CENTRE FOR BASIC SCIENCES 1986

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SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

ANNUAL REPORT 2021-22

Annual Report
2021-2022

Satyendra Nath Bose National Centre for Basic Sciences

Annual Report 2021-2022
Satyendra Nath Bose National Centre for Basic Sciences

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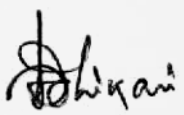
Bengal Eco Intelligent Park
Tower-1, 13th Floor, Unit 29
Block EM-3, Salt lake Sector-V, Kolkata – 700091
Contact : +91 98311 54106 | 91-90510 52358
E-Mail : cygnus.kolkata@gmail.com

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 12th 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 have 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 6th time the Annual Report is translated and typed in Hindi within the Centre. The Office Assistant (Hindi), Ajay Kumar Shaw has given sincere fatigueless effort to translate the entire Annual Report in Hindi and library staff - Amit Roy, 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

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MESSAGE FROM THE **DIRECTOR**

It gives me immense pleasure to present the Annual report of the Satyendra Nath Bose National Centre for Basic Sciences for the year 2021-2022. This special year coincides with the yearlong celebration of the 75th year of Independence, the Azadi ka Amrut Mahatsav. To mark this yearlong celebration initiated by the Govt. of India on the 15th of August, 2021, S.N. Bose National Centre for Basic Sciences announced a series of talks on lives and works of scientists in the pre-Independence era. These talks, given by various domain experts, brought alive the human dimensions of the scientists in their aspirations and achievements, in their moments of triumph and disappointments which will remain as an important document for the future generation.

This year, still under the effect of COVID-19 pandemic, had witnessed the struggle to achieve the mandated objectives of the Centre in carrying out cutting edge basic research and manpower training in advanced and emerging areas of physical and chemical sciences. Research activities were focused on theoretical and computational sciences, as well as on experimental sciences. Research accomplishments were achieved in diverse areas of Classical and Quantum Field Theory, Gravitational Physics, Quantum Information and Foundations, Statistical Physics, Non-linear Dynamics and Mathematical Physics, Physical and Quantum Chemistry interfacing with Biological Molecules, Ionic Liquids and Energy Harvesting Materials, Classical and Quantum Condensed Matter Physics, Advanced Materials Science problems including theory, experiments and simulation of Nanomaterials and Nanodevices, Investigation on Black Holes, Dark Matter, Dark Energy, Star Formation and Observational Astronomy and Astronomical instrumentation.

The Centre is maintaining its high standard of publication track record with 247 journal publications (~ 8.2 per faculty), and 10 patents (5 granted + 5 applied) in 2021-2022, and manpower training with 25 Ph.D. theses submitted and 19 awarded. 5 of the faculties have figures in the list of Stanford University's Top 2% most influential scientists.The Nature Index ranking of the Centre remained as third among the top DST institutes. Several faculties have earned national and internal recognitions, Dr. Nitesh Kumar has been appointed as the head of the Max-Plank partner group with Max Planck Institute for Chemical Physics of Solids, Dresden, Prof. Priya Mahadevan has been elected as a Fellow of The World Academy of Sciences (TWAS). Dr. Manik Pradhan and his team has successfully transferred the technology titled "A system and kit for non-invasive detection of peptic ulcer diseases, non-ulcerous dyspepsia, and Helicobacter pylori infection" for commercialization from the TRC project through National Research Development Corporation (NRDC), New Delhi. The Centre is also running 34 sponsored projects other than the Technical Research Centre.

Following the mandate of networking with national and international Institutes, Centre has signed MoU with Sidho-Kanho-Birsha University, Aryabhatta Research Institute for cooperation in the area of observational astronomy, IIT Bombay in the area of Quantum Sciences and soft matter, and with IFW, Dresden in the area of novel Topological and Magnetic materials. Two webinar series, one on Quantum Materials and Devices, and another on Statistical Mechanics have been introduced and running very successfully with speakers of international fame. Open day has been observed following the birthday celebration of Prof S. N. Bose in which popular lecture, lab visit, visit of S. N. Bose Archive and sky watching were organized. Following the spirit of open day, the event was made open to all. After the spell of COVID-19, the conference activities have resumed with two conferences, an International Conference on the Topology in Condensed Matter Systems and a national conference on Future trends in gravitational physics. Jointly with IISER Kolkata, theoretical chemistry symposium has been also organized. Keeping in mind, the physical and mental well being in pandemic time, seminars have been organized to address the various issues related to this, as well as a COVID task force has been made responsible to handle the crisis situations.

I wholeheartedly thank all my colleagues, staffs and students of the Centre for the achievements which is essential for the overall growth of the Centre. I also put on record my gratitude to the members of the statutory and advisory and internal administrative committees of the Centre for their continuing support.

I wish the Centre to attain new heights in coming days.

Tanusri Saha-Dasgupta

Tanusri Saha-Dasgupta
Director
Satyendra Nath Bose National Centre for Basic Sciences

DEAN (FACULTY)

In the year 2021-22, the Centre was involved in several academic activities related to scientific collaborations, hosting national and international conferences, workshops, schools, organizing outreach programmes, refurbishing of the Bose Archives, etc. Our faculty Members continued to publish in top quality international journals and delivered lectures / seminars in national and international conferences / schools. In this fiscal year, the total number of publications was 247. A vibrant technology development programme was undertaken by the Technical Research Centre, resulting in the granting of 5 patents and agreements for technology transfers.

Throughout the year, the centre organized numerous seminars and six distinguished lectures on Illustrious Indian Scientists in Pre-independence Era delivered by reputed Scientists. 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 of the Centre. In the current year nine new extramural projects were sanctioned in addition to twenty four ongoing projects.

- **Awards received by Faculty Members (both Regular and Contract)**

1. **Prof. Anjan Barman, Senior Professor**
   i. Elected Fellow of Institute of Physics (FInstP), London, UK in 2021
   ii. EditorTial Board Member of Nanotechnology (2021)
   iii. Editorial Board Member of Pramana (2021-)
   iv. Highly cited Researcher (World's Top 2% Scientists) published by Stanford University

2. **Dr. Avijit Chowdhury, Assistant Professor --**
   i. IOP Outstanding Reviewer Awards 2020, Nanotechnology

3. **Prof. Kalyan Mandal, Senior Professor –**
   i. Highly cited Researcher (World's Top 2% Scientists) published by Stanford University

4. **Dr. Manik Pradhan, Professor --**
   i. Elected Fellow of the Institute of Physics (FInstP), London, UK
   ii. Chellaram Foundation Diabetes Research Award (First Prize), India

5. **Dr. Nitesh Kumar, Assistant Professor --**
   i. Awarded as a Leader of Max Planck-India Partner Group
   ii. Highly cited Researcher (World's Top 2% Scientists) published by Stanford University

6. **Dr. Pradip S Pachfule, Assistant Professor --**
   i. Highly cited Researcher (World's Top 2% Scientists) published by Stanford University

7. **Prof. Priya Mahadevan, Senior Professor --**
   i. Elected TWAS Fellow in 2022.
   ii. SERB-POWER Fellow (2021-2024)
   iii. Editorial Advisory Board Member (2021-2025), Journal of Magnetism and Magnetic Materials
   iv. Editorial Advisory Board Member (2021-2023), ACS Energy Letters

8. **Dr. Sakuntala Chatterjee, Associate Professor --**
   i. Invited by European Physical Society to act as co-editor for the journal Europhysics Letters

9. **Prof. Samir Kr Pal, Senior Professor --**
   i. Abdul Kalam Technology Innovation National Fellowship 2018 (Indian National Academy of Engineering: INAE) Extension for another two years
   ii. Core Committee Member of Electrical, Electronics & Computer Engineering 2021 (SERB) onwards.
   iii. Chairman of Expert Committee of Global Innovation & Technology Alliance (GITA).
   iv. Member of Governing Council Indian National Academy of Engineering: INAE
   v. Highly cited Researcher (World's Top 2% Scientists) published by Stanford University

10. Dr. Suman Chakrabarty, Associate Professor --

i. Editorial Board Member of DIALOGUE: Science, Scientists, and Society published by the Indian Academy of Sciences, Bengaluru

ii. Review Editor on the Editorial Board of Biophysics (specialty section of Frontiers in Physics, Frontiers in Physiology and Frontiers in Molecular Biosciences)

11. Prof. Tanusri Saha Dasgupta, Senior Professor --

i. Elected fellow of Indian National Science Academy

ii. Highly cited researcher (World's Top 2% Scientists) published by Stanford University

12. Dr. Urna Basu, Assistant Professor --

i. Associate of ICTS-TIFR, Bengaluru since 2018. The associateship has recently been renewed for 3 more years

1. Prof. Gautam De, Emeritus Professor (from 15.07.2020) --

i. External Member of CRNN (Calcutta University) Ph.D. committee (continued).

2. Prof. Rabin Banerjee, Raja Ramanna Fellow (from 03.05.2021) -

i. Awarded (DAE) Raja Ramanna Fellowship for a period of three years from 3 May, 2021.

ii. Mentioned in Stanford University's list of two percent of world's most influential scientists in the area of research (Nuclear and Particle Physics). Honorable mentioned in the top two percent (2%) of scientists, world-wide, in Nuclear and Particle Physics, in Stanford University's report.

- **New Faculty Members joined last year (including Inspire, Ramanujan etc.)**

1. Prof. Rabin Banerjee, Raja Ramanna Fellow, TS – 03.05.2021
2. Dr. Avijit Chowdhury, Assistant Professor, CMPMS – 12.05.2021
3. Dr. Manoj Mandal, Ramalingaswami Re-entry Fellow, CMPMS – 15.07.2021
4. Dr. Pradip S Pachfule, Assistant Professor, CBMS – 27.08.2021
5. Dr. Ali Hossain Khan, Ramanujan Fellow, CBMS – 01.11.2021
6. Prof. Prabhat Mandal, Emeritus Professor, CMPMS – 10.11.2021

- **Faculty Members left / retired last year (including Inspire, Ramanujan etc.)**

1. Prof. Milan K Sanyal, Emeritus Professor, CMPMS – 30.04.2021 (Retired)
2. Prof. S. K. Ray, Director & Senior Professor, CMPMS – 31.05.2021 (Retired)
3. Dr. Saumya Mukherjee, DST Inspire Faculty, CMPMS – 23.07.2021 (Resigned)
4. Dr. M. Sanjay Kumar, Associate Professor, TS - 31.07.2021 (Retired)
5. Prof. Manu Mathur, Professor, TS - 30.11.2021 (Retired)
6. Prof. Biswajit Chakraborty, Senior Professor, TS - 30.11.2021 (Retired)
7. Dr. Tatini Rakshit, DST Inspire Faculty, CMPMS – 10.12.2021 (Resigned)

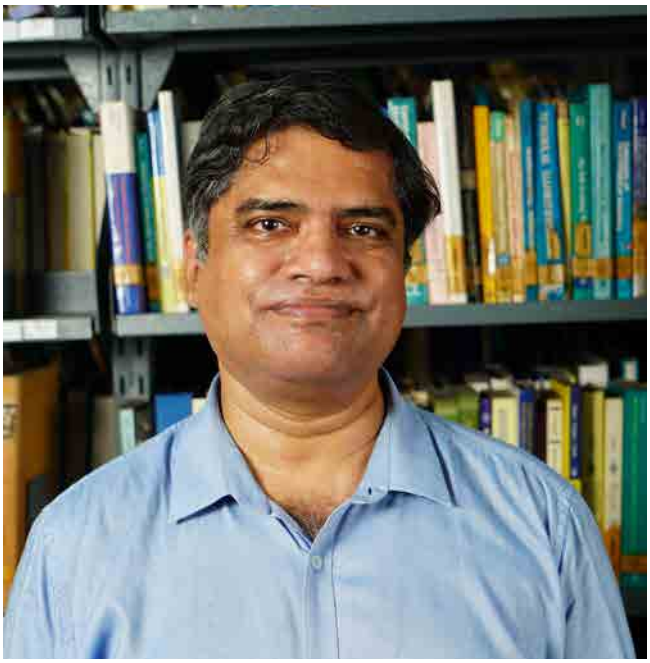
- **Total numbers of Inspire / Ramanujan / Visiting / Emeritus etc as on date -**

1. Inspire Faculty – 2
2. Ramanujan Fellow – 2
3. Raja Ramanna Fellow – 1
4. Ramalingaswami Re-entry Fellow - 1
5. Emeritus Professor – 2
6. Visiting (Hon.) Fellow – 4
7. Adjunct Faculty / Fellow – 3

- **Total no of PDRA / RA / Project Scientists etc. as on date**

1. PDRA (SNB Funded) – 18
2. RA / NPDF / SRA etc. – 10
3. Bridge Fellow (SNB Funded) - 1

Anjan Barman
Dean (Faculty)



Dean, Academic Programme

An important part of the mandate of our Centre is to train young scientists for research in the basic sciences. Numerous distinguished alumni bear witness to a vibrant research atmosphere created by, and for, the student researchers at the Centre. The 2021-22 academic year was badly affected by the COVID-19 outbreak all over the world and we were no exception. However, the Centre was able to resume functioning with strict requirement of vaccination, mask and sanitization protocols, and regulations about physical distancing including maintaining rosters for entering the main building, students' seating areas, and labs. Since there were several students staying in the hostels at all times, there were also restrictions on their leaving the campus, which continued after most students moved back into their hostels.

Admission interviews were held only in the online mode and the admission process was delayed by a few weeks since various National examinations, as well as university examinations, had been delayed due to COVID-19. Many classes were held in the hybrid mode, but after all students were back in the Centre, classes were switched to physical mode with distancing and mask regulations. I am happy to say that we handled the additional challenges quite successfully and are now getting back to normalcy in our academic activities.

In the academic year 2021-22, a total of 18 scholars joined the Ph.D. programme of the Centre. Of these, 5 joined Astrophysics and Cosmology, 2 joined Chemical, Biological and Macromolecular Sciences, 10 joined Condensed Matter Physics and Material Science, and 1 joined Theoretical Sciences. Of the total, 10 came from the Centre's own Integrated Ph.D. programme. In addition, 10 students joined the IPhD programme. A total of 19 students was awarded their Ph.D. degrees during this academic year and another 25 submitted their Ph.D. theses. Several conferences were organized by the Centre, as well as many colloquia and seminars, all of them in hybrid mode. The annual students' conference of the Centre, BOSE FEST, was also done in hybrid mode this year and was a resounding success.

Finally, it is a great pleasure to acknowledge enthusiastic cooperation provided by my faculty colleagues, the administrative staff members of the Academic section, and the students, in every official academic work of the Centre. Our achievements would not have been possible without their constant support and hard work.

COURSES TAUGHT IN 2021-2022

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

1st Semester:

- PHY 101, ***Classical Dynamics***, Tapas Baug;
- PHY 102, ***Mathematical Methods***, Sunandan Gangopadhyay;
- PHY 103, ***Quantum Mechanics I***, Priya Mahadevan;
- PHY 104, ***Computational Methods in Physics,*** Suman Chakrabarty;
- PHY 191, ***Basic Laboratory I***, Avijit Chowdhury & Pratip Kumar Mukhopadhyay;

2nd Semester:

- PHY 201, ***Statistical Mechanics***, Sakuntala Chatterjee;
- PHY 202, ***Quantum Mechanics II***, Punyabrata Pradhan;
- PHY 203, ***Electromagnetic Theory***, Thirupathaiah Setti;
- PHY 204, ***Electronics & Instrumentation***, Kalyan Mandal & Avijit Chowdhury;
- PHY 291, ***Basic Laboratory II***, Kalyan Mandal & Avijit Chowdhury.

3rd Semester:

- PHY 301, *Atomic & Molecular Physics*, Anjan Barman & Rajib Kumar Mitra;
- PHY 302, *Condensed Matter Physics*, Nitesh Kumar;
- PHY 303, *Advanced Quantum Mechanics & Applications*, Manoranjan Kumar & M Sanjay Kumar;
- PHY 304, *Project Research II*, Faculty Supervisors;
- PHY 305, *Nuclear & Particle Physics*, Ramkrishna Das & Subhendra Mohanti, PRL.

4th Semester:

- PHY 401, *Project Research III*, Faculty Supervisors;
- PHY 408, *Advanced Statistical Physics*, Amitabha Lahiri;
- PHY 409, *Magnetism & Superconductivity*, Kalyan Mandal & Ranjan Chaudhury;
- PHY 417, *General Relativity & Cosmology*, Archan S Majumdar & Sunandan Gangopadhyay;
- PHY 291, *Basic Laboratory II*, Atindra Nath Pal & Pratip Kumar Mukhopadhyay
- PHY 491, *Methods of Experimental Physics*, Nitesh Kumar, Rajib Kumar Mitra, Manik Pradhan, Ramkrishna Das & Kalyan Mandal (Coordinator)

Ph.D. Course Work Programme

- PHY 501, *Research Methodology*, Amitabha Lahiri & Pratip Kumar Mukhopadhyay;
- PHY 502, *Review of the Topical Research*, Faculty Supervisors;
- PHY/CB 591, *Project Research*, Faculty Supervisors;
- CB 524, *Physical Chemistry: Experiments & Theory*, Ranjit Biswas
- CB 527, *Molecular Physics & Spectroscopy*, Rajib Kumar Mitra & Anjan Barman;
- CB 528, *Stochastic Processes in Physics & Chemistry*, Gautam Gangopadhyay;
- CB 535, Non-equilibrium Statistical Mechanics, Urna Basu;
- PHY 503, *Condensed Matter Physics*, Nitesh Kumar;
- PHY 506, *Quantum Physics*, Manoranjan Kumar & M Sanjay Kumar;
- PHY 510, Astrophysics, Soumen Mondal, Ramkrishna Das & Debanjan Bose;
- PHY 601, *Advanced Condensed Matter Physics I*, Kalyan Mandal & Ranjan Chaudhury;
- PHY 602, *Advanced Condensed Matter Physics II*, Manoranjan Kumar;
- PHY 603, *Advanced Statistical Physics*, Amitabha Lahiri;
- PHY 607, *General Relativity & Cosmology*, Archan S Majumdar & Sunandan Gangopadhyay.

Note: Conducted partially in combination with IPhD Programme.

