustrated system

Teaching activities at the Centre

1. Spring semester; Condensed Matter I; Integrated PhD; and PhD(10) students

Publications

a) In journals

1. R. Das, **M. Kumar** and S. Mishra, Polar flock in the presence of random quenched rotators, Phys. Rev. E 98, 060602 (R) (2018).

Lectures Delivered

1. The International Conference on Magnetic Materials and Applications; Dec 12, 2018; NISER, Bhubaneswar
2. Indo-French School cum Workshop on Molecular Magnetism; Nov 30, 2018; IISc

Membership of Committees

a) Internal Committee

1. Jest Co-ordinator from S N Bose Centre

Sponsored Projects

1. Ramanujan Fellowship; DST; 5 years; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Young Investigator Meet on Quantum Condensed Matter Theory; Nov 20, 2018; S N Bose National Centre for Basic Sciences; 3 days

Participation in Science Outreach program

1. Bose125 at IIT Mandi

Significant research output / development during last one year

a) General research areas and problems worked on

Frustrated magnets, Topological Insulators, Majorana Fermions, Exotic phase in magnetic systems, Nonequilibrium phenomena in classical and quantum systems.

b) Interesting results obtained

A New Hybrid ED/DMRG approach to find the thermodynamic properties of quantum many body

The study of low temperature properties of quantum many body has been challenging for frustrated and fermionic system away from

half-filling. In this work we have implemented a new numerical method based on of density matrix renormalization group method (DMRG) and exact diagonalization (ED) to handle thermodynamics of many body model systems. Exact diagonalization of small model systems gives the thermodynamics of spin chains or quantum cell models at high temperature T. DMRG calculations of progressively larger systems are used to obtain excitations up to a cutoff W_C and the low-T thermodynamics. We develop a hybrid approach to the magnetic susceptibility $\chi(T)$ and specific heat C(T) of spin-1/2 chains with isotropic exchange such as the linear Heisenberg antiferromagnet (HAF) and the frustrated J_1-J_2 model with ferromagnetic (F) $J_1<0$ and antiferromagnetic (AF) $J_2>0$. The hybrid approach is fully validated by comparison with HAF results. It extends J_1-J_2 thermodynamics down to $T\sim0.01|J1|$ for $J_2/|J_1|=\alpha={}^1/_4$ and is consistent with other methods. The criterion for the cutoff $W_C(N)$ in systems of N spins is discussed. The cutoff leads to bounds for the thermodynamic limit that are best satisfied at a specific T_N at system size N.

[on Phys. Rev. B **99**, 195144 (2019), S. K. Saha, D. Dey, M. Kumar, and Z. G. Soos]

Polar flock in the presence of random quenched rotators

Polar active systems have been studied extensively in the last two decades, as the natural systems like components of a school of fishes follow the same physics. However, recently scientists have started to look for the effect of various inhomogeneity agents, as inhomogeneities are inevitable in natural systems. It has been long known that two-dimensional polar active systems can have long-range ordering due to their non-equlibrium convective nature. We have shown that in the presence of quenched inhomogeneities, no long-range order, but a quasi-long range order can prevail in the system. This study is reported on the basis of our numerical results, which has been further augmented by the hydrodynamic theory. We have shown that introduction of quenched inhomogeneity enhances fluctuation in the system that eventually destroys the usual long range order of the system. However, these fluctuations do not destroy a quasi-long range order in the system.

[on Phys. Rev. E **98**, 060602 (R) (2018) by R. Das, M. Kumar, and S. Mishra]

Enhanced dynamics of active Brownian particles in periodic obstacle arrays and corrugated channels

We study the motion of an active Brownian particle (ABP) using the Langevin dynamics on a two-dimensional substrate with periodic of obstacles and in a quasi-one-dimensional corrugated channel comprised of periodically arrayed obstacles. The periodic arrangement of the obstacles enhances the persistent motion of the ABP in comparison to its motion in the free space. Persistent motion increases with the activity of the ABP. We note that the periodic arrangement induces directionality in ABP motion at late time , and it increases with the size of the obstacles. We also note that the ABP exhibits a super-diffusive dynamics in the corrugated channel. The transport property is independent of the shape of the channel; rather it depends on the packing fraction of the obstacles in the system. However, the ABP shows the usual diffusive dynamics in the quasi-one-dimensional channel with flat boundary.

[on Eur. Phys. J. E **42**, 62 (2019) by S. Pattanayak , R. Das, M. Kumar, and S. Mishra]

Melting of Ferromagnetic Order on a Trellis Ladder

Frustrated quantum spin systems have been a frontier area of research due to the existence of various exotic ground states. Among them J_1-J_2 zigzag ladder model with ferromagnetic J_1 and antiferromagnetic J_2 has been studied extensively. In this model the ground state exhibits ferromagnetic phase for $J_2\leq J_1/4$. We consider a 4-legged trellis ladder structure where two J_1-J_2 zigzag ladders interact with each other through an anti-ferromagnetic coupling J_3. We focus on the effect of inter-zigzag ladder coupling J_3 on the ferromagnetic phase in each zigzag ladder for $J_2\leq J_1/4$. The previous studies were focused to explain mainly the trellis lattice model where all J_1,J_2 and J_3 are antiferromagnetic in nature. In this paper, we focus on the trellis ladder model where J_1 is ferromagnetic. The anti-ferromagnetic rung interaction J_3 opens spin gap in the system and induces anti-parallel spin arrangement on two zigzag ladders w.r.t. each other, but spins on each zigzag ladder remain parallel to each other. The spin-spin correlation decays exponentially along each zigzag leg, where correlation length is smaller for higher J_2 for a given J_3. The correlation length decreases algebraically with increase in J_3 for a given J_2. Consequently spin gap increases with J_3

following power law . We show that for large value of J_3 dimers along rungs dominate the ground state.

[on J. Mag. Mag. Mat. **486**, 165266 (2019) by D. Maiti and M. Kumar]

Parity gap and topological degeneracy in one dimensional chain of systems

Search of Majorana fermion excitations in condensed matter systems has recently emerged as a very active field of research, although experimental uncertainties still remain. The topological (TS) phase of a cold Fermi gas is also expected to host edge modes, which in one dimension (1D) can manifest into Majorana zero energy modes (MZMs) with an associated exponential topological degeneracy. It has been proposed recently that a number-conserving 1D Fermi gas can exhibit such topological degeneracy in the presence of spin-orbit coupling (SOC), Zeeman field, and attractive on-site Hubbard interactions, upon application of an external parabolic potential that arises naturally in ultracold atom systems confined by a harmonic trap potential. We have used density matrix renormalization group (DMRG) numerical technique to explore the phases that emerge from the interplay of SOC and Zeeman field in such a trapped 1D Fermi gas. To verify the existence of any topological phase, and its robustness in this set-up, we have calculated the lowest excitation energy gap, pair binding energy, expectation values of local operators, and the effect of local perturbations in this system. We find that the apparent exponential degeneracy in the pair binding energy and spectral energy gaps notwithstanding, strictly speaking, the system cannot be used for topological computation due to susceptibility to local perturbations, and lack of local between the lowest lying states that are expected to be degenerate. However, in absence of impurities, the exponential decay of energy gaps in the regime of weakly attractive interactions, low electron density, moderate strengths of SOC and Zeeman field, are indicative of an underlying topological phase.

[on arXiv:1904.03660 [cond-mat-] by M. Singh. Roy, M. Kumar, J. D. Sau , and S. Tewari]

c) Proposed research activities for the coming year

1. Our group is actively working on the Quantum many body systems and modeling for electronic properties of materials. We are trying to develop algorithm of density matrix renormalisation group (DMRG) method for two dimensional systems. We will also extend our study of low temperature DMRG to fermionic systems as well as for molecular systems in near future.

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Supervision of Research / Students

a) Ph.D. Students

1. Arnab Singh and Gouranga Manna; SINP

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Prof. Milan Kumar Sanyal delivered an invited talk on "Formation and Ordering of Nanocrystals at a Liquid-liquid Interface" in the 15th International Conference (July 15-19, 2018) on Surface X-ray and Neutron Scattering (SXNS15) held in Pohang Accelerator Lab, South KOREA.
2. Prof. Milan Kumar Sanyal delivered a Plenary Talk on "Evolving Scattering and Imaging Techniques in High-brilliance Synchrotrons for Solid-State Physics" in the 63rd DAE Solid State Physics Symposium held in G.J. University of Science, Hisar, Haryana, December 18 – 22, 2018.
3. Prof. Milan Kumar Sanyal delivered Dr. A. S. Divatia Memorial Lecture on "Modern accelerators and their use in research and industry" in the 33rd GUJARAT SCIENCE CONGRESS (2nd and 3rd Feb 2019) in the LJ Institute Auditorium, Ahmedabad, Gujarat.
4. Prof. Milan Kumar Sanyal delivered an invited talk on "Two-dimensional magnetism" in the India-UK meeting on Neutron Scattering Collaboration (February 5 – 7, 2019) at JNCASR, Bangalore.
5. Prof. Milan Kumar Sanyal delivered an invited talk on "Two-dimensional magnetism – fascinating physics in flatland" in the conference Frontiers of Sciences (Past, Present & Future) - Physical Sciences, Chemical and Earth Sciences, Banaras Hindu University (BHU), March 8-9, 2019.

Conference / Symposia / Workshops / Seminars etc. organized

1. Prof. Milan Kumar Sanyal (with Dr. Thirupathaiah Setti) organized "Winter School on Synchrotron Techniques in Materials Science" from 25th to 31st October 2018. Around 20 prominent scientists from India and Germany, including scientists from INDUS synchrotron, RRCAT delivered talks on various topics. This school was attended by 90 PhD students coming from all over country including several students from well-known IITs and IISERs.

Significant research output / development during last one year

a) Interesting results obtained

During this first year of Raja Ramanna Fellowship at S. N. Bose National Centre for Basic Sciences, the activities of Prof. Milan K. Sanyal (MKS) in research are summarized below. The results presented here are primarily obtained with Synchrotron X-ray and neutron scattering studies of novel and emerging materials.

1. Structure and optical-property correlation in quantum structures:

   Epitaxially-grown, self-assembled, semiconductor quantum dots (QDs) have emerged as a zero-dimensional photonic material giving atom-like energy states, which can be tuned with size, composition and shape. MKS is studying molecular beam epitaxy (MBE) grown two types of QDs, namely Si-Ge grown in his group with MBE in Saha Institute of Nuclear Physics (SINP) and InGaAs grown in collaboration with University of Cambridge, UK. The understanding of the correlation between structural and photoluminescence (PL) properties of InGaAs QDs grown on (001) GaAs substrates is crucial for both fundamental research and optoelectronic device applications. It was reported for the first time [Dey, Sanyal et al, Scientific Reports 8, 7514 (2018)] that both structural and PL measurements can be measured from an uncapped layer of InGaAs QDs to correlate directly composition, strain and shape of QDs with the optical properties. Synchrotron X-ray scattering measurements show migration of In atoms from the apex

of QDs giving systematic reduction of height and enlargement of QDs base in the capping process.

[PhD thesis work of MKS's student Arka Bikash Dey at SINP]

2. Liquid interfaces and Langmuir Blodget films:

MKS and his collaborators have developed Indian beamline in Photon Factory, KEK, Japan and this facility is being used by several (more than 50) Indian Institutes as this beamline can be configured to carry out different types of experiments. Recently it has started working also for liquid-interface experiments [Maiti, Sanyal et al, Chemical Physics Letters 712, 177 (2018)]. Langmuir-Blodgett (LB) films having large stack of amphiphilic-fatty-acids bearing rare-earth-ions are ideal two-dimensional (2D) magnetic systems to study spin-vortex ordering as the distances of the magnetic-ions along the out-of-plane and in-plane directions differ by an order of magnitude. Systematic measurements of 2D magnetic properties of LB films of Holmium, Erbium and Gadolinium are being carried out now.

[PhD thesis work of MKS's student Santanu Maiti, Gouranga Manna and Arnab Singh at SINP]

3. Two-dimensional magnetism and skyrmion-lattice:

Atomically thin magnetic materials have generated renewed interest in 2D ordering of spins from a fundamental scientific point of view and for possible spintronic applications. MKS and his collaborators have carried out resonant coherent X-ray scattering measurements from a Fe/Gd thin-film heterostructure that exhibit highly tunable magnetic phases to understand the effect of topological order in skyrmion phase on the domain-fluctuations through statistical measurements of speckle patterns. A speckle pattern is a fingerprint, unique to the specific domain configuration illuminated by the X-ray beam - If the domain morphology changes either spontaneously or due to an external influence, then the speckle pattern will change as well. Nanoscale fluctuations and stochastic motion of the atomic and/or electronic constituents have profound impact on the emergence of functionality in complex materials. It was observed that different critical behaviour for avalanches in the stripe and skyrmion phases of the Fe/Gd heterostructure occur [A. Singh et al. Nature Communications 10, 1988 (2019)], suggesting existence of different universality classes [PhD thesis work of MKS's student Arnab Singh at SINP].

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Supervision of Research / Students

a) Ph.D. Students

1. Abhishek Bagchi; Photo Induced Microactuation; Under progress
2. Sarowar Hossain; Dynamic elastic properties of FSMA; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. P. Gokul (M.Tech Project); FSMA materials; Amrita Vishwavidya - peetham, TN
2. Ritwick Sarkar; PIMA effect investigation; Ramakrishna Mission Vivekananda University, Belur Math
3. Pronay Dutta; HiTc materials; Central University of Hyderabad
4. Ankit Kargetti; FSMA materials; Invertis University, Bareily

c) Post Doctoral Research Scientist/s

1. Alo Dutta; Ferroelectric material
2. S. Vinod Kumar; FSMA materials
3. S. Sarkar, Scientist-D, TRC

Teaching activities at the Centre

1. Spring PHY291; 200; 7 students; Shared with Prof. K. Mandal

Publications

a) In journals

1. Abhishek Bagchi, Suman Sarkar, Sandip Bysakh, Susenjit Sarkar and **P. K. Mukhopadhyay**, Possible mechanisms for degradation of Photo Induced Micro Actuation effect in a Ferromagnetic Shape Memory Alloy at high temperatures, J. Appl. Phys., 125, 144505, 2019.
2. Injamamul Arief and **P. K. Mukhopadhyay**, Magnetorheology in CoNi Nanoplatelet Based MRFs: Effect of Platelet Orientation and Oscillatory Shear, J. Magn. Magn. Mater, 479, 326, 2019.
3. Md. Sarowar Hossain, Tanmoy Ghosh, Bhoguju Rajini Kanth and **Pratip K. Mukhopadhyay**, Effect of Annealing on the Structural and Magnetic Properties of CoNiAl FSMA, Cryst. Res. Technol, 54, 1800153, 2019.
4. Tanmoy Ghosh, Takashi Fukuda, Tomoyuki Kakeshita, S.N. Kaul, **P. K. Mukhopadhyay**, Magnetic properties of disordered interacting electron system $FeAl_{2-x}Ga_x$ ($0 = x = 0.5$): Origin of local moment behaviour and the stabilization of an antiferromagnetic phase by weak interplanar magnetic interaction, J. Alloy. Compd, 782, 915,2019.
5. Md Sarowar Hossain, Barnana Pal and **P. K. Mukhopadhyay**, Ultrasonic Characterization of Newtonian and Non-newtonian Fluids, Universal Journal of Physics and Application, 12(3), 41, 2018.
6. S. Vinodh Kumar, M. Mahendran, M. Manivel Raja, V.L. Niranjani and **P. K. Mukhopadhyay**, Phase structure evolution on Ni-Mn-Ga/Si (100) thin films: Effect of substrate temperature, Intermetallics, 101, 18, 2018.

b) Other Publications (including conferences)

1. Abhishek Bagchi, Suman Sarkar, Susenjit Sarkar, P. K. Mukhopadhyay: "Effect of Temperature On The Photo Induced Microactuation Property of FSMA", Oral Presentation at Condensed Matter Days – 2018 organized by University of Burdwan held in Burdwan, India.
2. Gurdeep Singh, Susmita Dey, Suman Sarkar and P. K. Mukhopadhyay, "Electrostatic micro actuation system to study Electrostatic Force and Young modulus of the pure metals and alloys", Oral Presentation at Condensed Matter Days – 2018 organized by University of Burdwan held in Burdwan, India.

3. Md. Sarowar Hossain, S. Vinodh Kumar, Barnana Pal and P.K. Mukhopadhyay, "Elastic Moduli of Ni-Fe-Al Ferromagnetic Shape Memory Alloy Studied by Resonant Ultrasound Spectroscopy", Oral Presentation at Condensed Matter Days – 2018 organized by University of Burdwan held in Burdwan, India.
4. Abhishek Bagchi, Suman Sarkar, Sandip Bysakh, Susenjit Sarkar, P. K. Mukhopadhyay: "Microstructural Evolution And Ferromagnetic Shape Memory Response In Rapidly Solidified Co-Ni-Al Alloys", Digital Poster Presentation at NMD – ATM 2018 organized by Indian Institute of Metals and Tata Steel Ltd. Under the aegis of Ministry of Steel, Govt. of India held in Kolkata, India.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Discovery of a new photoinduced microactuation phenomenon in S. N. Bose centre; 28/08/2018; CMDays 2018, Burdwan University; 28-30/8/2018.

Membership of Committees

a) Internal Committee

1. Internal (chairman and convener) and External (convener) Technical committees, Project and patent cell member, till September 2018

Fellow / Member of Professional Body

APS, Life member of IPS, Life member of ISCongress

Sponsored Projects

1. Technical Research Centre; DST; Till Dec 2020; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Young Physicists Colloquium, as an organizing committee member; Aug. 23 -24, 2018; SINP; 2 days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Dr. Sandip Bysakh; Sl. No. 1; National
2. Dr. Susenjit Sarkar; Sl. No. 1; National
3. Dr. Tanmoy Ghosh; Sl. No. 4; National
4. Dr. B. Rajini Kanth; Sl. No. 3; National
5. Prof. Takashi Fukuda; Sl. No. 4; International
6. Prof. Tomoyuki Kakeshita; Sl. No. 4; International
7. Prof. S.N. Kaul; Sl. No. 4; National
8. Dr. Injamamul Arief; Sl. No. 2; International
9. Prof. Barnana Pal; Sl. No. 5; International
10. Dr. M. Mahendran; Sl. No. 6; National
11. Dr. M. Manivel Raja; Sl. No. 6; National
12. Dr. V. I. Norjami; Sl. No. 6; National

Participation in Science Outreach program

1. 125 years birth anniversary of Prof. S. N. Bose, popular lecture given in the Burdwan University, 28/8/2018

Significant research output / development during last one year

a) General research areas and problems worked on

The field of work was mainly on smart materials, solid and fluid. The ferromagnetic alloys were studied with conventional techniques as well as by dynamic elastic moduli. One Magnetorheological fluid work was completed and published. The interesting case of FeAl based system was studied through theoretical modelling and the data we obtained were explained using the modelling. Various techniques were used to understand and use the PIMA effect that we discovered. Finally, the smart fluid body armour were tested in Kolkata Police for effectiveness in protection.

b) Interesting results obtained

In this year, the main thrust of work was on the Ferro Magnetic Shape Memory Alloys (FSMA). While one student was working on dynamic elastic properties of FSMA materials, the other student was busy studying the Photo Induced Micro Actuation (PIMA) property measurements on these. One of these measurements was a very careful TEM studies on the actual atomic mapping to find how this PIMA property was getting destroyed due to corrosion and temperature effect. The main finding was that at higher temperatures, there was an atomic migration of Co species, breaking loose the underlying CoNiAl half Heusler structure. In presence of air, oxygen atoms diffused in the solid and pinned these migrating atoms, thereby stopping them from rejoining the half Heusler structure. The PIMA effect is so far found to be restricted to the FSMA class of materials only, so this action of oxygen atoms blocked the effect from occurring any further. Apart from that, the student had designed Arduino based robotic arm movements which were controlled solely by light in the gripper or end effector area. This is an effort that's first time in the world.

The TRC project is another aspect in this discovery. Atherosclerosis, especially Myocardial infarction is a

leading cause of death in humans, all over the world. There are various procedures to deal with this condition, starting from medication in the first stage to Angioplasty, Bypass surgery and finally Endarterectomy. In the last case, the plaque material is surgically removed and taken out. In contrast to conventional machines, we are trying to use our discovered PIMA effect to make it smaller, cheaper and a better viable alternative. In short, the microshovel will be attached to the tip of the catheter that will be inserted by the doctor in the body through the arteries, and on reaching the spot, will scrap out the material under light control. No more mechanical intervention is required. The problem of designing such a system for the first time in the world is time taking, and a lot of obstacles had to be overcome one by one.

In the regular work with FSMA materials, we have installed a new mini rf induction furnace and melt spinner. We made various metallic glass ribbons with these and sound velocity and other properties are under study.

Finally we are working on the smart fluid derived body armour for the use by peacekeeping personnel. Here the idea is to prepare a fluid that will remain fluidic in ordinary mechanical stresses, but will turn solid like when touched by a fast projectile and offer resistance to this object. After the passage of the bullet, it will turn to fluidic again. All these must occur in no more than a few microsecond scale. This way it will be better for the wearer, being lighter and flexible, as compared to the conventional steel or ceramic materials. The main project was sanctioned by DRDO and was for use of military people. Here, in the present case, it is being tried for use by Kolkata Police. We already had conducted a few rounds of tests with their revolvers and further trials will be started shortly.

Fig. 1. Laser induced actuation of an FSMA met glass ribbon

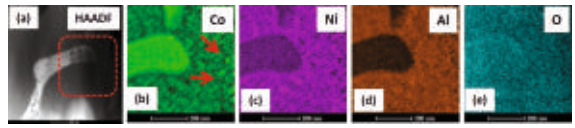

Fig. 2. Effect of environmental corrosion on an FSMA system w.r.t. the PIMA effect. A microscopic study

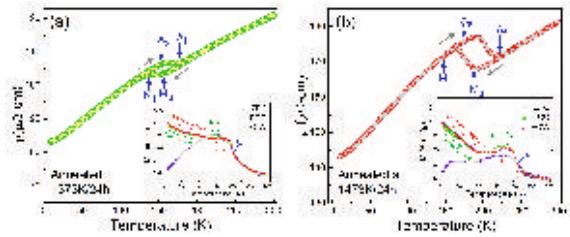

Fig. 3. Effect of annealing heat treatment on an FSMA system

c) Proposed research activities for the coming year

The plan is to develop TRC compatible research, products that are geared towards market. As such one of our targets is for healthcare, the other for micro engineering, still another for use by police personnel. Along with, some more ideas are being tried, but it is too early to talk about these at present.