Ph.D. THESIS SUBMITTED

1. ***Studies On Therapeutic Potential Of Various Nanomaterials And Ethnobotanical Ingredients In Preclinical Disease Model***, Aniruddha Adhikari, Supervisor: Samir Kumar Pal, in the University of Calcutta, in April, 2021
2. ***Study of Dynamical Aspects of Some Class of ODEs and PDEs***, Ankan Pandey, Supervisor: Partha Guha, in the University of Calcutta, in April, 2021
3. ***Interactions, Correlations, and Competing Orders in Strongly Correlated One Dimensional Quantum Wires and Quantum Gases,*** Monalisa Singh Roy, Supervisor: Manoranjan Kumar, in the University of Calcutta, in June, 2021
4. ***Spectral and Timing Properties of Class Variable Source GRS 1915+105 Using Two-Component Advective Flow Solution***, Anuvab Banerjee, Supervisor: Sandip K Chakrabarti, in the University of Calcutta, in June, 2021
5. ***The electronic and structural properties of semiconductor heterostructures,*** Joydeep Chatterjee, Supervisor: Priya Mahadevan, in the University of Calcutta, in July, 2021
6. ***Investigation Of Temperature And Frequency Dependent Electrical Transport Phenomena At The Interface Of Bilayered Ferromagnetic – Ferroelectric Thin Films And Related Issues***, Subhamita Sengupta, Supervisor: Arup K Raychaudhuri, in the University of Calcutta, in July, 2021
7. ***Some aspects of quantum mechanics and quantum field theory on quantum space-time***, Partha Nandi, Supervisor: Biswajit Chakraborty, in the University of Calcutta, in July, 2021
8. ***On some theories on quantum space-time and matter and their plausible implications***, Sayan Kumar Pal, Supervisor: Biswajit Chakraborty, in the University of Calcutta, in July, 2021

9. ***Studies On Ultrafast Dynamics And Spectroscopic Investigations On Fluorescent Probes In Bimolecular And Biomimetic Recognition***, Sk Imadul Islam, Supervisor: Rajib Kumar Mitra, in the University of Calcutta, in July, 2021
10. ***Thermodynamics of Low-Dimensional Interacting Quantum Systems: A Hybrid Exact Diagonalization and Density Matrix Renormalization Group Study***, Sudip Kumar Saha, Supervisor: Manoranjan Kumar, in the University of Calcutta, in July, 2021
11. ***Study Of Various Quantum Information Theoretic Resources And Their Applications***, Ananda Gopal Maity, Supervisors: Archan S Majumdar & Manik Banik, in the University of Calcutta, in July, 2021
12. ***Spectral And Temporal Properties Of Super-Massive Black Holes In Light Of Two Component Advective Flows***, Prantik Nandi, Supervisor: Sandip K Chakrabarti, in the University of Calcutta, in July, 2021
13. ***First Principles Study On Novel and Functional Materials***, Shreya Das, Supervisor: Tanusri Saha Dasgupta, in the University of Calcutta, in August, 2021
14. ***Spin Dynamics in 2D and 3D Confined Magnetic Structure and Thin Film, Heterostructures***, Sourav Sahoo, Supervisor: Anjan Barman, in the University of Calcutta, in August, 2021
15. ***Synthesis And Characterization Of Nanoscale Alloys And Metal Oxides For Potential Application In Catalysis***, Arnab Samanta, Supervisor: Samir Kumar Pal & Subhra Jana, in the University of Calcutta, in September, 2021
16. ***Certification And Preservation Of Quantum Correlations***, Shashank Gupta, Supervisor: Archan S Majumdar, in the University of Calcutta, in December, 2021
17. ***Electronic, structural and optical properties of transition metal dichalcogenides heterostructures***, Sumanti Patra, Supervisor: Priya Mahadevan, in the University of Calcutta, in December, 2021
18. ***Spin Dynamics in Ferromagnetic Nanostructures***, Kartik Adhikari, Supervisor: Anjan Barman, in Jadavpur University, in December, 2021
19. ***Microscopic studies on biomolecular complexes***, Sasthi Charan Mandal, Supervisor: Jaydeb Chakrabarti, in the University of Calcutta, in December, 2021
20. ***Multiwavelength Studies of Planetary Nebulae***, Rahul Bandyopadhyay, Supervisor: Ramkrishna Das, in the University of Calcutta, in December, 2021
21. ***Solar Energy Harvesting In A Photoelectrochemical Cell: Development Of Photoanodes Based On Earth Abundant Materials***, Dipanjan Maity, Supervisor: Kalyan Mandal, in the University of Calcutta, in December, 2021
22. ***Investigation Of Optical Beam Shifts For Two-Dimensional (2D) Materials***, Akash Das, Supervisor: Manik Pradhan, in the University of Calcutta, in December, 2021
23. ***Improvement in Rheological Response of Transition Metal Oxide Based Magnetic Fluids***, Priyanka Saha, Supervisor: Kalyan Mandal, in the University of Calcutta, in December, 2021
24. ***Some Studies On The Effects Of Crowding Agents On The Structure, Functionality And Activity Of Biomolecules***, Saikat Pal, Supervisor: Rajib Kumar Mitra, in the University of Calcutta, in January, 2022
25. ***Aspects of Holographic Entanglement Entropy and Complexity***, Sourav Karar, Supervisors: Sunandan Gangopadhyay & Archan S Majumdar, in the University of Calcutta, in February, 2022

Ph.D. AWARD RECEIVED

1. ***The Effect of Spin-Orbit Coupling on Electronic StructPriya Mahadevanure and Magnetism in Low Dimensional Compounds***, Poonam Kumari, Supervisor: Priya Mahadevan, in the University of Calcutta, in April, 2021
2. ***Field Theoretic Approach to Gravity***, Subhasish Chakrabarty, Supervisor: Amitabha Lahiri, in the University of Calcutta, in April, 2021
3. ***Development of Microactuator Systems Basrd On The Photoinduced Microactuation Effect Found In Ferromagnetic Shape Memory Alloys***, Abhishek Bagchi, Supervisor: Pratip Kumar Mukhopadhyay, in Jadavpur University, in April, 2021
4. ***Interactions and Dynamics of Cryoprotectants, Energy Materials and Other Complex Mixtures***, Kajal Kumbhakar, Supervisor: Ranjit Biswas, in Jadavpur University, in April 2021
5. ***Oxide Semiconductors for Energy Applications***, Keshab Karmakar, Supervisor: Kalyan Mandal, in the University of Calcutta, in July, 2021

6. ***Experimental Study of Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Multilayers***, Santanu Pan, Supervisor: Anjan Barman, in Jadavpur University, in July, 2021
7. ***Investigations of Multi-component mixtures and complex systems with longer-ranged interactions***, Juriti Rajbangshi, Supervisor: Ranjit Biswas, in Jadavpur University, in August, 2021
8. ***Investigation of Electronic and Thermal Transport and Opto-Electronic Properties of Single Germanium Nanowires***, Shaili Sett, Supervisor: Arup K Raychaudhuri, in the University of Calcutta, in September, 2021
9. ***Evanescent wave and cavity enhanced absorption spectroscopy for trace molecule sensing using diode and quantum cascade lasers***, Sanchi Maithani, Supervisors: Manik Pradhan, in the University of Calcutta, in September, 2021
10. ***Magnetic, Dielectric and Microwave Absorption Properties of Transition Metal based Ferrite Nanostructures***, Dipika Mandal, Supervisor: Kalyan Mandal, in Jadavpur University, in September, 2021
11. ***Large Magnetocaloric Effect in Low-Cost Transition Metal Based Alloys for Magnetic Refrigeration***, Subrata Ghosh, Supervisor: Kalyan Mandal, in Jadavpur University, in September, 2021
12. ***Aspects of gauge/gravity duality and it's applications***, Debabrata Ghorai, Supervisor: Sunandan Gangopadhyay & Biswajit Chakraborty, in the University of Calcutta, in October, 2021
13. ***Nano Scale Control On The Properties Of Perovskite Type Oxide***, Putul Malla Chowdhury, Supervisor: Arup K Raychaudhuri, in the University of Calcutta, in November, 2021
14. ***Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis***, Arka Chatterjee, Supervisor: Samir Kumar Pal, in Jadavpur University, in November, 2021
15. ***Influence of Accretion Disk Size on Spectral and Timing Properties of Stellar Mass Black Holes***, Arindam Ghosh, Supervisor: Sandip K Chakrabarti, in the University of Calcutta, in December, 2021
16. ***Spectroscopic And Computational Studies On Functionalized Nanohybrids For Potential Manifold Applications***, Tuhin Kumar Maji, Supervisor: Samir Kumar Pal, in the University of Calcutta, in December, 2021
17. ***Dynamical Aspects of Confined Media, Bulk Binary Mixtures and Other Complex Systems***, Atanu Baksi, Supervisor: Ranjit Biswas, in Jadavpur University, in December, 2021
18. ***Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications***, Soumendra Singh, Supervisor: Samir Kumar Pal, in University of Calcutta, in December, 2021
19. ***Study Of Generalized Spin And Charge Stiffness Constants Of Doped Quantum Anti-Ferromagnets On Low Dimensional Lattices Based On T-J-Like Models***, Suraka Bhattacherjee, Supervisor: Ranjan Chaudhury, in the University of Calcutta, in January, 2022

POST-Ph.D. PLACEMENT

- Aniruddha Adhikari – Postdoctoral Fellow at University of California, Los Angeles,USA
- Ankan Pandey – Assistant Professor, Sarda University. India
- Monalisa Singh Roy - Postdoc, Bar-Ilan University, Israel
- Anuvab Banerjee – Post-doctoral Fellow, SNBNCBS
- Sudip Kumar Saha – Bridge Fellow, SNBNCBS
- Shreya Das – RA-I, SNBNCBS
- Kartik Adhikari – Assistant Professor, New Alipur College, Kolkata, India
- Rahul Bandyopadhyay – Project Assistant , Technical University , Munich, Germany.
- Sourav Karar - Assistant Professor, Govt. General Degree College, Muragachha, Nadia, WB
- Poonam Kumari - Post-doctoral Research Fellow, CRN-ICCOM, Pisa, Italy
- Subhasish Chakrabarty - Assistant Professor, Dept. of Physics, Ramanuj Gupta Degree College, Silchar, Assam
- Kajal Kumbhakar - Post Doctoral Fellow, CMSD, Institute for Basic Science, South Korea
- Keshab Karmakar - Research Associate, IACS, Kolkata
- Santanu Pan – Assistant Professor, Netaji Nagar Day College, West Bengal
- Juriti Rajbangshi - Post Doctoral Researcher, Department of Chemistry, Louisiana State University
- Shaili Sett - Research Associate, IISc., Bangalore
- Sanchi Maithani - Postdoctoral Research Associate, Max Plank Institute of Quantum Optics, Garching, Germany

- Dipika Mandal – Post –Doctoral Fellow, University of Pittsburgh, USA
- Subrata Ghosh – Post-doctoral Fellow, Pen State University, USA
- Debabrata Ghorai – PDRA, Hanyang University, South Korea
- Putul Malla Chowdhury - Assistant Professor, Physics, Netaji Nagar College for Women, West Bengal
- Arka Chatterjee - Postdoctoral Research Associate, POSTECH, Pohang, South Korea
- Prantik Nandi - Post-doctoral Research Associate,PRL, Ahmedabad , India
- Tuhin Kumar Maji - Post-doctoral Research Associate, Indian Institute of Science Bangalore
- Atanu Baksi – Post Doctoral Fellow, University of Houston
- Soumendra Singh – Entrepreneur ,Neo Care Inc, Canada · Self-employed, Halifax, Nova-Scotia, Canada
- Suraka Bhattacherjee – Post-doctoral Fellow, Raman Research Institute (RRI), Bangalore

Continuing at SNBNCBS in Various Research Projects

- Subhamita Sengupta - Visiting Research Fellow, SNBNCBS
- Partha Nandi - Visiting Research Fellow, SNBNCBS
- Sayan Kumar Pal - Visiting Research Fellow, SNBNCBS
- Sk Imadul Islam - Visiting Research Fellow, SNBNCBS
- Ananda Gopal Maity - Visiting Research Fellow, SNBNCBS
- Sourav Sahoo - Visiting Research Fellow, SNBNCBS
- Arnab Samanta - Visiting Research Fellow, SNBNCBS
- Sumanti Patra - Visiting Research Fellow, SNBNCBS
- Sasthi Charan Mandal - Visiting Research Fellow, SNBNCBS
- Dipanjan Maity - Visiting Research Fellow, SNBNCBS
- Akash Das - Visiting Research Fellow, SNBNCBS
- Priyanka Saha - Visiting Research Fellow, SNBNCBS
- Saikat Pal - Visiting Research Fellow, SNBNCBS

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

	VISITING RESEARCHER	SUPERVISOR	
2014-2015:			
1.	Tuhin Kumar Maji (INSPIRE)	Samir Kumar Pal	till 15/04/2021
2.	Anulekha De	Anjan Barman and Rajib Kumar Mitra	till 07/08/2021
2015-2016:			
3.	Dipika Mandal (CSIR)	Kalyan Mandal	till 29/12/2021
4.	Subrata Ghosh (CSIR)	Kalyan Mandal	till 29/12/2021
5.	Kajal Kumbhakar (CSIR)	Ranjit Biswas	till 31/07/2021
6.	Chandan Samanta	Barnali Ghosh (Saha)	till 31/07/2021
7.	Sudip Kumar Saha (INSPIRE)	Manoranjan Kumar	till 31/12/2021
2016-2017:			
8.	Sk Imadul Islam (UGC)	Rajib Kumar Mitra	
9.	Sasthi Charan Mandal (CSIR)	Jaydeb Chakrabarti	
10.	Partha Nandi	Biswajit Chakraborty	
11.	Sayan Kumar Pal (UGC)	Biswajit Chakraborty	
12.	Akash Das (UGC)	Manik Pradhan	
13.	Saikat Pal (CSIR)	Rajib Kumar Mitra	
14.	Priyanka Saha (INSPIRE)	Kalyan Mandal	
15.	Dipanjan Maity (CSIR)	Kalyan Mandal	
16.	Subhamita Sengupta (UGC)	Barnali Ghosh(Saha) (O)	
17.	Sumanti Patra	Priya Mahadevan	

	SENIOR RESEARCH FELLOW	SUPERVISOR	
2015-2016:			
18.	Aniruddha Adhikari	Samir Kumar Pal	till 30/06/2021
19.	Avisek Maity	Barnali Ghosh (Saha)	till 31/07/2021
20.	Rahul Bandyopadhyay	Ramkrishna Das	till 31/07/2021
21.	Alik Panja	Soumen Mondal	till 02/08/2021
22.	Arnab Sarkar	Archan S Majumdar	till 31/07/2021
23.	Shounak Datta (INSPIRE)	Archan S Majumdar	till 02/08/2021
24.	Shreya Das (INSPIRE)	Tanusri Saha Dasgupta	till 31/12/2021
2016-2017:			
25.	Piklu Santra (UGC)	Ramkrishna Das (O)	till 19/04/2021
26.	Prantik Nandi (CSIR)	Ramkrishna Das (O)	till 10/01/2022
27.	Koushik Mandal (UGC)	Manoranjan Kumar (O)	
28.	Bihalan Bhattacharya (INSPIRE)	Archan S Majumdar	
2017-2018:			
29.	Arka Chatterjee (INSPIRE)	Samir Kumar Pal	till 12.11.2021
30.	Edwine Tendong (TWAS-BOSE)	Tanusri Saha Dasgupta	
31.	Souma Mazumdar	Gautam Gangopadhyay (O)	
32.	Anirban Mukherjee (INSPIRE)	Punyabrata Pradhan	
33.	Shubhadip Moulik (CSIR)	Atindra Nath Pal	
34.	Vishal Kumar Aggarwal	Arup Kumar Raychaudhuri & Manik Pradhan	
35.	Arundhati Adhikari	Anjan Barman	
36.	Parushottam Maji	Arup Kumar Raychaudhuri & Barnali Ghosh (Saha)	
37.	Didhiti Bhattacharya	Samit Kumar Ray & Rajib Kumar Mitra	
38.	Koustav Dutta (INSPIRE)	Anjan Barman	
39.	Amrit Kumar Mondal	Anjan Barman	
40.	Sk Saniur Rahaman (UGC)	Manoranjan Kumar	
41.	Rituparna Mandal (INSPIRE)	Sunandan Gangopadhyay	
42.	Abhik Ghosh Moulik (INSPIRE)	Jaydeb Chakrabarti	
43.	Arpan Bera (CSIR)	Samir Kumar Pal	
44.	Biswajit Pabi (INSPIRE)	Atindra Nath pal	
45.	Dhrubajyoti Majhi (INSPIRE)	Ranjit Biswas	
46.	Indrani Kar	Thirupathaiah Setti	
47.	Jayanta Mondal (INSPIRE)	Ranjit Biswas	
48.	Rafiqul Alam (INSPIRE)	Atindra Nath Pal	
49.	Rahul Karmakar (INSPIRE)	Jaydeb Chakrabarti	
50.	Shubhrasish Mukherjee (INSPIRE)	Samit Kumar Ray & Atindra Nath Pal	
51.	Siddhartha Biswas (INSPIRE)	Soumen Mondal	
52.	Sudipta Chatterjee	Barnali Ghosh (Saha)	
2018-2019:			
53.	Sumana Pyne	Rajib Kumar Mitra	
54.	Dipanjan Mukherjee	Samir Kumar Pal	
55.	Biswajit Panda	Manik Pradhan	

	SENIOR RESEARCH FELLOW	SUPERVISOR	
56.	Narayan Chandra Maity (CSIR)	Ranjit Biswas	
57.	Shobhan Dev Mandal (CSIR)	Sakuntala Chetterjee	
58.	Premashis Kumar	Gautam Gangopadhyay	
59.	Anish Das	Biswajit Chakraborty	
60.	Md Nur Hasan (CSIR)	Samir Kumar Pal	
61.	Tanmoy Chakraborty (CSIR)	Punyabrata Pradhan	
62.	Susmita Mondal	Samir Kumar Pal	
63.	Deepsikha Das	Punyabrata Pradhan & Sakuntala Chatterjee	
64.	Prasun Boyal (CSIR)	Priya Mahadevan	
65.	Debayan Mondal (CSIR)	Priya Mahadevan	
66.	Jyotirmoy Sau (UGC)	Manoranjan Kumar	
67.	Monalisa Chatterjee (INSPIRE)	Manoranjan Kumar	
68.	Susmita Changdar (UGC)	Thirupathaiah Setti	
69.	Pratap Kumar Pal (CSIR)	Anjan Barman	
70.	Shivam Mishra (INSPIRE)	Priya Mahadevan	

	JUNIOR RESEARCH FELLOW	SUPERVISOR	
2019-2020:			
71.	Krishnendu Patra	Priya Mahadevan	
72.	Ria Saha	Rajib Kumar Mitra	
73.	Somashree Ghosal (CSIR)	Manoranjan Kumar	till 25/10/2021
74.	Krishnendu Sinha	Suman Chakraborty	
75.	Amrita Mondal	Ranjit Biswas	
76.	Subhajit Singha	Rajib Kumar Mitra	
77.	Soma Dutta	Anjan Barman	
78.	Kanchan Meena (CSIR)	Prosenjit Singha Deo	
79.	Sreya Pal (CSIR)	Anjan Barman	
80.	S. Adarsh	Archan S. Majumdar	till 26/07/2021
81.	Manodip Routh	Manoranjan Kumar	
82.	Abhinandan Das	Suman Chakrabarty	
83.	Subhajit Kar	Ramkrishna Das	
84.	Anirban Paul (CSIR)	Jaydeb Chakrabarti	
85.	Ardhendu Pal	Manik Pradhan	
86.	Gesesew Reta Habtie (TWAS-BOSE)	Ramkrishna Das	
2020-2021:			
87.	Rajib Kumbhakar (INSPIRE)	Soumen Mondal	
88.	Shashank Shekhar Pandey (CSIR)	Archan S. Majumdar	
89.	Shounak Mukherjee	Suman Chakrabarty	till 29/04/2021
90.	Sudip Mandal (CSIR)	Manik Pradhan	till 07/12/2021
91.	Sudipta Mitra	Ranjit Biswas	
92.	Aishwaryo Ghosh (INSPIRE)	Tanusri Saha Dasgupta	
93.	Manoj Gupta (CSIR)	Tanusri Saha Dasgupta	

	JUNIOR RESEARCH FELLOW	SUPERVISOR	
94.	Shinjini Paul (INSPIRE)	Priya Mahadevan	
95.	Koushik Pradhan	Tanusri Saha Dasgupta	
96.	Indrajit Ghose	Amitabha Lahiri	
97.	Riya Barick	Amitabha Lahiri	
98.	Rik Niranjan Mukherjee (INSPIRE)	Ranjit Biswas & Pradip K Ghorai (IISER-K)	
99.	Suchetana Mukhopadhyay (INSPIRE)	Anjan Barman & Chiranjit Mitra (IISER-K)	
100.	Ankit Mandal (INSPIRE)	Prasanta Panigrahi (IISER-K) & Sunandan Gangopadhyay	
101.	Ariful Hoque (CSIR)	Tapas Baug	
102.	Sanuja Kumar Khuntia (UGC)	Priya Mahadevan	
103.	Chandradip Khamrai (CSIR)	Sakuntala Chatterjee	
104.	Ritwick Sarkar (CSIR)	Urna Basu	
105.	Ramesh Pramanik (CSIR)	Sakuntala Chatterjee	
2021-2022:			
106.	Arijit Maiti	Soumen Mondal	till 20/12/2021
107.	Avijit Mandal	Ramkrishna Das	
108.	Bivas Mallick (INSPIRE)	Archan S. Majumdar	
109.	Saheli Mukherjee	Archan S. Majumdar	
110.	Nishant Garg	Tapas Baug	
111.	Debashish Paul	Jaydeb Chakrabarti and Tatini Rakshit	till 10/12/2021
112.	Soumyadipta Chakraborty	Manik Pradhan	
113.	Chandan Kumar	Anjan Barman	
114.	Arunanshu Panda	Nitesh Kumar	
115.	Raj Gupta (CSIR)	Kalyan Mandal	
116.	Saikat Mitra	Avijit Chowdhury and Barnali Ghosh (Saha)	
117.	Sayan Ghosh (INSPIRE)	Manoranjan Kumar	
118.	Shivam Jani	Priya Mahadevan	
119.	Soumik Das	Avijit Chowdhury	
120.	Soumya Ghorai (UGC)	Thirupathaiah Setti	
121.	Sourabh Saha (INSPIRE)	Manoranjan Kumar	
122.	Sourav Sarkar (INSPIRE)	Kalyan Mandal	
123.	Rupayan Saha	Punyabrata Pradhan	

RESEARCH SCHOLARS - INTEGRATED Ph.D. PROGRAMME (by year of joining)

	VISITING RESEARCHER	SUPERVISOR	
2014–2015:			
124.	Avinash Kumar Chaurasiya (INSPIRE)	Anjan Barman	till 15/05/2021
125.	Sanchi Maithani (INSPIRE)	Manik Pradhan	till 14/07/2021
126.	Ananda Gopal Maity	Archan S Majumdar	
127.	Sourav Sahoo	Anjan Barman	
2016-2017:			
128.	Arnab Samanta	Samir Kumar Pal	

	SENIOR RESEARCH FELLOW	SUPERVISOR	
2013–2014:			
129.	Ankan Pandey	Partha Guha	till 31/07/2021
130.	Riddhi Chatterjee	Archan S Majumdar	till 31/07/2021
2014–2015:			
131.	Ruchi Pandey	Ramkrishna Das	
2015–2016:			
132.	Anupam Gorai	Kalyan Mandal	
133.	Atul Rathod	Manu Mathur	
134.	Shantonu Mukherjee	Amitabha Lahiri	
135.	Shashank Gupta	Archan S Majumdar	till 31/12/2021
136.	Sudip Majumdar	Anjan Barman & Rajib Kumar Mitra	
137.	Surya Narayan Panda	Anjan Barman	
138.	Swarnali Hait	Kalyan Mandal	
2016-2017:			
139.	Achintya Low	Thirupathaiah Setti	
140.	Ankur Srivastav	Sunandan Gangopadhyay	
141.	Anwesha Chakraborty	Biswajit Chakraborty	
142.	Sayan Routh	Thirupathaiah Setti	
143.	Neeraj Kumar	Sunandan Gangopadhyay	