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Supervision of Research / Students

a) Ph.D. Students

1. Shishir Kumar Pandey; Models for magnetism; Awarded
2. Sagar Sarkar; Understanding structural distortions in perovskites; Awarded
3. Sowmyadipta Pal; Understanding martensitic transitions in Heusler alloys; Thesis submitted
4. Poonam Kumari; Role of spin-orbit interactions on the physical properties; Under progress
5. Joydeep Chatterjee; Electronic structure of low-dimensional semiconductors; Under progress
6. Sumanti Patra; Excited state properties of nanoplatelets; Under progress
7. Prasun Boyal; Topological properties of transition metal dichalcogenides; Under progress
8. Debayan Mondal; Structure and properties of hybrid perovskites; Under progress
9. Shivam Mishra; Growth of semiconductor nanoplatelets; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. K.P. Aathira; Band unfolding of supercell band structure; Shree Keralavarma College, Trissur
2. Surender Kumar; Models for magnetism; Central University of Haryana

c) Post Doctoral Research Scientist/s

1. Deepika Srivastava; Electronic structure of materials

Teaching activities at the Centre

1. Spring semester; Physics of Materials/Advanced Condensed Matter 1; PhD; 20 students; with 1 (Ranjan Chaudhuri,) co-teacher

Publications

a) In journals

1. Shyamashis Das, Somnath Ghara, **Priya Mahadevan**, A Sundaresan, J Gopalakrishnan and DD Sarma, Designing a Lower Band Gap Bulk Ferroelectric Material with a Sizable Polarization at Room Temperature, ACS Energy Lett. 3, 1176 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Seminar at Physics Department, IIT Indore; Jun 1, 2018; IIT Indore; Jun 1st
2. Invited talk at NAWCMP 2018; Aug 4, 2018; Viswabharathi University; Aug 3-4
3. Invited talk at Winter School on synchrotron techniques; Oct 25, 2018; S.N.Bose centre; Oct 25-26
4. Invited talk at Asian electronic structure workshop, Daejeon; Oct 29, 2018; KAIST Oct 29-31
5. Invited talk at ICMAGMA 2019; Dec 9, 2018; NISER; Dec 9
6. Invited talk at ICEE-2018; Dec 17, 2018; Bengaluru; Dec 17-19
7. Invited talk at Indo-Japan meeting; Feb 2, 2019; University of Tokyo; Jan 31-Feb 2
8. Invited talk at MRSI Materials Conclave; Feb 13, 2019; IISc; Feb 12-14

Membership of Committees

a) Internal Committee

1. Associate Dean (Academic Programme); Chairperson Computer Services Advisory Cell

Fellow / Member of Professional Body

1. Fellow of Indian Academy of Sciences

Sponsored Projects

1. Electronic, structural and optical properties of semiconductor nanoplatelets; DST-Nanomission; 2019-2021; PI
2. Novel Phenomena in Emergent Materials; DST-JSPS; 2019-2021; PI
3. Materials for sustainable Energy and Electronics: Linking Communities at Duke and in India; Duke University; 2017-2018; Co-PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Novel Phenomena in Emergent Materials; Jan 31, 2019; University of Tokyo; Jan 31-Feb 2

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Designing ferroelectric oxides for photovoltaic applications by co-doping; Oct 29-31; National

Participation in Science Outreach program

1. DST Vigyan joshi camp at IIT Indore, June 2018.

Significant research output / development during last one year

a) General research areas and problems worked on

Electronic and structural properties of materials; models for magnetism; models for ferroelectricity

b) Interesting results obtained

A key focus of the group during this period has been the study of layered semiconductors, with the focus on transition metal dichalcogenides. The recent exfoliation of graphene has led to the interest in this class of materials as well as an entire new class of heterostructures realizeable by stacking one layer on another. These layers do not have perfect registry, but instead result in one layer being rotated with respect to the other, leading to properties entirely different from the perfectly stacked materials. In a recent work we have examined the electronic structure of MoSe2. While a single layer has a spin splitting of the valence band maximum at the K symmetry point, as a result of spin-orbit interactions, the bilayer has no spin splitting when we consider the 2H stacking. This has been attributed to the presence of inversion symmetry in the structure. The question we asked was if the slightest rotation from the point that we had inversion symmetry would lead to the spin splitting being restored. Contrary to what was speculated earlier, the spin splitting of the valence band maximum did not emerge for the slightest angle of rotation from the configuration where we had inversion symmetry. It was observed that for certain angles of rotation, which were otherwise arbitrary, there is a net spin-splitting of the valence band maximum K whereas for other angles this net spin-splitting vanishes. Our results suggest that there is an alternate mechanism at work which can lead to a vanishing spin splitting at arbitrary angles of rotation. This is operational even when there is no inversion symmetry in the lattice, indicating a distinct origin. Additionally we find that for every angle of rotation theta that we find a spin splitting, there is no spin splitting for 60-theta. As the choice of rotation angles was arbitrary, this relation emerges from the hexagonal symmetry of the lattice. This mechanism is general and should be valid for other transition metal dichalcogenides also.

c) Proposed research activities for the coming year

1. We are examining the electronic structure of twisted bilayers of MoSe2 in instances where the Moire cells are large. Additionally we are examining the role of strain in driving the valence band maximum in twisted MoS2 bilayers to the K point. We are also examining the role of interlayer coupling in determining the properties of these materials with thickness and setting up a microscopic model. Strain has been found to play a role in stabilizing unusual phases. We explore this in the context of monolayers of Bi and show how a quantum spin hall insulator can be realized. The electronic properties of the edge states of the quantum spin hall insulators will also be investigated.

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Publications

a) In journals

1. P. Singha Deo and U. Satpathi, Transmitting a signal in negative time, Results in Physics, 12, 1506 (2019).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Special session talk on "non-ergodic systems" in Physicists congress Japan in May 2018, Tokyo, Japan; May 12, 2018; Tokyo, Japan; 45 minutes

Significant research output / development during last one year

a) General research areas and problems worked on

Mesoscopic physics, Foundations of quantum mechanics

b) Interesting results obtained

We have shown that one can transmit a signal in negative time. That is the signal can be sent to the past violating special theory of relativity in the quantum regime of single particle coherence length. We have shown using electron waves. It also suggests that one can have a bound state of two electrons in the process.

c) Proposed research activities for the coming year

1. There are many aspects of Aharonov-Bohm effect in quantum rings that are still not understood. In the wake of a few recent experiments it is possible to address these issues afresh. That is our future plan.

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Supervision of Research / Students

a) Ph.D. Students

1. Soumi Roy Chowdhury; Superconducting Pairing Mechanism in Low Dimensional Materials; Thesis submitted
2. Suraka Bhattacharjee; Generalized Stiffness constants and Spin and Charge Correlations in Strongly Correlated doped Quantum Anti-ferromagnets in low dimensions; Under progress
3. Koushik Mandal; Superconducting pairing in Correlated Fermionic systems; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Sayan Routh (I-PhD Project Student); Landau Diamagnetism and its application in Condensed Matter Systems; S.N. Bose Centre, Kolkata
2. Karabi Chatterjee (M.Sc. Project Student); Study Of Cooper Pairing Mechanism Using One & Two Square Well Potential Models & Isotope Exponent From The BCS Theory; Diamond Harbour Women's University, Kolkata
3. S. Devi Bala Saraswathi (M.Sc. Summer Student under VASP/EVLP); Theoretical Studies on Quantum Spin Modeling of DNA--- Consequences of Asymmetric Inter-strand Coupling; The Gandhigram Rural Institute , Gandhigram, Tamil Nadu

Teaching activities at the Centre

1. 4th; Physics of Materials; IPhD; 5 students; with Prof. P. Mahadevan
2. 2nd; Advanced Cond. Mat. Physics I; PMSC_PhD; 14 students; with Prof. P. Mahadevan

Publications

a) In journals

1. Suraka Bhattacharjee and **Ranjan Chaudhury**, Effective Interaction in a Non-Fermi Liquid Conductor and Spin Correlations in Under-Doped Cuprates, Journal of Low Temperature Physics, 193, 21-38, 2018.
2. Soumi Roy Chowdhury and **Ranjan Chaudhury**, Theoretical Investigation of the feasibility of Electronic Mechanism for Superconducting Pairing in overdoped Cuprates, Journal of Low Temperature Physics, 196, 335-346, 2019.

Membership of Committees

a) Internal committee

1. Acted as the Chairperson of the Asset Verification Committee
2. Acted as the Chairperson of the Committee for Consideration of Outsourcing of the Contractual Administrative Staff/positions
3. Worked as a Committee Member of the VASP/EVLP
4. Worked as a Member of the Bose Archive Committee

Fellow / Member of Professional Body

1. Continued as a Member of the Physical Chemistry Division of the American Chemical Society (USA)
2. Continued as an Active Member of Physics Unit of Athens Institute For Education And Research (ATINER), Athens (Greece)

Participation in Science Outreach program

Taught at RKMVERI (Belur) 2 Condensed Matter Physics courses viz. (i) 'Basic' during July- November 2018 and (ii) 'Advanced' during January-May 2019, for the M.Sc. Physics students.

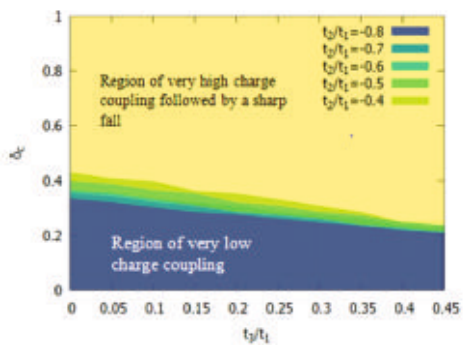
Significant research output / development during last one year

a) General research areas and problems worked on

(i) Theoretical condensed matter physics and (ii) Quantum biology

b) Interesting results obtained

(i) Generalized charge stiffness constant was determined for the strongly correlated doped quantum antiferromagnets in both 1D and 2D. Various types of extended t-J-like models were considered for the calculations corresponding to the under-doped, optimally-doped and over-doped regimes. The equivalence between charge stiffness and effective Coulomb interaction was established for both strongly correlated as well as weakly correlated situations with both lattice version and continuum case. The occurrence of 'quantum screening' in the effective interaction between the mobile holes, was studied throughly as a function of doping concentration. Our theoretical results exhibit a sharp peak followed by a sharp fall for the stiffness constant in the vicinity of the optimal doping concentration, signalling a possible tendency for the charge density wave ordering in the cross-over regime between the strongly correlated to the weakly correlated phase. Besides, the existence of repulsive effective interaction between the mobile holes for all doping concentration, almost rules out the possibility of conventional momentum-space based Cooper pairing for generating superconductivity from the pure t-J-like models for 2D or quasi-2D systems. The theoretical results are consistent with the experimental properties extracted from the optical measurements on the normal phases of the cuprate superconductors, particularly in the underdoped phases.



Phase diagram showing the critical doping concentration separating the regions of different charge couplings, corresponding to t_3/t_1, with t_2/t_1 ratio as the parameter. The regions of doping concentration below δc represent the regimes of very low charge couplings and above δc, the interactions shows a very high value, followed by a sharp fall. The different colours are used for different ratios of t_2/t_1 [α=1 has been considered]

(ii) A theoretical methodology for exploring the conventional Bardeen-Cooper-Schrieffer (BCS) pairing instability for superconductivity from a correlated normal phase for all possible degrees of many-body correlation, was initiated. The Gutzwiller projection scheme with a correlation parameter was applied for generating the normal phase and subsequently the BCS pairing state was constructed from this. A variational scheme was thereafter implemented, leading to a self-consistent equation for superconducting gap function. This equation shows explicit dependence of the gap function on the many-body correlation parameter as well as on the electronic band filling factor. Detailed consequences are being worked out.

(iii) A realistic mathematical formulation was set up for a possible and consistent unification of Pauli Paramagnetism, Landau Diamagnetism and De Hass Van Alphen Effect.

(iv) A theoretical investigation of Cooper's one pair problem, extended to the situations with both one and two square well potential models was done quite extensively for the pairing energy. The corresponding expressions for the isotope exponents were determined with the help of the BCS theory for many pairs and were applied to various real superconductors.

(v) An asymmetry in base-pair coupling was introduced in the quantum spin modeling for DNA, keeping in mind the realistic situations. Detailed numerical calculations bring out interesting structures in the Degeneracy versus Energy plot for all the Watson-Crick ordered configurations as well as the corresponding mutated states. The consequences for mutation and compensation rates have been analyzed.

(vi) Finalization of the calculations for the investigation of the role of the inter-layer pair hopping in generation of superconducting gap anisotropy, was completed.

c) Proposed research activities for the coming year

(i) Investigation of several aspects of itinerant magnetism, in particular the spin dynamics. Besides, its consequences for various other related phenomena

involving many-body physics would also be probed.

(ii) Detailed investigation of the asymmetry of the inter-strand coupling in various molecular bio-physical processes.

(iii) To continue probing of the effects of normal phase correlation and inter-layer couplings in superconducting pairing.

(iv) To initiate a project on environment related issues.

Any other matter

1. The manuscript of a book entitled "Gateway to Condensed Matter Physics and Related Interdisciplinary Problems" authored by me, has ben submitted to the Apple Academic Press. It is undergoing various formalities.
2. Received an invitation from ATINER for delivering a talk entitled "Superconducting pairing mechanism, magnetism and change stiffness in low dimensional conductors - implications for novel superconductors " in the International Conference on Physics to be held at Athens (Greece) in July 2019.
3. My research on superconductivity would be beneficial for exploring materials of both conventional type as well as non-conventional type towards achieving dissipationless electrical transport at temperatures in the vicinity of room temperature, which would revolutionize technology.
4. My research on quantum biology is expected to throw more light on the energetics and the possible internal dynamics of the bio-molecules, leading to better understanding of the propagation of the mutational damages and their repairs.
5. My academic position at RKMVERI (Belur) became Professor (Full) since 01.01.2019.

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Supervision of Research / Students

a) Ph.D. Students

1. Didhiti Bhattacharya; Colloidal 2D nanocrystals for optical and photo-catalytic applications; Under progress
2. Subhrasish Mukherjee; An investigation of electronic and optical properties of 2D semiconductors and their heterostructures; Under progress

b) Post Doctoral Research Scientist/s

1. Arka Dey; Photovoltaic devices

Publications

a) In journals

1. R K Chowdhury, S. Nandy, S. Bhattacharya, M. Karmakar, S.N B Bhaktha, P.K Datta, A. Taraphder, **S. K Ray**, Ultrafast time-resolved investigations of excitons and biexcitons at room temperature in layered WS_2, 2D Materials, 6, 015011 (2018).
2. S. Mukherjee, K. Das, S. Das and **S. K. Ray**, Highly Responsive, Polarization Sensitive, Self-biased Single GeO_2-Ge Nanowire Device for Broadband and Low Power Photodetectors, ACS Photonics, 5, 4170-4178 (2018).
3. T. Dey, S. Mukherjee, A. Ghorai, S. Das, **S. K. Ray**, Surface state selective tunable emission of graphene quantum dots exhibiting novel thermal quenching characteristics, Carbon, vol. 140, pp. 394-403 (2018).
4. S. Pal, S. Bayan and **S. K. Ray**, Piezo-phototronic mediated enhanced photodetection characteristics of plasmonic Au-g-C_3N_4/CdS/ZnO based hybrid heterojunctions on a flexible platform, Nanoscale, 10, 19203 (2018).
5. S. Mukherjee, S. Biswas, A. Ghorai, A. Midya, S. Das, and **S. K. Ray**, Tunable Optical and Electrical Transport Properties of Size and Temperature Controlled Polymorph MoS_2 Nanocrystals, J. Phys. Chem. C, 122, 12502-12511 (2018).
6. S. Hassan, S. Bera, D. Gupta, **S. K. Ray**, and S.Sapra, $MoSe_2$-Cu_2S Vertical p-n Nanoheterostructures for High-Performance Photodetectors, ACS Appl. Materials & Interfaces, 11, pp. 4074-4083, (2019).
7. A. Sarkar, A. K Katiyar, A. K. Das, **S. K Ray**, Si membrane–ZnO heterojunction-based broad band visible light emitting diode for flexible optoelectronic devices, Flexible and Printed Electronics, 3, 025004 (2018).
8. A. Sarkar, A. K.Katiyar, S. Mukherjee, S. Singh, S. K Singh, A. K. Das, and **S. K. Ray**, Geometry Controlled White Light Emission and Extraction in CdS/ Black-Si Conical Heterojunctions, ACS Appl. Electron. Mater., 1, 25, (2019).
9. A. Ghorai, **S. K. Ray**, and A. Midya, Ethylenediamine-Assisted High Yield Exfoliation of MoS_2 for Flexible Solid-State Supercapacitor Application, ACS Appl. Nano Mater., 2, 1170 (2019).
10. P. Guha, A.Ghosh, A. Sarkar, S. Mandal, **S. K Ray**, D.K Goswami and P. V Satyam, P-type ß-MoO_2 nanostructures on n-Si by hydrogenation process: synthesis and application towards self-biased UV-visible photodetection, Nanotechnology 30, 035204 (2019).
11. P. Chakrabarty, N Gogurla, N.Bhandaru, **S.K Ray** and R. Mukherjee, Enhanced Performance of Hybrid Self-biased Heterojunction Photodetector on Soft-lithographically Patterned Organic Platform, Nanotechnology 29, 505301 (2018).
12. P. Das, S. Mukherjee, M. Wan, **S. K Ray** and S. Bhaktha, Optical Tamm state aided room – temperature amplified spontaneous emission from carbon quantum dots embedded one-dimensional photonic crystals, J. Phys. D., 52, 035102 (2019).
13. S. Dey, S. Santra, **S. K. Ray**, and P. K. Guha, Coral-Like CuxNi(1-

x)O-Based Resistive Sensor for Humidity and VOC Detection, IEEE Sensors Journal, Vol. 18, pp. 6078-6084, (2018).

14. S. Dey, S. Santra, S. Sen, D. Burman, **S. K. Ray** and P. K. Guha, Photon-Assisted Ultra-Selective Formaldehyde Sensing by Defect Induced NiO-Based Resistive Sensor, IEEE Sensors Journal, Vol. 18, pp. 5656 – 5661 (2018).

b) Other Publications (including conferences)

1. P Chakrabarty, M Banik, S Santra, N Gogurla, S K Ray, R Mukherjee. "Colloidal particle assisted fabrication of self-cleaning ordered ZnO nanostructures for enhanced room temperature gas sensing by light trapping mechanism", ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY 256, 2018,
2. Arijit Sarkar, Ajit K. Katiyar, Amal K Das and Samit K. Ray, "Broad band LED and Piezo-phototronic Enhanced Photodetector on CMOS Compatible Flexible Si Platforms", MRS Fall Meeting 2018, Boston, Massachusetts, USA, 2018
3. A. Ghorai, A. Midya and S. K. Ray, "Growth of WS2 Nanocrystals and Nanosheets by a New Lithium Intercalation Method for Multifunctional Device Application", MRS Fall Meeting & Exhibit -2018, Boston, Massachusetts, USA, November 25 – November 30, 2018
4. S. Singh, A.K Katiyar, A. Ghorai, A, Midya, D.K. Goswami and S.K. Ray, "Green route synthesized copper zinc tin sulphide nanocrystals for heterojunction solar cells on silicon platforms", MRS Fall Meeting & Exhibit, Boston, US, 2018.
5. Tamal Dey, Subhrajit Mukherjee, Arup Ghorai, Soumen Das, Samit K. Ray, "Surface Functional Group Dependent Photoluminescence Emission and Anomalous Quenching Behavior Observed in Graphene Quantum Dots", MRS Fall Meeting & Exhibit -2018, Boston, Massachusetts, USA, November 25 – November 30, 2018
6. Sourabh Pal, Sayan Bayan, Samit K. Ray "Enhanced photodetection of Au-g-C3N4 /CdS/ZnO based flexible heterojunction device utilizing piezo-phototronic effect", MRS Fall 2018, Boston, November 25-30, 2018

Lectures Delivered

1. 2D/Si Heterostructures for Photonic Devices, Intl. Conference : Condensed Matter & Materials Physics; Aug 16, 2018; London
2. Low Dimensional Structures: From Materials to Devices, Recent Advances in Condensed Matter Physics: Theory and Experiment" (NAWCMP – 2018); Date: August 3, 2018; Visva-Bharati, Santiniketan; Aug 3, 2018; Viswa Bharati University
3. Photonic Devices using Nanoparticles Embedded 2D Layers, International Conference on Fiber Optics and Photonics (Photonic 2018); Dec 14, 2018; IIT Delhi
4. Silicon based Nanophotonic Devices, Recent Developments in Nanoscience & Nanotechnology;Jan 29, 2019; Jadavpur University
5. Si / Ge Nanowires for Photonic Devices, 1st Indian Materials Conclave; Feb 14, 2019; IISc Bangalore

Academic Visits

a) International

1. Exchange Visit; Editorial Board Meeting of Nanotechnology, IOP Publishing, UK at London during the period 12th - 14th August, 2018

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. IIT Kharagpur; Sl. No. 1-5, 7-9, 11-14; National
2. IIT Delhi; Sl. No. 6; National
3. IOP, Bhubaneswar; Sl. No. 10; National

Participation in Science Outreach program

1. BOSE-125 Outreach lecture - Nanotechnology for Quantum Devices, Ramakrishna Mission Vivekananda Centenary College, 7th April, 2018
2. C.K. Majumdar Memorial Summer Workshop, Surfaces, Interfaces & Thin Films , S. N. Bose national Centre for Basic Sciences, 29th May, 2018
3. BOSE-125 Outreach Lecture - Hybrid Semiconductor Nanostructures for Photonic Devices, Kazi Nazrul University, Asansol, 21st June, 2018
4. BOSE-125 Outreach Lecture - Science, Society and Acharya Satyendra Nath Bose, National Library, Kolkata, 24th July, 2018
5. BOSE-125 Outreach Lecture - Life and Works of Satyendra Nath Bose, Prabhat Kumar College, Contai, October 1st, 2018
6. Winter School on Synchrotron Techniques in Material Research - Thin Film Heterostructures : Strain and Bandgap Engineering in Materials, S. N. Bose National Centre for Basic Sciences, 29th October, 2018

7. BOSE-125 Outreach Lecture - Life and Works of Satyendra Nath Bose, North Eastern Hill University, Shillong, 20th November, 2018
8. Semiconductor Quantum Structures for Photonic Devices - Recent developments in Physics: Theory and Experiment for College Teachers at Jadavpur University, 26th November, 2018
9. BOSE-125 Outreach Lecture - Quantum Physics to Quantum Technology, Hindu School, Kolkata, 11th December, 2018

Significant research output / development during last one year

a) General research areas and problems worked on

Semiconductor quantum structures, 2D materials, Nanodevices, Optoelectronics, Surface Physics

b) Interesting results obtained

a) Excitons & Bi-excitons in layered WS, dispersion:

The optical properties of TMDs are dominated mostly by the tightly bound excitons and more complex quasiparticles, the biexcitons. We explored the ultrafast excitonic phenomena in layered WS2 (mono-to-quad) dispersion using broadband (350–750 nm) femtosecond pump-probe spectroscopy at room temperature (300 K) which are inaccessible to the steady-state absorption or emission spectroscopy. The transient absorption spectra (TAS) suggest that the mono-to-quad layered dispersion of WS2 has similar spectral features as monolayer WS2 in terms of saturation absorptions (SA) and excited state absorptions (ESA). Similar to monolayer TMDs, we are able to identify excitons and biexcitons in multi-layered 2D stratum of WS2 as well as calculate the biexciton binding energies (?AA ~69 meV and ?BB ~66 meV), which are in excellent agreement with earlier theoretical predictions. Furthermore, using many-body physics, we demonstrated that the excitons in layered WS2 behave like Wannier–Mott excitons and explain their origins via first-principles calculations. Our detailed time resolved investigation has provided ultrafast radiative and non-radiative lifetimes of the excitons and biexcitons in layered WS2. Indeed, our results have unraveled the complex optical response of layered TMDs, which could lead to numerous technological applications for developing excitonic quasiparticle based valleytronic devices and ultrafast biexciton lasers at room temperature.

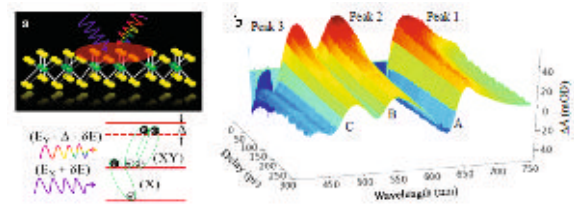

Figure 1 (a) Schematic representation of the formation of biexcitons in layered WS2 using two-step pump (EX + dE) - probe (EY - ? - dE) excitation process. Here excitons and biexcitons are defined as X and XY respectively. (b) Shows the contour map of TA signal for 405 nm, 3 mW pump excitation. Three saturation absorption valleys appear at the positions of steady state excitons (A, B and C), whereas three distinguish pump induced absorption peaks (peak 1, peak 2 and peak 3) appear in the contour map.

b) Polarization Sensitive, Self-Biased Single GeO2 Ge Nanowire Photodetectors

Highly uniform and dense GeO2 nanowires with Ge as the core were grown on Si (001) substrates by vapor-liquid-solid technique with an aim to utilize GeO2 as the active material for photodetectors. X-ray photoelectron spectroscopy was carried out to investigate the composition and interfaces of the resultant Ge/ GeO2 NWs. The observed broad and visible photoluminescence emission from as-grown core-shell NW heterostructure is attributed to oxygen-related defect states in the GeO2 shells. Single Ge-GeO2 NW based metal-semiconductor-metal photodetectors were fabricated using nanolithography techniques. Self-driven (zero bias) detectors have been found to be responsive to a broadband spectrum from 350 to 900 nm with a peak responsivity (~0.6 × 104 A/W) and detectivity (~3.8 × 1012 Jones). The high gain in photocurrent has been explained using a back-to-back metal-semiconductor junction model in single NW. The device also shows sensitivity to polarization dependence of light source. Finite element method (FEM) based optical simulation has been used to explain high and polarization dependent photoresponse of the single GeO_2-Ge NW device.

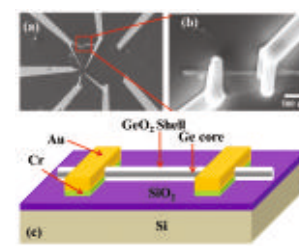

Figure 2: FESEM image of a single nanowire device with (a) lower and (b) higher magnifications. (c) Schematic device diagram on SiO_2 coated Si substrates

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Supervision of Research / Students

a) Ph.D. Students

1. Indrani Kar; Transition metal dichalcogenides; Under progress
2. Susmita Changdar; Topological semimetals; Under progress
3. Achintya Low; Quantum Spin Liquids; Under progress
4. Sayan Routh; Topological Superconductors; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Shubham Purwar; Electronic structure studies of 2D systems using tight-binding method; SNBNCBS
2. Samir Rom; Electronic structure studies of graphene using tight-binding method; SNBNCBS

Teaching activities at the Centre

1. Autumn semester; Lab course (XRD instrument); Integrated PhD; 7 students; with 5 co-teachers
2. Spring semester; Advanced Condensed Matter Physics-PHY601; PhD; 16 students; with 1 (Dr. Athindranath Pal,) co-teacher

Publications

a) In journals

1. **S. Thirupathaiah**, D. Efremov, Y. Kushnirenko, E. Haubold, T. K. Kim, B. R. Pienning, I. Morozov, S. Aswartham, B. Büchner, S. V. Borisenko, Absence of Dirac fermions in layered $BaZnBi_2$, Phys. Rev. Materials 3, 024202 (2019).
2. **S. Thirupathaiah**, I. Morozov, Y. Kushnirenko, A. V. Fedorov, E. Haubold, T. K. Kim, G. Shipunov, A. Maksutova, O. Kataeva, S. Aswartham, B. Büchner, S. V. Borisenko, Spectroscopic evidence of topological phase transition in the three-dimensional Dirac semimetal $Cd_3(As_{1-x}P_x)2$, Phys. Rev. B 98, 085145 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Winter School on Synchrotron Techniques in Materials Science; Oct 27, 2018; SNBNCBS; 25-31/10/2018
2. Young Investigator Meet on Quantum Condensed Matter Theory; Nov 21, 2018; SNBNCBS; 20-22/11/2018
3. National Conference on Electronic Structure; Dec 18, 2018; SRM IST, Kattankulathur, Tamil Nadu; 17-19/12/2018
4. Advances in Electron Spectroscopy - Experiment and Theory; Apr 15, 2019; Max Planck Institute for Chemical Physics of Solids, Germany; 14-17/04/2019

Fellow / Member of Professional Body

1. American Physical Society (APS)

Sponsored Projects

1. Inspire Faculty Fellowship; DST; 5 years; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Winter School on Synchrotron Techniques in Materials Science; Oct 25, 2018; SNBNCBS; 25-31/10/2018

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. IFW Dresden, Germany; Sl. No. 1 and 2; International

Participation in Science Outreach program

1. Outreach program on the occasion 125th year celebrations of S. N. Bose birth anniversary at IIT Mandi on 12th May, 2018.
2. Outreach program on the occasion 125th year celebrations of S. N. Bose birth anniversary at GITAM University 20th Dec., 2018.

Significant research output / development during last one year

a) General research areas and problems worked on

Experimental condensed matter physics, Electronic structure studies of Weyl and Dirac Semimetals

b) Interesting results obtained

A. Topological phase transition in 3D Dirac semimetal $Cd_3(As_{1-x}P_x)2$

In so far reported 3D Dirac semimetals, Na3Bi and Cd3As2, multiple Dirac nodes near the Fermi level have been observed. Recently, a topological phase transition has been theoretically proposed in these compounds using the DFT+CPA calculations with an isovalent substitution at the cite of Bi or As by Sb or P, respectively, leading to a phase transition from the semimetalic to the semiconducting in nature with a subsequent loss of the band inversion. Thus, the system undergoes a topological phase transition from nontrivial semimetalic to trivial semiconductivity. During this phase transition, interestingly, at a critical substitution, one would observe a novel band structure in which a lone bulk Dirac point exists in the vicinity of the Fermi level and thus leaving out the complexity of the multiple Dirac points as a case in the parent system. In addition, such a single Dirac cone semimetal can be further tuned into a novel Weyl semimetal just by breaking one of the aforementioned two symmetries. In such a novel semimetal there exist only two Weyl nodes, contrary to the so far reported minimal four or higher Weyl node systems. Therefore, finding out such a peculiar semimetal with the aforementioned novel band structure is of broad importance in both basic science and technology. Therefore, we studied the low-energy electronic structure of three-dimensional Dirac semimetal, $Cd_3(As_{1-x}P_x)2$ [x = 0 and 0.34(3)], by employing the angle-resolved photoemission spectroscopy (ARPES). We observe that the bulk Dirac states in $Cd_3(As_{0.66}P_{0.34})2$ are gapped out with an energy of 0.23 eV, contrary to the parent Cd_3As_2 in which the gapless Dirac states have been observed. Thus, our results confirm the earlier predicted topological phase transition in Cd3As2 with perturbation. We further notice that the critical P substitution concentration, at which the two Dirac points that are spread along the c-axis in Cd_3As_2 form a single Dirac point at Gamma point, is much lower [x(P)< 0.34(3)] than the predicted value of x(P)=0.9. Therefore, our results suggest that the nontrivial band topology of Cd3As2 is remarkably sensitive to the P substitution and can only survive over a narrow substitution range, i.e., 0 < x (P) < 0.34(3). See Figure 1.

B. Absence of Dirac fermions in $BaZnBi_2$

Using angle-resolved photoemission spectroscopy and density functional theory we study the electronic structure of layered $BaZnBi_2$. Our experimental results show no evidence of Dirac states in $BaZnBi_2$ originated either from the bulk or the surface. The calculated band structure without spin-orbit interaction shows linear band dispersions at X along $X-M$ high symmetry line. In addition, the calculations suggest gapless band crossing point along the $\Gamma-M$ high symmetry line. However, as soon as the spin-orbit interaction is turned on, the band crossing point is significantly gapped out. These observations suggest that the Dirac fermions in BaZnBi2 are trivial similar to the Dirac states observed in grapheme. The experimental observations are in good agreement with the DFT calculations. See Figure 2.

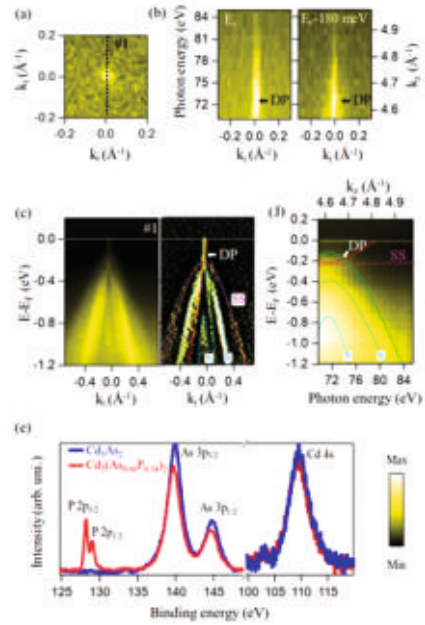


Figure 1. ARPES data of Cd_3As_2. (a) In-plane Fermi surface map. (b) k_z Fermi surface map (left panel) and constant energy map taken 180 meV below E_F (right panel). (c) Energy distribution map (EDM) measured along the cut 1 as shown on the Fermi surface map (left panel) and second derivative of the EDM (right panel). (d) Energy distribution map taken along the k_z direction. Dirac points (DP) are located in the panels (b), (c) and (d). (e) XPS data of Cd_3As_2 and $Cd_3(As_{0.66}P_{0.34})_2$. Multiplet peaks of P at the binding energy of 129 eV are confirming the element P substitution in $Cd_3(As_{0.66}P_{0.34})_2$. The k_z values in (b) and (d) are calculated using the inner potential of 10.6 eV [10].

c) Proposed research activities for the coming year

1. Dirac semimetals, Cd_3As_2, $PtBi_2$, Na_3Bi etc., are the other class of topological systems in which the Dirac fermions are bulk in nature, contrary to the topological insulators where the Dirac fermions are originated either form the edge or the surface of the crystal. Similarly, the Weyl semimetals, WTe_2, $MoTe_2$, TaAs etc., also possess bulk Dirac fermions. However, the main difference between the Dirac and Weyl semimetals is that the fermions at the band crossing point in the former have four-fold symmetry, while the fermions in the latter have two-fold symmetr. This is understood by the fact that the Weyl systems can be tuned starting from the Dirac systems by breaking one of the two protecting symmetries like the time-reversal symmetry or the crystal symmetry. In addition to the Dirac and Weyl semimetals there also exist nodal-line and nodal-ring semimetals protected by the nonsymmorphic symmetry of the crystal. More interestingly, there are recent predictions for the systems with the electronic structure properties beyond the Weyl and Dirac semimetals. That means, the fermions at the band crossing point have three-fold, six-fold or eight-fold symmetries depending on the space group of the crystal. However, experimental realization of such novel systems is still at the beginning. Thus, our future plan of work is to search and synthesize the materials having the manifold Dirac and to unearth the peculiar physical properties originated from the manifold Dirac fermions.

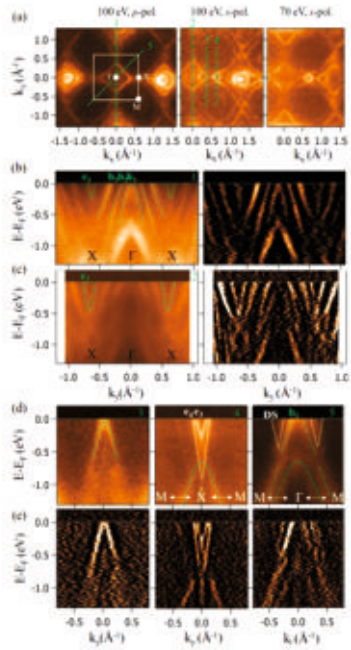
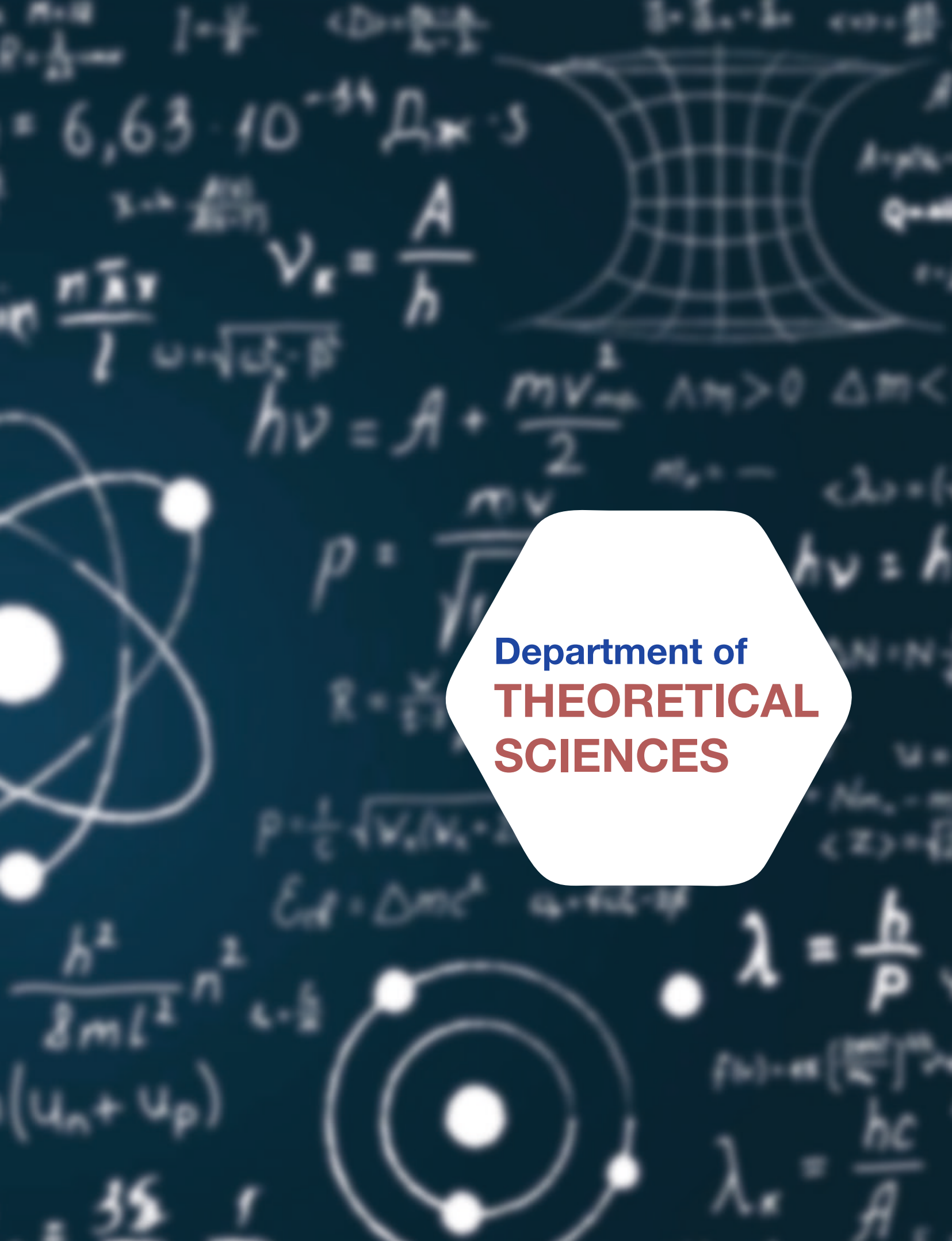


Figure 2. ARPES data of $BaZnBi_2$. (a) Fermi surface maps taken with different photon energies (20 and 100 eV) and polarizations (*s* and *p*). (b) and (c) are the energy distribution maps (EDM) taken along the cuts 1 and 2 (left panel) and corresponding second derivative (right panel) using *p* and *s* polarized photons, respectively, along the $\Gamma - X$ high symmetry line. (d) Shows EDMs taken along the cuts 3, 4, and 5 from left to right, respectively. (e) Shows respective second derivatives of (d). In the figure (d) the white and green dashed lines are guides to the eye representing the band dispersions. Further, DS represents Dirac states.


E = mc²
W = |Ψ|²
b = 2,9 · 10⁻³ m · K



Department of THEORETICAL SCIENCES

Department of Theoretical Sciences

Makhtedar Sanjay Kumar

Department profile indicators

Table_A : Manpower and resources

Number of faculties	8
Number of Post –doctoral research associate (centre+project)	4
Number of Ph.D students	32
Number of other project staff	01
Number of summer students	5
Projects (ongoing)	3

Table B: Research Activities indicators

Number of research papers in Journals	35
Number of Book-chapters/books	0
Number of other publications	1
Number of Ph.D students graduated (submitted+degree awarded)	Thesis Submitted = 8
Degree Awarded = 3	
Number of M.Tech/M.Sc projects	4

Table C: Academic activities and linkage		
Number of courses taught by faculties	12	
Number of Visitors (non –associates)	08	
Number of associates	01	
Number of Seminars organized	10	
Number of Conference/Symposia/Advanced Schools organized	04	
Number of talks delivered by members of department in conferences/Symposia	National	9
	International	0

Most important research highlights

- Gravity as a gauge theory using the Einstein-Palatini vierbein formalism.
- Constraints of Maxwell's theory in space-times with horizons.
- Gauge transformations on categorical principal bundles.
- Spectral distances on the doubled Moyal plane using Dirac eigenspinors
- Connecting dissipation and noncommutativity: A Bateman system case study
- Holographic superconductors in rotating AdS_3+1 spacetime
- Gravitational wave data as a probe of noncommutative structure of space.
- Construction of Galilean gauge theory from Poincare gauge theory
- Noncommutative fluid and Growing Modes of Inhomogeneity in Newtonian Cosmology
- Hydrodynamics, density fluctuations, and universality in conserved stochastic sandpiles
- Current reversal in interacting colloids under time-periodic drive
- Force generation mechanisms involved in actin filaments pushing against a barrier.
- A run-and-tumble random walk whose switching

frequencies depend on a stochastic signal.

- Role of post-relaxation on the jamming state and percolation properties of random sequential adsorption of dimers.
- A Geometrical formulation of relativistic mechanics is given
- Jacobi-Maupertuis principle for solutions of an equation of the Lienard type.

Summary of research activities

Gravity was studied as a gauge theory using the Einstein-Palatini vierbein formalism, which includes the tetrads and the spin connection as independent fields.

The geometrical nature of gauge transformations on categorical principal bundles was studied. More general gauge transformations were also studied.

Constraints of Maxwell's theory were studied in stationary axisymmetric space-times with horizons. It was found that the Gauss law is modified to include a surface contribution at the horizons.

A novel method for computing spectral distances in the doubled Moyal plane in a noncommutative geometrical framework using Dirac eigenspinors is given.

In the context of a Bateman system, a connection between dissipation and noncommutativity has been found. A duality between dissipative commutative theory and non-dissipative noncommutative theory has been pointed out.

Holographic superconductors in rotating AdS_3+1 spacetime have been investigated. It has been observed that the rotation parameter of the black hole affects the critical temperature and the condensation operator in a non-trivial way.

The insulator/superconductor phase transition in the presence of d-dimensional Gauss-Bonnet AdS soliton background has been analytically investigated.

Holographic entanglement thermodynamics for higher dimensional charged black hole has been computed.

Holographic complexity of a 3+1-dimensional Lifshitz spacetime having a scaling symmetry, as well as that of a 'black' non-susy D3-brane, has been computed.

Phase transition of rainbow inspired higher dimensional Schwarzschild black hole incorporating the effects of the generalized uncertainty principle has been studied.

It has been proposed that gravitational wave data can be used as an effective probe of noncommutative structure of space.

An algorithm for constructing a nonrelativistic theory in a curved background from the relativistic couterpart has been given.

The effects of noncommutativity were studied in a fluid model leading to

It is demonstrated that a broad class of conserved stochastic sandpiles possesses a remarkable hydrodynamic structure: there is an Einstein relation which connects bulk-diffusion coefficient, conductivity, and mass fluctuation, or scaled variance of subsystem mass.

Two force generation mechanisms involved in actin filaments pushing against a barrier have been investigated.

A simple run-and-tumble random walk whose switching frequencies between run mode and tumble mode depend on a stochastic signal have been studied.

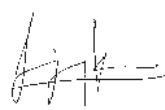
Particle transport in a system of interacting colloidal particles on a ring driven by a time-dependent external potential moving along the ring has been studied. When the external potential barrier moves in discrete jumps, the time-averaged particle current is found to reverse its direction, upon tuning the particle number density and jump length.

The role of post-relaxation on the jamming state and percolation properties of random sequential adsorption of dimers on a two-dimensional lattice has been investigated.

Relativistic mechanics with a Lagrangian including a potential term and relativistic Hamiltonian mechanics in curved spaces have been investigated.

A Jacobi-Maupertuis principle for solutions of an equation of the Lienard type has been established.

Generalized Hamiltonian dynamics of the activator-inhibitor (AI) systems of Turing pattern formation problems has been investigated. It has been demonstrated that various subsystems of AI are described either by conformal or contact Hamiltonian dynamics or both.



Makhtedar Sanjay Kumar

Head, Department of Theoretical Sciences

AMITABHA LAHIRI
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Supervision of Research / Students

a) Ph.D. Students

1. Ishita Dutta Choudhury; Some implications of gauge invariant mass of vector bosons; Awarded
2. Karan Savio Fernandes; Field theories on curved spacetimes with boundaries; Thesis submitted
3. Ambalika Biswas; Aspects of two Higgs doublet models; Thesis submitted
4. Subhasish Chakrabarty; Field theoretic approach to gravity; Under progress
5. Pratik Tarafdar; Accreting black hole systems as classical analogue gravity models; Under progress (with Dr. Tapas K. Das of HRI)
6. Shantonu Mukherjee; Aspects of topological physics; Under progress

Teaching activities at the Centre

1. Autumn semester; Classical Dynamics; Integrated PhD; 14 students

Publications

a) In Journals

1. Subhasish Chakrabarty and **Amitabha Lahiri**, Different types of torsion and their effect on the dynamics of fields, Eur. Phys. J. Plus 133, 242, 2018.
2. S. Chatterjee, **Amitabha Lahiri** and A. N. Sengupta, Gauge transformations for categorical bundles, J. Geom. Phys. 133, 219, 2018.
3. K. Fernandes and **Amitabha Lahiri**, Constrained field theories on Kerr backgrounds, Eur. Phys. J. C79, 160, 2019.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Quarks, magnetic monopoles, and confinement; Jan 17, 2019; Expanding Horizon in Physics (EHP-2019) 10th Vidyasagar Satyendra Nath Bose National Workshop, Vidyasagar University; Jan 16-22, 2019
2. Session Chair, Classical Gravity, 30th meeting of the Indian Association for General Relativity and Gravitation (IAGRG); Jan 3, 2019; BITS Pilani Hyderabad campus; Jan 03-05, 2019

Membership of Committees

a) Internal Committee

1. Chairman, Grievance Redressal Committee, SNBNCBS

Conference / Symposia / Workshops / Seminars etc. organized

1. Current Developments in Quantum Field Theory and Gravity; Dec 3, 2018; SNBNCBS; Dec 03-07, 2019

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators):

1. IISER Thiruvananthapuram; 2; National
2. University of Connecticut; 2; International

Societal impact of Research

1. Social impact of research: Like all research in basic science, my work will add to what we know about the universe and the theories that describe it. It will lead to answers of questions about how quantum fields like the photon propagate near black holes. It will lead to new descriptions of motions of spin-half particles like electrons and neutrinos in curved space-time. In mathematics my work will contribute to the geometrical understanding of the description and dynamics of extended objects like charged strings. During the course of my research, many new students are trained who in turn will train more students in future and carry forward scientific research in the country.

Significant research output / development during last one year

a) General research areas and problems worked on

Quantum Field Theory, General Relativity, Mathematical Physics

b) Interesting results obtained

1. General Relativity and Field Theory: Gravity was studied as a gauge theory using the Einstein-Palatini vierbein formalism, which includes the tetrads and the spin connection as independent fields. It was found that conformal transformations of off-shell spin connection is not uniquely determined unless additional assumptions are made. A one-parameter family of transformations of the spin connection was found to interpolate between Nieh-Yan theory (torsion as the gauge field of conformal transformations) and a theory where torsion is conformally invariant. For dynamically generated torsion, the spin connection was found not to have well defined conformal properties and can be sourced by fermions as well as non-minimally coupled scalars.
2. General Relativity and Field Theory: Constraints of Maxwell's theory were studied in stationary axisymmetric space-times with horizons. It was found that the Gauss law is modified to include a surface contribution at the horizons. These correspond to induced surface charges and surface currents and match with similar results in the membrane paradigm. This modification also affects gauge-fixing and Dirac brackets of the system.
3. Mathematical Physics: Gauge transformations on categorical principal bundles are a special class of functorial isomorphisms of such bundles. The geometrical nature of these gauge transformations were studied. Specifically, for a twisted categorical principal bundle defined in our earlier works and one whose structure group is a 2-group consisting of Lie groups G and H, it was shown that gauge transformations were determined by a traditional G-valued scalar gauge function and an L(H)-valued 1-form field. More general gauge transformations were also studied.

c) Proposed research activities for the coming year

1. Mathematical Physics: I plan to investigate, with my collaborators, gauge transformations on path space fiber bundles in terms of the connection. We plan to translate this work into gauge transformations of local fields on the categorical fiber bundles.
2. General Relativity and Quantum Field Theory: I plan to further analyze the role of gauge theory constraints on space-times with horizons. In particular I plan to look at the effect of the newly found surface terms in the gauge constraints on quantization of gauge theories, more precisely on the Hamiltonian BRST quantization of Maxwell's theory of electromagnetism on black hole space-times. I also plan to investigate the effect of torsion, specifically torsion sourced by fermions, on the dynamics of fermions in curved space-time. The torsion field can be integrated out from the theory, leaving a four-fermion interaction term. This leads to an effective mass for fermions propagating through curved space-time, and can in principle produce neutrino oscillations even when the neutrinos are massless.

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Supervision of Research / Students

a) Ph.D. Students

1. Partha Nandi; Noncommutative Quantum theories; Under progress
2. Sayan Kumar Pal; Noncommutative Quantum theories; Under progress
3. Anwesha Chakraborty; Noncommutative Quantum theories; Under progress
4. Debabrata Ghorai; High-T_c superconductivity through AdS/CFT correspondence; Under progress (jointly with Dr. S. Gangopadhyay)
5. Anish Das; AdS/CFT correspondence; Under progress (jointly with Dr. S. Gangopadhyay)

b) Post Doctoral Research Scientist/s

1. Dr. Kumar Das; Aspects in Standard model in Particle Physics

Teaching activities at the Centre

1. Autumn semester; General Relativity & Cosmology; PhD; 2 students; (With Prof. Archan S. Majumdar, co-teacher)
2. Spring semester; Quantum Physics (Application) (PHY-604); PhD; 3 students

Publications

a) In journals

1. Kaushlendra Kumar, **Biswajit Chakraborty**, Spectral distances on the doubled Moyal plane using Dirac eigenspinors, Phys. Rev. D 97, 086019 (2018).
2. Sayan K. Pal, Partha Nandi and **Biswajit Chakraborty**, Connecting dissipation and noncommutativity: A Bateman system case study, Phys. Rev. A 97, 062110 (2018).
3. Yendrembam Chaoba Devi, Kaushlendra Kumar, **Biswajit Chakraborty** and Frederik G. Scholtz, Revisiting Connes' finite spectral distance on noncommutative spaces: Moyal plane and fuzzy sphere, Int. J. Geom. Meth. Mod. Phys. 15, 1850204 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Gave a talk on "Quantum mechanics and geometry on noncommutative spaces" at the International Conference on Quantum and Atom Optics-18; Dec 16, 2018; IIT, Patna; 40 minutes
2. Gave a talk on "On a plausible nature of space-time in the vicinity of Planck scale and the associated concept of 'metric' " in the One-day meeting on Relativity at the Relativity and Cosmology Centre, Physics Department, Jadavpur University, Kolkata Mar 15, 2019; Jadavpur University, Kolkata; 1 hour

Membership of Committees

a) Internal Committee

1. Member of CAC, Admission Committee, CWEP, FSC

b) External Committee

1) Board of Research Studies (BRS) of the Physics Department, West Bengal State University, Barasat, West Bengal.