	JUNIOR RESEARCH FELLOW	SUPERVISOR	
2017-2018:			
144.	Nivedita Pan	Samir Kumar Pal	
145.	Riju Pal	Atin Pal	
146.	Samir Rom	Tanusri Saha Dasgupta	
147.	Shubham Purwar	Thirupathaiah Setti	
148.	Manjari Dutta	Sunanadan Gangopadhyay	
2018-2019:			
149.	Soham Saha	Kalyan Mandal	
150.	Gaurav I Patel	Soumen Mondal	till 16/08/2021
151.	Animesh Hazra	Punyabrata Pradhan	
152.	Avik Sasmal	Jaydeb Chakrabarti	
153.	Ishita Jana	Kalyan Mandal	
154.	Anirban Roychowdury	Sunandan Gangopadhyay	

	JUNIOR RESEARCH FELLOW	SUPERVISOR	
155.	Soumen Mandal	Manik Pradhan	
156.	Rajdeep Biswas	Tanusri Saha-Dasgupta	
157.	Arnab Chakraborty	Amitabha Lahiri	
158.	Vishwajeet Kumar	Sakuntala Chatterjee	till 22/01/2021
2019-2020:			
159.	Ajay Sharma	Sakuntala Chatterjee and Debanjan Bose	
160.	Arnab Paul	Tanusri Saha Dasgupta	
161.	Banik Rai	Nitesh Kumar	
162.	Dibyendu Maity	Suman Chakraborty	
163.	J Sridhar Mohanty	Kalyan Mandal	
164.	Jayarshi Bhattacharya	Gautam Gangopadhyay	
165.	Sagar Kumar Maity	Amitabha Lahiri	
166.	Soham Sen	Sunandan Gangopadhyay	
167.	Soumyabrata Hazra	Archan S. Majumdar	
168.	Saurav Kantha	Amitabha Lahiri	

PART TIME RESEARCH SCHOLARS - Ph.D. PROGRAMME	
169.	Ashis Saha, Kalyani University, under Sunandan Gangopadhyay
170.	Sukanta Bhattacharyya, West Bengal State University, under Sunandan Gangopadhyay
171.	Dhrimadri Khata, Astrophysics & Cosmology, under Soumen Mondal
172.	Samrat Ghosh, Astrophysics & Cosmology, under Soumen Mondal

	PROJECT FELLOWS / ASSISTANTS / TRAINEES	SUPERVISOR	
2019-2020:			
	Arun Kumar Das (Project JRF)	Archan S Majumdar	
	Subhankar Bera (Project JRF)	Archan S Majumdar	
2020-2021:			
	Suranjana Chakraborty (Project Assistant)	Anup Ghosh	
2021-2022:			
	Madhurita Das (Project JRF)	Priya Mahadevan	
	Tina Dey (Project Assistant)	Tatini Rakshit	till 10/12/2021
	Neha Bhattacharyya (Project Research Staff)	Samir Kumar Pal	
	Ria Ghosh (Project SRF)	Samir Kumar Pal	
	Arnab Mukherjee (Project JRF)	Archan S. Majumdar	
	Soumyadeep De (Project Assistant Adhoc)	Ali Hossain Khan	

	INTEGRATED PPROGRAMME	SUPERVISOR	
2019-2020:			
	Ram Surya Sri Shourie		till 01/10/2021
	Kaliprasanna Majumdar		till 31/07/2021
2020-2021:			
	Ananya Chakraborty		
	Pritam Roy		
	Rajdwip Bhar		
	Sudip Chakrabarty		
	Devangshu Roy		
2021-2022:			
	Kanad Sengupta		till 10/12/2021
	Anish Chaudhuri		
	Debraj Dutta		
	Sayari Bhattacharya		
	Debendra Meher		
	Partha Patra		
	Prapti Mukherjee		
	Prerak Gupta		
	Shrabasti Banerjee		
	Souvik Paul		

Amitabha Lahiri

Amitabha Lahiri
Dean, Academic Programme

Extended Visitors and Linkage Programme

VISITORS AND LINKAGE PROGRAMME

OUTREACH ACTIVITY

- India International Science Festival (IISF) 2021 – The Centre participated in the IISF 2021 held during 10-13 December, 2021 at Goa. Current research activities, focused areas of research activities etc. were showcased in the event.
- Open Day 2022 – The Centre observed Open Day 2022 on 4th January, 2022 to commemorate the 129th Birth Anniversary of Satyendra Nath Bose. Prof. Jayanta Kumar Bhattacharjee, Distinguished Visiting Professor, IACS delivered popular science talk. Also, visit to the scientific laboratories and S N Bose archive, plant and star watching programmes were also organized. General public as well as scientific researcher actively participated in the event.
- National Science Day 2022 – The Centre observed National Science Day on 28th February, 2022 based on the theme 'Integrated approach in S&T for sustainable future'. Prof. Gautam I. Menon, Ashoka University was the keynote speaker on this occasion. Research scholars delivered talks on the department-wise research activities of the Centre. Staff and students actively participated in the debate competition on the topic 'Science in pre and post-independence era: are we going uphill or downhill'.

Summer Research Programme:

Sl. No.	Name	Affiliation	Department	Supervisor at SNB
1	Aashique Unnikrishnan	National Institute of Technology, Calicut	A&C	Tapas Baug
2	Aishani Majumder	Amity University, Kolkata	A&C	Ramkrishna Das
3	Arjun Dawn	Jadavpur University	A&C	Ramkrishna Das
4	Arkajyoti Maity	Indian Association for the Cultivation of Science	TS	Subhrangshu Sekhar Manna
5	Chandreyee Banerjee	Indian Association for the Cultivation of Science	CBMS	Jaydeb Chakrabarti
6	Debkanta Ghosh	Jawaharlal Nehru University	TS	Rabin Banerjee
7	Diptatanu Das	Indian Institutes of Science Education and Research, Kolkata	CBMS	Suman Chakrabarty
8	Disha Bandyopadhyay	Ramakrishna Mission Vivekananda Educational & Research Institute (RKMVERI)	A&C	Archan S. Majumdar
9	Gourav Ghosh	Indian Institute of Technology, Tirupati	TS	Subhrangshu Sekhar Manna
10	Nirabindu Ganguly	Delhi University	CBMS	Gautam Gangopadhyay
11	Payal Roy	University of Calcutta	TS	Amitabha Lahiri
12	Pritesh Srivastava	Indian Institute of Technology, Kanpur	CBMS	Rajib Kumar Mitra
13	Raghvendra Rathore	Indian Institute of Technology, Kharagpur	A&C	Archan S. Majumdar
14	Sayantan Das	Rajabazar Science College, University of Calcutta	CBMS	Gautam Gangopadhyay
15	Smridhi Chawla	Delhi University	CMP&MS	Anjan Barman

Sl. No.	Name	Affiliation	Department	Supervisor at SNB
16	Souvik Kumar Naskar	Indian Institute of Technology, Guwahati	CMP&MS	Priya Mahadevan
17	Sudipta Sil	Indian Institute of Technology (Indian School of Mines) Dhanbad, Dhanbad	CBMS	Rajib Kumar Mitra
18	Suprabha Mukhopadhyay	Indian Institutes of Science Education and Research, Kolkata	TS	Punyabrata Pradhan
19	Swagata Bera	Visva-Bharati University	A&C	Tapas Baug
20	Sweta Mallick	St. Xavier's College (Autonomous), Kolkata	A&C	Debanjan Bose
21	Varsha Felsy	Maharajas College, Ernakulam (Mahatma Gandhi University)	A&C	Debanjan Bose
22	Varun R P	National Institute of Technology, Karnataka	CMP&MS	Tanusri Saha Dasgupta
23	Vikram S. Gaikwad	Savitribai Phule Pune University	CBMS	Suman Chakrabarty

Summer Research Programme:

Date	Speaker & Affiliation	Title
27.08.2021	**Prof. Sreerup Raychaudhuri** Tata Institute of Fundamental Research, Mumbai	The Life and Work of Satyendra Nath Bose
21.09.2021	**Prof. B.N. Jagatap** IIT Bombay & Chairman, Governing Body, SNBNCBS	Acharya Prafulla Chandra Ray: Why His legacy Relevant Today
17.12.2021	**Prof. Gautam Gangopadhyay** University of Calcutta	Meghnad Saha : Scientist, Builder, Planner
21.01.2022	**Prof. Srubabati Goswami** Physical Research Laboratory, Ahmedabad	Remembering a star from another sky
25.02.2022	**Prof. Kankan Bhattacharyya** Department of Physical Chemistry, IISER, Bhopal	C V Raman and National Science Day

Bose Colloquium:

Date	Speaker & Affiliation	Title
20.08.2021	**Prof. Shobhana Narasimhan** Jawaharlal Nehru Centre for Advanced Scientific Research	Designing novel nanomaterials: one atom at a time
03.09.2021	**Prof. Mustansir Barma** Tata Institute of Fundamental Research, Hyderabad	Random Walks in Driven, Arrested and Coded Systems
17.09.2021	**Prof. Roop Mallik** Indian Institute of Technology, Bombay	ON and OFF Controls inside a Cellular Nano-machine
10.11.2021	**Prof. Partha Pratim Majumder** National Institute of Biomedical Genomics	Genes as a Guide to Human History and Culture
28.01.2022	**Prof. Bernd Büchner** Director of the Institute for Solid State Research, IFW Dresden and Professor for Experimental Physics at the Dresden University of Technology	Orbitals, Nematics, and Strain Tuning in Fe based High Tc Superconductors
11.03.2022	**Prof. Uwe Bovensiepen** University of Duisburg-Essen, Germany	Microscopic dynamics of propagating and localized excitations across interfaces analyzed by femtosecond solid state spectroscopy
31.03.2022	**Prof. Manoj Harbola** Professor, Department of Physics, Indian Institute of Technology, Kanpur and GB Member	Bubbles, Soda, Whiskey and Wine

Institute Colloquium

Date	Speaker & Affiliation	Title
30.04.2021	**Prof. K. Ganpathy Ayappa** Professor, IISc, Bangalore	Unravelling Membrane- Protein Intermediates and Lipid Modulation by Pore Forming Toxins
06.05.2021	**Prof. Sumit Mazumder** Professor, Physics Dept., University of Arizona at Tucson	Spin Ladders to Nowhere
30.07.2021	**Dr. Prerna Sharma** Associate Professor, IISc Bangalore	Mechanics of ciliary beating and phototaxis
10.09.2021	**Dr. Sarika Maitra Bhattacharyya** ACSIR CSIR-National Chemical Laboratory, Pune	The Elusive Connection Between Structure and Dynamics in the Supercooled Liquids
01.10.2021	**Dr. Debashree Ghosh** Indian Association for the Cultivation of Science	Quantum chemistry methods to study strongly correlated systems - from variational to machine learning approaches
12.11.2021	**Prof. B. Ananthanarayan** Indian Institute of Science, Bangalore	The Life and Scientific Work of Steven Weinberg

Visitor's & Associates & Student's Programme :"

1) Webinar Series on "Quantum Materials & Devices"

Date	Speaker & Affiliation	Title
29.09.2021	**Prof. Robert J. Cava** Princeton University, USA	Finding New Materials - a Chemical Perspective
03.11.2021	**Prof. Anders W. Sandvik** Boston University	The enigmatic deconfined quantum critical point
10.11.2021	**Prof. Subir Sachdev** Harvard University, USA	Planckian Metals and Black Holes
22.12.2021	**Prof. Rajiv R. P. Singh** University of California, Davis	Rare Earth Magnetic materials : Platforms for Exotic Spin States and Bose Condensation

2) Webinar Series on "Statistical Mechanics"

Date	Speaker & Affiliation	Title
30.11.2021	**Prof. Mehran Kardar** Massachusetts Institute of Technology	Forces from non-equilibrium fluctuations in Active Matter and QED
21.12.2021	**Prof. Yariv Kafri** Technion - Israel Institute of Technology, Israel	The long-ranged influence of disorder on active systems

A BRIEF REPORT OF CONFERENCES, WORKSHOPS AND EXTENSION PROGRAMME (CWEP) FROM 01.04.2021 TO 31.03.2022 FOR THE ANNUAL REPORT 2021-22

As per available records, during the period under reference, the following workshops/seminars/discussion meetings held at the Centre:

(1) International Conference on Physical Chemistry Physical Biology (PCPB-2021) jointly organized (online mode) by IIT Tirupati (Dr. Rajib Biswas), SNBNCBS Kolkata (Dr. Suman Chakrabarty & Prof. Ranjit Biswas) and IIT Bombay (Prof. Rajarshi Chakrabarti & Prof. Anindya Dutta) under the mentorship of Prof. Biman Bagchi, IISc Bangalore. Duration: 5 days (24.09.2021 to 28.09.2021).

(2) International Conference on Future Trends in Gravitational Physics 2022 (FTGP-2022) (online mode). Convener: Prof. Amitabha Lahiri, Senior Professor and Dr. Sunandan Gangopadhyay, Associate Professor. Duration: 3 days (08.02.2022 to 10.02.2022).

(3) International Conference on the Topology in Condensed Matter Systems (ICTCMS-2022) (both physical and virtual mode). Duration: 3 days (21.02.2022 to 23.02.2022). Conveners: Dr. Manoranjan Kumar, Associate Professor, Dr. Thirupathaiah Setti, Associate Professor, Dr. Nitesh Kumar, Assistant Professor and Prof. Prabhat Mandal, Emeritus Professor.

(4) STATPHYS Kolkata XI (online mode) jointly organized by SNBNCBS, Kolkata, IISER, Kolkata, VECC, Kolkata, SINP, Kolkata and IACS, Kolkata. Duration: 5 days (21.03.2022 to 25.03.2022). Dr. Sakuntala Chatterjee, Associate Professor, SNBNCBS and Prof. Pradeep K Mohanty, IISER, Kolkata were the Conveners.

Advanced Postdoctoral Research Programme (APRP)

Sl. No.	Name	Status	Dept.	Mentor
1	Aayatti Mallick Gupta	PDRA – I (Till 01.08.2021)	CBMS	Prof. Jaydeb Chakrabarti
2	Amit Mukherjee	PDRA – I (Till 05.09.2021)	A&C	Prof. Archan S Majumdar
3	Arpan Bhattacharyya	PDRA – I (from 19.12.2019 --)	CMPMS	Prof. Anjan Barman
4	Buddhadeb Pal	PDRA – I (from 20.08.2019 --)	CMPMS	Dr. Atindra Nath Pal
5	Deblina Majumder	PDRA –I (Till 31.05.2021)	CMPMS	Prof. Kalyan Mandal
6	Dharmesh Jain	PDRA –III (from 01.10.2019 --)	TS	Dr. Sunandan Gangopadhyay
7	Dusmanta Patra	PDRA –I (from 26.04.2021 --)	A&C	Prof. Kalyan Mandal
8	Ipsita Basu	PDRA –II (from 03.12.2019 --)	CBMS	Dr. Suman Chakrabarty
9	Mustaque Ali Khan	PDRA – I (from 12.07.2021 --)	CMPMS	Dr. Barnali Ghosh (Saha)
10	Piyali Saha	PDRA – I (from 23.04.2021 --)	A&C	Dr. Tapas Baug
11	Priyanka Garg	PDRA – I (from 05.02.2020 --)	CMPMS	Prof. Priya Mahadevan
12	Prasanta Kundu	PDRA –II (from 26.04.2021 --)	CBMS	Prof. Gautam Gangopadhyay
13	Pankaj Kr. Maheswari	PDRA – I (from 15.07.2021 --)	CMPMS	Dr. T. Setti
14	Santanu Pal	PDRA – I (from 19.05.2021 --)	CMPMS	Dr. Manoranjan Kumar
15	Soumya Chakrabarti	PDRA –II (from 05.07.2021 --)	TS	Prof. Amitabha Lahiri
16	Subhadip Chakrabarty	PDRA –I (from 25.06.2021 --)	CBMS	Prof. Rajib K Mitra
17	Tanmoy Paul	PDRA –III (from 23.04.2021 --)	CMPMS	Prof. Tanusri Saha Dasgupta
18	Yogesh V	PDRA – I (Till 05.09.2021)	TS	Dr. M. Sanjay Kumar

NPDF / RESEARCH ASSOCIATE (EXTERNAL FUND)

Sl. No.	NAME	STATUS	DEPT.	MENTOR	Title of the Project
1	Anuvab Banerjee, RA – I (Ad-hoc)	Till 05.03.2022	A&C	Dr. Debanjan Bose	Study of Astrophysical Sources in Very High Energy Regime using ground based Gamma ray and Neutrino Telescope
2	Alo Dutta, SRA – CSIR fund	From 07.01.2020	CMPMS	Prof. Kalyan Mandal	
3	Debarshi Das, NPDF	From 15.01.2021	A&C	Prof. Archan S Majumdar	Characterizing and utilizing quantum resources in the context of information processing tasks
4	Debashis Saha, NPDF	From 15.03.2021	A&C	Prof. Archan S Majumdar	Self-testing of quantum devices and device-independent information processing
5	Jayeta Banerjee, NPDF	From 31.12.2020	CBMS	Dr. Manik Pradhan	Theoretical and experimental investigations on transition metal dichalcogenide based surface plasmon resonance structure with applications in sensing

Sl. No.	NAME	STATUS	DEPT.	MENTOR	Title of the Project
6	Sanjukta Paul, RA – I	From 07.06.2021	CMPMS	Prof. Priya Mahadevan	Twistronics with transition metal dichalogenides
7	Soumita Mondal, RA – I (Ad-hoc)	Till 31.05.2021	CMPMS	Prof. Priya Mahadevan	Twistronics with transition metal dichalogenides
8	Soumendu Dutta, RA – III	From 25.08.2021	CMPMS	Prof. Tanusri Saha Dasgupta	Thematic Unit of Excellence on Computational Material Science
9	Sumit Nandi, RA – I	From 05.07.2021	A&C	Prof. Archan S Majumdar	Application of Quantum Information
10	Sumit Haldar, RA – I	From 01.09.2021	CMPMS	Dr. Manoranjan Kumar	Exploring Quantum and Thermal fluctuations in Frustrated Magnets at Low Temperature
11	Shreya Das, RA – I (Ad-hoc)	From 10.01.2022	CMPMS	Prof. Tanusri Saha Dasgupta	Thematic Unit of Excellence on Computational Material Science

EMERITUS / DST (INSPIRE) / RAMANUJAN FELLOW

Sl. No.	Name	Status	Dept.
1	Prof. Rabin Banerjee	Raja Ramanna Fellow	TS
2	Prof. Gautam De	Emeritus Professor	CBMS
3	Prof. Prabhat Mandal	Emeritus Professor	CMPMS
4	Prof. Milan Kr. Sanyal	Emeritus Professor (Till 30.04.2021)	CMPMS
5	Prof. Subhrangshu Sekhar Manna	Visiting (Honorary) Fellow	TS
6	Prof. Ranjan Chaudhury	Visiting (Honorary) Fellow	CMPMS
7	Prof. M. Sanjay Kumar	Visiting (Honorary) Fellow	TS
8	Prof. P.K. Mukhopadhyay	Visiting (Honorary) Fellow	CMPMS
9	Prof. Bikash Chakrabarty	Visiting (Honorary) Fellow (Till 31.12.2021)	TS
10	Prof. Bhupendra Nath Dev	Visiting (Honorary) Fellow (Till 25.08.2021)	CMPMS
11	Dr. Anup Ghosh	DST INSPIRE Faculty	CMPMS
12	Dr. Dipanwita Majumdar	DST INSPIRE Faculty	CMPMS
13	Dr. Tatini Rakshit	DST INSPIRE Faculty (Till 10.12.2021)	CBMS
14	Dr. Debanjan Bose	Ramanujan Fellow	A&C
15	Dr. Ali Hossain Khan	Ramanujan Fellow	CBMS
18	Dr. Manoj Mandal	Ramalingaswami Re-entry Fellow	CBMS

Nibedita Konar **Debashish Bhattacharjee** **Rupam Porel** **Sanchari Dasgupta**

Registrar

Report on Administrative Matters

The Centre has rendered administrative support to the academic activities through its administrative and technical staff members who have professionally and sincerely carried out their duties for making the various activities of the Centre in the year 2021-2022 successful. The Centre has a staff strength of 22 in permanent, 10 in temporary and 30 in contractual category as on 31st March 2022, performing their duties efficiently 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 have been made possible due to the professional services provided by the various service agencies working closely with the administrative sections of the Centre. The Centre has maintained close liasion with the Department of Science and Technology and other ministries and have replied to their various queries. All parliament information/reports sought by DST have been submitted on time. The Centre has successfully handled the CAG Audit Team and Audit Queries. The Hindi Cell of the Centre has been functioning effectively since April 2008. The Centre undertakes substantial administrative work in hindi and makes sincere effort to implement and follow the provision of Official Language Act. The Hindi Parliamentary Committee (Sansadiya Rajbhasha Samiti) visited SNBNCBS, Kolkata on 23rd November 2021 and interacted with the Hindi Implementation Committee. They also inspected the works done in Hindi by the Centre and gave their valued comments and instructions.