2) I was one of the external members in the Post-Graduate expert committee (Physics) meeting, held at Gurudas College, Kolkata on 10th January 2018.

3) I was one of the external expert committee members for the faculty selection meeting at IIT, Patna during May and June 2018.

Conference / Symposia / Workshops / Seminars etc. organized

1. I was the convener for the ``International Conference On Noncommutative Geometry: Physical and Mathematical Aspects", November 2018. Around 20 participants were from abroad; Nov 27, 2018; SNBNCBS; 4 days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators):

1. Yendrembam Chaoba Devi, Kaushlendra Kumar, Biswajit Chakraborty and Frederik G. Scholtz, "Revisiting Connes finite spectral distance on noncommutative spaces: Moyal plane and fuzzy sphere"; 3; International

Participation in Science Outreach program

1. As a part of year-long 125th birth anniversary celebration of Prof. S.N.Bose, I gave a popular lecture on the topic "Life and works of Acharya Satyendra Nath Bose" for school students, held at Sodepur High School, West Bengal, India on 11th May, 2018.
2. As a part of year-long 125th birthday celebration of Prof. S.N.Bose, I gave a popular lecture on the topic "Life and works of Acharya Satyendra Nath Bose" for college students, held at Hooghly Girl's College, Chinsurah, West Bengal on 11th September, 2018.

Societal impact of Research

The impact of basic research, particularly in areas like Mathematical Physics, in society is very difficult to foresee. This area of research is entirely curiosity driven and a scientist is not bothered about their social implications to begin with- as it should be. Nevertheless, history has taught us that the benefits of pure research have always percolated to different applications in science and technology. To cite a few examples one can recall that certain number-theoretical results from pure Mathematics have found applications in cryptography-used for security purposes. Another very important example being the application of General Theory of Relativity in Global Positioning System (GPS) used for navigation purposes. None of these kinds of applications could ever be foreseen by the respective scientists while formulating their theories. It is indeed generally believed that any real development in basic science will inevitably find some application or the other in the long run. My area of research is Noncommutative geometry and its applications in Physics. This was essentially developed by Alain Connes and is supposed to provide another avenue towards quantum gravity. Already it has made successful predictions/postdictions on different results in the Standard model of particle physics. This is expected to provide deep insights into even other areas of physics, given that the issues involved in quantum gravity research are very deep and fundamental. For example, it has got very strong overlap with quantum information theory having a very bright future ahead. Finally the collaborative works with students help in capacity building.

Significant research output / development during last one year

a) General research areas and problems worked on

Noncommutative Geometry and Noncommutative Quantum Theories

b) Interesting results obtained

(i) I started working on certain aspects of Lorentzian spectral triples, which is a major issue in the field of Noncommutative Geometry. This is particularly important because the original Connes' formulation of Noncommutative Geometry was formulated only for spaces with Euclidean signature and only recently the efforts towards the construction of Lorentzian spectral triples have been initiated in order to make contacts with the real world. To begin with we intend to compute the spectral distance on the Lorentzian Moyal plane. This should pave the way to construct appropriate spectral triples describing gauge theories on Lorentzian manifolds and/or Noncommutative spaces.

(ii) We have carried out the path integral formulation of Noncommutative quantum mechanics for three dimensional fuzzy space ($R^3_.$) and the fuzzy sphere ($S^2_.$), where it was shown that the classical equations of motion for a particle on three dimensional fuzzy space and on the fuzzy sphere are underpinned by a natural Lorentz geometry. We identify these Lorentz geometries to be a Minkowski metric on R^4 and $R\times S^2$ in the cases of a free particle on three dimensional fuzzy space ($R^3_.$) and the fuzzy sphere ($S^2_.$), respectively. From this geometric perspective, we have found that the equations of motion are invariant under arbitrary diffeomorphisms and correspond to a forced geodesic motion. We also demonstrate the equivalence of the on-shell dynamics of S^2_* and a relativistic charged particle on the commutative sphere coupled to the background magnetic field of a Dirac monopole.

c) Proposed research activities for the coming year

1. We intend to study entanglement aspect arising in the formulation of quantum mechanics using Hilbert-Schmidt operatorial formulation.
2. We plan to study the kinematical invariance group for a simple harmonic oscillator embedded in a Noncommutative Moyal plane and extend the study to deal with dissipative systems like the damped harmonic oscillator by using Bateman's doubling approach. We would also like to extend our earlier work on Noncommutativity induced dissipation in Bateman like system by using the formulation of path integrals in terms of Lefschetz thimbles.

MAKHTEDAR SANJAY KUMAR
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Supervision of Research / Students

a) Ph.D. Students

1. Soumyakanti Bose; 'INFORMATION THEORETIC ASPECTS OF SOME NON-GAUSSIAN CLASSICAL AND QUANTUM OPTICAL FIELDS'; Thesis submitted
2. Saniur Rahman; Aspects of quantum many body systems; Under progress

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Gokul Arakkal; Gaussian States in Quantum Optics; Department of Nuclear Physics, Univ. of Madras

3. Teaching activities at the Centre

1. Spring semester; Quantum Mechanics II (PHY203); Integrated PhD; 6 students
2. Autumn semester; Quantum Mechanics I (PHY103); Integrated PhD; 13 students
3. Autumn semester; Quantum Information Theory (PHY613); PhD; 3 students

Membership of Committees

a) Internal Committee

1. Chairperson, Medical Committee
2. Member, SCRE Committee
3. Member, APMP Committee
4. Member, Admissions Committee & Admissions Coordinator

Significant research output / development during last one year

a) General research areas and problems worked on

QUANTUM OPTICS & QUANTUM INFORMATION

b) Interesting results obtained

We have studied aspects of quantum teleportation with beam splitter generated non-Gaussian entangled resource states. In particular we have critically examined the role of various ingredients thought to be essential in the literature for quantum teleportation. We have observed that none of these are in fact necessary for quantum teleportation. Based on numerical evidence on the beam splitter generated resource states as well as other non-Gaussian resource states as well as somevanalytical arguments, we have argued that a U(2)-invariant two-mode quadrature defined by R. Simon and coworkers (1994) is a necessary condition.

c) Proposed research activities for the coming year

1. Two further works that have formed part of the thesis of my Ph.D. student Soumyakanti Bose will be expanded upon. (i) A scheme for spatially redistributing two-mode entanglement generated at a point by using a two-dimensional array of beam splitters. (ii) Some aspects nonclassicality of single-mode non-Gaussian states. We have identified states that show interesting properties as regards the coexistence or otherwise of quadrature squeezing on the one hand and sub-Poissonian statistics on the other. This matter needs further investigation.

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Supervision of Research / Students

a) Ph.D. Students

1. Atul Rathor; Duality in SU(N) Lattice Gauge Theories; Under progress

Teaching activities at the Centre

1. Autumn semester; Mathematical Methods; Integrated PhD; 13 students

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. "Duality and Disorder Operators in Lattice Gauge Theory" in Current Developments in Quantum Field Theory and Gravity, 3rd to 7th December 2018; Dec 5, 2018; SNBNCBS; 45 minutes

Membership of Committees

a) Internal Committee

1. Convener - Visitor, Associates and Students' Programme (VASP) Committee
2. Chairman- Medical Cell

Significant research output / development during last one year

a) General research areas and problems worked on

Lattice Gauge Theories, Group Theory and Coherent States

b) Interesting results obtained

1. The SU(3) Outer Multiplicity Problem

   The reduction of the direct product of two irreducible representations of SU(N) (N > 2) group is generally not multiplicity free. This is an old problem and is known as the outer multiplicity problem. In other words, there are missing labels or operators whose eigenvalues identify individual irreducible representations uniquely and lift the above degeneracy. In the case of SU(3), using Schwinger boson representation, we have constructed the SU(3) X SU(3) invariant group SO(4,2). We find that the eigenvalues of the 3 Casimir operators of the invariant group SO(4,2) lift the above degeneracy completely.

2. SU(2) Disorder Operator in (2+1) dimension

   Using the exact duality of pure lattice gauge theory in (2+1) dimension we had found the most general SU(2) disorder operator. This disorder operator is characterized by an angle T and creates a magnetic vortex on a single plaquette. Further, it satisfies the most general order-disorder algebra with the Wilson loop operator. Our disorder operator reduces to the t-Hooft disorder operator at T = pi. We are now explicitly checking the behavior of this disorder operator across deconfinement transition for various values of T by Monte Carlo simulations.

3. SU(N) Duality in (3+1) Dimensions

   We are generalizing the above exact duality of pure SU(N) lattice gauge theory in (2+1) dimension to (3+1) dimension. It is expected that SU(N) Gauss law and the SU(N) Bianchi identities will interchange their roles. Partial results to this effect have been obtained.

c) Proposed research activities for the coming year

1. The SU(N) Outer Multiplicity Problem: An invariant group analysis of SU(N) (N>3) to resolve the multiplicity problem (similar to SU(3) case mentioned above) is under investigation.

PARTHA GUHA
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Supervision of Research / Students

a) Ph.D. Students

1. Sumanto Chanda; Geometry, Physics and integrability on curved spaces; Awarded
2. Ankan Pandey; Nonlinear dynamics; Under progress
3. Souma Mazumdar; Generalized entropy and quantum information; Under progress

c) Post Doctoral Research Scientist/s

1. Supriyo Dutta; Generalized entropy, generalized thermostatistics and quantum information

Teaching activities at the Centre

1. Spring semester; Advanced Mathematical Methods (PHY 507); Integrated PhD; 4 students; with 1 (Samir Paul) co-teacher

Publications

a) In journals

1. Sumanto Chanda, **Partha Guha**, Geometrical formulation of relativistic mechanics, Int. J. Geom. Methods Mod. Phys. 15 (2018), no. 4, 1850062.
2. Ogul Esen, **Partha Guha**, On time-dependent Hamiltonian realizations of planar and nonplanar systems, J. Geom. Phys. 127 (2018), 32--45.
3. Sumanto Chanda, Anindya Ghose-Choudhury, **Partha Guha**, Jacobi-Maupertuis metric of Liénard type equations and Jacobi last multiplier, Electron. J. Differential Equations 2018, Paper No. 120, 1-9.
4. **Partha Guha**, A. Ghose-Choudhury, Generalized conformal Hamiltonian dynamics and the pattern formation equations, J. Geom. Phys. 134 (2018), 195--208.
5. Ogul Esen, **Partha Guha**, On the geometry of the Schmidt-Legendre transformation, J. Geom. Mech. 10 (2018), no. 3, 251--291.
6. Kumar Abhinav, **Partha Guha**, Indranil Mukherjee, Study of quasi-integrable and non-holonomic deformation of equations in the NLS and DNLS hierarchy, J. Math. Phys. 59 (2018), no. 10, 101507, 18 pp.
7. Jose F. Carinena, **Partha Guha**, Nonstandard Hamiltonian structures of the Liénard equation and contact geometry. Int. J. Geom. Methods Mod. Phys. 16 (2019), suppl. 1, 1940001.
8. A. Ghose-Choudhury, Aritra Ghosh, **Partha Guha**, Ankan Pandey, On purely nonlinear oscillators generalizing an isotonic potential, International Journal of Non-Linear Mechanics 106, November 2018, Pages 55--59.
9. **Partha Guha**, A. Ghose-Choudhury, A note on generalization of the Ermakov–Lewis invariant and its demystification, Mod. Phys. Lett. A Vol. 34, No. 3 (2019) 1950021.
10. **Partha Guha**, Saddle in linear curl forces, cofactor systems and holomorphic structure, Eur. Phys. J. Plus (2018) 133: 536.

b) Other Publications (including conferences)

1. Guha, Partha, {\rm The role of the Jacobi last multiplier in nonholonomic systems and locally conformal symplectic structure}. Mathematical structures and applications, 275–291, STEAM-H: Sci. Technol. Eng. Agric. Math. Health, Springer, Cham, 2018.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited speaker at One Day Workshop on Nonlinear Systems, Gebze Technical University, 26 November, 2018; Nov 26, 2018; Turkey
2. Talk given at Department of Mathematics, Gebze Technical University; Oct 26, 2018; Turkey; colloquium

3. Talk given at Department of Physics, Mimar Sinan Fine Arts University, Istanbul; Nov 8, 2018; Turkey; seminar

Academic Visits

a) International

1. Exchange Visit; Visited Professor Ogul Esen, Department of Mathematics, Gebze Technical University, 1-10-2018 to 1-12-2018, under TUBITAK visiting professorship program.

Membership of Committees

a) Internal Committee

1. CWEP

Awards / Recognitions

1. TUBITAK (The Scientific and Technological Research Council of Turkey) 2221 Fellowship.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Ogul Esen, Department of Mathematics, Gebze Technical University, Turkey; Sl. No. 2, 5; International
2. Jose Carinena, University of Zaragoza, Spain; Sl. No. 7; International
3. Anindya Ghose-Choudhury, Diamond harbour women university, West Bengal; Sl. No. 3,4,8,9; National
4. Indranil Mukherjee, Maulana Abul Kalam Azad University of Technology, West Bengal; Sl. No. 6; National
5. Kumar Abhinav, The Institute for Fundamental Study, Naresuan University, Thailand; Sl. No. 6; International

Participation in Science Outreach program

1. Given lectures at DST-INSPIRE INTERNSHIP CAMP - 2018 at Visva-Bharati during September 10-14, 2018.

Significant research output / development during last one year

a) General research areas and problems worked on

Mathematical Physics, Geometric Mechanics, Nonlinear Dynamics, Integrable Systems

b) Interesting results obtained

Project 1 : Contact Geometry, Cosymplectic Geometry and their applications. We have studied generalized Hamiltonian mechanics through conformal or contact structures, using this formalism different examples describing both Turing and non-Turing pattern formation are completely analyzed. We have also studied cosymplectic geometry and its application to time dependent 2D Hamiltonian systems. We then generalized the cosymplectic structures to time-dependent Nambu-Poisson Hamiltonian systems and corresponding Jacobi's last multiplier for 3D systems. We have studied the geometrical structure of nonholonomic system and elucidate the relationship between Jacobi's last multiplier (JLM) and nonholonomic systems endowed with the almost symplectic structure. In another problem, construction of nonstandard Lagrangians and Hamiltonian structures for Liénard equations satisfying Chiellini condition is presented and show that such nonstandard Lagrangians are deformations of simpler standard Lagrangians. We also exhibit their connection with contact Hamiltonian mechanics.

Project 2: Quasi-deformed and nonholonomic deformed integrable PDEs: We have studied hierarchy of equations belonging to two different but related integrable systems, the nonlinear Schrödinger (NLS) and its derivative variant the derivative nonlinear Schrödinger (DNLS), is subjected to two distinct deformation procedures, viz., quasi-integrable deformation that generally does not preserve the integrability, with the system only asymptotically integrable, and non-holonomic deformation that does integrability. In a separate problem explores the class of equations of the Non-linear Schroedinger (NLS) type by employing both geometrical and spectral analysis methods. In particular, the spectral technique (Tu method) is applied to obtain the hierarchies of equations belonging to these types and the trace identity along with other techniques is used to obtain the corresponding Hamiltonian structures. We have also discussed the Adler-Kostant-Symes theory and its connection to Tu's method.

Project 3: Geometric Mechanics: We have investigated relativistic mechanics with a Lagrangian including a potential term depending only on the coordinates. Since this Lagrangian isn't invariant under the Lorentz transformation due to the potential term, the spacetime metric can be views as a perturbation of the flat case. We have also studied relativistic Hamiltonian mechanics in curved spaces. In a different problem, Tulczyjew's triples are constructed for the Schmidt-Legendre transformations of both second and third-order Lagrangians.

Symplectic diffeomorphisms relating the Ostrogradsky-Legendre and the Schmidt-Legendre transformations are derived, illustrated via several examples.

Project 4: Nonlinear dynamics : We have established a Jacobi-Maupertuis principle for solutions of an equation of the Lienard type and characterizes solutions of the equation as geodesics (up to parameterization) of a certain Riemannian metric (Jacobi-Maupertuis) in the configuration space. As a corollary of the main result, we have shown that it is possible to reformulate the Newtonian equation of motion for the case of a variable mass, the Painlevé-Gambier XXI equation, the Jacobi equation and the Hénon-Heiles system in terms of geodesic flows of the Jacobi-Maupertuis metric. In a different problem, we have considered a nonlinear generalization of the isotonic oscillator with an asymmetric potential. The period function in this potential has the same value as in the original asymmetric potential, it is amplitude dependent and expressible in terms of the hypergeometric function.

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Supervision of Research / Students

a) Ph.D. Students

1. Subhadip Chakraborti; Studies of fluctuations in systems of self-propelled particles; Thesis submitted
2. Dhiraj Tapader; Studies of hydrodynamics and fluctuations in mass-transport processes; Under progress
3. Anirban Mukherjee; Mass and current fluctuations in driven diffusive systems; Under progress
4. Tanmoy Chakraborty; Studies of active lattice gases; Under progress
5. Deepshikha Das; Exclusion processes in the presence of moving defects; Under progress

b) Post Doctoral Research Scientist/s

1. Dr. Shubhshis Rana (NPDF); Interacting particles in a periodically moving external potential

Teaching activities at the Centre

1. Spring semester; PHY 204; Integrated PhD; 13 students

Publications

a) In journals

1. Sayani Chatterjee, Arghya Das, and **Punyabrata Pradhan**, Hydrodynamics, density fluctuations, and universality in conserved stochastic sandpiles, PHYSICAL REVIEW E, vol. 97, 062142 (2018).
2. Shubhashis Rana, Sanchari Goswami, Sakuntala Chatterjee, and **Punyabrata Pradhan**, Current reversal in interacting colloids under time-periodic drive, PHYSICAL REVIEW E, vol. 98, 052142 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. Invited talk in the international conference "Universality in random structures: Interfaces, Matrices, Sandpiles"; Talk title: Hydrodynamics of conserved stochastic sandpiles; Feb 6, 2019; International Centre for Theoretical Sciences (ICTS), Bengaluru; 45 minutes
2. Invited talk during an academic visit; Talk title: Characterizing fluctuations in driven many-body systems; Mar 13, 2019; The Institute of Mathematical Sciences, Chennai; one hour

Membership of Committees

a) Internal Committee

1. Library committee, Newsletter committee, various interview committees

Sponsored Projects

1. Additivity principle and thermodynamic characterization of mass transport processes (EMR/2014/000719); Science and Engineering Research Board (SERB); 3 years; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Initiating research topics of statistical physics to young physicists (school; one of the organizers); Jun 4, 2018; S. N. Bose National Centre for Basic Sciences, Kolkata; 12 days
2. Young Investigators Meet on Quantum Condensed Matter Theory (conference; one of the organizers); Nov 20, 2018; S. N. Bose National Centre for Basic Sciences, Kolkata; 3 days

Societal impact of Research

1. Development of manpower and knowledge base in higher-education sector in terms of teaching (as mentioned above, I taught one course) and training of the doctoral students as well as the postdoctoral researchers.

Significant research output / development during last one year

a) General research areas and problems worked on

Nonequilibrium statistical physics, steady-state thermodynamics and fluctuation relations in conserved-mass transport processes, such as exclusion processes, mass chipping and aggregation models, sandpile models and active-matter (living) systems, etc.

b) Interesting results obtained

In the above mentioned period, we have mainly worked on two different problems of characterization of density and current in two classes of driven systems - (1) when the driving is time-independent and, consequently, there is a nonequilibrium steady-state and (2) when the system is driven by a time-dependent force field.

In the first work, we have derived an exact hydrodynamic structure of a broad class of conserved-mass (fixed-energy) stochastic sandpiles (CSSs). Sandpiles were proposed three decades ago as paradigmatic models of "self-organized criticality" (SOC) to explain ubiquitous scale-invariant structures in nature. Since then, they continued to capture the imagination of physicists and mathematicians alike. Indeed, sandpiles, and SOC, produced a wealth of results through exact, numerical, and experimental studies. Yet, by and large, they resisted attempts to construct a unified statistical mechanics framework. In this work, we discover, in a broad class of conserved-mass sandpiles, a remarkable hydrodynamic structure, which could provide useful insights into large-scale properties of such systems. Importantly, we pointed out that a broad class of these systems possess a "gradient property," where local diffusive current and, therefore, time-evolution of local densities can be written as a gradient (discrete) of local observable like the activity. The gradient property essentially originates from the fact that, in the sandpiles studied here, the particle hopping rates depend only on the departure site, but not on the destination sites. We use the property and recently developed macroscopic fluctuation theory to uncover a remarkable thermodynamic structure, where bulk-diffusion coefficient, conductivity, and mass fluctuations are shown to be connected to the activity, through an equilibrium-like Einstein relation. The hydrodynamic structure obtained in this work has far-reaching consequences on the critical behavior of the CSS, through two new scaling relations, which, we believe, could help settle the long-standing issue of universality in such systems. Our work leads to several interesting open issues. For example, many of the CSSs can have "nongradient" structures in density evolution and thus the issue of determining universality in the CSS in general remains intriguingly poised at this stage.

Characterization of particle transport in driven systems is an important problem in statistical physics. There has been considerable progress made in the past in maneuvering small (micron-sized) colloidal particles using laser field, leading to new avenues of research in exploring transport in such systems. In the second work, we have studied particle transport in a system of interacting particles on a ring, where the system is driven by a time-dependent external potential in the following two cases: (i) The external potential barrier moves with a uniform velocity v along the ring, and (ii) it moves in discrete jumps with an effective velocity. Upon tuning the particle-number density and the effective barrier velocity, the DC (time-averaged) particle current, which always remains positive in the case (Iinterestingly reverses its direction in the case (ii). We have also found a scaling form for the current in terms of number density, barrier velocity, barrier height, and temperature of the system. Recently, a similar system was considered by Chaudhuri et. al., where colloidal particles moving in continuum under a sinusoidally varying traveling-wave potential were shown to support a current that only flows in the direction of the traveling wave. But our present work shows that, even in continuum, a negative current can be obtained, if the potential moves in discrete jumps in the system. Our findings can be tested in an experimental set up, where colloidal particles could be trapped in a narrow channel, and it would be quite interesting to see if a current reversal can be observed in a real system.

c) Proposed research activities for the coming year

1. Exploring fluctuation relation in Vicsek-like models of self-propelled particles.
2. Hydrodynamics of stochastic sandpiles with periodic as well as open boundaries.
3. Studies of of fluctuations in active lattice gases.
4. Exploring transport properties of interacting particles in the presence of a moving external potential.

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Supervision of Research / Students

a) Ph.D. Students

1. Arpan Krishna Mitra; Lagrangian and Hamiltonian formulation of fluid dynamics; To be submitted (work completed)
2. Shirsendu De; Fluids as fields; To be submitted (completed)

Publications

a) In journals

1. **Rabin Banerjee** and Pradip Mukherjee, Subtleties of nonrelativistic reduction and applications, Nucl.Phys. B938 1-21 (2019).
2. **Rabin Banerjee** and Pradip Mukherjee, Galilean gauge theory from Poincare gauge theory, Phys.Rev. D98, 124021 (2018).
3. **Rabin Banerjee**, Subir Ghosh and Arpan Krishna Mitra, Noncommutative fluid and Growing Modes of Inhomogeneity in (Newtonian) Cosmology, JCAP 10, 057 (2018).
4. **Rabin Banerjee**, Sumanta Chakraborty, and Pradip Mukherjee, Late-time acceleration driven by shift-symmetric Galileon in the presence of torsion, Physical Review D, 98, 083506 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. S.N.Bose and the development of quantum mechanics at the International Conference on Physics; February 2019; Physics Deptt. Dacca University; Invited Talk, 1 hr.
2. Newton's gravity from Galilean gauge theory at the Conference on Quantum field theory and Gravity; Dec 3, 2018; S.N.Bose Centre; Invited Talk, 1 hr.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Joint publications (Barasat Govt. College); Sl. No. 1, 2, 4; National
2. Joint publications (ISI, Kolkata); Sl. No. 3; National

Participation in Science Outreach program

Participated actively in several Bose 125 outreach programmes. Gave popular level talks on S.N.Bose and his role in the development of quantum mechanics. Specific mention may be made of:

One hour invited talk at the one day symposium organized by Lady Brabourne College, Kolkata (Nov. 2018)

A talk in Bengali on aspects of S.N.Bose's life and works at NATMO (National Atlas and Thematic Mapping Organisation) Kolkata, on National Science Day, 2019.

Significant research output / development during last one year

a) General research areas and problems worked on

Quantum field theory, Cosmology and Gravity

b) Interesting results obtained

In collaboration with Professor Pradip Mukheree I have developed a new method of coupling nonrelativistic theories to gravity. This has found applications in several areas. In particular, a dictionary was established that can take any given relativistic theory in a curved background to its corresponding nonrelativistic version. A nice result was the obtention of Newtonian gravity from Einstein's gravity. Yet another application was the demonstration of late time acceleration in a cosmological model involving torsion.

The effects of noncommutativity were studied in a fluid model leading to the presence of growing modes of inhomogeneity in Newtonian cosmology.

c) Proposed research activities for the coming year

I hope to continue the development of my ideas concerning the coupling of nonrelativistic theories to gravity. For instance, there is no well defined prescription for coupling the free nonrelativistic particle to gravity, that is completely general. Results are known for specific transformations only. Also, the passage to the flat limit is rather ambiguous. We expect to resolve these issues within our formalism.

Recently Newtonian cosmology has attracted attention. But the corresponding theory is far from developed. We hope to use our method to couple the Newton-Hooke particle to gravity that could form the basis for this type of cosmology.

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Supervision of Research / Students

a) Ph.D. Students

1. Subrata Dev; Effect of extra-cellular nutrient environment and intra-cellular biochemical conditions on the chemotactic performence of E.coli; Thesis submitted
2. Raj Kumar Sadhu; Force generation of actin filaments growing against a barrier; Thesis submitted
3. Shauri Chakraborty; Dynamics of propagating modes and characterization of ordering in coupled non- equilibrium systems; Under progress
4. Deepsikha Das; Periodically driven many particle system; Under progress
5. Shobhan Dev Mandal; Bacterial motility in complex environment; Under progress

Teaching activities at the Centre

1. Spring semester; Statistical Physics, Integrated PhD; 9 students

Publications

a) In journals

1. Raj Kumar Sadhu and **Sakuntala Chatterjee**, Actin filaments pushing against a barrier: Comparison between two force generation mechanisms, Eur. Phys. J. E 42, 15 (2019).
2. Subrata Dev and **Sakuntala Chatterjee**, Run-and-tumble motion with step-like responses to a stochastic input, Phys. Rev. E 99, 012402 (2019).
3. Shubhashis Rana, Sanchari Goswami, **Sakuntala Chatterjee**, and Punyabrata Pradhan, Current reversal in interacting colloids under time-periodic drive, PHYSICAL REVIEW E, vol. 98, 052142 (2018).

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. "Dynamics of coupled modes for sliding particles on a fluctuating landscape", in an international conference " UNIVERSALITY IN RANDOM STRUCTURES: INTERFACES, MATRICES, SANDPILES"; Jan 22, 2019; ICTS Bangalore; 14.1.19-8.2.19
2. "Effect of extra-cellular and intra-cellular environment on chemotactic performance of an E.coli cell" in 43rd Indian Biophysical Society Meeting; Mar 15, 2019; IISER Kolkata; 15-17 March 2019
3. "Run-and-tumble motion with steplike response to a stochastic input" in Indian Statistical Physics Community Meeting; Feb 14, 2019; ICTS Bangalore; 14-16 Feb, 2019
4. "Optimal methylation noise for best chemotactic performance of E. coli" in Soft Mattter Young Investigator Meet; May 23, 2018; Shimla; 23-25 May 2018

Membership of Committees

a) Internal Committee

1. TPSC coordinator

Sponsored Projects

1. Study of E.coli chemotaxis at the single cell level: a statistical physics approach, funded by DST; Duration : February 2017-February 2020.

Societal impact of Research

1. Manpower training

Significant research output / development during last one year

a) General research areas and problems worked on

Nonequilibrium Statistical Physics, Biological Systems

b) Interesting results obtained

Actin filaments pushing against a barrier: Comparison between two force generation mechanisms

To theoretically understand force generation properties of actin filaments, many models consider growing filaments pushing against a movable obstacle or barrier. In order to grow, the filaments need space and hence it is necessary to move the barrier. Two different mechanisms for this growth are widely considered in the literature. In one class of models, the filaments can directly push the barrier and move it, thereby performing some work in the process. In another type of models, the filaments wait till thermal fluctuations of the barrier position create enough space between the filament tip and the barrier, and then they grow by inserting one monomer in that gap. The difference between these two types of growth seems microscopic and rather a matter of modelling details. However, we find that this difference has an important effect on many qualitative features of the models. Our study highlights the importance of taking the details of the filament-barrier interaction into account while modelling the force generation properties of actin filaments.

Run-and-tumble motion with steplike responses to a stochastic input

We study a simple run-and-tumble random walk whose switching frequencies between run mode and tumble mode depend on a stochastic signal. We are interested in characterizing the effect of signaling noise on the long-time behavior of the random walker. We consider two different time-evolutions of the stochastic signal. In one case, the signal dynamics is an independent stochastic process and does not depend on the run-and-tumble motion. In this case we can analytically calculate the mean value and the complete distribution function of the run duration and tumble duration. In the second case, we assume that the signal dynamics is influenced by the spatial location of the random walker. For this system, we numerically measure the steady state position distribution of the random walker. We discuss some similarities and differences between our system and Escherichia coli chemotaxis, which is another well-known run-and-tumble motion encountered in nature.

Current reversal in interacting colloids under time-periodic drive

Using molecular dynamics simulations, we study particle transport in a system of interacting colloidal particles on a ring, where the system is driven by a time-dependent external potential, moving along the ring. We consider two driving protocols: (i) the external potential barrier moves with a uniform velocity and (ii) it moves in discrete jumps. The time-averaged (dc) particle current, which always remains positive in case (i) and interestingly reverses its direction in case (ii) upon tuning the particle number density and jump length. We also find a scaling form for the current in terms of number density, barrier velocity, barrier height, and temperature of the system.

c) Proposed research activities for the coming year

(A) Understanding bacterial motility in complex environment

(B) Effect of periodic drive on an interacting particle system

(C) Force generation by biopolymers

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Supervision of Research / Students

a) Ph.D. Students

1. Sumanta Kundu; Some Studies of Percolation Phenomena in Disordered Systems; Thesis submitted on 01 February, 2019
2. Chandreyee Roy; Some Studies Of The Brittle To Quasi-Brittle Transition In Fiber Bundle Models

Teaching activities at the Centre

1. Fall PHY 104; COMPUTATIONAL METHODS IN PHYSICS I; I.Ph.D First Semester; 14 students; Full course
2. Fall PHY 504; Computational Methods in Physics; Fifth Semester; 2 students; Full course

Publications

a) In journals

1. Sumanta Kundu, Nuno A. M. Araújo, and **S. S. Manna**, Jamming and percolation properties of random sequential adsorption with relaxation, Phys. Rev. E 98, 062118, 2018.

Conference / Symposia / Workshops / Seminars etc. organized

1. National Summer School on Statistical Physics; 04 – 15 June, 2018; S. N. Bose National Centre for Basic Sciences; 13 days
2. National Essay Competition; 05 – 06 September, 2018; S. N. Bose National Centre for Basic Sciences; 2 days

International Collaborations

1. "Jamming and percolation properties of random sequential adsorption with relaxation"; With professor Nuno A. M. Araújo; International

a) General research areas and problems worked on

Statistical Physics, Critical Phenomena

b) Interesting results obtained

The random sequential adsorption (RSA) model is a classical model in statistical physics for adsorption on two-dimensional surfaces. Objects are deposited sequentially at random and adsorb irreversibly on the landing site, provided that they do not overlap any previously adsorbed object. The kinetics of adsorption ceases when no more objects can be adsorbed (jamming state). Here, we investigate the role of post-relaxation on the jamming state and percolation properties of RSA of dimers on a two-dimensional lattice. We consider that, if the deposited dimer partially overlaps with a previously adsorbed one, a sequence of dimer displacements may occur to accommodate the new dimer. The introduction of this simple relaxation dynamics leads to a more dense jamming state than the one obtained with RSA without relaxation. We also consider the anisotropic case, where one dimer orientation is favored over the other, finding a non-monotonic dependence of the jamming coverage on the strength of anisotropy. We find that the density of adsorbed dimers at which percolation occurs is reduced with relaxation, but the value depends on the strength of anisotropy.

c) Proposed research activities for the coming year

Working on a model of electrical breakdown of a dielectric medium with quenched disorder. We are planning to study a phase transition analogous to the brittle to quasi-brittle transition in mechanical systems.

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Supervision of Research / Students

a) Ph.D. Students

1. Debabrata Ghorai; Holographic superconductors; Under progress
2. Ankur Srivastav; Applications of AdS/CFT duality to strongly coupled physical systems; Under progress
3. Rituparna Mandal; Quantum gravity as effective field theory; Under progress
4. Neeraj Kumar; Phase transitions in black holes; Under progress
5. Anish Das; Black hole shadows; Under progress (jointly with Prof. Biswajit Chakraborty)
6. Sourav Karar; Aspects of holographic entanglement entropy and complexity; Under progress
7. Swarup Saha; Response of bar detectors to gravitational waves in noncommutative space; Thesis submitted
8. Abhijit Dutta; Generalized uncertainty principle and black hole thermodynamics; Under progress
9. Saumya Ghosh; Quantum cosmology; Under progress
10. Diganto Parai; Holographic insulator/superconductor phase transitions; Under progress
11. Suchetana Pal; Meissner like effect in holographic superconductors; Under progress

Ph.D. Students outside the S. N. Bose Centre.

b) Projects of M.Sc./ M.Tech./ B.Tech./ Post B.Sc. student/s / Summer Training

1. Arnab Mukherjee; A brief review on Raychaudhuri equation; Jadavpur University

Teaching activities at the Centre

1. Spring semester; Electromagnetic Theory; Integrated PhD; 7 students
2. Autumn semester; Advanced Quantum Mechanics and Applications; Integrated PhD; 7 students
3. Spring semester; Electromagnetic Theory; Integrated PhD; 13 students

Publications

a) In journals

1. Ankur Srivastav, **Sunandan Gangopadhyay**, Analytic investigation of rotating holographic superconductors, Eur.Phys.J. C 79 (2019) 340.
2. Diganto Parai, **Sunandan Gangopadhyay**, Debabrata Ghorai, Holographic insulator/superconductor phase transition in higher dimensional Gauss-Bonnet gravity, Annals of Physics 403 (2019) 59-67.
3. Sukanta Bhattacharyya, **Sunandan Gangopadhyay**, Anirban Saha, Footprint of spatial noncommutativity in resonant detectors of gravitational wave, Class.Quant.Grav. 36 (2019) 055006.
4. **S. Gangopadhyay**, S. Karar, A. S. Majumdar, Holographic complexity of "black" non-SUSY D3-brane and the high temperature limit, Int. J. Mod. Phys. A 34, 1950003 (2019).
5. Sourav Karar, Debabrata Ghorai, **Sunandan Gangopadhyay**, Holographic entanglement thermodynamics for higher dimensional charged black hole, Nucl.Phys.B 938 (2019) 363.
6. Diganta Parai, Debabrata Ghorai, **Sunandan Gangopadhyay**, Noncommutative effects of charged black hole on holographic superconductors, Gen.Rel.Grav.50 (2018) 149.
7. Rituparna Mandal, Sukanta Bhattacharyya, **Sunandan Gangopadhyay**, Rainbow black hole thermodynamics and the generalized uncertainty principle, Gen.Rel.Grav. 50 (2018) 143.

8. Sourav Karar, **Sunandan Gangopadhyay**, Holographic complexity for Lifshitz system, Phys.Rev. D 98 (2018) 026029.
9. Ashis Saha, Madhav Modumudi, **Sunandan Gangopadhyay**, Shadow of a noncommutative geometry inspired Ayon Beato Garcia black hole, Gen.Rel.Grav. 50 (2018) 103.
10. Debabrata Ghorai, **Sunandan Gangopadhyay**, Conductivity of holographic superconductors in Born-Infeld electrodynamics, Nucl.Phys. B 933 (2018) 1-13.
11. **Sunandan Gangopadhyay**, Abhijit Dutta, Black hole thermodynamics and generalized uncertainty principle with higher order terms in momentum uncertainty, Adv.High Energy Phys. 2018 (2018) 7450607.

Lectures Delivered (Talks/ conferences/ seminars/ colloquia/ symposia)

1. A journey through General Theory of Relativity; Feb 27, 2019; Scottish Church College; 3 hours
2. S.N.Bose and his work; Nov 29, 2018; Aliah University; 1 hour

Membership of Committees

a) Internal Committee

1. Member of Canteen Committee

Awards / Recognitions

1. (India) Top Cited Author Award 2018 for the paper titled "Constraints on the Generalized Uncertainty Principle from black-hole thermodynamics", Euro. Phys. Lett. 112, 20006, (2015), IOP Publishing Top 1% most-cited papers in Physics published over the period of 2015–2017.

Fellow / Member of Professional Body

1. Visiting Associate of Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune from 2011-till date

Sponsored Projects

1. Implications of a minimum (Planck) length scale in particle physics, astrophysics, black hole physics and supersymmetry; DST SERB; 3 years; PI

Conference / Symposia / Workshops / Seminars etc. organized

1. Current Developments in Quantum Field Theory and Gravity; Dec 3, 2018; S.N. Bose National Centre for Basic Sciences; 5 days

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

1. Prof. Prashanta Panigrahi -IISER Kolkata; Sl. No. 1; International
2. Dr. Anirban Saha - West Bengal State University; Sl. No. 1; International

Participation in Science Outreach program

1. Delivered a 1 hour lecture On Prof. S.N.Bose's works in Sushil Kar College

Societal impact of Research

1. The social impact of my research would be to create human resource trained in Theoretical Physics. The human resource developed from this research can in principle serve any area of our society by using their analytical skills that they shall develop during their Ph.D. period. This would surely make our society a better place to live. Further, the impact of this theoretical research may help in developing technology in the future.

Significant research output / development during last one year

a) General research areas and problems worked on

Gauge/gravity correspondence and applications in condensed matter systems, quantum entanglement, signatures of noncommutativity of spacetime in gravitational waves, generalized uncertainty principle and its consequences

b) Interesting results obtained

I have been involved in investigating rotating holographic superconductors recently. Here I have found some interesting results along with my student. Here, we have investigated, in the probe limit, s-wave holographic superconductors in rotating AdS_3+1spacetime using the matching method as well as the Sturm-Liouville eigenvalue approach. We have calculated the critical temperature using the matching technique in such a setting and our results are in agreement with previously reported results obtained using the Sturm-Liouville approach. We have then obtained the condensation operators using both analytical methods. The results obtained by both these techniques share the same features as found numerically. We observe that the rotation parameter of the black hole affects the critical temperature and the condensation operator in a non-trivial way.

I have also analytically investigated the insulator/superconductor phase transition in the presence of d-dimensional Gauss-Bonnet AdS soliton background. Using the Sturm-Liouville eigenvalue method, we have calculated the value of the critical chemical potential \mu_C in any arbitrary dimension d\geq 5. We have then studied the condensation operator values and charge density in terms of the chemical potential and discussed the d=5,6,7 cases using our general results in d-dimensions. Our analytical results agree very well with the numerically findings in the literature.

I have also been involved in computing the holographic complexity of a 3+1-dimensional Lifshitz spacetime having a scaling symmetry. The change in the holographic complexity between the excited state and the ground state is then obtained. This is then related to the changes in the energy and the entanglement chemical potential of the system. The calculation is carried out for both the values of the dynamical scaling exponent z in the Lifshitz spacetime. The relations has a very similar form to the corresponding relation involving the change in entanglement entropy known to be an analogous relation to the first law of thermodynamics.

I have also been involved in computing the holographic complexity of a `black' non-susy D3-brane is computed. The difference in the holographic complexity between this geometry in the Fefferman-Graham coordinates and that of the AdS_5 geometry is obtained for a strip type subsystem. This is then related to the changes in the energy and the entanglement entropy of the system. We next take the high temperature limit of the change in complexity and observe that it scales with the temperature in the same way as the holographic entanglement entropy. The crossover of the holographic complexity to its corresponding thermal counterpart is similar to the corresponding crossover of the holographic entanglement entropy in the high temperature limit.

I have also proposed that gravitational wave data can be used as an effective probe of noncommutative structure of space and demonstrate how spatial noncommutativity modifies the responding frequency of the resonant mass detectors of GW and also the corresponding probabilities of GW induced transitions that the phonon modes of the resonant mass detectors undergo.

c) Proposed research activities for the coming year

1. I would like to investigate the magnetic behaviour of rotating holographic superconductors and also try to compute its conductivity analytically. The next thing which I would like to investigate in details is p-wave holographic superconductors using non-linear Born-Infeld Yang-Mills theory. I would also like to investigate the holographic complexity for boosted black brane for a strip-like subsystem. The idea is to compute the complexity for a subsystem chosen along and perpendicular to the boost direction. The Fisher information metric and the fidelity susceptibility are the quantities which I would like to compute. I would also like to compute the exact form of the bulk geometry emerging from a (1+1)-dimensional conformal field theory using the holographic principle. I would first consider the (2+1)-dimensional asymptotic AdS metric in Poincare coordinates and compute the area functional corresponding to the static minimal surface and obtain the entanglement entropy making use of the holographic entanglement entropy proposal. Using the results of the entanglement entropy for (1+1)-dimensional conformal field theory on an infinite line, on an infinite line at a finite temperature and on a circle and comparing with the holographic entanglement entropy, the proper structure of the bulk metric can be obtained.

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 15800 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, 25 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 and American Library 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 and e-mail intimation is given to all library members.

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. The report also includes h-index, citation received per year etc. It is being 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. 2018-19

1 Approximately 300 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 2017 and 1999 have been uploaded in the repository.

3. In the Financial Year 2018-19, the Fiction Section has been enriched by procuring 40 books of classic literature, novel, short story, biography and books of general interests.

4. 23 Hindi books are added in the Library collection the mentioned financial year.

5. Online Public Access Catalogue (OPAC) Corner has been made near the stack area of the Library. OPAC is accessible from any computer in the Centre connected to the campus LAN. However, this OPAC Corner helps the library users to search book instantly. OPAC searching window of Libsys is always open in this facility for the users. A comfortable seating arrangement and writing aids are available so that users can easily note the call number of desired book and search it in the stack quickly.

6. The newly submitted theses have been added in the PhD Thesis Collection Section. A new almirah is provided to rearrange the thesis volumes in chronological order.

Saumen Adhikari

Librarian – cum – Information Officer

ENGINEERING SECTION

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

A. CIVIL

i) **Construction of Integrated Hostel Building and Transit Quarters Complex (IHB&TQC) G +3 Phase-I:**

After the completion of Building upto G+3 floors, the Building has been made to use for various purposes. Various institutional programmes are being held in the newly furnished dining halls and other recently furnished rooms of the building. Besides, a part of the TRC office has also been accommodated in the Building.

Construction for further 2 floors will start shortly.

New Dining Hall

Furnished Hostel Room

ii) **S N Bose Archive:**

To preserve and display the artifacts and mementoes of Prof. S. N. Bose in a suitable environment, a new Archive has been developed at the Ground floor of Basundhara Building which has been made ready after providing all necessary decoration like False ceiling, Painting etc.

Interiors of Bose Archive

iii) **Construction of 2 Nos. Laboratory Buildings at SNBNCBS:**

Construction additional work space of about 10550 Sqft, to facilitate advanced research works, comprising of 2 nos. laboratories have been taken up. Out of these labs, the construction of Lab-1 including Air-conditioning and Electrical works has been completed and the Construction of Lab-2 is under progress. Besides, a smaller VSM extension lab has also been completed and has been put to use since September 2018.

Interiors of Lab No :2

iv) **Various Construction and renovation:**

a) A boundary wall with decorative MS Grills has been constructed around the Director's Bunglow.

b) Face-lifting of the main building by renewing of existing damaged external surface has been taken up for better aesthetics.

c) 9 nos. of toilet blocks in the Main Building, which became dilapidated during decade-long use have been completed and presently under use.

d) Internal painting of main Building, Guest House with necessary repair work has also been initiated.

v) **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 constructed.

vi) In addition to the above, the Engineering Section has to look after day to day upkeep, sweeping and cleaning Service for the Main Building, the Hostel Buildings, Guest House, Director's Bunglow, Sub-station and ESQ Building.

Illuminated facia of Main Building

Krishnachura Hostel Building

vii) The Centre has around 3.5 Km of Water pipeline network of various sizes spread all over the Campus and also in the buildings.

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

ix) 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 It.) all of which are maintained and regularly cleaned and periodically tested to ensure hygiene for the users. There is also an Iron-removal plant of 35,000 litre/hr. capacity efficiently operated and maintained to supply Iron-free potable water for the entire Campus.

x) RCC Overhead Water Tank: 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.

Different Shades of Horticulture

A few fruit trees and blossoms inside the Centre

B. Estate Management Activities:

Making allotment of hostel rooms and office spaces, maintaining all the records of the allotment of the offices, hostels, Guest houses, proper co-ordination during allotment and surrender of office/living areas by new entrants and outgoing students/PDRAs.

C. Electrical Work:

(a) **Lab 1 and Lab-2 Buildings :**

i) The entire electrical work including cable laying, internal electrical installation work has been carried out including electrical panels and cables laid within 450 M long newly constructed cable trench.

ii) Installation of VRF Air-conditioning system and Illumination of the buildings including State of Art Fire-fighting facilities have been taken up.

b) **Basundhara Building :**

i) Electrical, ornate Illumination, Ductable Air-conditioning system have been provided in the Bose Archive.

ii) Electrical, Illumination, Air-conditioning system have been installed in the newly developed Dining Halls.

b) **Revision of contract demand** :A long-pending requirement of increasing the contract demand of the

electrical load of the Centre has been implemented.

c) **Electrical facilities for Computer Centre Servers** : Supply, Installation, Testing & Commissioning of New Electrical Panel Boards & Additional Power Cable was completed, keeping in mind the future expansion and probable additional power demand at Computer Centre Servers.

(d) **Other Activities related to Electrical and Air-conditioning works :**

i) Modification and renewal of electrical installation work for various laboratories at the Centre were carried out.

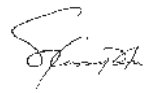
ii) Dedicated earthing system was installed at various laboratories to protect the sophisticated research equipments/instruments and also for the proper electrical installation.

(iii) Annual Maintenance, Preventive Maintenance and daily requirement of electrical support for all the Buildings and Campus of SNBNCBS

e) Maintenance of DG Sets : The Centre is having Two 500 KVA and one 320 KVA DG sets are maintained to provide energey power for back up which are being maintained to provide emergency power requirement in the event of main power failure.

f) Air-conditioning work and Lifts: The Centre is having approximately 450 Nos of Air-conditioners of various capacities and various makes which need to be maintained periodically and systematically to take care of the requirement of various labs as well as offices. Upkeep and maintenance work for 4 nos of 8-passenger lifts in the Centre are also looked after by the Engineering Section.

g) Water and Fire Pump: 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 for maintaining water supply of the Campus, there are 1 no. 75 HP Fire Pump, 1 no. 75 HP Diesel Driven Pump, 1 no. 5HP Jocky Pump for fire fighting of Krishnachure Building whice are being regularly maintained. In additiona to that there is 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 – D

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.

a) Academic Work - General research areas and problems worked on:

1. Perusing PhD in Computer Science and Engineering at National Institute of Technology, Meghalaya on Artificial Intelligence and machine learning.

Artificial Intelligence (AI) is poised to disrupt our world. With intelligent machines enabling high-level cognitive processes like thinking, perceiving, learning, problem solving and decision making, coupled with advances in data collection and aggregation, analytics and computer processing power, AI presents opportunities to complement and supplement human intelligence and enrich the way people live and work. My primary focus is to develop something some novel ideas which is fitting to our national mindset and targeted to serve Indian necessities as well for the environment. An effective education sector has the ability to transform a country through development of human resources and increased productivity. In the context of emerging countries particularly, levels of education and literacy of the population play an important role in development and overall transition to an advanced economy. The adoption of technology in education is improving, though not at the pace required. Strategy of utilize Artificial Intelligence in education sector can help us to develop predictive tools to inform pre-emptive action for students predicted to drop out of school in remote rural areas, automated rationalisation of teachers, as well as Customised professional development courses

2. Massive astronomical data pipeline using hybrid computing: A collaborative research work

The Proposed Real life fully automated fault-tolerant Massive Astronomical Data Movement and Processing using data pipeline through Multiscale Parallel Hybrid Computing.

The purpose of this research work is to help astrophysicists analyse the available massive data, by creating better algorithms and applying distributed computing technique.

3. Working on parallelizing big data analysis algorithms & performance analysis for health care data.

The Proposed work has described that even though usage of EMR has been underway for decades now; its performance is still questionable and prone to inefficiency.

Hadoop (**data analysis algorithms**) method has only been verified on a trivial cluster using a moderately small medical dataset dimension.

4. Working on Molecular computing in the field of Computer Science and Engineering with

i) **Molecular Computing:**

i) Using Molecular Dynamics (GROMACS, NAMD, and Quantum WISE) simulation to explore the modalities of Carbon Nanotubes.

ii) Hybrid Computing (CPU and GPU, Collaborative Research Work with- Institute of Bioinformatics and Applied Biotechnology (IBAB)): High-throughput DNA sequences 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.

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

The **Computer Services Cell (CSC)** is equipped with most modern and advanced infrastructure to provide a distributed computing environment to cater to the computing and networking needs of the inmates of the institute. The centre has a state of art Computer Network along with blade server and HPC infrastructure. The Computer Centre is providing Electronics class facility to scholars as part of their academic curriculum. It has a wide range of specialized licensed software mined in the software vault of the institute intranet for easy use of researchers. Frequently the centre organizes training programs on specialized software by specialized trainer for students, researchers and staffs. The computer centre also has many dedicated logical servers such as HPC, Mail server, Backup server, Intranet server, Webserver, Authentication server, Blog server, Antivirus server, etc. which provide dedicated resources to different applications.. 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. Sagar S. De, Ms. Deblina Mukherjee and Ms. Somasree Mal) and Jr. Assistant (Mr. Bijay Pramanik) had supported all day-to-day activities associated to the cell.