No cases related to vigilance have been reported during the period of 2021-2022. The Centre has also adhered to the norms of the Right to Information Act and so far has received 20 (twenty) cases under the said Act in the last financial year all of which has been successfully disposed off. All quarterly / annual reports pertaining to Hindi, Vigilance & RTI have been submitted timely through online mode.

As part of Vigilance Awareness Week 2021 during 26th October 2021 to 1st November 2021, the Centre organised Vigilance Pledge and an invited talk by Dr. Preeti Mahto, Chief Vigilance Officer, Vigilance Department, Kolkata Port Trust and an Essay Competition (Topic: "Independent India@75 Self Reliance with Integrity"). 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. Akash Das, Senior Research Fellow.
- 3rd Prize – Mr. Raj Gupta, Junior Research Fellow.

The Centre also organised the International Yoga Day on 21st June 2021 through online mode due to COVID-19 pandemic. The staff and students participated enthusiastically.

Meetings of the Statutory Committees of the Centre :

- The 63rd & 64th Governing Body (GB) meetings of the Centre were held on 20.09.2021 and 31.03.2022 respectively.
- The 41st & 42nd Finance Committee (FC) meeting of the Centre was held on 15.09.2021 and 28.03.2022 respectively.
- The 29th & 30th Academic & Research Programme Advisory Committee (ARPAC) meeting of the Centre was held on 17.08.2021 and 09.03.2022 respectively.

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 (for 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 and Homeopath

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 cashless tie ups 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, Apollo Gleneagles Hospital Ltd, Institute of Neurosciences, Kolkata etc. for indoor hospitalisation facility. Outdoor treatments are also available as per CGHS rates. The Centre has been successfully able to handle the COVID-19 pandemic through providing initial medical advice and timely hospitalisation to some of the COVID infected scholars. An emergency Covid Care Facility has been made in the Centre. The facility is equipped with two beds, pulse oximeter, blood pressure monitor, oxygen concentrator, one refrigerator (for preserving essential machines) and one washing machine.

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 provides accommodation to Post Doctoral Fellows, on request. The Integrated Hostel Building and Transit Quarter by the name 'Basundhara' is being moderately put into use through its dining hall facilities and housing of few faculty members, summer students etc.

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 rental basis.

The Centre successfully organised 129th Birth Anniversary of Prof. Satyendra Nath Bose, International Women's Day, National Science Day 2022 in hybrid mode and by maintaining all COVID-19 pandemic restrictions. The administration efficiently carried out its activities during the pandemic times by maintaining duty roster as and when required and restrictive entrance of visitors, vendors etc. The Centre is adhering to all the COVID-19 protocols in its premises.

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 ***[till 31.05.2021]*** & Prof. Tanusri Saha-Dasgupta, Director ***[w.e.f. 01.06.2021]*** for their valuable guidance and advice on administrative matters.

Shohini Majumder
Registrar

Hindi (Rajbhasha) Implementation in the Centre

Activities of the Hindi Cell

The Centre implemented the provisions of the Official Language Act in the year 2021-22. 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 were circulated in Hindi also and uploaded in the Centre's website. Many of the internal notings and signing in the Attendance Register (on the first of every month) were 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 correspondences in Hindi with the Ministry and other government 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 training of staff in the 'Parangat' course. The Centre timely submits quarterly progress report in hindi to the Dept of Official languages. The Centre is doing many of its routine administrative works in hindi eg. notings, letters etc.

In the month of September 2021, 'Hindi Mahina' was celebrated by organising Hindi Hindi Extempore, Hindi Debate Competition, Hindi Quiz, Hindi Essay Competition by maintaining COVID-19 restrictions. The essay competition carried a cash award of Rs.3,000/- (1st prize), Rs.2,000/- (2nd prize) and Rs.1,000/- (3rd prize). The winners of Essay Competition were:

Essay Competition:

- 1st Prize – Mr. Shivam Mishra, Senior Research Fellow.
- 2nd Prize – Ms. Mitali Bose, Office Assistant.
- 3rd Prize – Mr. Debasish Mitra, Telephone Operator.

On 14th September 2021 "Hindi Diwas Samaroh" was organised by maintaining all COVID-19 restrictions; Guest Lecturer, Shri Sunil Kumar 'Suman', Professor, Mahatma Gandhi International Hindi University, Kolkata and Shri L.K.Singh, Pradhyapak, Rajbhasha Bibhag, Kolkata delivered a talk on the said occasion.

The Hindi Parliamentary Committee (Sansadiya Rajbhasha Samiti) visited SNBNCBS, Kolkata on 23rd November 2021 and inspected the works done in Hindi by the Centre and gave their valued comments and instructions. The Committee members interacted with the members of the Hindi Implementation Committee of the Centre and stated that the Centre should work more proactively in implementation of Official Languages Act.

The Centre also organised three 'Hindi Workshops' through online mode pertaining to each quarter and by maintaining COVID-19 restrictions during 2021-2022: i) Talk on "Karyalayen Hindi ka Vyakaranik Swarup" by Shri L.K.Singh, Pradhyapak, Rajbhasha Bibhag, Kolkata on 22.09.2021; ii) Talk on "Computer ve taknik ke madhyam se Rajbhasha Hindi me Sahaj Karya ve Hindi vise typing" by Shri Narayan Shaw, Mukhya Prabhandak, Power Grid Corporation of India Ltd. Kolkata on 27.09.2021; iii) Talk on "Karyaleen Patrachaar me Hindi ka Sahaj Prayog" by Shri Sunil Kr. Loka, Assistant Director, Rajbhasha Bibhag, Nizam Palace, Kolkata on 23.12.2021; iv) Talk on "Hindi ka Mankikaran & Computer par Bharitiya Bhashayo ka Prayog " by Shri Rajesh Chaturvedi, Mukhya Prabandak (Rajbhasha), State Bank of India, Kolkata on 11.03.2022.

Majumder

Shohini Majumder
Registrar

Committees
(As on 31.03.2022)

Governing Body

Prof. B. N. Jagatap Professor Department of Physics, IIT Bombay, Mumbai	Chairman
Dr. Srivari Chandrashekhar Secretary Department of Science & Technology Government of India, New Delhi	Member
Prof. Prasanta K Panigrahi Professor Materials Science Centre, IIT, Kharagpur	Member
Prof. Pallab Banerji Professor Materials Science Centre, IIT, Kharagpur	Member
Dr. D.S. Ramesh Former Director IIG, Navi Mumbai	Member
Prof. Manoj Harbola Professor Dept. of Physics, IIT, Kanpur	Member
Financial Advisor Department of Science & Technology Government of India, New Delhi	Member
Prof. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Uday Bandopadhyay Director Bose Institute, Kolkata	Member
Prof. Tapas Chakraborty Director (Additional Charge) Indian Association for Cultivation of Science, Kolkata	Member
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. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Chairperson
Additional Secretary & Finance Advisor Department of Science & Technology, New Delhi	Member
Prof. Somak Raychaudhury Director Inter-University Centre for Astronomy and Astrophysics	Member
Prof. Pallab Banerji Professor Materials Science Centre, 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. Somak Raychaudhury Director, Inter-University Centre for Astronomy and Astrophysics, Pune	Member
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 Former Senior Professor, Bose Institute, Kolkata	Member
Prof. S. M. Yusuf Scientific Officer (H+), BARC, Mumbai	Member
Prof. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Anjan Barman Dean (Faculty) S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Amitabha Lahiri 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

Prof. Archan S Majumdar Head, Department of Astrophysics and Cosmology S. N. Bose National Centre for Basic Sciences, Kolkata	Permanent Invitee
Prof. Punyabrata Pradhan Head, Department of Theoretical Sciences S. N. Bose National Centre for Basic Sciences, Kolkata	Permanent Invitee
Prof. Priya Mahadevan Head, Department of Condensed Matter Physics and Material Sciences S. N. Bose National Centre for Basic Sciences, Kolkata	Permanent Invitee
Prof. Rajib K Mitra Head, Department of Chemical, Biological and Macromolecular Sciences S. N. Bose National Centre for Basic Sciences, Kolkata	Permanent Invitee

Building Committee

Prof. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Chairperson
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

Consultative Advisory Committee

Prof. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Chairperson
Prof. Anjan Barman Dean (Faculty) S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Amitabha Lahiri Dean (Academic Programme) S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Punyabrata Pradhan Head, Department of Theoretical Sciences S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Archan S Majumdar Head, Department of Astrophysics and Cosmology S. N. Bose National Centre for Basic Sciences, Kolkata	Member

Prof. Rajib K Mitra Head, Department of Chemical, Biological and Macromolecular Sciences S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Prof. Priya Mahadevan 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. Suman Saha 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. Tanusri Saha-Dasgupta Director S. N. Bose National Centre for Basic Sciences, Kolkata	Chairperson
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Dr. Manoranjan Kumar Associate Professor S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Dr. Nitesh Kumar Assistant Professor 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. Nibedita Konar Deputy Registrar (Academic) S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Mr. Suman Saha **Deputy Registrar (Finance)** S. N. Bose National Centre for Basic Sciences, Kolkata	Member
Mr. Mithilesh Kumar Pande Campus Engineer cum Estate Officer 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

Academic members 2021-22

ACADEMIC MEMBERS (REGULAR FACULTIES) : 2021-2022

Sl. No.	Name of the faculty	Designation
1	Tanusri Saha-Dasgupta	Director & Senior Professor : CMPMS
2	Samit Kumar Ray [till 31.05.2021]	Director & Senior Professor : CMPMS
3	Archan S Majumdar	Senior Professor : A&C
4	Kalyan Mandal	Senior Professor : CMPMS
5	Amitabha Lahiri	Senior Professor : TS
6	Priya Mahadevan	Senior Professor : CMPMS
7	Ranjit Biswas	Senior Professor : CBMS
8	Samir Kumar Pal	Senior Professor : CBMS
9	Anjan Barman	Senior Professor : CMPMS
10	Gautam Gangopadhyay	Senior Professor : CBMS
11	Jaydeb Chakrabarti	Senior Professor : CBMS
12	Biswajit Chakraborty [till 30.11.2021]	Senior Professor : TS
13	Manu Mathur [till 30.11.2021]	Professor : TS
14	Prosenjit Singha Deo	Professor : CMPMS
15	Soumen Mondal	Professor : A&C
16	Rajib Kumar Mitra	Professor : CBMS
17	Manik Pradhan	Professor : CBMS
18	Punyabrata Pradhan	Professor : TS
19	Barnali Ghosh (Saha)	Scientist 'F'
20	M. Sanjay Kumar [till 31.07.2021]	Associate Professor : TS
21	Sakuntala Chatterjee	Associate Professor : TS
22	Manoranjan Kumar	Associate Professor : CMPMS
23	Ramkrishna Das	Associate Professor : A&C
24	Sunandan Gangopadhyay	Associate Professor : TS
25	Suman Chakrabarty	Associate Professor : CBMS
26	Atindra Nath Pal	Associate Professor : CMPMS
27	Sanjoy Choudhury	Scientist 'D'
28	Thirupathaiah Setti	Assistant Professor : CMPMS
29	Urna Basu (From 15.09.2020)	Assistant Professor : TS
30	Tapas Baug (From 15.01.2021)	Assistant Professor : A&C
31	Nitesh Kumar (From 23.02.2021)	Assistant Professor : CMPMS
32	Avijit Chowdhury (From 12.05.2021)	Assistant Professor : CMPMS
33	Pradip S Pachfule (From 27.08.2021)	Assistsant Professor : CBMS

ADVANCED POST DOCTORAL RESEARCH PROGRAM (APRP) : 2021-2022 [as on 31.03.2022]

Sl. No.	NAME	STATUS	DEPT.	MENTOR
1	Aayatti Mallick Gupta	PDRA – I (Till 01.08.2021)	CBMS	Prof. Jaydeb Chakrabarti
2	Amit Mukherjee	PDRA – I (Till 05.09.2021)	A&C	Prof. Archan S Majumdar
3	Arpan Bhattacharyya	PDRA – I (from 19.12.2019 --)	CMPMS	Prof. Anjan Barman
4	Buddhadeb Pal	PDRA – I (from 20.08.2019 --)	CMPMS	Dr. Atindra Nath Pal
5	Deblina Majumder	PDRA –I (Till 31.05.2021)	CMPMS	Prof. Kalyan Mandal
6	Dharmesh Jain	PDRA –III (from 01.10.2019 --)	TS	Dr. Sunandan Gangopadhyay
7	Dusmanta Patra	PDRA –I (from 26.04.2021 --)	A&C	Prof. Kalyan Mandal
8	Ipsita Basu	PDRA –II (from 03.12.2019 --)	CBMS	Dr. Suman Chakrabarty
9	Mustaque Ali Khan	PDRA – I (from 12.07.2021 --)	CMPMS	Dr. Barnali Ghosh (Saha)
10	Piyali Saha	PDRA – I (from 23.04.2021 --)	A&C	Dr. Tapas Baug
11	Priyanka Garg	PDRA – I (from 05.02.2020 --)	CMPMS	Prof. Priya Mahadevan
12	Prasanta Kundu	PDRA –II (from 26.04.2021 --)	CBMS	Prof. Gautam Gangopadhyay
13	Pankaj Kr. Maheswari	PDRA – I (from 15.07.2021 --)	CMPMS	Dr. T. Setti
14	Santanu Pal	PDRA – I (from 19.05.2021 --)	CMPMS	Dr. Manoranjan Kumar
15	Soumya Chakrabarti	PDRA –II (from 05.07.2021 --)	TS	Prof. Amitabha Lahiri
16	Subhadip Chakrabarty	PDRA –I (from 25.06.2021 --)	CBMS	Prof. Rajib K Mitra
17	Tanmoy Paul	PDRA –III (from 23.04.2021 --)	CMPMS	Prof. Tanusri Saha Dasgupta
18	Yogesh V	PDRA – I (Till 05.09.2021)	TS	Dr. M. Sanjay Kumar

NPDF/ RESEARCH ASSOCIATE (EXTERNAL FUND) : 2021-2022

Sl. No.	NAME	STATUS	DEPT.	MENTOR
1	Anuvab Banerjee, RA – I (Ad-hoc)	From 06.09.2021	A&C	Dr. Debanjan Bose
2	Alo Dutta, SRA – CSIR fund	From 07.01.2020	CMPMS	Prof. Kalyan Mandal
3	Debarshi Das, NPDF	From 15.01.2021	A&C	Prof. Archan S Majumdar
4	Debashis Saha, NPDF	From 15.03.2021	A&C	Prof. Archan S Majumdar
5	Jayeta Banerjee, NPDF	From 31.12.2020	CBMS	Dr. Manik Pradhan
6	Sanjukta Paul, RA – I (SERB)	From 07.06.2021	CMPMS	Prof. Priya Mahadevan
7	Sayan Bayan, SRA – CSIR Fund	Till 13.04.2021	CMPMS	Prof. Samit Kr. Ray
8	Shreya Das, RA – I (Ad-hoc)	From 10.01.2022	CMPMS	Prof. Tanusri Saha Dasgupta
9	Soumita Mondal, RA – I (Ad-hoc)	Till 31.05.2021	CMPMS	Prof. Priya Mahadevan
10	Soumendu Datta, RA – III (Ad-hoc)	Till 31.05.2021	CMPMS	Prof. Tanusri Saha Dasgupta
11	Soumendu Datta, RA – III (JC Bose Award)	From 25.08.2021	CMPMS	Prof. Tanusri Saha Dasgupta
12	Sumit Halder, RA – I (Ad-hoc)	Till 31.08.2021	CMPMS	Dr. Manoranjan Kumar
13	Sumit Halder, RA – I (SERB)	From 01.09.2021	CMPMS	Dr. Manoranjan Kumar
14	Sumit Nandi, RA – I (DST)	From 05.07.2021	A&C	Prof. Archan S Majumdar
15	Sudip Kr. Saha, Bridge Fellow	From 01.03.2022	CMPMS	Dr. Manoranjan Kumar

EMERITUS / DST (INSPIRE) / RAMANUJAN FELLOW : 2021-2022

Sl. No.	NAME	STATUS	DEPT.
1	Prof. Rabin Banerjee	Raja Ramanna Fellow	TS
2	Prof. Gautam De	Emeritus Professor	CBMS
3	Prof. Prabhat Mandal	Emeritus Professor	CMPMS
4	Prof. Milan Kr. Sanyal	Emeritus Professor (Till 30.04.2021)	CMPMS
5	Prof. Subhrangshu Sekhar Manna	Visiting (Honorary) Fellow	TS
6	Prof. Ranjan Chaudhury	Visiting (Honorary) Fellow	CMPMS
7	Prof. M. Sanjay Kumar	Visiting (Honorary) Fellow	TS
8	Prof. P.K. Mukhopadhyay	Visiting (Honorary) Fellow	CMPMS
9	Prof. Bikash Chakrabarty	Visiting (Honorary) Fellow (Till 31.12.2021)	TS
10	Prof. Bhupendra Nath Dev	Visiting (Honorary) Fellow (Till 25.08.2021)	CMPMS
11	Dr. Anup Ghosh	DST INSPIRE Faculty	CMPMS
12	Dr. Dipanwita Majumdar	DST INSPIRE Faculty	CMPMS
13	Dr. Tatini Rakshit	DST INSPIRE Faculty (Till 10.12.2021)	CBMS
14	Dr. Debanjan Bose	Ramanujan Fellow	A&C
15	Dr. Ali Hossain Khan	Ramanujan Fellow	CBMS
16	Dr. Manoj Mandal	Ramalingaswami Re-entry Fellow	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

Staff Members of Academic Section

Administrative and Technical Staff Members

Shohini Majumder	Registrar
Kalyan Mandal	Vigilance Officer (w.e.f. 18.10.2021)
Debashish Bhattacharjee	Public Information Officer

Other Members

Saumen Adhikari	Librarian cum Information Officer
Nibedita Konar	Deputy Registrar (Academic)
Debashish Bhattacharjee	Deputy Registrar (Administration)
Suman Saha	Deputy Registrar (Finance)
Mithilesh Kumar Pande	Campus Engineer cum Estate Officer
Santosh Kumar Singh	Assistant Registrar (Purchase)
Sirsendu Ghosh	Programme Coordinating Officer
Achyut Saha	Personal Assistant to Director
Swapnamoy Datta	Stenographer
Sanchari Dasgupta	Assistant (General)
Jaydeep Kar	Programme Assistant
Prosenjit Talukdar	Programme Assistant
Shiba Prasad Nayak	Pump Operator [superannuated on 31.07.2021]
Bijoy Kumar Pramanik	Junior Assistant (Guest House)
Bhupati Naskar	Library Stack Assistant
Siddhartha Chatterjee	Upper Division Clerk
Swarup Dutta	Project Assistant
Sushanta Kumar Biswas	Driver
Partha Mitra	Attendant
Ratan Acharya	Attendant [superannuated on 30.04.2021]
Swapan Ghosh	Attendant
Rajarshi Barman	Attendant
Sabyasachi Mondal	Attendant

PERSONNEL WITH TEMPORARY STATUS

Biman Roy	Attendant (Administration) [superannuated on 30.06.2021]
Dulal Chatterjee	Attendant (Maintenance)
Somnath Roy	Attendant (Accounts)
Sudhanshu Chakraborty	Attendant (Technical Cell)
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

A.K. Sarkar	Advisor (Finance)
B.S. Panda	Consultant (Legal)
Amitabha Haldar	Executive Engineer [till 03.02.2022]
Ayan Deb	Assistant Engineer (Electrical)
Sutapa Basu	PS to Registrar
Abhijit Ghosh	Junior Computer Engineer
Sagar Samrat De	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
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
Suvendu Dutta	Office Assistant
Sonali Sen	Office Assistant
Lina Mukherjee	Jr. Office Assistant
Debasish Mitra	Telephone Operator
Sani Amed Ali Molla	Technician (AC & Refrigeration)
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