Centre's Computing Facilities are all facilities related to numerical and symbolic computations and communications and network access such as, but not limited to, e-mail and Internet access.CSC provides these to facilitate the research, education and administrative efforts of its members and staff. To this end the Computer Centre (CC) provides support in networking and information resources for its computing community. The Computer Centre undertakes security and monitoring measures to preserve the integrity and performance of its networking and computing resources.

The Computer Centre is solely responsible for keeping the Information and Communication Technology & Computation related facilities available to each and every member of the Centre.

These facilities are constantly upgraded to meet the evolving standards of Centre.

The Centre is also engaged in designing and facilitates the NKN Project with NIC. National Knowledge Network (NKN) project is aimed at establishing a strong and robust internal Indian network which will be capable of providing secure and reliable connectivity. Using NKN, all vibrant institutions with vision and passion will be able to transcend space and time limitations in accessing information and knowledge and derive the associated benefits for themselves and for the society towards ushering in a knowledge revolution in the country. NKN is intended to connect all the knowledge and research institutions in the country using high bandwidth / low latency network.

At the end of the academic year 2018-19, there were more than 900 users including faculty members, administrative staffs, PDRAs, and students. The Centre is backboned with a fibre 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, and 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 as well as CRAY supercomputer **TUE-CMS** project are also maintained by the cell. **New super computer (TRC CRAY)** has been installed as a part of **Technical Research Centre (TRC)**. 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
UNANST	480	12 TB	25
UNANST	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
CRAY	7808	255	50
TRC CRAY	960	120	30

CSC-AC Members:

Sr. Prof. Priya Mahadevan, Sr. Prof. Jaydeb Chakrabarti, Dr. Sakuntala Chatterjee, Dr. Soumen Mondal, Dr. Manoranjan Kumar, Deputy Registrar(Finance), Deputy Registrar(Administration) Campus Engineer cum Estate Officer, Mr. Sanjoy Choudhury.

CSC-WG Members:

Sr. Prof. Priya Mahadevan, Sr. Prof. Jaydeb Chakrabarti, Dr. Manoranjan Kumar, Mr. Sanjoy Choudhury, Ms. Nibedita Konar, Deputy Registrar(Administration) , Mr. Soumen Adhikari, Mr. Sanjoy Choudhury, Mr. Abhijit Ghosh, Mr. Sagar S. De, Ms. Deblina Mukherjee, Ms.Somasree Mal

Central Computational Resources (2018-19):

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

SNBNCBS is the top 22 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.

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

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.

At present Centre is using 1Gbps internet leased line from National Knowledge Network 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 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 include high performance cluster 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. The Centre has also installed sophisticated computing facility with extra mural research support include high performance cluster and recently a TRC Cray (24 node, 960 Core) has been installed with extramural support that allows 74 TF speed with 120 TB memory network security components, and set of applications.
8. S N Bose National Centre for Basic Sciences used NKN for high speed Internet, VPN, in addition to this NKN also helps connecting nodes to provide mail, messaging, DNS, Video portals and streaming etc.
9. 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.
10. Centre has procured pool of 256 public IP addresses along with Autonomous System Number (ASN) from Indian Registry for Internet Name and Numbers (IRINN) to reducing dependencies from ISPs and to increase network reliability. Through NKN, the Centre configured Linux based personal firewall, gateway for the Centre, VPN service has been revised and reconfigured in the dedicated gateway firewall supporting LAN as well as Journal access.
11. Centre Website had been developed for bilingual (English and Hindi) facility.
12. For day-to-day use, new web applications had been developed and deployed - to work within intranet.
13. Newly developed Administrative & Academic software has been deployed for keeping records of all the staffs and students of the Centre.
14. New Faculty Search cum Selection blog has been developed as per the recommendations of Faculty Search Committee.
15. Ticketing system for the Engineering and Estate Office Complaints had been introduced.
16. Hall booking application had been developed for reliable and sophisticated use with new feature.
17. Initiated and completed the development and implementation of almost all the system backup (Administration, Intranet, Web server, Mail server, Admission Server, Software Server) for any unusual accidental breakdown..
18. GeM, Govt. of Indian e-marketplace has been implemented for day to day purchasing of common goods and services.
19. Govt. of India Central Public Procurement Portal (CPPP) E-Procurement Portal has been implemented for the transparency of every new procurement through Centre.
20. Initiate Computational Training/Workshop for the Scientists and Researchers for the better way of utilizing Central Computational Resources.
21. 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.
22. LAN infrastructures has been upgraded to capable for higher bandwidth, Network racks had been rearranged for better arrangement and maintenance concern.
23. CSC configured Linux based new personal firewall, gateway for the centre.
24. Web applications such as New Admission Portal, Online Annual Appraisal application for Academic members, Radhachura booking, Guesthouse Billing, Visitor pass, Asset Manager, Online Confreg had been developed and deployed in the intranet server.
25. New Admission application has been modified to fulfil 2019 admission criteria.
26. BCRC blog has been created & upgraded.
27. 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.
28. Old CO2 and Dry Powder based fire extinguishers had been replaced with safer clean agent based fire extinguishers in the cell.

29. Comprehensive fire safety solution had been design and proposed for the entire computer centre, which will be implemented very soon.
30. CSC have started to do security audit of the Centre network and systems recently and identified various vulnerabilities -- and we plan to carry this out as a yearly exercise to ensure that the institute network and systems is less risk prone. Currently the Centre are also working on awareness of digital governance in the center.

Our Future Vision:

- Currently our goal is to build up the center of excellence in DATA Center for Research & Academic Infrastructure at the Centre. Centralized State-of-the–Art Data Centre for content storing

  The eventual goal is to establish our center as "the" center for excellence in research, education and training in India, and be counted as one of most productive research centers in the world.
- To up-grade the campus network to next generation IP Infrastructure. The proposed 10G solution will provide the latest state-of-the-art content delivery enabled multilayer switched campus network with very high reliability, scalability and performance to provide video/voice/data applications.(under Process)
- Design and Implementation of centralised SAN based storage solution for the Centre.
- Design and Implementation of redundant core switch with Next Generation IP Infrastructure features and enhanced back plane and uplink.
- Implementation of Multipoint-to-Multipoint Video Conferencing Solution.
- WiMax base secure wireless Internet Access in Campus
- Implementation UTM and Internet Policy Deployment (under Process)
- Upgrading Network Active/Passive Devices for Next Generation IP Infrastructure Application in a High availability mode and redundancy.
- Implementation of EDUROAM in the Campus.
- Complete Office Automation (ERP)Implementation (under Process)

sanjoy choudhury

Sanjoy Choudhury

In-charge, Computer Services Cell

PROJECT AND PATENT CELL

The Project and Patent Cell acts as the record keeping cell of the projects and patents of the Centre. It keeps tracks of the project proposals submitted for extramural funding, the sanctioned projects, the patent proposals filed and the patents granted to the Centre. The cell also keeps track of the manpower under projects. It also coordinates with the committee(s) constituted by the Authority for evaluating proposals to be filed for grant of patent and also takes care of the administrative matters during the filing of patents under the instruction of the inventor(s).

The members of the Project and Patent Cell during the year 2018-19:

- Prof. Samir Kumar Pal, Convenor
- Dr. Atindra Nath Pal
- Prof. Gautam Gangopadhyay
- Dr. Soumen Mondal
- Mr. Debashish Bhattacharjee, Deputy Registrar (Administration)
- Mr. Shiladitya Chatterjee, Deputy Registrar (Finance)
- Mr. Rupam Porel, O.A. – Representative from office of Dean(F)
- Ms. Chandrakana Chatterjee, O.A. – Representative from office of Students and Academic Section

The following table summarizes the details of the externally funded projects in the Centre, for the last five years:

Year	No. of Projects	Amount Received (Rs.)
2014-2015	32	4,72,26,394=00
2015-2016	38	4,71,50,347=00
2016-2017	35	4,05,49,788=00
2017-2018	32	3,04,37,606=00
2018-2019	31	4,62,15,993=00

Apart from this, the Centre has also received the TRC project during January 2016.

S. N. Bose National Centre for Basic Sciences
Projects during 2018-19

Project Title	PI / Co – PI	Funding Agency
"J.C. Bose Fellowship"	Prof. A.K. Raychaudhuri	DST SR/S2/JCB-17/2006
"Thematic Unit of Excellence on Computational Materials Science at the SNBNCBS, Kolkata"	Prof. Tanusri Saha Dasgupta	DST SR/NM/NS-29/2011
“Ramanujan Fellowship”	Dr. Manoranjan Kumar	DST (SERB) SR/S2/RJN-69/2012

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
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
CSIR/RB/13-14/116 – "Jump Dynamics in Ionic Liquids and non-exponential Relaxation"	Prof. Ranjit Biswas	(CSIR) 01(2811)/14/EMR-II
DBT/SKP/13-14/126-2 – "Nanogels: Biophysical characterization and Potential Biomedical Applications in Drug Delivery"	Prof. S.K. Pal	DBT BT/PR11534/NNT/28/766/2014
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
DST(SERB)/PP/14-15/141 – "Additivity Principle and Thermodynamic Characterization of Mass Transport Processes"	Dr. Punyabrata Pradhan	DST (SERB) EMR/2014/000719
DST/SJ/14-15/142 – "Solution phase conversion of Nanoscale Metals into Intermetallics: Efficient Catalysts for Chemoselective Organic Transformations"	Dr. Subhra Jana	DST SR/NM/NS-18/2014
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)
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
DST(SERB-NPDF)/JR/16-17/168 – "Investigation of electrostatic charge induction in Superconductors"	Dr. Jashashree Ray	DST (SERB-NPDF) PDF/2015/000684
DST(SERB-NPDF)/AG/16-17/169 – "Interface Physics in Multilayered Perovskite Complex Oxides"	Dr. Ankita Ghatak	DST (SERB-NPDF) PDF/2015/000179

DST/SC/16-17/170 – (SERB) – "Study of E.Coli Chemotaxis at the single cell level: A Statistical Physics Approach"	Dr. Sakuntala Chatterjee	DST (SERB) EMR/2016/001663
SERB(DST)/AKR/16-17/171 – "An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films"	Prof. A.K. Raychaudhuri & Dr. Barnali Ghosh Saha	DST (SERB) EMR/2016/002855
SERB/SKP/16-17/173 – "Exploration of key photoinduced dynamics in inorganic nanohybrids for enhanced biological activities"	Prof. S.K. Pal	SERB EMR/2016/004698
DST/MM/16-17/175 – "Design of biocompatible fluorescent magnetic nanoparticles for imaging the cancer cells and their possible theranostic use"	Dr. Madhuri Mandal Goswami	DST (KIRAN DIVISION) SR/WOS-A/CS-158/2016 (G)
DST(RFBR)/TSD/16-17/176 – "Topological phase transitions in quasi-two-dimensional magnets"	Prof. Tanusri Saha Dasgupta	DST INT/RUS/RFBR/P-274
SERB (DST)/SJ/16-17/180 – SERB Women Excellence Award - "Low Temperature Synthesis of Multi Metallic Inorganic Nanostructures for Catalysis and Chemical Sensing"	Dr. Subhra Jana	DST (SERB) SB/WEA-08/2016
SERB(DST)/JS/17-18/183 – Ramanujan Fellowship – "Developing Ferromagnetic Thin Film Hetero-structures viable for Spintronics based Devices and to Investigate the Magnetization Dynamics by means of Electrical Current and / or Laser Light"	Dr. Jaivardhan Sinha	DST (SERB) SB/S2/RJN-093/2014
SERB/BGS/17-18/189 – "Understanding the Growth of Vertically Aligned Nanowires or Nanotubes of Binary Oxides and Physics of Isotopic Fractionation of Gases by them"	Dr. Barnali Ghosh (Saha) – PI Dr. Manik Pradhan – Co. PI	SERB EMR/2017/001990
DST/PM/17-18/194 – "Novel Phenomena in Emergent Materials – Designing Emergent Materials"	Prof. Priya Mahadevan	DST DST/INT/JSPS/WS-19/2018
DST (SERB-NPDF)/SR/17-18/195 – "Interacting particles in a periodically moving external potential"	Dr. Shubhashis Rana	SERB (NPDF) PDF/2017/002896

DST (SERB-NPDF)/SS/17-18/196 – "Ultrafast Magnetization Dynamics: Use of 2D Layered Material as Non-magnetic Underlayer in Ferromagnetic / Non-magnetic Bilayer System"	Dr. Sumona Sinha	SERB (NPDF) PDF/2017/000519
DST/PM/17-18/204 – "Electronic, Structural and Optical Properties of Semiconductor Nanoplatelets"	Prof. Priya Mahadevan	DST DST/NM/NS/2018/18 (G)
DST (WOS-A)/MR/18-19/208 – "Theoretical Studies on Silicon Version of Metathesis Reactions for Searching New Efficient Synthetic Routes to Prepare Advanced Silicon Materials"	Dr. Mausumi Ray	DST (WOS-A) SR/WOS-A/PM-81/2017
SERB(DST)/TD/18-19/209 (NPDF) – "Remediation of pharmaceutical waste-products and other industrial pollutants using diverse metal-organic frameworks"	Dr. Tanushree Dutta	SERB (NPDF) PDF/2017/002448
SERB (DST – NPDF)/SB/18-19/217 – "Dynamics and Thermodynamics of Qubits in Spin Environments"	Dr. Samyadeb Bhattacharya	SERB (NPDF) PDF/2017/001333
INAE/SKP/18-19/219 – "Large Scale Validation / Field Trial of an Indigenous Non-Invasive Non-Contact Robust Portable Hand-held device for Accurate Measurement of Bilirubin Level, Haemoglobin Concentration and Oxygen Saturation in Neonatal Subject" Abdul Kalam Technology Innovation National Fellowship	Prof. S.K. Pal	INAE INAE/121/AKF
SERB(DST)/SC/18-19/221 – "Moleceular Mechanism of regulation of Rho GTPases through Phosphorylation of RhoGDI: Towards Unraveling the "Phosphorylation Code" Using Computational Methods"	Dr. Suman Chakrabarty	SERB ECR/2018/002903

*** Apart from this, the Centre has also received the TRC project during January 2016

Details the list of Postdocs, Scientists, DST INSPIRE Faculty, etc. under projects for the Year 2018-19

Sl.	Name	Designation	Project Name	P. I. of Project	Joined on	Appt. upto
1	Dr. Madhuri Mandal	Visiting Faculty Fellow	Design of biocompatible fluorescent magnetic nanoparticles for imaging the cancer cells and their possible theranostic use	Self	01.12.2017	30.11.2020
2	Dr. Alo Dutta	Young Scientist of SERB	Fast Track Scheme of DST Microwave Dielectric properties and collective vibrational modes of double perovskite oxides	Self	02.02.2015	01.08.2018
3	Dr. Jashashree Ray	National Post Doctoral Fellow	Investigation of electrostatic charge induction in Superconductors	Self	01.06.2016	31.05.2018
4	Dr. Ankita Ghatak	National Post Doctoral Fellow	Interface Physics in Multilayered Perovskite Complex Oxides	Self	01.06.2016	31.05.2018
5	Dr. Tanushree Dutta	National Post Doctoral Fellow	Remediation of Pharmaceutical Waste-products and Other Industrial Pollutants Using Diverse Metal-Organic Frameworks	Self	01.12.2017	Resigned on 31.03.2019
6	Dr. Sumona Sinha	National Post Doctoral Fellow	Ultrafast Magnetization Dynamics: Use of 2D Layered Material as Non-magnetic Underlayer in Ferromagnetic/Non-magnetic Bilayer System	Self	24.10.2017	23.10.2019
7	Dr. Shubhashis Rana	National Post Doctoral Fellow	Interacting particles in a periodically moving external potential	Self	01.09.2017	Resigned on 14.04.2019
8	Dr. Samyadeb Bhattacharyya	National Post Doctoral Fellow	Dynamics and Thermodynamics of qubits in spin environments	Self	30.10.2017	29.10.2019
9	Dr. Mausumi Ray	Women Scientist	Theoretical studies on silicon version of metathesis reactions for searching new efficient synthetic routes to prepare advanced silicon materials	Self	10.10.2018	Resigned on 26.04.2019
10	Dr. Dayasindhu Dey	Research Associate-I	Ramanujan Fellowship	Dr. Manoranjan Kumar	15.03.2018	14.09.2018
11	Dr. Subhra Jana	DST INSPIRE Faculty	Low Temperature Chemical Routes to Alloys, Intermetallics, and Hybrid Nanomaterials	Self	01.11.2012	Tenure ended on 30.10.2018
12	Dr. Soumendu Dutta	DST INSPIRE Faculty	Materials for Photocatalytic water splitting	Self	22.01.2013	Tenure ended on 21.01.2019

Sl.	Name	Designation	Project Name	P. I. of Project	Joined on	Appt. upto
13	Dr. Manik Banik	DST INSPIRE Faculty	Quantum nonlocality and its implications for device independent technology	Self	18.04.2018	17.04.2023
14	Dr. Tatini Rakshit	DST INSPIRE Faculty	Biophysical characterization of extracellular vesicles (EVs) using single molecule detection (SMD) methods: a potential non-invasive diagnostic tool	Self	01.11.2018	12.08.2023
15	Dr. Anup Ghosh	DST INSPIRE Faculty	Ultrafast 2D-IR spectroscopy on the structural dynamics of DNA/G Quadruplex	Self	01.01.2019	31.12.2023
16	Dr. Dipanwita Majumdar	DST INSPIRE Faculty	Optical and Electronic Properties of Metal Nanoparticles Decorated Transition Metal Dichalcogenides and Their Applications	Self	03.01.2019	16.04.2022

LIST OF STUDENTS UNDER PROJECT 2018-19

SL	NAME OF THE STUDENT	CURRENT DESIGNATION	PROJECT INSTRUCTOR	DEPT.	NAME OF THE PROJECT	JOINED ON	APPOINTMENT TENURE	DURATION OF THE PROJECT	APPOINTED UPTO	RESIGNED ON
1	Sudipta Chatterjee	Project - JRF	Arup K Raychaudhuri, Barnali Ghosh (Saha)	CMPMS	An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide flims (SERB)	27.11.2017	23.03.2020	23.03.2020	23.03.2020	
2	Anirban Goswami	Project - JRF	Arup K Raychaudhuri, Barnali Ghosh (Saha)	CMPMS	An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide flims (SERB)	11.12.2017	23.03.2020	23.03.2020	23.03.2020	
3	Sourav Kanthal	Project - JRF	Anjan Barman, Sudipta Bandyopadhyay,CU, Tanusri Saha Dasgupta (Coordinator)	CMPMS	Topological phase transition in quasi two-dimensional magnets	06.04.2018	25.07.2019	10.08.2019	25.07.2019	
4	Saikat Mitra	Project - JRF	Barnali Ghosh (Saha) & Manik Pradhan	CMPMS	Understanding the growth of vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them	27.12.2018	Up to the duration of the project based on the periodic / yearly assessment	05.07.2021	05.07.2021	
		DEPT. TOTAL		**4**						
1	Arnab Samanta	Project - JRF	Subhra Jana	CBMS	Solution Phase Conversion of Nanoscale Metals into Intermetallics: Efficient Catalysts for Chemoselective Organic Transformations	20.09.2016	Initially for One Year + Continued after evaluation	05.06.2019	02.06.2019	
2	Animesh Halder	Project - SRF	Samir Kumar Pal	CBMS	Nanogels: Biophysical Characterization and Potential Biomedical Applications in Drug Delivery	07.10.2016	10.05.2018	03.05.2019	10.05.2018	

SL	NAME OF THE STUDENT	CURRENT DESIGNATION	PROJECT INSTRUCTOR	DEPT.	NAME OF THE PROJECT	JOINED ON	APPOINTMENT TENURE	DURATION OF THE PROJECT	APPOINTED UPTO	RESIGNED ON
3	Suman Mondal	Project Assistant	Tatini Rakshit	CBMS	Biophysical Characterization of Extracellular Vesicle (Evs) using Single Molecule Detection (SMD) Methods: A Potential Non-invasive Diagnostic Tool	15.03.2019	6 Months	12.08.2023	14.09.2019	
		DEPT. TOTAL		**3**						
1	Dhiraj Tapader	Project - JRF	Punyabrata Pradhan	TS	Additivity Principle and Thermodynamic Characterization of Mass Transport Processes	06.06.2016	08.09.2018	08.09.2018	08.09.2018	
				1						
		TOTAL		**8**						

Patents Granted during 2018-19

Patent Granted:

1. Patent No.: 296270

   Application No.: 979/KOL/2011

   Date of Filing: 25/07/2011

   Date of Grant: 27/04/2018

   Tartrate functionalized La.67Sr.33MnO3 nanoparticles, its manner of manufacture and biomedical processes/devices involving the same

2. Patent No.: 306194

   Application No.: 1477/KOL/2009

   Date of Filing: 29/12/2009

   Date of Grant: 24/01/2019

   A rot resistant jute comprising silver nanoparticles

Patents Applied:

- (Cu)PP-TiO2 -based photo-catalytic converter of toxic metal ions in water including Cr (VI) (Prof. Samir Kumar Pal & others)
  Application No.: 201731027537 (Date: 02-08-2017) (Provisional)
  (Complete Specification filed with amended title: "Development of a Photo-Catalytic Converter for Potential Use in the Detoxification of Cr(VI) Metal in Water from Natural Resources" on 02-08-2018)
- Digital Camera based Spectrometric System for Point-of-Care Analysis of Ultra-Low Volume Whole Blood Sample
  (Prof. Samir Kumar Pal & others)
  Application No.: 201731029433 (Date: 19-08-2017) (Provisional)
  (Complete Specification filed on 10-08-2018)
- DNA-Based Fiber Optic Sensor for Direct In-Vivo Measurement of Oxidative Stress
  (Prof. Samir Kumar Pal & others)
  Application No.: 201731029434 (Date: 19-08-2017) (Provisional)
  (Complete Specification filed on 14-08-2018)
- A Non Invasive Screening System for Neonatal Hyperbilirubinemia
  (Prof. Samir Kumar Pal & others)
  Application No.: 201831029718 dated 07-08-2018
- A Method of Fabricating Monodispersed Silica Nanoflowers For Carbon Dioxide Adsorption
  (Dr. Subhra Jana)
  Patent Application No: 201831048458 dated 20/12/2018

Samir Kumar Pal

Convenor, Project & Patent Cell

TECHNICAL RESEARCH CENTRE

The **Technical Research Centre (TRC)**, funded by Department of Science & Technology, Ministry of Science & Technology, Government of India at S. N. Bose National Centre for Basic Sciences has been launched on 1st January 2016. The aim is to establish an innovation cum translational research centre within the S. N. Bose National Centre that would build harnessable science and technology platforms by leveraging on its existing core strength in materials science and spectroscopic techniques. The primary focus is in the areas of:

- Health care
- Environment and mitigation of hazards in work environment
- Food and agro sector
- Innovations for low cost instrumentation
- Material and alloy industry

Project Investigators :

Prof. A.K.Raychaudhuri (Nodal Officer); Prof. Tanusri Saha Dasgupta (on-lien); Prof. Samir K. Pal; Prof. P. K. Mukhopadhyay; Prof. Jaydeb Chakrabarti; Prof. Ranjit Biswas; Dr. Barnali Ghosh Saha; Dr. Manik Pradhan; Dr. Soumen Mondal, Dr. Subhra Jana, Dr. Atindra Nath Pal and Dr. Suman Chakrabarti.

Manpower and Resources

- Number of Scientists (C & D): 06
- Number of Project Students: 17
- Number of Project Assistants: 08
- Number of Project Officers: 02

Research Activities

A. Activities undertaken under TRC Project:

- A non-invasive breath analysis system and process based detection of peptic ulcer disease, non-ulcerous dyspepsia and Helicobacter Pylori infection.
- Flexible paper-based highly sensitive sensor for ammonia gas detection by visual effects (color change).
- Low cost portable thermal analyzer (working range 30 °C – 400 °C).
- Development of Non-Contact Optical Device for Clinical Diagnostics of Anaemia, Jaundice and Oxygen Deficiency (AJO Device,अजेय) at Resource Limited Point of Care Setting.
- High sensitivity (better than 1 ppm) and high selectivity hazardous gas sensor for unheated operation with remote read-out capability.
- Hand held device for detection of adulteration of milk.
- Synthesis of hybrid nanocomposites for use as efficient carbon dioxide capture materials.
- Piezoelectric energy generation and harvesting using PZT nanowires.
- Development of light operated micro-actuator using photomechanical actuation of specific alloys.
- Analysis of adulterated milk using NIR spectroscopic method.
- Computational materials design.