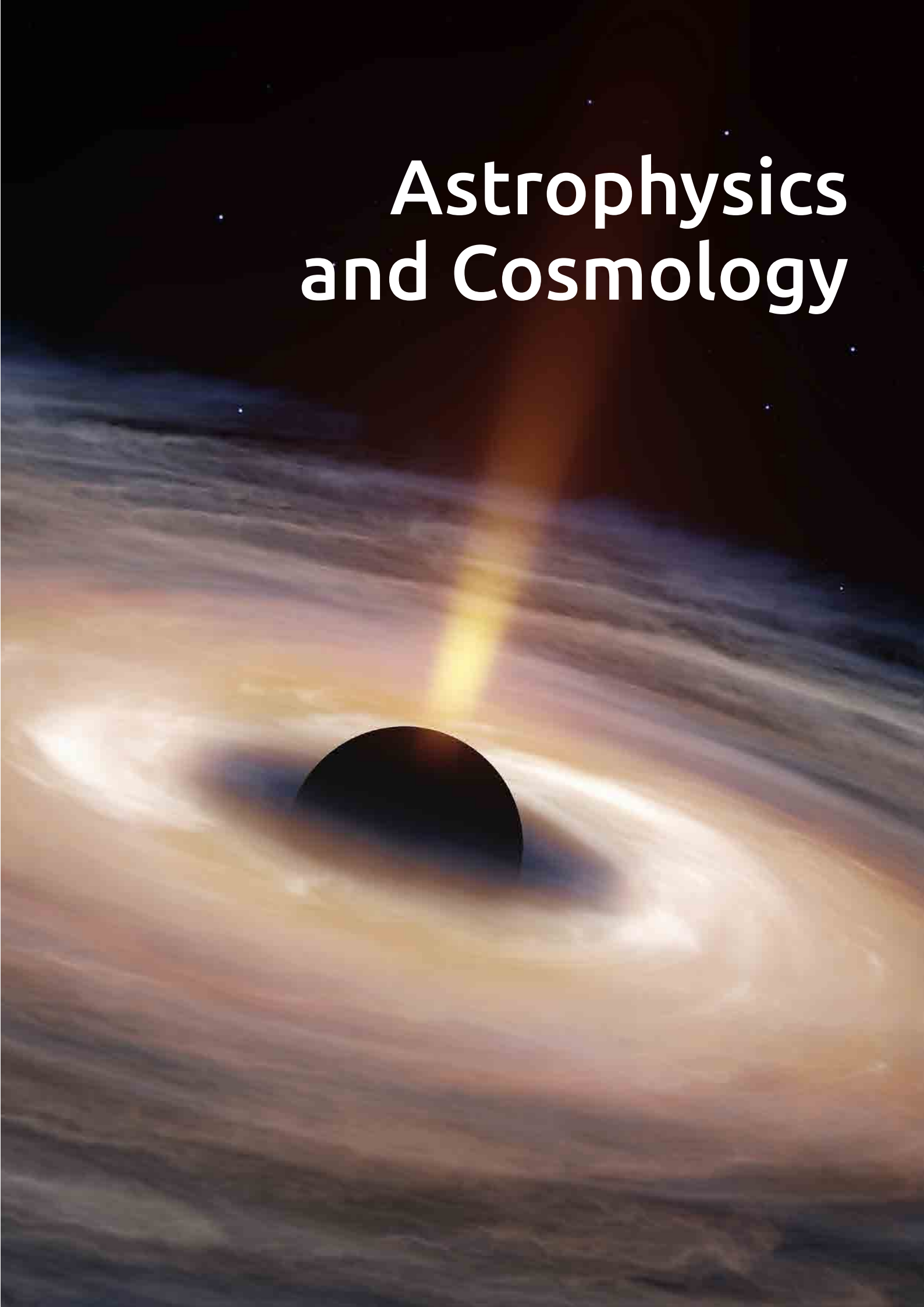
Staff members of the Centre

Staff members, Administrative Section

Staff membes, Engineering Section

Staff members, Purchase Section

Astrophysics and Cosmology



Department of Astrophysics and Cosmology

Archan Subhra Majumdar

Department profile indicators

Table A: Manpower and resources

Number of faculty Members	4 Regular + 1 Ramanujan Fellow
Number of Post –doctoral research associate (centre+project)	7
Number of Ph.D students	22
Number of other project staff	3
Number of summer students	7
Projects (ongoing)	5

Table B: Research Activities indicators

Number of research papers in Journals	27
Number of Book-chapters/books	1
Number of other publications	2
Number of Ph.D students graduated (submitted+degree awarded)	5
Number of M.Tech/M.Sc projects	4
Projects (ongoing)	5

Table C: Academic activities and linkage

Number of courses taught by faculty Members	10
Number of Visitors (non –associates)	1
Number of associates	-
Number of Seminars organized	22
Number of Conference/Symposia/Advanced Schools organized	3
Number of talks delivered by Members of department in conferences/Symposia	National : 6
	International : 3

Most important Research Highlights

- Supernova model discrimination with hyper-Kamiokande
- Photoionization modeling of dusty nova and compact planetary nebulae
- Estimation of M-Dwarf parameters using high-resolution optical and NIR features
- ALMA three-millimeter observations of massive star-forming regions
- ALMA discovery of a dual dense probably rotating outflow from a massive young stellar object
- ALMA study of outflow parameters of protoclusters
- Evidence of "rocket effect" through clustering of low mass stars
- Formulation of self-testing protocols without entanglement
- Scheme for distillation of genuine tripartite quantum steering
- Violation of gravitational equivalence principle in an atom-mirror system
- Demonstration of quantum advantage in shared randomness generation
- Protocols for random-receiver quantum communication

Summary of Research Activities

A "Nova" refers to an explosion that occurs on a white dwarf surface due to thermonuclear runaway. How dust forms in the hostile environment in novae ejecta has been an open question for many decades. We have modeled observed pre- and post-dust phase spectra of the dust forming nova V1280 Scorpii with a primary aim to understand how the physical parameters associated with the system evolve during dust formation. Some of the key results are: i) a very high hydrogen density (~10^{13}-10^{14} cm^{-3}) in the ejecta, (ii) dust condensation conditions are achieved at high ejecta density (~3.16×10^{8} cm^{-3}) and low temperature (~2000 K) in the outer region (R ~ 10^{15} cm) of the ejecta.

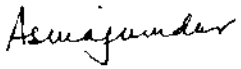
Core-collapse supernovae are among the most magnificent events in the observable universe. They produce many of the chemical elements necessary for life to exist. However, despite a century of astrophysical study, the explosion mechanism of core-collapse supernovae is not yet well understood. Hyper-Kamiokande is a next-generation neutrino detector that will be able to observe the neutrino flux from supernova in unprecedented detail. We use a newly-developed, high-precision supernova event generator to simulate Hyper-Kamiokande's response to five different supernova models and show that Hyper-Kamiokande will be able to distinguish between these models with high accuracy.

Star formation is a complex process that involves the collapse and accretion of gas onto protostars. Molecular outflows are ubiquitous in the early stages of star formation. Using Atacama Large Millimeter (ALMA) CO line data, we have identified outflows in eleven massive star-forming regions. Our results indicate that sufficient amount of energy to maintain turbulence is injected by outflows. In another study, we have discovered the dual rotating outflows associated with a massive young stellar object using ALMA data. Such an evidence for massive star formation has never been reported before.

We estimate effective temperature, stellar radius, and luminosity for a sample of 271 M-dwarf stars (M0V-M7V) observed as a part of CARMENES (Calar Alto high-Resolution search for M dwarfs with Exo-earths with Near-infrared and optical Echelle Spectrographs) radial-velocity planet survey. For the first time, using the simultaneously observed high-resolution (R~90000) spectra in the optical (0.52–0.96 μm) and near-infrared (0.96–1.71 μm) bands, we derive empirical calibration relationships to estimate the fundamental parameters of these low-mass stars. We also explore and compare our results with literature values obtained using other different methods for the same sample of M dwarfs.

The status of the gravitational weak equivalence principle in the realm of quantum theory is a hotly debated issue. We study the spontaneous excitation of a two-level atom in the presence of a perfectly reflecting mirror, when the atom, or the mirror, is uniformly accelerating in the framework of the generalised uncertainty principle (GUP). An explicit violation of the equivalence principle seems to be manifested. We further obtain an upper bound on the GUP parameter using standard values of the system parameters.

Characterization of quantum devices received from unknown providers is a significant primary task for any quantum information processing protocol. Self-testing protocols are designed for this purpose of certifying quantum components from the observed statistics under a set of minimal assumptions. We propose a self-testing protocol for certifying binary Pauli measurements employing the violation of a Leggett-Garg inequality. Our approach requires neither dimensional restrictions, nor other stringent assumptions on the type of measurements.



Archan Subhra Majumdar
Head, Department of Astrophysics and Cosmology

Archan Subhra Majumdar
Senior Professor
Astrophysics & Cosmology
archan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Shounak Datta; Quantum Information; Under progress
2. Riddhi Chatterjee; Relativistic Quantum Mechanics; Under progress
3. Arnab Sarkar; Gravitation and Cosmology; Under progress; K R Nayak, IISER Kolkata (Co-supervisor)
4. Ananda Gopal Maity; Quantum Information; Thesis submitted
5. Shashank Gupta; Quantum Information; Thesis submitted
6. Bihalan Bhattacharya; Quantum Information; Under progress
7. Arun Kumar Das; Quantum Information; Under progress
8. Subhankar Bera; Quantum Information; Under progress
9. Shashank Sekhar Pandey; Gravitation and Cosmology; Under progress
10. Bivas Mallik; Quantum Information; Under progress
11. Saheli Mukherjee; Quantum Information; Under progress
12. Arnab Mukhopadhyay; Relativistic Quantum Mechanics; Under progress

b) Post-Docs

1. Amit Mukherjee; Quantum Foundations
2. Debarshi Das; Quantum Information
3. Debashis Saha; Quantum Foundations
4. Sumit Nandi; Quantum Information

c) External Project Students / Summer Training

1. Disha Bandyopadhyay; Introduction to Gravitational Waves; RKMVERI
2. Raghvendra Rathore; Introduction to Dark Eneregy; IIT Kharagpur

Teaching

1. Spring semester; General Relativity and Cosmology; Integrated Ph.D.; 4 students; with 1 (Sunandan Gangopadhyay) co-teacher
2. Spring semester; General Relativity and Cosmology; Ph.D.; 5 students; with 1 (Sunandan Gangopadhyay) co-teacher

Publications

a) In journals

1. Ananda G. Maity, Shiladitya Mal, Chellasamy Jebarathinam, and **A. S. Majumdar**, *Self-testing of binary Pauli measurements requiring neither entanglement nor any dimensional restriction*, Physical Review A, 103, 062604, 2021
2. Riddhi Chatterjee, Sunandan Gangopadhyay & **A. S. Majumdar**, *Resonance interaction of two entangled atoms accelerating between two mirrors*, The European Physical Journal D, 75, 179, 2021
3. Bihalan Bhattacharya, Suchetana Goswami, Rounak Mundra, Nirman Ganguly, Indranil Chakrabarty, Samyadeb Bhattacharya and **A S Majumdar**, *Generating and detecting bound entanglement in two-qutrits using a family of indecomposable positive maps*, Journal of Physics Communications, 5, 065008, 2021
4. Shashank Gupta, Debarshi Das, and **A. S. Majumdar**, *Distillation of genuine tripartite Einstein-Podolsky-Rosen steering*, Physical Review A, 104, 022409, 2021
5. Riddhi Chatterjee, Sunandan Gangopadhyay and **A. S. Majumdar**, *Violation of equivalence in an accelerating atom-mirror system in the generalized uncertainty principle framework*, Physical Review D, 104, 124001, 2021
6. Shashank Gupta, Debarshi Das, Chellasamy Jebarathinam, Arup Roy, Shounak Datta & **A. S. Majumdar**, *"All-versus-nothing" proof of genuine tripartite steering and entanglement certification in the two-sided device-independent scenario*, Quantum Studies: Mathematics and Foundations volume 9, pages 175-198, 2022

Independent publication of Student / Post-Doc

1. Arkaprabha Ghosal, Debarshi Das, and Subhashish Banerjee, *Characterizing qubit channels in the context of quantum teleportation*, Physical Review A, 103, 052422, 2021
2. Debarshi Das, Arkaprabha Ghosal, Ananda G. Maity, Som Kanjilal, and Arup Roy, *Ability of unbounded pairs of observers to achieve quantum advantage in random access codes with a single pair of qubits*, Physical Review A, 104, L060602, 2021
3. Sumit Rout, Ananda G. Maity, Amit Mukherjee, Saronath Halder, and Manik Banik, *Multiparty orthogonal product states with minimal genuine nonlocality*, Physical Review A, 104, 052433, 2021
4. Tamal Guha, Mir Alimuddin, Sumit Rout, Amit Mukherjee, Some Sankar Bhattacharya and Manik Banik, *Quantum Advantage for Shared Randomness Generation*, Quantum, 5, 569, 2021
5. Some Sankar Bhattacharya, Ananda G. Maity, Tamal Guha, Giulio Chiribella, and Manik Banik, *Random-Receiver Quantum Communication*, PRX Quantum, 2, 020350, 2021
6. Arnab Sarkar, Amna Ali & Salah Nasri, *Perturbative correction terms to electromagnetic self-force due to metric perturbation: astrophysical and cosmological implications*, The European Physical Journal C, 81, 725, 2021
7. Rivu Gupta, Shashank Gupta, Shiladitya Mal, and Aditi Sen(De), *Constructive feedback of non-Markovianity on resources in random quantum states*, Physical Review A, 105, 012424, 2022

Talks / Seminars Delivered in reputed Conference / Institutions

1. Quantum Information and Computation - QFA 2021; Oct 18, 2021; Online; 45 mins
2. 26th International Conference on Advances in Relativistic Astrophysics and Cosmology; Dec 18, 2021; Online; 30 mins

Administrative Duties

1. Dean (Faculty) up to October 2021
2. HOD, A&C from November 2021

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Applications of Quantum Information; DST; 3 yrs; PI
2. Free space quantum communication; DST; 3 yrs; Co-PI
3. Quantum heat engines; DST; 3 yrs; Co-PI

Conference / Symposia / Schools organized

1. International Conference on Quantum Information and Foundations; Feb 14, 2022; ISI Kolkata; 10 days

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. National Cheng Kung University, Taiwan; Sl. No. 1; International
2. Centre for Theoretical Physics, Warsaw, Poland; Sl. No. 1, 6; International
3. IIIT Hyderabad; Sl. No. 3; National
4. Bose Institute; Sl. No. 7, 8; National
5. IIT Jodhpur; Sl. No. 7, 8; National
6. ICTQT, Gdansk, Poland; Sl. No. 9, 10; International
7. IISER Thiruvananthapuram; Sl. No. 9, 10, 11; National
8. ISI Kolkata; Sl. No. 9, 10; National
9. University of Hong Kong; Sl. No. 9, 10, 11; International
10. Jadavpur University; Sl. No. 12; National
11. ICTP, Trieste, Italy; Sl. No. 12; International
12. HRI, Prayagraj; Sl. No. 13; National

Areas of Research

Quantum Information & Communication; Cosmology

Characterization of quantum devices received from unknown providers is a significant primary task for any quantum information processing protocol. Self-testing protocols are designed for this purpose of certifying quantum components from the observed statistics under a set of minimal assumptions. Here we propose a self-testing protocol for certifying binary Pauli measurements employing the violation of a Leggett-Garg inequality. Our approach requires neither dimensional restrictions, nor other stringent assumptions on the type of measurements.

We study the resonance interaction between two entangled identical atoms coupled to a quantized scalar field vacuum, and accelerating between two mirrors. We show how radiative processes of the two-atom entangled state can be manipulated by the atomic configuration undergoing noninertial motion. We show that both the energy level shift and the relaxation rate can be controlled by tuning the relevant parameters such as atomic entanglement, acceleration, interatomic distance and position with respect to the boundaries.

We study the spontaneous excitation of a two-level atom in the presence of a perfectly reflecting mirror, when the atom, or the mirror, is uniformly accelerating in the framework of the generalised uncertainty principle (GUP). An explicit violation of the equivalence principle seems to be manifested. We further obtain an upper bound on the GUP parameter using standard values of the system parameters.

The problem of bound entanglement detection is a challenging aspect of quantum information theory for higher dimensional systems. Here, we propose an indecomposable positive map for two-qutrit systems, which is shown to detect a class of positive partial transposed (PPT) states. Further, we perform a structural physical approximation of the indecomposable map to make it a completely positive one, and find a new PPT-entangled state which is not detectable by certain other well-known entanglement detection criteria.

We consider two types of hybrid scenarios: one-sided device-independent (1SDI) scenario (where one observer is untrusted, and other two observers are trusted) and two-sided device-independent (2SDI) scenario (where two observers are untrusted, and one observer is trusted). In both the scenarios, we show distillation of perfectly genuine steerable assemblage of three-qubit Greenberger–Horne–Zeilinger (GHZ) states or three-qubit W states from many copies of initial partially genuine steerable assemblages of the corresponding states.. In case of practical scenarios employing finite copies, we show that the efficiency of our distillation protocols reaches near perfect levels using only a few number of initial assemblages.

We present an "all-versus-nothing" proof of tripartite Einstein-Podolsky-Rosen (EPR) steering by demonstrating the non-existence of a local hidden state (LHS) model in the tripartite network as a motivation to our main result. A full logical contradiction of the predictions of the LHS model with quantum mechanical outcome statistics for any three-qubit generalized Greenberger-Horne-Zeilinger (GGHZ) states and pure W-class states is shown, using which, one can distinguish between the GGHZ and W-class states in the two-sided device-independent (2SDI) steering scenario. We next formulate a 2SDI fine-grained steering inequality for the tripartite scenario. We show that the maximum quantum violation of this FGI can be used to certify genuine entanglement of three-qubit pure states.

Plan of Future Work Including Project

1. We consider a scenario of remote state preparation of qubits where a single copy of an entangled state is shared between Alice on one side, and several Bobs on the other, who sequentially perform unsharp single-particle measurements. In the given scenario, we first determine the classical bound of fidelity for the preparation of remote states by the Bobs. We then show that there can be at most 6 number of Bobs who can sequentially and independently prepare the remote qubit in Alice's lab with fidelity exceeding the classical bound in the presence of shared quantum correlations. The upper bound is achieved when the singlet state is initially shared between Alice and the first Bob and every Bob prepares a state chosen from the equatorial circle of the Bloch sphere. The maximum number of Bobs starts to decrease from 6 when either the choice of remote states is shifted from the equatorial circle towards the poles of the Bloch sphere, or when the initial state shifts towards non-maximally entangled pure and mixed states.

2. How best one can recycle a given quantum resource, mitigating the various difficulties involved in its preparation and preservation, is of considerable importance for ensuring efficient applications in quantum technology. Here we demonstrate quantitatively the resource theoretic advantange of reusing the single copy of a two-qubit entangled state towards information processing. To this end, we consider a scenario of sequential detection of the given entangled state by multiple independent observers on each of the two spatially separated wings. In particular, we consider equal numbers of sequential observers on the two wings. We first determine the upper bound on the number of observers who can detect entanglement employing suitable entanglement witness operators. In terms of the parameters characterizing the entanglement consumed and the robustness of measurements, we then compare the above scenario with the corresponding scenario involving the sharing of multiple copies of identical two-qubit states among the two wings. This reveals a clear resource theroretic advantage of recycling the single copy of a two-qubit entangled state.

3. We explore the fundamental origin of the quantum advantage behind random access code. We propose new temporal inequalities compatible with noninvasive-realist models and show that any non-zero quantum advantage of $n \mapsto 1$ random access code in presence of shared randomness is equivalent to the violation of the corresponding temporal inequality. As an immediate consequence of this connection we also prove that maximal success probability of $n \mapsto 1$ random access code can be obtained when the maximal violation of the corresponding inequality is achieved. We then show that any non-zero quantum advantage of $n \mapsto 1$ random access code, or in other words, any non-zero violation of the corresponding temporal inequality can certify genuine randomness.

4. Certification of quantum devices received from unknown providers is a primary requirement before utilizing the devices for any information processing task. Here, we establish a protocol for certification of {\color{red} a particular set of} d-outcome quantum measurements (with d being arbitrary) in a setup comprising of a preparation followed by two measurements in sequence. We propose a set of temporal inequalities pertaining to different d involving correlation functions corresponding to successive measurement outcomes, that are not satisfied by quantum devices. Using quantum violations of these inequalities, we certify d-outcome measurements under some minimal assumptions which can be met in an experiment efficiently. Our certification protocol neither requires entanglement, nor any prior knowledge about the dimension of the system under consideration. We further show that our protocol is robust against practical non-ideal realizations. Finally, as an offshoot of our protocol, we present a scheme for secure certification of genuine quantum randomness.

5. We consider the propagation of gravitational waves in our late time Universe with the presence of structure. Gravitational waves emitted from distant sources have to traverse through regions that are far from smooth and homogeneous, before detection. We investigate the effect of inhomogeneities on the observables associated with the gravitational waves sources. In particular, we evaluate the impact of inhomogeneities on gravitational wave propagation employing the Buchert's framework of averaging. In context of a toy model within the above framework, it is first shown how the redshift versus distance relation gets affected through the averaging process. We then study the variation of the redshift dependent part of the observed gravitational wave amplitude for different combination of our model parameters. We show that the variation of the gravitational wave amplitude with respect to redshift can deviate significantly in comparison with that in the ΛCDM-model. Our result signifies the importance of local inhomogeneities on precision measurements of parameters of gravitational wave sources.

Debanjan Bose
Ramanujan Fellow
Astrophysics & Cosmology
debanjan.bose@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Tanima Mondal; Neutrino Oscillation Measurements with HyperK; Ongoing; Sanjoy Majumdar (Co-supervisor)
2. Ajay Sharma; Study of blazers at very high energy regime; Ongoing; Sakuntala Chatterjee (Co-supervisor)

b) Post-Docs

1. Anuvab Banerjee; Multi-wavelength study of Blazars; Funded by research grant of my Ramanujan Fellowship

c) External Project Students / Summer Training

1. Sweta Mallick (Summer Student); Study of solar neutrinos with Cherenkov detectors
2. Varsha Felsy (Summer student); Study of blazars at high energy regime with gamma-rays and neutrinos
3. Priyanka Gangopadhyay (external project); Study of core-collapse supernova
4. Payal Roy (external project); Study of neutrino oscillations
5. Sudip Chakrabarty (Research project III); Cosmic Rays

Teaching

1. Spring 2022; Astrophysics; PHY510; 6 students; Prof. Soumen Mondal & Dr. Ramkrishna Das (Co-Supervisors)

Publications

a) In Journals

1. J. Abhir, R. Prince, J. Joseph, **D. Bose** and N. Gupta, *Study of Temporal and Spectral variability for Blazar PKS 1830-211 with Multiwavelength Data*, The Astrophysical Journal, 915, 26, 2021
2. K. Abe, P. Adrich, H. Aihara, R. Akutsu, I. Alekseev, A. Ali, F. Ameli, I. Anghel, L. H. V. Anthony, M. Antonova, A. Araya, Y. Asaoka, Y. Ashida, V. Aushev, F. Ballester, I. Bandac, M. Barbi, G. J. Barker, G. Barr, M. Batkiewicz-Kwasniak, M. Bellato, V. Berardi, M. Bergevin, L. Bernard, E. Bernardini, L. Berns, S. Bhadra, J. Bian, A. Blanchet, F. d. M. Blaszczyk, A. Blondel, A. Boiano, S. Bolognesi, L. Bonavera, N. Booth, S. Borjabad, T. Boschi, **D. Bose**, et al. *Supernova Model Discrimination with Hyper-Kamiokande*, The Astrophysical Journal, 916, 15, 2021

3. **D. Bose**, V. R. Chitnis, P. Majumdar & B. S. Acharya, *Ground-based gamma-ray astronomy: history and development of techniques*, The European Physical Journal Special Topics, 231, 3-26, 2022
4. **D. Bose**, V. R. Chitnis, P. Majumdar & A. Shukla, *Galactic and extragalactic sources of very high energy gamma rays*, The European Physical Journal Special Topics, 231, 27-66, 2022

b) Conference proceedings / Reports / Monographs / Books

1. High Energy Astrophysical Neutrinos; Debanjan Bose & Subhendu Rakshit; Springer Briefs in Astronomy (2021)

Talks / Seminars Delivered in reputed Conference / Institutions during the Period

1. Invited talk about ground based gamma ray astronomy during an online national conference on emerging trends on physics (NCETP-2021) organized by Tezpur University; 16th June, 2021; Online; 1 hour
2. Invited talk on probing high energy universe with gamma-rays and neutrinos; 22nd December, 2021; RKMVERI; 1 hour

Scientific collaborations with other National / International Invitations (based on Joint Publications)

1. Hyper-Kamiokande Collaboration; International
2. Cherenkov Telescope Array Collaboration; International

Areas of Research

Gamma-ray Astronomy, Neutrino Astronomy, Neutrino Physics, Cosmic Ray Physics

Multi-wavelength & Multi-Messenger Study of Blazars:

Blazars are a class of Active Galactic Nuclei (AGN) with their jets pointed towards us. It is believed that particles are accelerated to extremely high energies in these jets. These jets provide us a glimpse to the relativistic Universe. The broadband spectral energy distributions (SEDs) of blazars show characteristic two broad humps extended from radio to gamma-rays. The low-frequency hump is attributed to synchrotron emission from relativistic electrons, gyrating in the magnetic field of the jet. The origin of the higher frequency hump in SEDs is possibly inverse Compton (IC) scattering of relativistic electrons by the synchrotron photons (Synchrotron Self Compton, SSC) or the photons external to the jet (External Compton, EC). Alternatively, it is also possible to produce the higher energy photons in proton-photon interactions followed by the decay of neutral pions or proton synchrotron process in the hadronic scenario. Neutrinos will be produced from decay of charged pions. It is therefore crucial to study blazars with multi-wavelengths to understand emissions at high energies. Some of my master students are involved in this project. We have already published two articles on this and currently we are working on four different blazars. Apart from emission mechanism through modeling of spectral energy distribution we also do timing analysis of variability in different wavebands. Variability study provides indirect measurement of the size and location of the emission region.

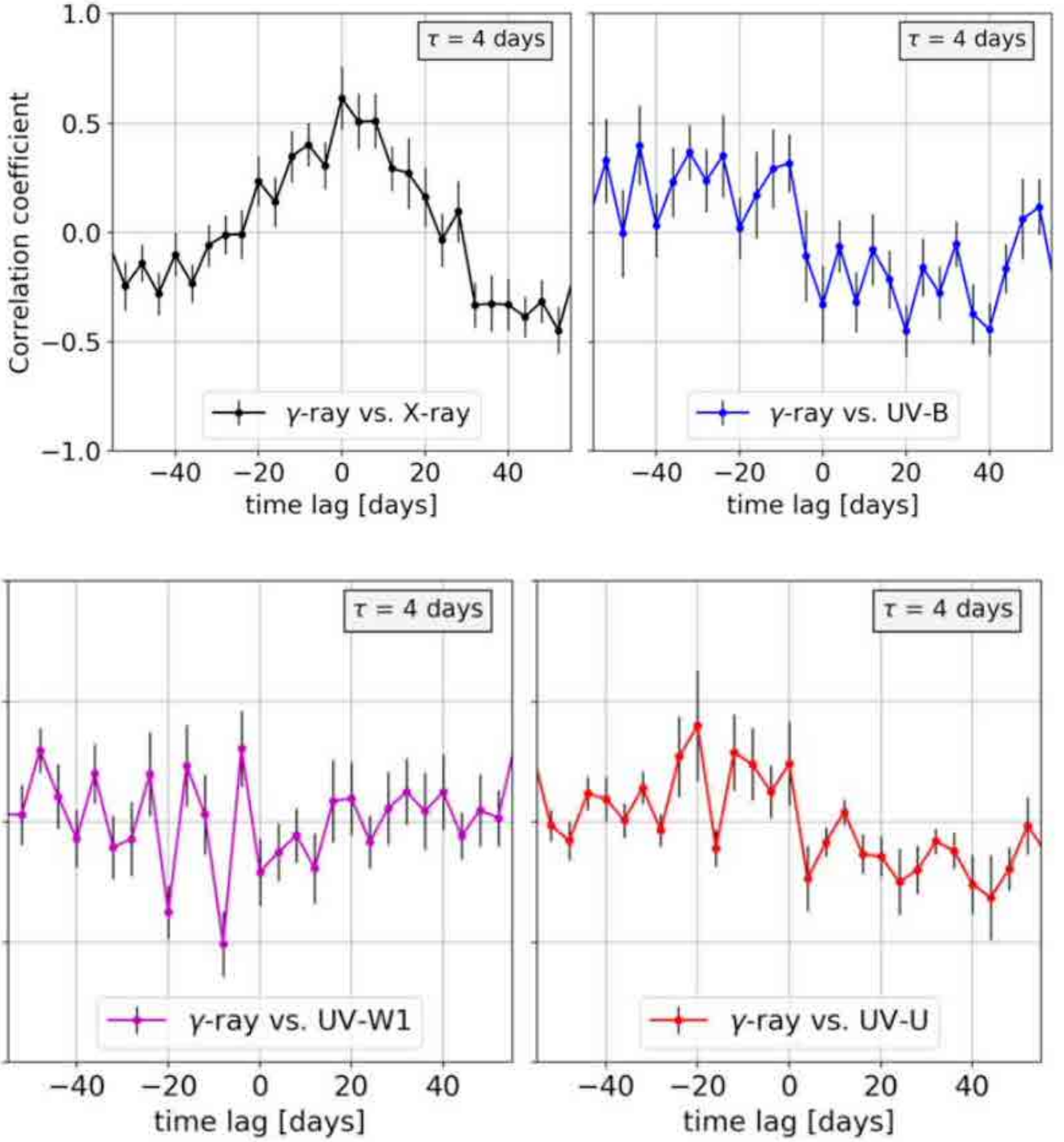


Figure1: The discrete correlation coefficient between gamma-rays and x-rays/UV/Optical band. Gamma-ray and x-ray are correlated with zero lag, impling that emision region of photons in these bands are cospatial. This for blazar PKS 1830 - 211.

Gamma Ray Bursts (GRBs) are the most powerful explosions in our Universe. They release huge energy in energy range keV - MeV within few seconds that outshine everything else, known as "prompt emission". Later it was discovered that prompt emission is followed by afterglow emission, that lasts long, in almost every avelength across electromagnetic spectrum. Even though very high energy (VHE) (GeV - TeV) gamma-ray emission was predicted earlier but only recently they were detected by ground based atmospheric telescopes. We have developed a model to explain VHE emission from GRBs. A paper will be submitted very soon.

Study of neutrino emission from core-collapse suparnova. Core-collapse supernovae are among the most magnificent events in the observable universe. They produce many of the chemical elements necessary for life to exist and their remnants-neutron stars and black holes-are interesting astrophysical objects in their own right. However, despite millennia of observations and almost a century of astrophysical study, the explosion mechanism of core-collapse supernovae is not yet well understood. The electromagnetic emission from a ccSN begins minutes to hours after the initial explosion when the outgoing shock wave breaks through the surface of the star. On the other hand almost 99% of energy during core-collapse is taken away by neutrinos. Therefore detecting these neutrinos are crucial to understand the core-collapse process. At this moment I am involved in study to determine how many neutrinos can be detected based on different core-collapse models available.

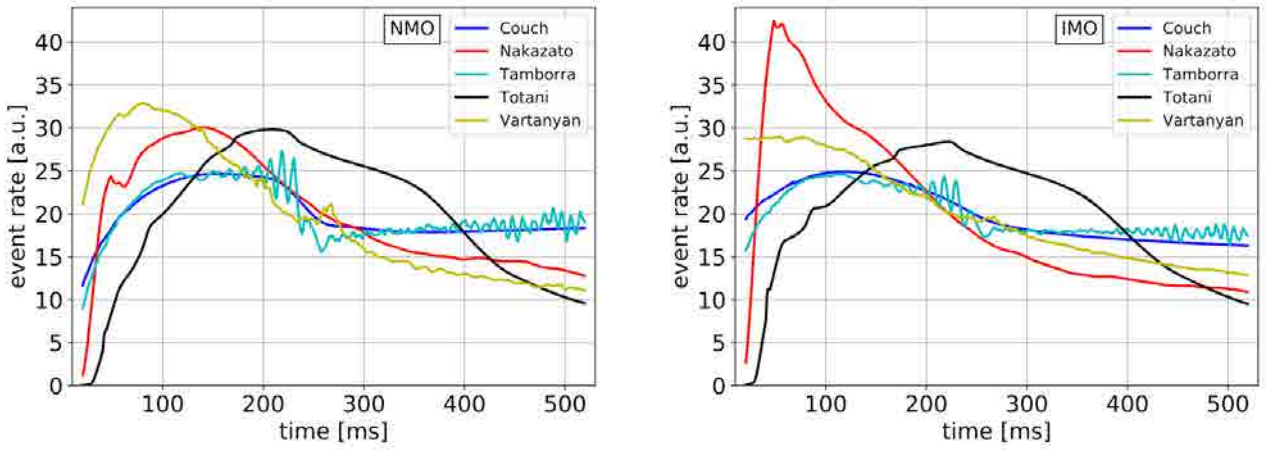


Figure2: Expected event rates at Hyper-Kamiokande experiment for different corecollapse models for two mass hierarchies, normal (left) and inverted (right).

I am leading Indo - Hyper-Kamiokande collaboration. We intend to contribute in hardware, software and in physics analysis. Last year, I have represented Indian consortium in the Hyper-Kamiokande Financial Forum (HKFF) Meeting. One of my Ph.D. Student (based in IIT-Kharagpur, who is a recepient of Prime Minister Research Fellowship) is actively working with oscillation working group to develop software based on machine learning algorithm for HyperK to study neutrino oscillation properties.

I am also a member of CTA-collaboration. One of my master student (from IIT-Kharagpur) did sensitivity study for star bursts galaxies using Gamma-py, for CTA. Starburst galaxies are characterized by a boosted formation rate of massive stars and an increased rate of supernovae in localized regions, which also exhibit very high densities of gas and of radiation fields. Starburst regions represent a favorable environment for the acceleration of cosmic rays. Cosmic-ray protons can produce gamma-rays by inelastic collisions with ambient gas particles and subsequent neutral pion-decay.

Plan of Future Work including Project

I am a member of Cherenkov Telescope Array (CTA), next generation ground based atmospheric Cherenkov Telescopes. I will pursue our proposal for CTA on behalf of Indian consortium as explained before. I will be also working particularly for the Large Size Telescope, installed at the La Palma, Spain. I will take part in developing software for data analysis.

For Hyper-Kamiokande, we are interested in contributing in for DAQ, and tank structure for IWCD (Intermediate Water Cherenkov Detector). Some activity has been initiated in this regard. Indian consortium also intend to contribute for software development for the detector and physics analysis for HyperK.

Multi-Messenger & Multi-Wavelength study for AGNs and GRBs will also continue.

Ramkrishna Das
Associate Professor
Astrophysics & Cosmology
ramkrishna.das@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Rahul Bandyopadhyay; Multiwavelength Study of Planetary Nebulae; Thesis submitted
2. Dhrimadri Khata; Physical Properties Of M-dwarfs: Optical And Near-IR Spectroscopic Studies"; Under progress; Prof. Soumen Mondal
3. Ruchi Pandey; Multiwavelength Study of Novae; Under progress
4. Gesesew H Reta; Multiwavelength Study of Novae; Under progress
5. Subhajit Kar; Massive Stars; Under progress
6. Avijit Mandal; Novae and Supernovae; Under progress

Teaching

1. Autumn semester; Advanced Laboratory (PHY 391); Integrated Ph.D.; 12 students; with 4 (Prof. Kalyan Mandal (Co-ordinator), Prof. Rajib Mitra,, and Dr. Manik Pradhan,Dr. T Setty) co-teachers
2. Spring semester; Observation Techniques in Astronomy (PHY 616); Ph.D.; 5 students; with 1 (Dr Soumen Mondal) co-teacher
3. Autumn semester; Nuclear & Particle Physics (PHY 305); Integrated Ph.D.; 5 students; with 1 (Prof. Suvendra Mohanty) co-teacher
4. Autumn semester; Advanced Laboratory (PHY 491); Integrated Ph.D.; 5 students; with 5 (Prof. Kalyan Mandal (Co-ordinator), Prof. Rajib Mitra,, Dr. Manik Pradhan, Dr. T Setty and Dr. Nitesh Kumar) co-teachers
5. Autumn semester; Astrophysics (PHY 510); Ph.D.; 6 students; with 2 (Prof. Soumen Mondal and Dr. Debanjan Bose) co-teachers

Publications

a) In Journals

1. Ruchi Pandey, **Ramkrishna Das**, Gargi Shaw and Soumen Mondal, *Photoionization Modeling of the Dusty Nova V1280 Scorpii*, The Astrophysical Journal, 925, 187, 2022
2. Rahul Bandyopadhyay, **Ramkrishna Das,** Soumen Mondal, *Compact planetary nebulae MaC 2-1 and Sp 4-1: photoionization models and dust characteristics*, Monthly Notices of the Royal Astronomical Society, 504, 816-829, 2021

3. Supriyo Ghosh, Soumen Mondal, **Ramkrishna Das**, and Somnath Dutta, *Spectroscopic and Photometric Monitoring of a Poorly Known Highly Luminous OH/IR Star: IRAS 18278+0931*, The Astronomical Journal, 161, 198, 2021

b) Conference proceedings / Reports / Monographs / Books

1. Ramkrishna Das, "Elemental abundances in Novae", Journal of Astrophysics and Astronomy (JAA), Volume 42, p. 13, 2021

Talks / Seminars Delivered in reputed Conference / Institutions

1. Invited Colloquium on "Recurrent Novae: Possible Progenitors of Type Ia Supernovae"; Nov 3, 2021; Presidency University; 1 hour
2. Invited by Tripura State Council for Science & technology to deliver a talk on "Role of Telescopes in understanding the Universe" at the Validictory Session of the program "Vigyan Sarvatra Pujyate-VSP"; Feb 28, 2022; Sukanta Academy, Agartala, Tripura; 1 hour
3. Invited by Tripura State Council for Science & technology talk on "Observational Astronomy: Past, Present and Future" on the occassion of Observance of National Scicene Day 2022; Feb 28, 2022; Institute of Engineers (India) Tripura Chapter Building, Agartala, Tripura, 30 minutes

Administrative Duties

1. Liaison Office & Chairman, Reservation Cell of the Centre
2. Member, Newsletter Committee
3. Member, Conference, Workshop and Extension Programme (CWEP)
4. Member, Committee to facilitate and initiate the process of land acquisition and construction activities at the proposed site for setting up of astronomical observatory and installation of telescope
5. Member, Committee for Selection of Integrated Ph.D. students
6. Member, Committee for Selection of Junior Research Fellow, Department of Astrophysics & Cosmology

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. A new Astronomical Observatory under S. N. Bose National Centre for Basic Sciences (S. N. Bose Astronomical Observatory) (submitted)); DST; 5 years; Co-PI

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. Dr Gargi Shaw, Tata Institute of Fundamental Research (TIFR); SL. No. 1; National
2. Dr Supriyo Ghosh, Tata Institute of Fundamental Research (TIFR); Sl. No. 3; National
3. Dr Somnath Dutta, Institute of Astronomy and Astrophysics, Academia Sinica, Taipei 10617, Taiwan; Sl. No. 3; International

Outreach Program organized / participated

1. Invited by Tripura State Council for Science & technology to the Validictory Session of the program "Vigyan Sarvatra Pujyate-VSP". Delivered a talk on "Role of Telescopes in understanding the Universe" at Sukanta Academy, Agartala
2. Invited by Tripura State Council for Science & technology on the occasion of Observance of National Scicene Day 2022. Delivered a talk on "Observational Astronomy: Past, Present and Future" at Institute of Engineers (India) Tripura Chapter Building, Agartala, Tripura

Areas of Research

Novae and cataclysmic variables, Stellar evolution, Astronomical Spectroscopy, Modeling of spectra, Astronomical Instrumentation

I have been working on the spectroscopic study of different astronomical objects, e.g. Novae, Planetary Nebulae, massive stars etc. Observations of the objects are made using the national facilities. The data are analyzed and modeled using different astronomical codes. Here, I discuss two results that we obtained during the past year.

Dust formation in Novae: A "Nova" ("Novae" in plural) refers to an explosion that occurs on a white dwarf (WD) surface due to thermonuclear runaway. A few (~ 20%) of the novae have been observed to form dust, ~30-100 days after the outburst. Observations show that the composition of

novae dust includes carbon, silicates, SiC, and hydrocarbons, and some times, a combination of these. It is found that novae grains can grow as large as ~ 0.2 to 8μm larger than the grains in the interstellar medium which have radius ≤ 0.2μm. However, how dust forms in the hostile environment in novae ejecta has been an open question for many decades. As a paradigmatic case, we have modeled observed pre- and post-dust phase spectra of the dust forming nova V1280 Scorpii (Figure 1) with a primary aim to understand how the physical parameters associated with the system evolve during dust formation. Hence, we constructed a simple phenomenological model assuming a spherical geometry, and added the dust grains in the outer shell of the ejecta in the post-dust phase. Such detailed photoionization modeling of dust forming nova has not been done earlier. The key results are: i) a very high hydrogen density (~1013-1014 cm-3) exists in the ejecta, (ii) dust condensation conditions are achieved at high ejecta density (~3.16 × 108 cm-3) and low temperature (~2000 K) in the outer region (R ~ 1015 cm) of the ejecta, (iii) a mixture of small (0.005-0.25 μm) amorphous carbon dust grains and large (0.03-3.0 μm) astrophysical silicate dust grains is present in the ejecta in the post-dust phase, (iv) high elemental abundance values as C/H = 13.5-20, N/H = 250, O/H = 27-35, by number, relative to solar values, were estimated during the pre-dust phase, which decrease in the post-dust phase (Pandey et al., 2022, ApJ, 925, 187).

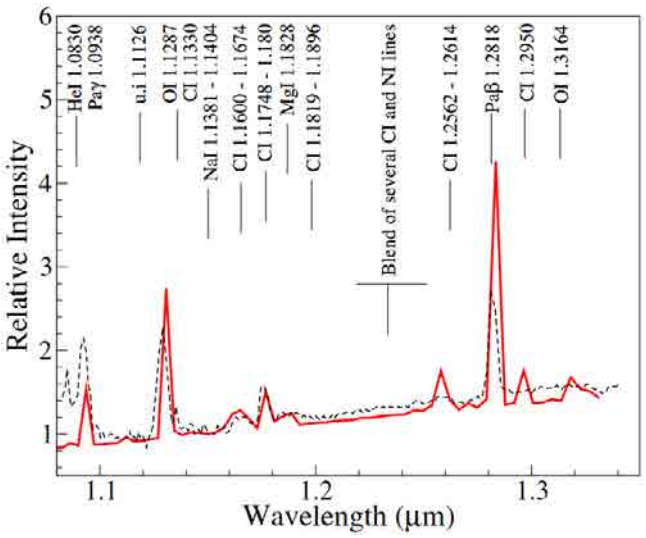


Figure 1: Observed (black dashed solid) and model generated post-dust phase J-band spectra (red solid line) of the dust forming nova V1280 Scorpii.