B. Transfer of Technology (TOT) to an Industry under TRC :

- A low-cost non-contact machine for anemia detection to a start-up Company for scaling-up.
- A Non-contact Optical Device for Clinical Diagnostics of Jaundice.
- A Non-contact Optical Device for Oxygen Deficiency

C. Number of Patents (submitted during 01.01.2018-31.12.2018)

Sl.	Title	Inventors	Country	File No.	Status
1	A Method to Grow Single Crystalline Sharp Nano Needles of Piezoelectric Materials Ankita Ghatak, Snehamoyee Hazra	Barnali Ghosh, A. K. Raychaudhuri,	India	201931015347	Filed on 16/04/2019

Sl. No.	Title	Inventors	Country	File No.	Status
2	A Method of Fabricating Monodispersed Silica Nanoflowers for Carbon Dioxide Adsorption	S. Das, A. Samanta and S. Jana	India	201831048458	Filed on 20/12/2018
3	A non invasive screening system for neonatal Hyperbilirubinemia	S. K. Pal	India	201731040027	Filed on 07/08/2018
4	A paper based ammonia gas selective sensor with electrical read out and a method for manufacturing the same	A. Maity, A.K. Raychaudhuri and B. Ghosh	India	201831001993	Filed on 17/01/2018

D. Research Publication :

1. S. Roy Moulik, A. Maity, P. Chakraborty, M. Pradhan and Barnali Ghosh, Evidence of Isotope Selective Diffusion of Ambient CO2 Gas in WO3 Nanostructures, Journal of Physical Chemistry C 123, 2573–2578 (2018)
2. A. Modak and S. Jana, Advancement in Porous Adsorbents for Post-Combustion CO2 Capture, Microporous and Mesoporous Materials 276, 107–132 (2019)
3. A. Modak, S. Das, D. K. Chanda, A. Samanta and S. Jana, Thiophene Containing Microporous and Mesoporous Nanoplates for Separation of Mercury from Aqueous Solution, New Journal of Chemistry 43, 3341 – 3349 (2019)
4. A. Halder, D. Nafday, P. Sanyal and T. Saha-Dasgupta, Computer predictions on Rh-based double perovskites with unusual electronic and magnetic properties, npj Quantum Materials (a Nature research journal) 3, 17 (2018)
5. S. Das, A. Samanta, G. Gangopadhyay and S. Jana, Clay Based Nanocomposites as Recyclable Adsorbent toward Hg(II) Capture: Experimental and Theoretical Understanding, ACS Omega 3, 6283-6292 (2018)
6. A. Maity and B. Ghosh, Fast response paper based visual color change gas sensor for efficient ammonia detection at room temperature, Scientific Reports, 8:16851 (2018)
7. C. Samanta, R. Ram Ghimire and B. Ghosh, Fabrication of Amorphous Indium–Gallium–Zinc–Oxide Thin-Film Transistor on Flexible Substrate Using a Polymer Electrolyte as Gate Dielectric, IEEE Transactions on Electron Devices, 65, 7 (2018)
8. A. Samanta, S. Das and S. Jana, Exploring ß-FeOOH Nanorods as Efficient Adsorbent for Arsenic and Organic Dyes, ChemistrySelect 3, 2467-2473 (2018)

E. Societal Impacts & Industrial Collaboration :

Several projects on translational research, as given in the following, have been undertaken under TRC which may have enormous societal benefits.

- A low-cost non-contact machine for anemia detection is being used under National Anemia Mission for large-scale clinical trial for induction in "Anemia Mukt Bharat".
- The instrument developed for the screening of "Neonatal Jaundice" is being used in several Govt. Hospital for large-scale clinical trial.
- A low-cost high sensitive "Fuoride Sensor (FeFlu)" is under large-scale validation in Rajasthan, one of the most fluoride affected state in India.
- Non-invasive detection of Helicobacter Pylori Infection using human breath analysis - under clinical trials using Breath samples from a Hospital in Kolkata

Contract research from a Scotland-based international hospital received for the non-invasive diagnostics of "Urine Bladder Cancer". An Indian industry has already joined hand in the project and invested for scaling-up of the instrument.

F. Knowledge Based Services at TRC:

The TRC offers knowledge based services in a number of highly sophisticated instrumentation, ranging from several spectroscopic to microscopic instruments. For more information, please visit our web site : **http://newweb.bose.res.in/departments/TRC**

G. Industry Academia Meet -2018 :

S N Bose National Centre for Basic Sciences, Kolkata organized a one-day intense event, **"Industry Academia Meet -2018"**, under the banner of **Technical Research Centre**. The dignitaries from industry and academia shared their ideas and experiences that would help in building up the roadmaps for the fruitful translational research environment in the near future. Notable speakers from various sector of industry and academia discussed the key ideas and challenges of the translational research of the country in the current days' scenario. An exhibition cum demonstration of newly developed prototypes/technologies of the Centre was organized. The Meet was enlightened by the gracious presence of 120 participants from Industry and academia.

Soumen Mondal

Member Secretary, LMC of TRC

Technical Research Centre

A new milestone in the Annals of S. N. Bose Centre. The Centre has done its first Technology transfer under Technical Research Centre (TRC) project through National Research Development Corporation (NRDC) to a start up company for 'Non-invasive Quantitative Estimation of Haemoglobin in Blood'.

TECHNICAL CELL

Technical cell was established in the year of 2008 to maintain the central experimental facilities of SNBNCBS which can be availed by any researcher from our Centre as well as from other institutions / laboratories. The details of the available experimental facilities and the terms and conditions for using these facilities are mentioned in the website: https://newweb.bose.res.in/facilities/TechnicalCell/. The activities of Technical Cell during April 2018 - March 2019 are reported in the following sections:

I. Equipments available under Technical Cell

Sl. No.	Name of the equipment
1.	Transmission electron Microscope (TEM) with other attachments
2.	Thermo Gravimetry/Differential Thermal Analyzer (TG-DTA)
3.	Dynamic Light Scattering(DLS)
4.	Clean Room
5.	E-beam evaporator
6.	ICP-RIE
7.	Dual beam FIB/SEM
8.	Wire Bonder
9.	Mask aligner
10.	3K Resistivity Measurement Setup
11.	Field Emission Scanning Electron Microscopy(FESEF) Quanta FEG 250
12.	X-ray Diffraction
13.	UV Visible Spectrometer(UV-VIS)(2600)
14.	UV Visible Spectrometer(UV-VIS)(2450)
15.	Circular Dichroism (CD)
16.	Chemical Lab
17.	Ellipsometer
18.	Viscometer
19.	Densitymeter
20.	X-ray Diffractometer(XRD) (PANalytical X-PERT PRO)
21.	Pulsed Laser Deposition (PLD) Unit
22.	Helium Leak Detector
23.	Liquid Nitrogen and Gases for Laboratory Use
24.	Fluorescence spectrometer(Fluorolog)
25.	Spevtrofluorometer(Fluoromax)
26.	Fourier Transform Infrared Spectrometer(FTIR)
27.	Mechanical workshop, Sputtering Unit, Millipore Water
28.	Vibrating Sample Magnetometer (VSM)
29.	Differential Scanning Calorimeter (DSC)
30.	Atomic Force Microscope (AFM)

II. Support to research activities:

About 97 students of our centre used the above experimental facilities extensively for their Ph.D. thesis work. 10 students completed their M.Sc. / M.Tech. Project work and 19 students did their summer project performing extensive work in technical cell. About 86 external users used our Technical cell facilities for their research work.

III. Support to the teaching activities of SNBNCBS

Students of our IPhD programme used our technical cell facilities and performed some of the experiments on X-ray diffraction, UV – VIS spectroscopy, Differential Scanning Calorimetry as a part of their Advanced Experimental course (PHY 391). They did their project works as a part of IPhD curriculum.

IV. Outreach Programme

a) C. K. Majumder Memorial Summer Workshop 2018 was held during 28th May to 7th June 2018. 30 nos. 3rd year Physics (Hon.) students from different colleges participated in the workshop and performed experiments on X-Ray diffraction, differential scanning calorimetry, Scanning Electron microscope, Vibrating sample Magnetometer of technical cell.

b) Scientific visit of students from North East: 56 students visited our center on 17th March 2019 and the instruments of Technical Cell were demonstrated to them.

c) Visit of students from St. Xaviers College:

Students from St. Xaviers College visited various laboratories of Technical cell on 9th April 2018

V. Major maintenance and up-gradation:

Name of Instrument	Major repair and up- gradation
1. FESEM	1) Ultragrade 19 oil & EMF 10 Oil Mist Filter 2) Pirani Gauge for gold coater system
7. PLD	1. KrF premix gas for Coherent Excimer Laser 2. P/N 280686 HV-TRIGGER PCB for Excimer Laser
11. Millipore	ELIX/OSM DC Pump W/Support, ZF3000000 (RO motor for Millipore system)
12. HRTEM	Emitter Low Drift Mono (FEG Source)
13. FLUOROLOG-3	1) Xenon arc lamp power housing
2. FTIR	1) FTIR Cells
3. CD Spectrometer	Mirrors (M0,M1) and xenon arc lamp

VI. Utilization of equipment

ITEM	USAGE (time & hour)	UP TIME %	DOWN TIME %	No. of external users
PLD	1340	90%	10%	NIL
FESEM	900	90%	10%	18
XPERT PRO	910	90%	10%	8
MINI XRD	229	90%	10%	NIL
TG/DTA	510	92%	8%	18
DSC	460	80%	20%	12
AFM	647	85%	15%	19
VSM	1320	90%	10%	11
TEM	300	25%	75%	NIL

VII. Revenue Generation

Some revenue was generated from the external users for using the facilities of Technical Cell.

Kalyan Mandal
(Chairman, 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 operated one fixed day in a week and is also available on other days on demand.

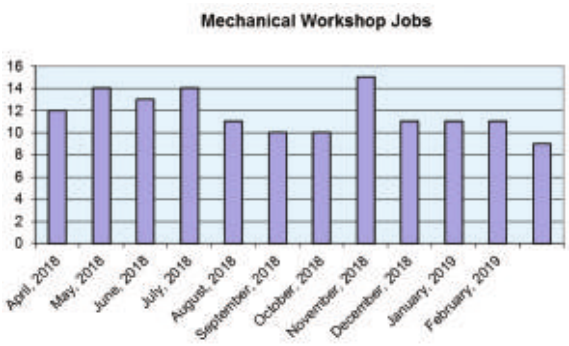
The specialized vacuum glass (and quartz) ampouling facility is a special feature in the glass blowing section. Since this facility is not available for any institute nearby, we get demands from them, like CRNN, Calcutta University. The mechanical section has a lathe machine, a milling machine and a 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 – 141, glass blowing section – 138 inside and 58 jobs for outside. Month wise breakups are given below: (2018 – 2019).

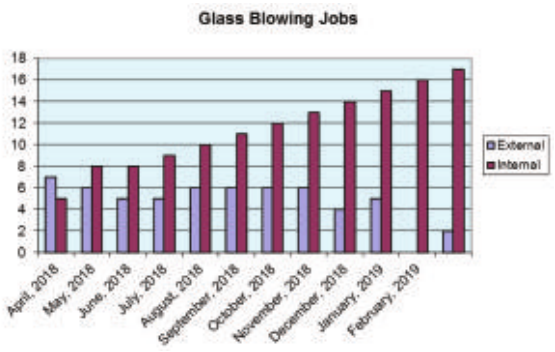
Month wise breakups are given below: (2018 – 2019)

Atindra Nath Pal

Atindra Nath Pal

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. It houses 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 air-conditioned and are fully furnished and have attached baths. All rooms are provided with basic amenities like hot and normal water, telephone, television with DTH connection, electric kettle etc. The Guest House is Wi-Fi enabled. A state-of-the-art display unit is installed in the Guest House Front Desk displaying various information about the Guest House. These guests' rooms spread across the ground floor, first floor and second floor of the Bhagirathi building. Presently, the third floor of the building comprising of twenty two (22) single bedded rooms and four (4) double bedded rooms are being 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 state-of-the art 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. Various academic and research organizations also use the guest house for accommodating their visitors from abroad.

Shohini Majumder
Registrar

RECREATIONAL AND CULTURAL PROGRAMMES

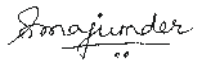
Throughout the year, the Centre organized number of cultural events involving participation of all staff and students of the Centre.

On the occasions of the 70th Republic Day on 26th January 2019 the Director hoisted the national flag and 72nd Independence Day on 15th August 2018, Prof. Archan S Majumdar, Officiating Director & Dean (Faculty) hoisted the national flag in the premises of the Centre. On both the occasions, national anthem was sung by students and staff present and parade was performed by the Centre's security personnel. Small replicas of national flags were distributed amongst the members present in the gathering and snacks and sweets were distributed.

'Muktangan' organised the following events:-

- "International Day of Yoga" on 21st June 2018 under the aegis of 'Muktangan' featuring an Interactive Yoga Session conducted by Mr. Lokesh Mishra, Yoga Instructor & Therapist where the staff and students participated enthusiastically.
- Fresher's Welcome - 2018 was organised by 'Muktangan' on 12th September 2018.
- An Intra-Institute Table Tennis Tournament was organised both Singles & Doubles on 3rd and 4th April 2018.
- An Intra-Institute Carrom Tournament 2018 was organised both Singles & Doubles on 18th and 19th December 2018.
- To celebrate the closing ceremony of 125th Birth Anniversary of Prof. S. N. Bose a 5 Km Marathon was organised on 31st December 2018 by the Sports Activity Group of 'Muktangan' in which staff and students of the Centre took part along with participants from the nearby research institutes. The event was a grand success.
- An Intra- Institute Cricket Tournament 2019 was organised on 12th & 13th January 2019 followed by an Intra-Institute Football Tournament 2019 on 30th and 31st January 2019. Both the events were successfully organised.
- A one-day Intra Institute knock out Singles & Doubles Badminton Tournament was organised on 16th March 2019.

On the occasion of 'BOSE FEST 2019' held during 7th March 2019 – 8th March 2019, Family Day was celebrated in the evening of 8th March 2019. On 8th March 2019, the Performing Arts Group of 'Muktangan' organised an in-house programme comprising of individual and group performances of singing, recitation and a dance drama "Poojarini". 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 7th March 2019, renowned Bengali Singer Raghab Chatterjee entertained the audience with his popular numbers. Art & Photography Fest along with Oral & Poster presentations by the students were also held during the above period.



Shohini Majumder
Registrar

PUBLICATIONS

LIST OF PUBLICATIONS 2018-2019

Journal Publications

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Other Publications

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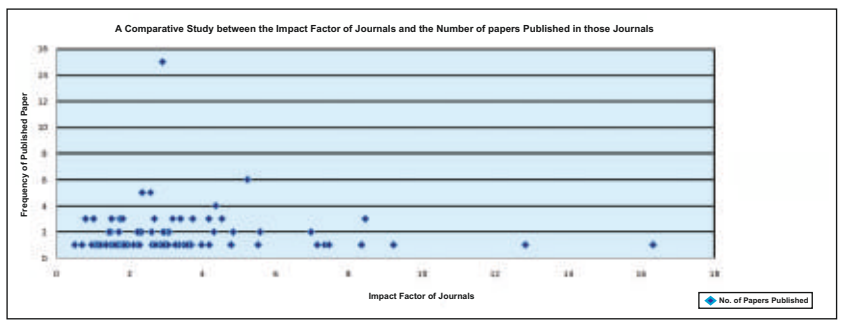
Total number of Other Publications : 17

IMPACT FACTOR FOR PUBLICATIONS IN THE FINANCIAL YEAR 2018-19

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
1	2D Materials	7.343	1	7.343
2	ACS Applied Bio Materials	New	1	New
3	ACS Applied Electronic Materials	New	1	New
4	ACS Applied Materials & Interfaces	8.456	3	25.368
5	ACS Applied Nano Materials	New	1	New
6	ACS Central Science	12.837	1	12.837
7	ACS Energy Letters	16.331	1	16.331
8	ACS Omega	2.584	5	12.92
9	ACS Photonics	7.143	1	7.143
10	Advances in High Energy Physics	1.74	1	1.74
11	Advances in Space Research	1.746	3	5.238
12	Annals of physics	2.267	2	4.534
13	Astrophysical Journal	5.58	2	11.16
14	Beilstein Journal of Nanotechnology	2.968	1	2.968
15	Biomedical Physics & Engineering Express	NA	1	NA
16	Carbon	7.466	1	7.466
17	Chemical Engineering Journal	8.355	1	8.355
18	Chemical Physics	1.822	3	5.466
19	Chemical Physics Letters	1.901	1	1.901
20	Chemistry-An Asian Journal	3.698	1	3.698
21	ChemistrySelect	1.716	2	3.432
22	ChemElectroChem	3.975	1	3.975
23	ChemPhysChem	3.077	2	6.154
24	Classical and Quantum Gravity	3.487	1	3.487
25	Crystal Research & Technology	1.09	1	1.09
26	Electronic Journal of Differential Equations	0.71	1	0.71
27	European Physical Journal C	4.843	2	9.686
28	European Physical Journal E	1.686	1	1.686
29	European Physical Journal Plus	2.612	2	5.224
30	Flexible and Printed Electronics	1.069	1	1.069
31	General Relativity and Gravitation	1.515	3	4.545
32	IEEE Sensors Journal	3.076	2	6.152
33	IEEE Transactions on Electron Devices	2.62	1	2.62

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
34	IEEE Transactions on Magnetics	1.467	2	2.934
35	Intermetallics	3.353	1	3.353
36	International Journal of Applied and Computational Mathematics	NA	1	NA
37	International Journal of Biological Macromolecules	4.784	1	4.784
38	International Journal of Geometric Methods in Modern Physics	1.022	3	3.066
39	International Journal of Modern Physics A	1.153	1	1.153
40	International Journal of Non-linear Mechanics	2.225	1	2.225
41	Isotopes in environmental and health studies	1.51	1	1.51
42	Journal of Alloys and Compounds	4.175	3	12.525
43	Journal of Analytical Atomic Spectrometry	3.646	1	3.646
44	Journal of Applied Physics	2.328	2	4.656
45	Journal of Biosciences	1.823	1	1.823
46	Journal of Breath Research	3	1	3
47	Journal of Chemical Physics	2.84	1	2.84
48	Journal of Chemical Sciences	1.496	1	1.496
49	Journal of computer-aided molecular design	3.25	1	3.25
50	Journal of Cosmology and Astroparticle Physics	5.524	1	5.524
51	Journal of Fluorescence	1.913	1	1.913
52	Journal of Geometric Mechanics	0.97	1	0.97
53	Journal of Geometry and Physics	0.806	3	2.418
54	Journal of Low Temperature Physics	1.491	2	2.982
55	Journal of Luminescence	2.961	2	5.922
56	Journal of Magnetism and Magnetic Materials	2.683	3	8.049
57	Journal of Mathematical Chemistry	1.81	1	1.81
58	Journal of Mathematical Physics	1.355	1	1.355
59	Journal of Photochemistry and Photobiology A: Chemistry	3.261	1	3.261
60	Journal of Physical Chemistry B	2.923	2	5.846
61	Journal of Physical Chemistry C	4.309	2	8.618
62	Journal of Physics A: Mathematical and Theoretical	2.11	1	2.11
63	Journal of Physics D: Applied Physics	2.829	1	2.829
64	Journal of Physics: Condensed Matter	2.711	1	2.711
65	Journal of the Optical Society of America B	2.284	1	2.284
66	Langmuir	3.683	1	3.683
67	Laser Physics	1.231	1	1.231
68	Materials Letters	3.019	1	3.019

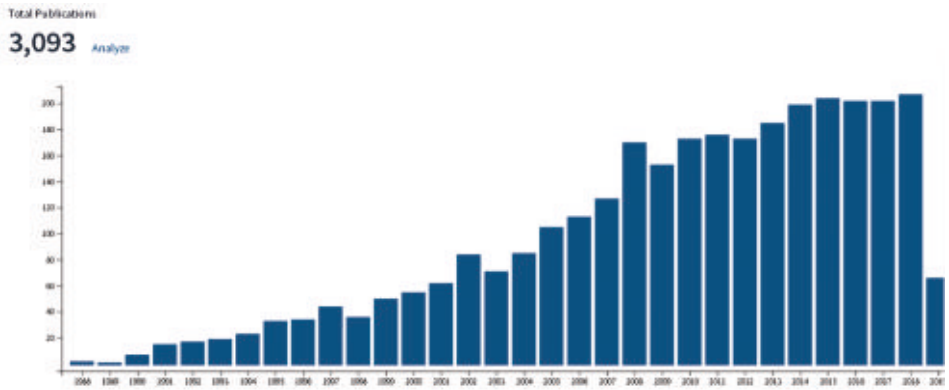
Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
69	Materials Research Express	1.449	2	2.898
70	Microporous and Mesoporous Materials	4.182	1	4.182
71	Modern Physics Letters A	1.367	1	1.367
72	Monthly Notices of the Royal Astronomical Society	5.231	6	31.386
73	Nanoscale	6.97	2	13.94
74	Nanotechnology	3.399	3	10.197
75	New Journal of Chemistry	3.069	1	3.069
76	Nuclear Physics B	3.185	3	9.555
77	Optics Communications	1.961	1	1.961
78	Pharmaceutical and Chemical Journal	0.51	1	0.51
79	Physica B	1.874	1	1.874
80	Physica Status Solidi A	1.606	1	1.606
81	Physical Chemistry Chemical Physics	3.567	1	3.567
82	Physical Review A	2.907	15	43.605
83	Physical Review Applied	4.532	3	13.596
84	Physical Review B	3.736	3	11.208
85	Physical Review D	4.368	4	17.472
86	Physical Review E	2.353	5	11.765
87	Physical Review Letters	9.227	1	9.227
88	Physical Review Materials	2.926	1	2.926
89	Quantum Information Processing	2.222	2	4.444
90	Results in Physics	3.042	1	3.042
91	Review of Scientific Instruments	1.587	1	1.587
92	RSC Advances	3.049	1	3.049
93	Science Advances	NA	1	NA
94	Scientific Reports (Nature Publishing Group)	4.525	2	9.05
95	Soft Matter	3.399	2	6.798
96	Superlattices and Microstructures	2.385	1	2.385
97	Universal Journal of Physics and Application	NA	1	NA
	TOTAL	**298.286**	**169**	**529.36**

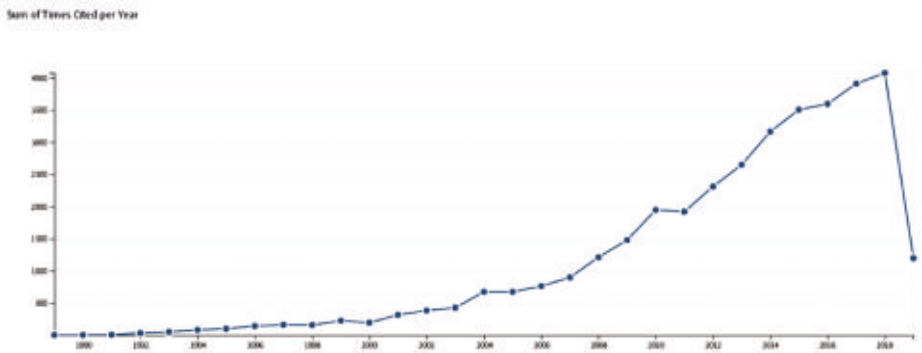


Research Publication Status

Citation Report (On 31st March, 2019)

Time span = All years. Database =SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.





No. of Publications	:	3093
Sum of the Times Cited	:	36269
Sum of Times Cited without self-citations	:	28574
Citing Articles	:	23422
Citing Articles without self-citations	:	21305
Average Citations per Item	:	11.73
h-index	:	69

Total no. of Papers published	Total no. of Citation received	Citations per paper	Citation per year*	h-index
3093	**36269**	**36269 / 3093= 11.73**	**36269 / 32 =1133.41**	**69**

* Year of establishment of the Centre is 1986. Citations received from 1988 to 2019 = 32 years

Source	:	web of science
Address	:	(SN Bose Natl Ctr Basic Sci OR Satyendra Nath Bose Natl Ctr Basic Sci OR SNBNCBS)
Prepared by	:	Dr. Saumen Adhikari, Librarian – cum – Information Officer

ACCOUNTS

Satyendra Nath Bose National Centre for Basic Sciences
Block JD, Sector-III, Salt Lake, Kolkata – 700 106

BUDGET SUMMARY 2018-2019

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the year 2018-2019. (*Figure in Lakhs*)

	Actuals 2017-2018	Budget Estimate 2018-2019	Revised Estimate 2018-2019
Plan	4008.89	3756.94	4148.83
TOTAL	4008.89	3756.94	4148.83

* Sanctioned by DST Plan **Rs.** 3491.02 released as under:

Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/SAL/003/2018/1	08.05.2018	62078000.00
2	AI/SNB/SAL/003/2018/2	28.06.2018	83805000.00
3	AI/SNB/SAL/003/2018/3	27.09.2018	41149000.00
4	AI/SNB/SAL/003/2018/4	30.01.2019	33006000.00
5	AI/SNB/GEN/003/2018/1	07.05.2018	29631000.00
6	AI/SNB/GEN/003/2018/2	28.06.2018	40002000.00
7	AI/SNB/GEN/003/2018/3	27.09.2018	9545000.00
8	AI/SNB/GEN/003/2018/4	22.02.2019	13972000.00
9	AI/SNB/CAP/003/2018/1	08.05.2018	5124000.00
10	AI/SNB/CAP/003/2018/2	28.06.2018	6917000.00
11	AI/SNB/CAP/003/2018/3	27.09.2018	18486000.00
12	AI/SNB/CAP/003/2018/4	22.02.2019	5387000.00
TOTAL (PLAN)			**Rs. 349102000.00**

INDEPENDENT AUDITOR'S REPORT

To the Governing Body of Satyendra Nath Bose National Centre For Basic Sciences

Opinion

We have audited the financial statements of Satyendra Nath Bose National Centre For Basic Sciences, ("the Centre") which comprise the Balance sheet as at March 31st 2019, Income & Expenditure Account, Receipts and Payments Account for the year ended on that date along with notes to the financial statements, including accounting policies. In our opinion, the accompanying financial statements give a true and fair view of the financial position of the Centre as at March 31, 2019 and the surplus for the year then ended in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI).