Study of the Planetary Nebulae (PNe) MaC 2-1 and Sp 4-1: Planetary Nebulae (PNe) are formed out of the expelled outer layers of evolved stars (~1–8 solar mass). Study of PNe gives significant understanding on galactic chemical evolution through the knowledge about their progenitors and prediction of enrichment of the surrounding interstellar medium (ISM). For this, having accurate values of physical parameters associcated with the system is crucial. However, majority of PNe have not been investigated in details, mostly due to their faintness. In order to study the fainter and less-studied PNe, we have taken up an observational programme using the 2-m Himalayan Chandra Telescope (HCT), Hanle, India and observed a handful of such faint and less-studied PNe. Out of these, we have studied the characteristics of the PNe, MaC 2-1 and Sp 4-1. Both the PNe seem to have born in metal poor environment and were found in the low- to moderate-excitation class. MaC 2-1 shows the presence of SiC and MgS dust. Sp 4-1 hosts PAH molecules. We computed photoionization models of the PNe for self-consistent estimation of physical parameters associated with the central star and the nebula. The progenitor mass of MaC 2-1 and Sp 4-1 were estimated as 1.2 and 1.55 solar mass, respectively. Both are distant PNe, ~ 16 and 18 kpc for MaC 2-1 and Sp 4-1, respectively. From morpho-kinematic study, we have constructed their 3-D structure using HST images (Figure 2). (Bandyopadhyay et al., 2021, MNRAS, 504, 816)

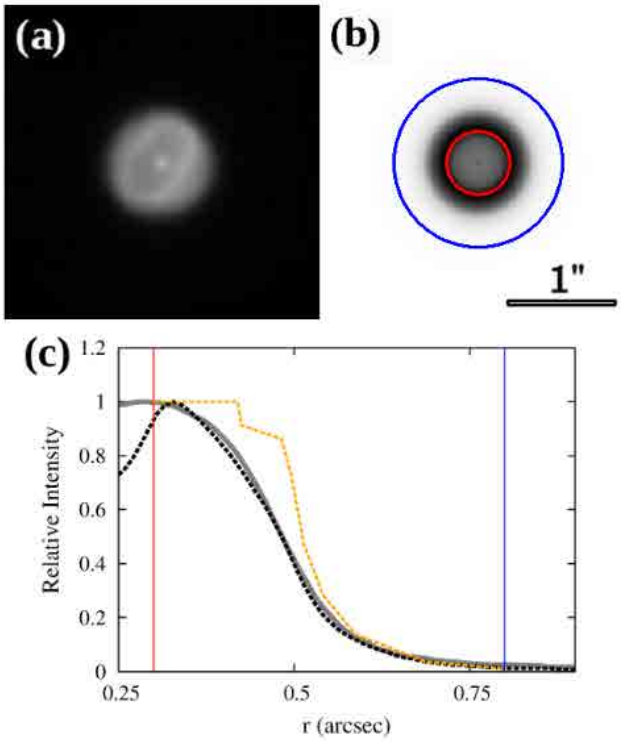


Figure 2: (a) The HST image of Sp 4-1 in [O iii] . (b) The grey scale 3D model image of Sp 4-1 constructed in SHAPE. The concentric circles are the inner (in red) and outer (in blue) radii of the shell. (c) The grey solid line presents the observed

radial intensity profile obtained from the HST image. The orange dotted line shows the radial density structure of the 3D model. The best-fitting modeled radial intensity profile (black dotted line) shows a good fit with the observed profile. The vertical red and blue lines denote the inner and outer radii, respectively, as mentioned above.

Plan of Future Work including Project

1. In past few years we have observed a handful of data on Novae, PNe, W-R stars etc. using the national observational facilities and also collected data from data archives. We are analyzing those data and modeling the reduced data to understand different aspects of novae phenomena. Already, analysis of few objects have been completed. The manuscripts of these papers are under preparation. We are analyzing rest of the observed data. We have also modeled the photo-dissociation region (PDR) in PNe; the paper is under preparation.
2. I am also involved in the S N Bose Centre's Telescope project. Already the land for the observatory has been acquired at Panchet hill-top, Purulia, West Bengal. Currently, we are working to complete the processes for repairing the approach road and making it motorable. We are also planning to install a weather station at the site and initiate the different experiments for site characterization.

Any other Relevant Information including Social Impact of Research

1. Visited Panchet hill-top during 22-25 March, 2022 to inspect the land. I also took atmospheric seeing data during nights of 23-24 March, at an elevation of ~300 m on the hill. Also, we met the local administrative people (Zilla Sabhadhipati, DFO (Kangsabati North) and others) in a meeting organized at SKB University, Purulia, and discussed about the repairing/construction process of the approach road towards the observatory site.
2. I actively participated in the processes related to MoUs between SNBNCBS and ARIES, Nainital, and between SNBNCBS and Sidho-Kanho-Birsha University, Purulia.
3. Attended New Indo-Belgium network project: 3rd discussion meeting on 30 August 2021.
4. Attended several meetings with AMOS, Belgium to discuss about 1.5-m telescope for S N Bose Observatory.
5. Acting as the Seminar Coordinator, Department of Astrophysics & Cosmology

Soumen Mondal
Professor
Astrophysics & Cosmology
soumen.mondal@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Alik Panja; A Multiwavelength Study of Galactic Star-forming Regions; Under progress
2. Samart Ghosh; Understanding the Atmosphere of Brown Dwarfs and Low Mass Stars; Under progress
3. Dhrimadri Khata; Understanding of Physical Properties of M-dwarfs: Optical and Near-IR Spectroscopic Studies; Under progress; Dr. Ramkrishna Das
4. Siddhartha Biswas; Studies of Pre-main Sequence stars in the Galactic Starformation processes; Under progress
5. Diya Ram; Understanding Stellar Activity in M dwarfs; Under progress
6. Rajib Kumbhakar; Studies of Galactic Very Low-mass Stars and Brown Dwarfs; Under progress
7. Soumita Chakraborty; Studies of Galactic Star-forming regions; Under progress

b) Post-Docs

1. Dusmanta Patra; Radio Galaxies and AGNs

Teaching

1. Autumn semester; Basic Laboratory1; Integrated Ph.D.; 6 students; with 1 (Prof. Samir K. Pal) co-teacher
2. Spring semester; Astronomy and Astrophysics (PHY 510); 5 students; with 1 (Dr. Ramkrishna Das) co-teacher

Publications

a) In Journals

1. Dhrimadri Khata, **Soumen Mondal**, Ramkrishna Das, Tapas Baug, *Estimating Teff, radius, and luminosity of M-dwarfs using high-resolution optical and NIR spectral features*, Monthly Notices of the Royal Astronomical Society, 507, 1869-1885, 2021
2. Rahul Bandyopadhyay, Ramkrishna Das, **Soumen Mondal**, *Compact planetary nebulae MaC 2-1 and Sp 4-1: photoionization models and dust characteristics*, Monthly Notices of the Royal Astronomical Society, 504, 816-829, 2021
3. Supriyo Ghosh, **Soumen Mondal,** Ramkrishna Das, and Somnath Dutta, *Spectroscopic and Photometric*

Monitoring of a Poorly Known Highly Luminous OH/IR Star: IRAS 18278+0931, The Astronomical Journal, 161, 198, 2021

4. Ruchi Pandey, Ramkrishna Das, Gargi Shaw and **Soumen Mondal**, *Photoionization Modeling of the Dusty Nova V1280 Scorpii*, The Astrophysical Journal, 925, 187, 2022

b) Conference proceedings / Reports / Monographs / Books

1. VizieR Online Data Catalog: NGC 2282 photometry of variable stars (Dutta+, 2018) - VizieR On-line Data Catalog: J/MNRAS/476/2813, April 2021

Talks / Seminars Delivered in reputed Conference / Institutions

1. A pitch talk "Understanding Fundamental Parameters of Evolved stars: High and Intermediate Spectroscopic Studies" at IAU Symposium 366 during 1 -5 November 2021 in Belgium; Nov 1, 2021; Belgium - virtual meeting; 3 minutes
2. A Contributory talk "Understanding of Pre-main Sequence Stars in Galactic Star-Forming Regions" at 21st National Space Science Symposium during 31st January to 4th February 2022 at IISER, Kolkata; Feb 1, 2022; IISER, Kolkata- Virtual; 20 minutes

Administrative Duties

1. Nodal Officer, Technical Research Centre (TRC)
2. Member of Board of studies (BoS), Calcutta university, Member UG BoS of Sidho-Kanho-Birsha University,
3. Internal committees : members of Library, Advisory committee of Computer Cell, member of Project and Patent Cell, Faculty Search committee, etc.

Patents Taken and Process Developed with Details

1. FER report of "A Spectroscopy-based Optical Device for estimation of milk quality (Patent appl. No. 201931028306) is submitted on 25th June 2021; Patent appl. No. 201931028306; Applied

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Technical Research Centre (TRC); TARE, SERB, DST; January 2016 - September 2021; PI

Conference / Symposia / Schools organized

1. 21st National Space Science Symposium (NSSS) during 31st January to 4th February 2022 at IISER, Kolkata; Jan 31, 2022; IISER, Kolkata; 31st January 2022 to 4th February 2022

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. Dr. Gargi Shaw, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Homi Bhabha Road, Navy Nagar, Colaba, Mumbai 400005, India; Sl. No. 4; National
2. Dr. Somnath Dutta, Academia Sinica Institute of Astronomy and Astrophysics, PO Box 23-141, Taipei 106, Taiwan; Sl. No. 3; International

Outreach Program organized / participated

1. Member of the 21st National Space Science Symposium (NSSS) outreach activities

Areas of Research

i. Multi-wavelength studies of Galactic star-forming regions and Pre main-sequence stars; (ii) Photometric variabilities of Very Low Mass Stars (VLMs) and Brown Dwarfs; (iii) Spectrpscopic studies of M dwarfs and Giants; (iv) Astronomical Instrumentation

Estimating Teff, radius, and luminosity of M-dwarfs using high-resolution optical and NIR spectral features (Khata et al, 2021, MNRAS):

Using a sample high-resolution spectra (R ~90,000)of 271 M-dwarf stars (M0V-M7V) from the CalarAlto high-Resolution search for Mdwarfs with Exo-earths with Near-infrared and optical Echelle Spectrographs (CARMENES) radial-velocity planet survey. For the first time, using the simultaneously observed high-resolution spectra in the optical (0.52–0.96 μm) and near-infrared (0.96–1.71 μm) bands, we derive empirical calibration relationships to estimate the fundamental parameters of these low-mass stars. We select a sample of nearby and bright M-dwarfs as our calibrators for which the physical parameters are acquired from high-precision interferometric measurements. To identify the most suitable indicators of Teff, radius, and luminosity (log L_*/L_Sun), we inspect a range of spectral features

and assess them for reliable correlations. We perform multivariate linear regression and find that the combination of pseudo-equivalent widths and equivalent width ratios of the Ca II at 0.854 μm and Ca II at 0.866 μm lines in the optical and the Mg I line at 1.57 μm in the near-infrared give the best fitting linear functional relations for the stellar parameters with root mean square errors of 99K, 0.06 R, and 0.22 dex, respectively. We also explore and compare our results with literature values obtained using other different methods for the same sample of M dwarfs.

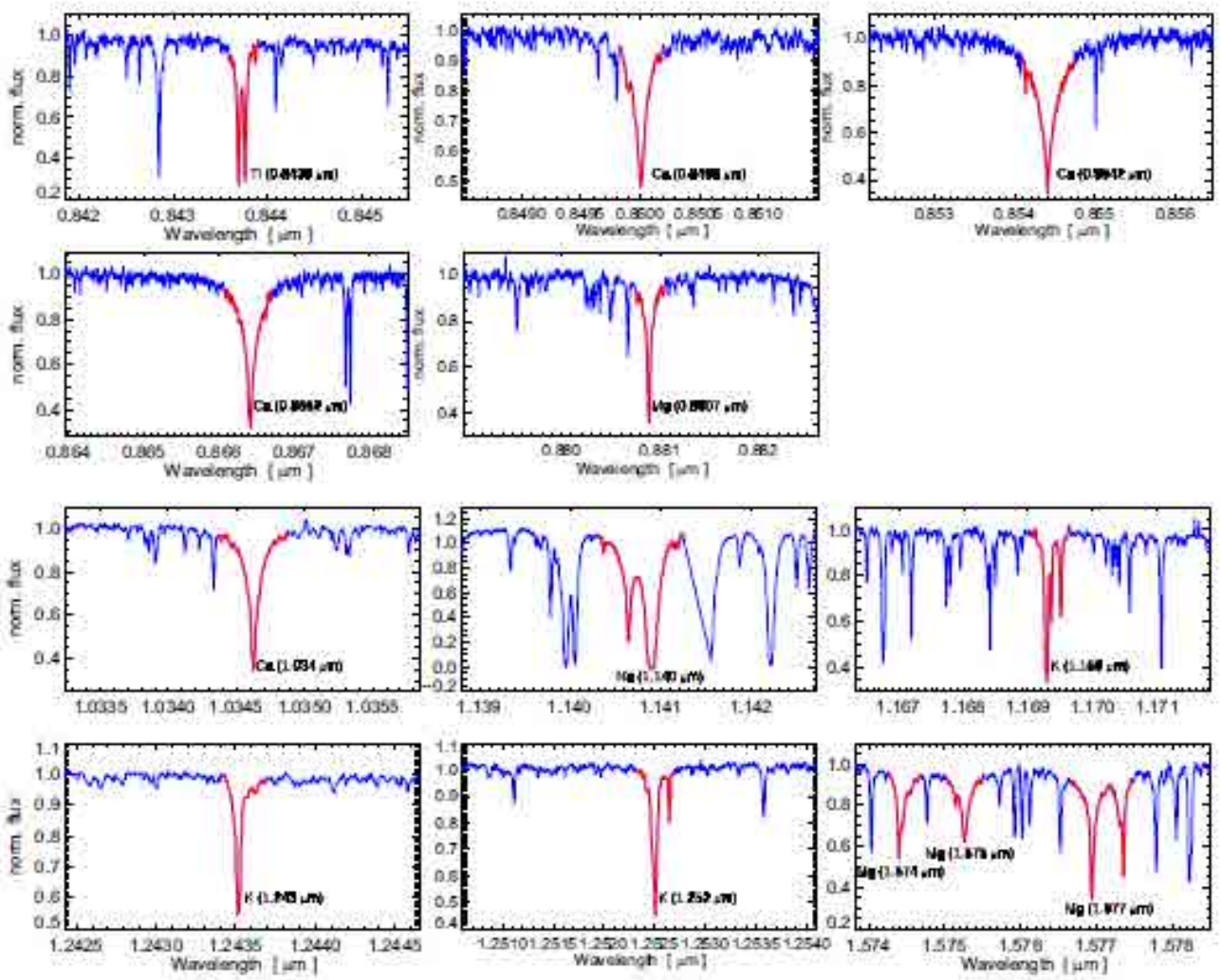


Figure 1. A representation of atomic absorption features in optical (Ti I [0.844 μm], Ca II [0.850, 0.854, 0.866 μm], Mg I [0.881 μm]) and Near-infrared (Ca I [1.035 μm], Na I [1.141 μm], KI [1.169, 1.240, 1.250 μm], Mg I [1.570 μm]) for the CARMENES spectra of the M-Dwarf GJ 2 (J00051 + 457) of spectral type M1.0V. We have calculated the EWs of these features with the feature window shown in red colour to find and establish the strongest correlations with the stellar parameters.

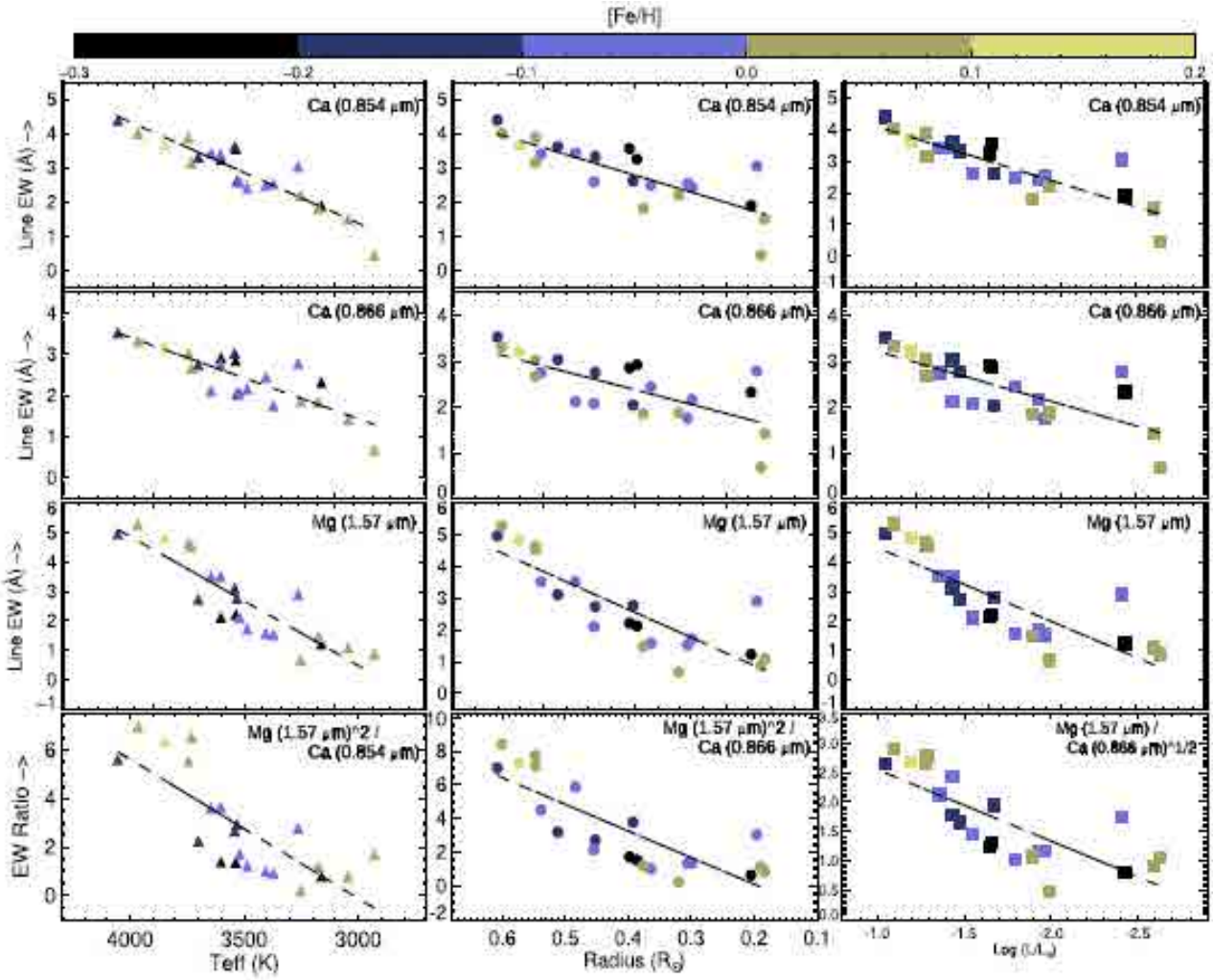


Figure 2. EWs and functional forms of EW ratios in optical and NIR CARMENES spectra that are used to establish best fitting calibration relationships are plotted against the measured Teff, radius, and luminosity (log L/L/) for our calibration sample. The data points are colour coded according to the [Fe/H] values taken from Schweitzer et al. (2019) and the dashed straight lines represent the linear correlation.

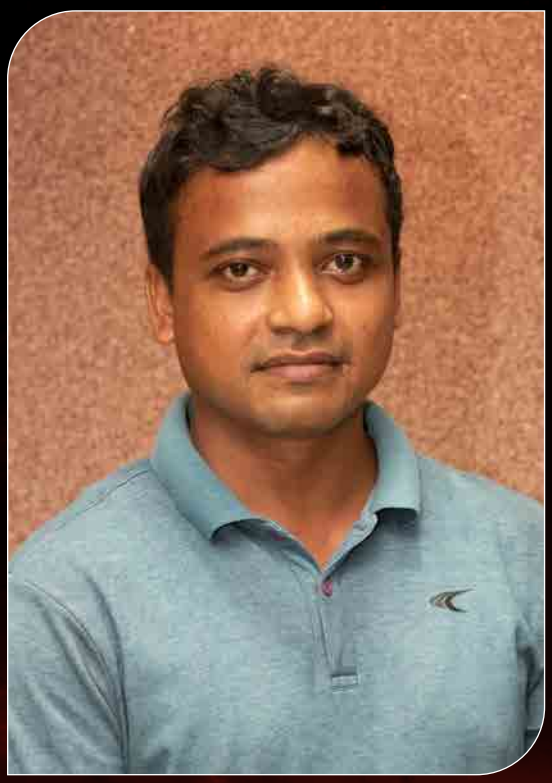
Plan of Future Work including Project

1. A. Scientific programs in the observational Astronomy : (i) Spectroscopic studies of late M-type stars (dwarfs and giants) and Miras: Low-to-intermediate mass stars represent a vital test of theoretical models of stellar evolution, structure, and atmospheres. Optical/Near-IR spectroscopic studies of these objects are undertaken to understand their atmospheres, exoplanets, and pulsation. (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 and star-formation. Variability in young Very Low Mass (VLM) objects and brown dwarfs provide information on their atmospheres. (iii). Astronomical Instrumentation: With our expertise in the Optical/IR instrument design and development, we are working to establish an Astronomical Instrumentation Laboratory for building the state-of-art backend

instruments for the telescopes. B. Establishment of the S. N. Bose Observatory at Panchet Hilltop, Purulia: The S. N. Bose Observatory project, a new Astronomical telescope observing facility is planned at Panchet hill, West Bengal. This project envisages establishing a 1.5-meter telescope, first in the eastern part of the country. Two hectares land at Panchet hill-top for this observatory site is acquired from the Forest department of Govt. Of India and state Govt. Of West Bengal. A project proposal for the new observatory is placed at Department of Science and Technology, Govt. of India for approval and funding.