Basis for Opinion

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Association in accordance with the Code of Ethics issued by ICAI and we have fulfilled our other ethical responsibilities in accordance with the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Emphasis of Matter

Without qualifying our opinion we draw attention to the following:

i. Note No. 2.2.1 of schedule 25 regarding physical verification of fixed assets.

ii. Centre has invoked bank guarantee of Dustan G Engineers Pvt. Ltd. For non-performance of work and amount realized Rs. 12,70,577 has been shown under other liabilities of Current Liabilities in Schedule 7. We are given to understand that adjustment will be made in the accounts in the subsequent year after obtaining legal opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation of these financial statements that give a true and fair view of the state of affairs, results of operations of the Centre in accordance with the accounting principles generally accepted in India. 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. Those charged with governance are responsible for overseeing the Centre's financial reporting process.

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

For Mookherjee Biswas & Pathak
Chartered Accountants
FRN No 301138E

(S. P. Mukherjee)
Partner
Membership No 010807
UDIN
Place: Kolkata
Date: 21.08.2019

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

BALANCE SHEET AS AT 31ST MARCH 2019

Amount (₹)

	Schedule	Current Year	Previous Year
FUNDS AND LIABILITIES			
Capital / Corpus Fund	1	1036922087.13	1048440173.65
Reserves And Surplus	2	-	
Earmarked/Endowment Funds	3	523723174.73	477094566.55
Secured Loans And Borrowings	4		
Unsecured Loans And Borrowings	5		
Deferred Credit Liabilities	6		
Current Liabilities And Provisions	7	80433185.31	99768471.31
TOTAL		**1641078447.17**	**1625303211.51**
ASSETS			
Fixed Assets	8	684029447.36	729966880.69
Investments-From Earmarked/Endowment Funds	9	172387641.38	156885405.38
Investments - Others	10	595324963.00	624873415.00
Current Assets, Loans, Advances Etc.	11	189336395.43	113577510.44
Miscellaneous Expenditure			
(to the extent not written off or adjusted)			
TOTAL		**1641078447.17**	**1625303211.51**
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date

Date:21.08.2019
Place: Kolkata

For Mookherjee Biswas & Pathak
Chartered Accountants
FRN: 301138E

(S P Mukerjee)
Partner
Membership no:010807 UDIN

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 2019 Amount (₹)

	Schedule	Current Year	Previous Year
INCOME			
Income from Sales/Services	12	7382797.00	6317259.00
Grants/Subsidies	13	313188000.00	321977000.00
Fees/Subscriptions	14		
Income from Investments (Income on Investment)	15		
from earmarked/endowment Funds transferred to Funds)			
Income from Technology Transfer & Contract Project	16	1200000.00	
Interest Earned on fixed deposit	17	25375118.00	16393426.00
(including interest on loan to employees)			
Other Income	18	461888.20	527117.00
Increase/(decrease) in stock of finished goods and	19		
works-in-progress			
TOTAL (A)		**347607803.20**	**345214802.00**
EXPENDITURE			
Establishment Expenses	20	139814819.00	153121589.00
Other Administrative Expenses etc.	21	175463456.13	162195523.71
Expenditure on Grants, Subsidies etc.	22		
Interest earned on fixed deposit and savings bank		25094860.00	16126971.00
(Refundable to Govt of India,DST)			
TOTAL (B)		**340373135.13**	**331444083.71**
Balance being excess of Income over Expenditure(A-B)		7234668.07	13770718.29
Prior period adjustments (Credit)		1244535.74	453237.00
Transfer to/from Capital Fund			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED			
TO CORPUS/CAPITAL FUND		**8479203.81**	**14223955.29**
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date

For Mookherjee Biswas & Pathak
Chartered Accountants
FRN: 301138E

Date:21.08.2019
Place: Kolkata

(S P Mukerjee)
Partner
Membership no:010807 UDIN

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 2019

Amount (₹)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Expenses :**		
a) Cash in hand	25681.00	36760.00	a) Establishment Expenses	170295699.00	123730495.00
b) Bank Balances :			b) Administrative Expenses	139190830.07	155367087.83
I. In current accounts(Schd 11A)	17173847.86	36822075.95	c) Maintenance	48265361.00	33758024.00
ii. In deposit accounts			**II. Payments made against funds for**		
Schedule - 10	624873415.00	568248614.00	**various Projects**		
Schedule - 11A	35689927.00	16134692.00			
iii. Savings accounts (Schd 11A)	21980563.01	18466138.76	**III. Investments and deposits made**		
iv. Remittance-in-Transit			a) Out of Earmarked/Endowment	22603185.00	107084939.00
II. Grants Received			b) CPWD Deposit and NBCC Deposit		
a) From Government of India			c) Bank Gurantee & LC A/C	3024500.00	0.00
-For the year			d) Out of Own Fund	38911998.00	123187790.00
-For the previous year	592441737.00	427503787.00			
b) From State Government			**IV. Expenditure on Fixed Assets &**		
c) From Other sources (details)			**Capital Work-in-Progress**		
(Grants for capital & revenue exp.			a) Purchase of Fixed Assets	144238520.00	63986926.05
To be shown separately)			b) Expenditure on Capital Work-in-Progress	8029954.00	4444758.00
			V. Refund of surplus money/Loans		
III. Interest Received			a) To the Government of India		
a) On Bank deposits	9956510.00	2809326.00	b) To the State Government		
			c) To other providers of funds		
IV. Other Income	5399232.00	6883496.00	**VI. Finance Charges (Interest)**		
V Amount Borrowed			**VII. Other Payments**	80470326.67	36517612.11
VI. Any other receipts	16081330.16	3180848.15	**VIII. Closing Balances**		
			a) Cash in hand	32161.00	25681.00
VII. Amount transferred from	1222485.00	267735328.00	b) Bank Balances :		
Current Account/Savings					
Account to Deposit Account.			i. In current accounts(Schd 11A)	67299391.44	17173847.86
			ii. In deposit accounts		
VIII. Amount transferred from	80048597.00		Schedule - 10	595324963.00	624873415.00
Deposit Account to Savings					
Account & Currect Account.			Schedule - 11A	26326381.00	35689927.00
			iii. Savings accounts(Schd.11A)	60880054.85	21980563.01
			iv. Remittance-in-Transit		
	1404893325.03	**1347821065.86**		**1404893325.03**	**1347821065.86**

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 31.03.2019 Amount (₹)

	Current Year		Previous Year	
SCHEDULE 1 -CAPITAL FUND:				
Balance as at the beginning of the year	1048440173.65		1018592287.34	
Add:Interest earned on FD and savings bank(adjustable) for last year	16126971.00		10529332.00	
Add : Contributions towards Corpus/Capital Fund	35914000.00		75085000.00	
Less:Depreciation for the year	72038261.33		69990400.98	
Add : Surplus during the year	8479203.81		14223955.29	
		1036922087.13		1048440173.65
BALANCE AS AT THE YEAR - END		**1036922087.13**		**1048440173.65**
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 31.03.2019

Amount (₹)

	FUND-WISE BREAK UP					TOTAL	
SCHEDULE 3 - EARMARKED/ ENDOWMENT FUNDS	**Technical Research Centre**	**Project Fund**	**Retirement Benefits Fund**	**Staff Medical Fund**	**Corpus Fund**	**Current Year**	**Prev. Year**
a) Opening balance of the funds	303850284.52	59077972.65	94753057.00	6148355.00	13264897.38	477094566.55	511238579.43
b) Additions to the Funds							
I) Donations/grants/Contributions	182089000.00	66775078.00	3726398.00	636960.00	1550661.00	254778097.00	49667282.00
ii) Income from investments made on account of funds	12151740.00	3523161.00	8376279.00	494105.00	184595.00	24729880.00	33633503.00
iii) Other additions -Provision during the year					-		
TOTAL (a + b)	498091024.52	129376211.65	106855734.00	7279420.00	15000153.38	756602543.55	594539364.43
c) Utilisation/Expenditure towards objectives of funds							
I) Capital Expenditure							
Fixed Assets	121059598.00	11379871.00	-	-		132439469.00	52345037.05
Others							
Total							
ii) Revenue Expenditure							
Salaries, Wages and allowances etc.	11920398.00	24833390.00	-	-		36753788.00	24749609.00
Rent							
Other Administrative expenses							
Other Payments	18645733.90	10903278.92	15266920.00	494105.00		45310037.82	40350151.83
iii) Adjustment (Interest) Interest Refunded to DST				18376074.00			
TOTAL (c)	**170001803.90**	**47116539.92**	**15266920.00**	**494105.00**	**-**	**214503294.82**	**117444797.88**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**328089220.62**	**82259671.73**	**91588814.00**	**6785315.00**	**15000153.38**	**523723174.73**	**477094566.55**

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2019

Amount (₹)

	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 31.03.2019 — Amount (₹)

	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:				
a) Acceptances secured by hypothecation of capital equipment and other assets				
b) Others				
TOTAL	Nil	Nil	Nil	Nil

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2019 — Amount (₹)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS				
A. CURRENT LIABILITIES				
1. Acceptances				
2. Sundry Creditors:				
a) For Capital expenditure	3424270.00			6267288.00
b) Others - Revenue expend including TRC	26528648.00			54024139.00
3. Othert Liabilities	5108903.88			4032924.00
4. Deposit from Contractors (including Project & TRC)	10831285.00			10397119.88
5. Deposit from Students	1714500.00			1542500.00
6. Deposit from Contractual Employees	1819148.00			1700776.00
7.Provident Fund Account (Payable)	472.00			425390.00
8.Project Overhead Fund	5911098.43			5251363.43
9.Interest earned on fixed deposit	25094860.00			16126971.00
and savings bank (adjustable)				
TOTAL (A)	**80433185.31**			**99768471.31**
B. PROVISIONS				
1. For Taxation				
2. Gratuity				
3. Superannuation/Pension				
4. Accumulated Leave Encashment				
5. Trade Warranties/Claims				
6. Others - Adhoc Bonus				
TOTAL (B)	**0.00**	**-**		**0.00**
TOTAL (A + B)	**80433185.31**			**99768471.31**

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 31.03.2019

SCHEDULE 8 - FIXED ASSETS

Amount (₹)

DESCRIPTION	GROSS BLOCK				DEPRECIATION				NET BLOCK	
	Cost/valuation As at begin. of the year	Additions during the year	Adjustment during the year	Cost/valuation at the year-end	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
A. FIXED ASSETS:										
1. LAND:										
a) Freehold										
b) Leasehold	10950654.60	0.00		10950654.60	0.00	0.00		0.00	10950654.60	10950654.60
2. BUILDINGS:										
a) On Leasehold Land	417037785.86	20250658.00		437288443.86	53078183.53	6608974.77		59687158.30	377601285.56	363959602.33
b) On Freehold Land										
c) Ownership Flats/Premises										
d) Superstructures on Land not belonging to the entity										
3. PLANT MACHIENRY & EQUIPMENT	472777916.22	10847083.00		483624999.22	334921392.17	58286865.49		393208257.66	90416741.56	137856524.05
4. VEHICLES	321013.00	721186.00		1042199.00	321011.00	53261.56		374272.56	667926.44	2.00
5. FURNITURE, FIXTURES	39117690.22	1982491.00		41100181.22	28172580.14	2708952.15		30881532.29	10218648.93	10945110.08
6. OFFICE EQUIPMENT	5819929.29	170869.00		5990798.29	3514787.46	831355.38		4346142.84	1644655.45	2305141.83
7. COMPUTER & LAN INSTALLATION	72564419.44	3452447.00		76016866.44	65001709.00	2549075.78		67550784.78	8466081.66	7562710.44
8. ELECTRIC INSTALLATIONS	11699040.00	0.00		11699040.00	5539693.98	999776.20		6539470.18	5159569.82	6159346.02
9. LIBRARY BOOKS	231564763.11	7602905.00		239167668.11	69586478.05	0.00		69586478.05	169581190.06	161978285.06
10. TUBEWELLS & W.SUPPLY	-	-		0.00	-	-		0.00	0.00	-
11. OTHER FIXED ASSETS	84225.55	0.00		84225.55	80014.27	0.00		80014.27	4211.28	4211.28
TOTAL OF CURRENT YEAR	**1261937437.29**	**45027639.00**	**0.00**	**1306965076.29**	**560215849.60**	**72038261.33**	**0.00**	**632254110.93**	**674710965.36**	**701721587.69**
PREVIOUS YEAR	**1129150170.29**	**132787267.00**		**1261937437.29**	**490225448.62**	**69990400.98**		**560215849.60**	**701721587.69**	**683007814.80**
B. CAPITAL WORK IN PROGRESS	**28245293.00**	**8029954.00**	**26956765.00**	**9318482.00**					**9318482.00**	**28245293.00**
TOTAL (A + B)	**1290182730.29**	**53057593.00**	**26956765.00**	**1316283558.29**	**560215849.60**	**72038261.33**	**0.00**	**632254110.93**	**684029447.36**	**729966880.69**

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 31.03.2019

Amount (₹)

	Current Year	Previous Year
SCHEDULE 9 - INVESTMENTS FROM		
EARMARKED/ENDOWMENT FUNDS		
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Project Fund Investment (Fixed Deposit with Union Bank of India & IOB)	53848010.00	48592470.00
7. Retirement Benefit Fund Investment (Fixed Deposit with IOB)	101905864.00	92789961.00
8. Staff Medical Fund Investment (Fixed Deposit with IOB)	5777995.00	5342523.00
9. Corpus Fund Investment (Project) (Fixed Deposit with IOB)	10855772.38	10160451.38
TOTAL	**172387641.38**	**156885405.38**
SCHEDULE 10 - INVESTMENTS - OTHERS		
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	142053297.00	185390074.00
(including Project Overhead Investment)		
Fixed Deposit with Union Bank of India	158850194.00	177338135.00
7. Technical Research Centre fund investment	294421472.00	262145206.00
(Fixed Deposit with Union Bank of India & IOB)		
TOTAL	**595324963.00**	**624873415.00**

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 31.03.2019 Amount (₹)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.				
A. CURRENT ASSETS:				
1. Inventories:				
a) Stores and Spares		66894.14		33691.57
2) Cash balances in hand		32161.00		25681.00
3) Bank Balances:				
a) With Scheduled Banks:				
On Current Accoutns:				
Indian Overseas Bank (CA-089302000000220)	52224297.82		11953444.84	
Indian Overseas Bank (CA-089302000000273)	12308994.46		5070477.12	
Union Bank of India (CA-460901010034252)	2766099.16	67299391.44	149925.90	17173847.86
On Deposit Accounts for LC&BG:				
Indian Overseas Bank (CA-089302000000220)	11840183.00		9419568.00	
Indian Overseas Bank (SB-089301000018596 TRC)	10544518.00		25353179.00	
Indian Overseas Bank (CA-089302000000273 PROJECT)	3941680.00	26326381.00	917180.00	35689927.00
On Savings Accounts:				
Indian Overseas Bank(SB-089301000010662 UNAST)	1030917.00		542784.00	
Indian Overseas Bank(SB-089301000012029 SYNC.)	741833.30		716446.00	
Indian Overseas Bank(SB-089301000011479 NANO TECH)	526040.00		508026.00	
Union Bank of India (SB-460901110050013)	7987205.93		7177027.49	
Axis Bank (SB-775010100024408)	26975822.00		2474087.00	
Axis Bank (SB-775010100017860)	1682.00		1625.00	
Union Bank of India(SB-460902010097273 TRC)	8545271.80		2207745.00	
Indian Overseas Bank (SB- 089301000018598 TRC)	15071282.82	60880054.85	8352822.52	21980563.01
5. Remittance - in - Transit				
6. Post Office-Savings Accounts				
TOTAL (A)		**154604882.43**		**74903710.44**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEUDLES FORMING PART OF BALANCE SHEET AS AT 31.03.2019 Amount (₹)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS,				
ADVANCES ETC.(Contd.)				
B. LOANS, ADVACNES AND OTHER ASSETS				
1. Loans:				
a) Staff including HBA ,Vehicle &PC Advance		1724551.00		1539991.00
(includes Project A/c)				
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	438840.00		438840.00	
b) GST payment			3492.00	
c) Others	315650.00		404048.00	
d) Contractors & Suppliers	4407461.00	5161951.00	3008608.00	3854988.00
3. Income Accrued:				
a) On Investments from Earmarked/				
Endowment Funds(Including Project & TRC)	16620322.00		25478371.00	
b) On investmetns - Others	10476071.00		7800450.00	
c) Income tax (TDS) Refundable	70000.00	27166393.00	0.00	33278821.00
4. Sundry Debtors - Ezerex Health Tech Pvt.Ltd		590000.00		-
5. Security Deposit		88618.00		88618.00
TOTAL (B)		**34731513.00**		**38673800.00**
TOTAL (A + B)		**189336395.43**		**113577510.44**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 12 - INCOME FROM SALES/SERVICES		
1) Income from Sales		
a) Sale of Finished Goods		
b) Sale of Raw Material		
c) Sale of Scraps	3225.00	0.00
2) Income from Services		
a) Guest House Rent	2006500.00	1822900.00
b) Hostel Charges (Recovery of HRA)	3117813.00	2685404.00
c) Equipment Utilisation Fees	404803.00	394926.00
d) Hostel Maintenance Fees	1345221.00	1004024.00
e) Project Overhead	437960.00	282000.00
f) Income from BSNL	33275.00	73205.00
g) Course Fees	14000.00	17000.00
h) Seminer Hall Rent	20000.00	28900.00
i) Dining Hall Rent	0.00	8900.00
j) Car Deduction	0.00	0.00
TOTAL	**7382797.00**	**6317259.00**
SCHEDULE 13 - GRANTS/SUBSIDIES		
(Irrevocable Grants & Subsidies Received)		
1) Central Government	313188000.00	321977000.00
2) State Government(s)		
3) Government Agencies		
4) Institutions/Welfare Bodies		
5) International Organsations		
6) Others		
TOTAL	**313188000.00**	**321977000.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 14 - FEES/SUBSCRIPTIONS		
1) Entrace Fees		
2) Annual Fees/Subscriptions		
3) Seminar/Program Fees		
4) Consultancy Fees		
5) Others		
TOTAL	**Nil**	**Nil**

Note: Accounting Policies towards each item are to be disclosed

Amount (₹)

	Investment from Earmarked Fund		Investment - Others	
SCHEDULE 15 - INCOME FROM INVESTMENTS	**Current Year**	**Previous Year**	**Current Year**	**Previous Year**
(Income on Invest. From Earmarked/Endowment				
Funds transferred to Funds)				
1) Interest				
a) On Govt. Securities				
b) Other Bonds/Debentures				
2) Dividends:				
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 INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 16 - INCOME FROM TECHNOLOGY TRANSFER & CONTRACT PROJECT		
1. Income from Technology Transfer	700000.00	0.00
2. Income from Contract Project	500000.00	0.00
3. Others	0.00	0.00
TOTAL	**1200000.00**	**0.00**

Amount (₹)

	Current Year	Previous Year
SCHEDULE 17 - INTEREST EARNED		
1) On Term Deposits:		
a) With Scheduled Banks	24931853.00	16056277.00
b) With Institutions		
c) Others		
2) On Savings Accounts:		
a) With Scheduled Banks	163007.00	70694.00
b) Post Office Savings Accounts		
c) Others		
3) On Loans:		
a) Employees/Staff (Interest on HBA etc.)	280258.00	266455.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	**25375118.00**	**16393426.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 18 - OTHER INCOME		
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	461888.20	527117.00
TOTAL	**461888.20**	**527117.00**
SCHEDULE 19 - INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS		
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		
a) Salaries and Wages	123324678.00	113006276.00
b) Other Allowances and Bonus	0.00	0.00
c) Contribution to Provident Fund	4038424.00	8582428.00
d) Contribution to Retirement Benefits Fund	3474832.00	24317111.00
e) Staff Welfare Expenses (Medical)	2455554.00	3158497.00
f) Contribution to NPS	2826205.00	2521015.00
g) Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	3695126.00	1536262.00
TOTAL	**139814819.00**	**153121589.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.		
a) Extended Visitors Programme.(Including Seminars & Workshops)	22224194.00	17849904.00
b) Meeting Expenses	1062167.00	1313161.00
c) Library General Expenses	128870.00	180614.00
d) Electricity and Power	36197454.00	38272262.00
e) Laboratory Expenses	11182577.55	13012905.00
f) Insurance	85608.00	3266.00
g) Repairs and Maintenance	57024227.43	45304867.75
h) TPSC Programme	1073815.00	1060039.00
i) Parliamentary Committee Meeting Exps	1352225.00	0.00
j) Vehicles Hire Charges	2457104.00	2339062.00
k) Postage, Telephone and Communication Charges	1298219.00	1240625.00
l) Printing and Stationary	1193841.00	1218221.00
m) Travelling and Conveyance Expenses	2709889.00	4274630.00
n) Contingency to Faculty	337390.00	82822.00
o) Auditors' Remuneration	47200.00	47200.00
p) Bank Charges	683178.67	193330.11
q) Professional Charges (Legal Charges)	864047.00	402050.00
r) Staff Training & Welfare	162282.00	236496.00
s) Patent & Trademark	332050.00	1,01,450.00
t) Integrated Ph.D.	32876737.00	32936717.00
u) Hindi Programme	80424.00	161301.00
v) Advertisement and Publicity	732417.00	894556.00
w) Others	557894.48	848338.85
x) Municipal Tax	141388.00	141388.00
z) Bose Archive Expenses	658257.00	80318.00
TOTAL	**175463456.13**	**162195523.71**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2019 Amount (₹)

	Current Year	Previous Year
SCHEDULE 22 - EXPENDITURE ON GRANTS, SUBSIDIES ETC.		
a) Grants given to Institutions/Organisations		
b) Subsidies given to Institutions/Organisations		
TOTAL	**Nil**	**Nil**
SCHEDULE 23 - INTEREST		
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 LC/BG 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.

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 106

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.

SCHEDULE 25

CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Centre not acknowledged as debts – Rs. Nil (Previous year Rs. Nil).

1.2 In respect of

- Bank guarantees given by/on behalf of the Centre – Rs.1,05,00,000.00 against 100% margin money by way of fixed deposit (Previous year Rs.86,73,658.00). Interest earned on such deposit is accounted on cash basis.
- Letters of Credit opened by Bank on behalf of the Centre and Project– Rs. 1,58,26,381.00 (Previous year Rs.2,70,16,269.00) against 100% margin money. Interest earned on such deposit is accounted on cash basis.
- Bills discounted with banks – Rs. Nil (Previous year Rs. Nil).

1.3 Disputed demands in respect of:

Income-tax	Rs. Nil (Previous year Rs. Nil)
Goods & Services Tax	Rs. Nil (Previous year Rs. Nil)

1.4 In respect of claims from parties for non-execution of orders, but contested by the Centre – Rs.Nil (Previous year Rs.Nil).

NOTES ON ACCOUNTS

2.1.1 Capital Commitments:

Estimated value of contracts remaining to be executed on capital account(2 nos lab under TRC) and not provided for Rs. 2,12,56,839/-. (Previous year Rs. 29,16,667).

2.2.1 Physical verification of fixed assets has been entrusted to an out side agency and verification is under process, adjustments if any will be given in the accounts on the submission of the Physical Verification Reports.

2.2.2 Capital work-in-progress as on 1st April, 2018 was Rs.2,82,45,293/- addition during the year is Rs.80,29,954/- totaling to Rs.3,62,75,247/- an amount of Rs.2,69,56,765/- has been capitalized, leaving balance of Rs.93,18,482/- which has been carried forward.

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 106

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.

Unadjusted Travelling advances:-

Name	Amount	Remarks
Amrtya Sarkar	Rs. 63000/-	Unadjusted since 2012-13
Venkata Kamalakar	Rs. 70000/-	Unadjusted since 2008-09

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) Value of Imports Calculated on C.I.F basis :

(Amount in Rs.)

	Current Year	Previous Year
- Capital Goods	6,57,34,323/-	4,87,27,247 /-
- Consumables	25,29,487 /-	13,65,136 /-

ii) 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

iii) Earnings:

Value of Exports on FOB basis: Nil

2.5 Corresponding figures for the previous year have been re-grouped/re-arranged, wherever necessary.

Kolkata
Dated: 21.08.2019

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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