Any other Relevant Information including Social Impact of Research

1. Advanced manpower generation (Human resource development) through training of Ph.D./Integrated Ph.D. students for National need in educational sectors as well as a need for National/ International mega projects (like TMT, LIGO, SKA-India etc.).
2. A spectroscopic-based low-cost instrument "Mil-Q-Way" is being developed under the Technical Research Centre (TRC), SNBNCBS for the detection of adulteration of milk. A prototype instrument is already developed at the Centre, which is under field trials. Such a project is intended for societal benefit and valuable Knowledge resource for the food sector and security.



Tapas Baug
Assistant Professor
Astrophysics & Cosmology
tapasbaug@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Ariful Hoque; Role of Filaments in Galactic Star formation; Under progress; Dr. Ramkrishna Das, SNBNCBS (Co-supervisor)
2. Nishant Garg; Magnetic field and filamentary star-forming clouds; Under progress

b) Post-Docs

1. Piyali Saha; Galactic star formation and feedback effect

c) External Project Students / Summer Training

1. Aashique Unikrishnan; Characterization of a few Star-forming Filaments; National Institutes of Technology, Calicut
2. Swagata Bera; Distance of a Sample of Mira Variables Using two Methods and their Comparison; Visva Bharati University, Bolpur

Teaching

1. Autumn semester; Classical Dynamics; Integrated Ph.D.; 10 students
2. Spring semester; Research Project of Ariful Hoque; Ph.D.; 1 student
3. Spring semester; Research Project of Nishant Garg; Ph.D.; 1 student

Publications

a) In Journals

1. Hong-Li Liu, Tie Liu, Neal J Evans II, Ke Wang, Guido Garay, Sheng-Li Qin, Shanghuo Li, Amelia Stutz, Paul F Goldsmith, Sheng-Yuan Liu, Anandmayee Tej, Qizhou Zhang, Mika Juvela, Di Li, Jun-Zhi Wang, Leonardo Bronfman, Zhiyuan Ren, Yue-Fang Wu, Kee-Tae Kim, Chang Won Lee, Ken'ichi Tatematsu, Maria R Cunningham, Xun-Chuan Liu, Jing-Wen Wu, Tomoya Hirota, Jeong-Eun Lee, Pak-Shing Li, Sung-Ju Kang, Diego Mardones, Isabelle Ristorcelli, Yong Zhang, Qiu-Yi Luo, L Viktor Toth, Hee-weon Yi, Hyeong-Sik Yun, Ya-Ping Peng, Juan Li, Feng-Yao Zhu, Zhi-Qiang Shen, **Tapas Baug**, L K Dewangan, Eswaraiah Chakali, Rong Liu, Feng-Wei Xu, Yu Wang, Chao Zhang, Jinzeng Li, Chao Zhang, Jianwen Zhou, Mengyao Tang, Qiaowei Xue, Namitha Issac, Archana Soam, Rodrigo H Álvarez-Gutiérrez, *ATOMS: ALMA three-millimeter observations of massive star-forming regions – III. Catalogues of*

candidate hot molecular cores and hyper/ultra compact H ii regions, Monthly Notices of the Royal Astronomical Society, 505, 2801-2818, 2021

2. I I Zinchenko, L K Dewangan, **T Baug**, D K Ojha, N K Bhadari, *ALMA discovery of a dual dense probably rotating outflow from a massive young stellar object G18.88MME*, Monthly Notices of the Royal Astronomical Society: Letters, 506, L45–L49, 2021
3. L K Dewangan, J S Dhanya, N K Bhadari, D K Ojha, **T Baug**, *Lynds Bright Nebulae: sites of possible twisted filaments and ongoing star formation*, Monthly Notices of the Royal Astronomical Society, 506, 6081-6092, 2021
4. R Arun, Blesson Mathew, G Maheswar, **Tapas Baug**, Sreeja S Kartha, G Selvakumar, P Manoj, B Shridharan, R Anusha, Mayank Narang, *Clustering of low-mass stars around Herbig Be star IL Cep – evidence of 'Rocket Effect' using Gaia EDR3 ?*, Monthly Notices of the Royal Astronomical Society, 507, 267-281, 2021
5. Dhrimadri Khata, Soumen Mondal, Ramkrishna Das, **Tapas Baug**, *Estimating T_{eff}, radius, and luminosity of M-dwarfs using high-resolution optical and NIR spectral features*, Monthly Notices of the Royal Astronomical Society, 507, 1869-1885, 2021
6. **T Baug**, Ke Wang, Tie Liu, Yue-Fang Wu, Di Li, Qizhou Zhang, Mengyao Tang, Paul F Goldsmith, Hong-Li Liu, Anandmayee Tej, Leonardo Bronfman, Kee-Tae Kim, Shanghuo Li, Chang Won Lee, Ken'ichi Tatematsu, Tomoya Hirota, L Viktor Toth, *An ALMA study of outflow parameters of protoclusters: outflow feedback to maintain the turbulence*, Monthly Notices of the Royal Astronomical Society, 507, 4316-4334, 2021
7. Hong-Li Liu, Anandmayee Tej, Tie Liu, Namitha Issac, Anindya Saha, Paul F Goldsmith, Jun-Zhi Wang, Qizhou Zhang, Sheng-Li Qin, Ke Wang, Shanghuo Li, Archana Soam, Lokesh Dewangan, Chang Won Lee, Pak-Shing Li, Xun-Chuan Liu, Yong Zhang, Zhiyuan Ren, Mika Juvela, Leonardo Bronfman, Yue-Fang Wu, Ken'ichi Tatematsu, Xi Chen, Di Li, Amelia Stutz, Siju Zhang, L Viktor Toth, Qiu-Yi Luo, Feng-Wei Xu, Jinzeng Li, Rong Liu, Jianwen Zhou, Chao Zhang, Mengyao Tang, Chao Zhang, **Tapas Baug**, E Mannfors, Eswaraiah Chakali, Somnath Dutta, *ATOMS: ALMA Three-millimeter Observations of Massive Star-forming regions – V. Hierarchical fragmentation and gas dynamics in IRDC G034.43+00.24*, Monthly Notices of the Royal Astronomical Society, 510, 5009-5022, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. DAC Departmental Seminar; Sep 30, 2021; Webinar; 1 hour
2. ALMA-IMF Line Analysis Workshop, Large Consortium Meeting; Mar 15, 2022; France (Online); 20 min

Administrative duties

1. Committee Member of CSC-WG
2. Committee Member of New website designing
3. Member of 3 Interview Panels (Ph.D., IPhD, and Candidacy Test)
4. Committee member and Co-PI of S.N. Bose Observatory, and participated in several activities. Also, we held several meetings with the telescope manufacturers around the world (particularly the AMOS-Belgium), and discussed the final configuration of the Bose Telescope.

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. S.N. Bose Observatory, Panchet Hilltop, Purulia; DST; 5 yrs; Co-PI
2. Belgo-Indian projects on Precision Astronomical spectroscopy for Stellar and Solar system bodies (BIPASS); DST and BELSPO; 3 yrs; Co-PI

Conference / Symposia / Schools organized

1. Bose Fest - 2021 (Organized and Judged); Aug 3, 2021; SNBNCBS (Online); 3 days

Scientific collaborations with other national / international institutions (based on joint publications)

1. Hong-Li Liu (Yunnan University, Kunming, China); Sl. No. 1, 6, 7; International
2. Ke Wang (Kavli Institute for Astronomy and Astrophysics, Beijing, China); Sl. No. 1, 6, 7; International
3. Igor I. Zinchenko (Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia); Sl. No. 2; International
4. Tie Liu (Shanghai Astronomical Observatory, Shanghai, China); Sl. No. 1, 6, 7; International

5. L. K. Dewangan (Physical Research Laboratory, Ahmedabad, India); Sl. No. 2, 3; National
6. Dhrimadri Khata, Soumen Mondal, Ramkrishna Das (SNBNCBS, Kolkata, India); Sl. No. 5; National
7. R. Arun, Blesson Mathew (CHRIST (Deemed to be University), Bangalore, India); Sl. No. 4; National

Areas of Research

Observational study of Galactic massive star-forming regions, Astronomical instrumentation

Star formation is a complex process that involves the collapse and accretion of gas onto protostars (Lada 1985). Molecular outflows are ubiquitous in the early stages of star formation. It is expected that at the protostellar phase a fraction of the accreted material from the envelope/disk is expelled as a result of angular momentum conservation. These outflows also inject a large amount of mechanical energy into the parent molecular cloud. Such energetic feedback from young stars may significantly influence the self-regulation of star formation. Feedback may provide the required turbulence to the parent molecular cloud for stabilizing it against the gravitational collapse (Matzner & Jumper 2015). The impact of outflows on surrounding gas has been studied in several massive and low-mass star-forming regions (Narayanan et al. 2012; Li et al. 2015; Feddersen et al. 2020, and references therein). Majority of these studies reported that the outflows do not have sufficient energy to sustain the observed turbulence in their parent molecular clouds (see e.g., Li et al. 2020, and references therein). In a survey on Perseus molecular cloud, Arce et al. (2010) found that even though outflows have a large impact on the local clouds near the active star-forming area, the energy from outflows is not sufficient to produce the observed turbulence in the entire Perseus complex. A similar result was also found by Narayanan et al. (2012) and Li et al. (2015) for Taurus region.

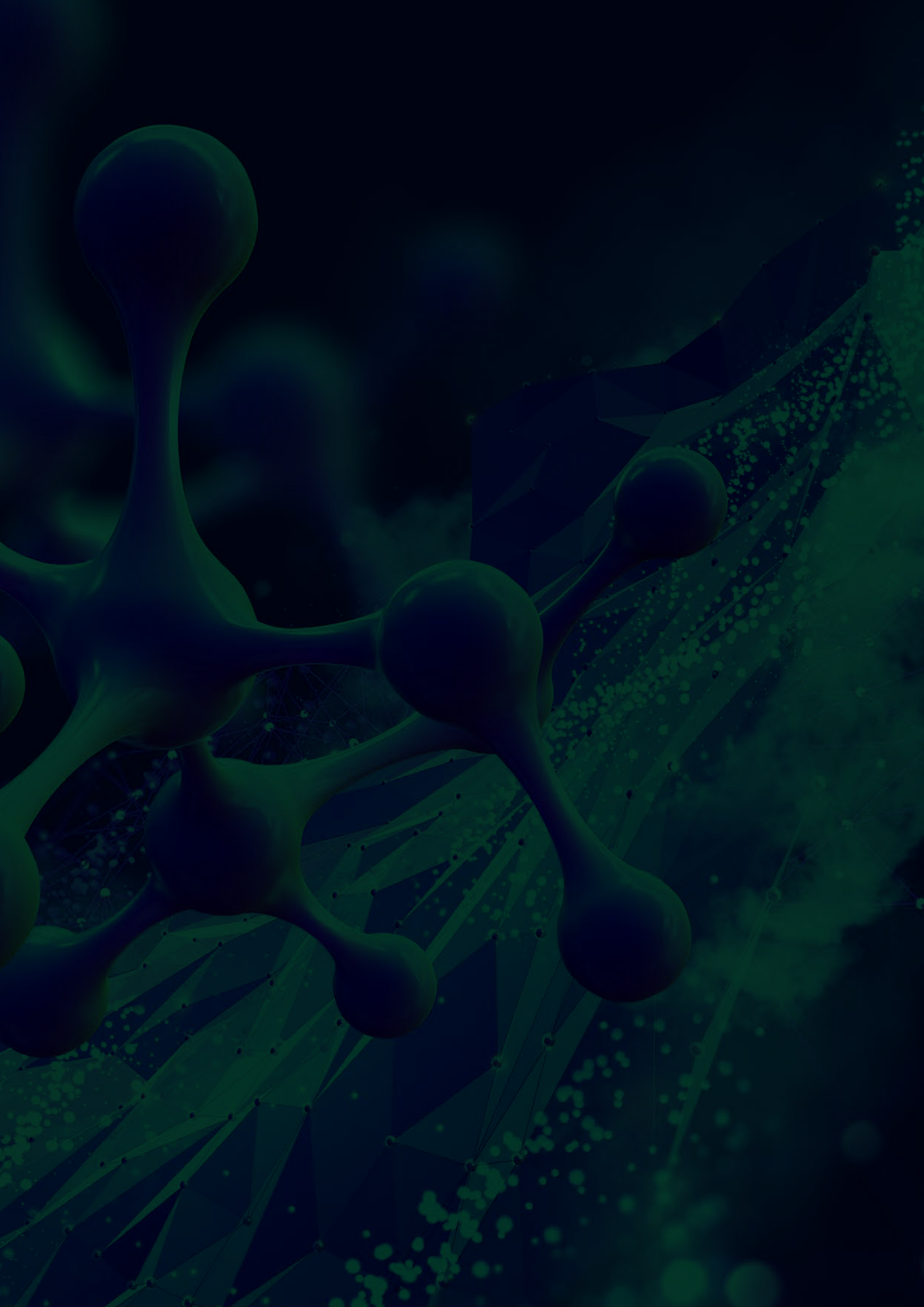
We identified outflows in eleven massive star-forming regions using Atacama Large Millimeter/sub-millimeter Array (ALMA) CO line data, and studied whether outflows can significantly influence the surrounding molecular clouds in terms of self-regulation of star formation. We derived the mass, momentum, energy, outflow rate, and outflow force for each outflow assuming they are in local thermodynamic equilibrium and the emission is optically thin. Comparison of total energy input from outflows with that of their host clouds shows that outflow energy is typically two orders less compared to the turbulent energy observed in their host molecular clouds. We also found that the energy injection rate from these outflows into the surrounding clouds is comparable with the energy dissipation rate of the same cloud. Overall, these results suggest that outflows in these regions do not inject sufficient energy to develop turbulence in their parent clouds. But they inject sufficient amount of energy to maintain the turbulence already present in those clouds. More details on this work can be found in Baug et al. (2021).

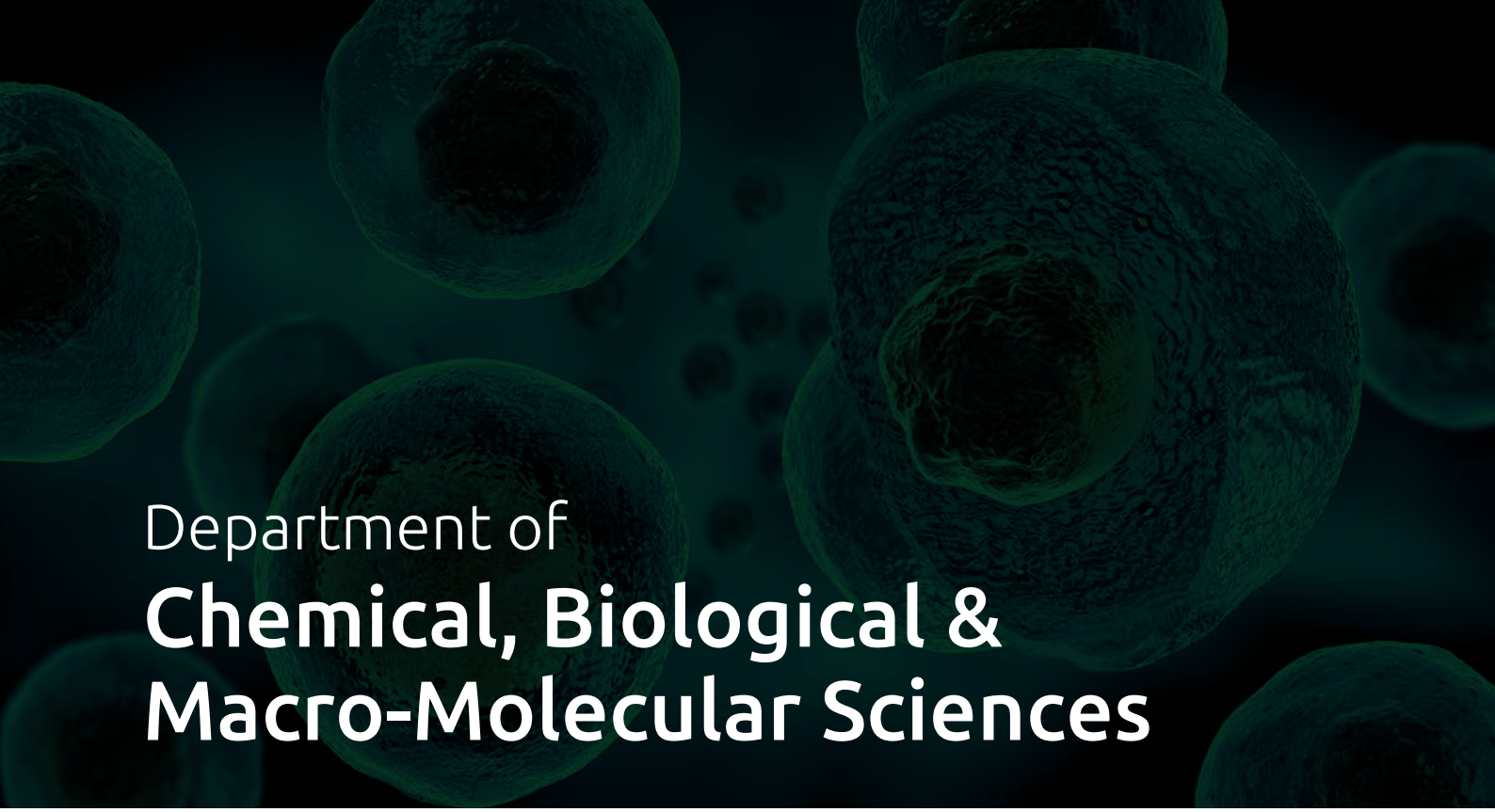
In another study, we discovered the dual rotating outflows associated with a massive young stellar object using ALMA data. Such an evidence for massive star formation has never been reported before. (Zinchenko et al., 2021).

Plan of Future Work Including Project

1. With the advent of Herschel Observations in the year 2013, elongated filaments are found to be ubiquitous in Galactic molecular clouds. These filaments are believed to play crucial role in both low-mass and massive star formation. Indeed, large-scale flow of gas have been noted by several authors in several parsec-scale filaments (e.g., Baug et al., 2018, Chen et al., 2019). However, the scale of gas flow along these filaments are yet unknown. It is still unknown whether these filaments carry gas onto protostellar disk having typical dimension <0.01 parsec. I would like to study the role of filaments at sub-parsec scale using the mm/sub-mm data from ALMA.
2. The Centre has taken an initiative to build S. N. Bose Observatory at Panchet Hilltop, Purulia, and a considerable progress has already been made. A funding proposal has also been submitted to Department of Science and Technology. I would like to keep on contributing in the development of this telescope project.
3. Outflows are ubiquitous phenomena in the early phase of star formation. Probing these outflows at different wavelengths may help us in understanding the finer details of the outflow parameters and their launching mechanisms. For example, observations in near-infrared bands help in acquiring the hotter parts (>1000 K) of the outflows while observations of the same outflows in the mm band helps us to obtain the information in the lower temperature regime (20-100 K). I would like to pursue a study several Galactic star-forming regions using data from ALMA (mm band data) and 3.6-m Devasthal Optical Telescope (optical/near-infrared data).

Chemical, Biological & Macro-Molecular Sciences





Department of
Chemical, Biological & Macro-Molecular Sciences

Rajib Kumar Mitra

Department profile indicators

Table A: Manpower and resources

Number of faculty members	8
Number of Post –doctoral research associate (centre+project)	4
Number of Ph.D students	45
Number of other project staff	4
Number of summer students	7
Projects (ongoing)	12

Table B: Research Activities indicators

Number of research papers in Journals	81
Number of Book-chapters/books	1
Number of other publications	1
Number of Ph.D students graduated (submitted+degree awarded)	6+7
Number of M.Tech/M.Sc projects	0

Table C: Academic activities and linkage

Number of courses taught by faculty members	
Number of Visitors (non –associates)	
Number of associates	
Number of Seminars organized	
Number of Conference/Symposia/Advanced Schools organized	
Number of talks delivered by members of department in conferences/Symposia	National
	International

Most important research highlights

- Study of the effects of mutations in some of the epitope region of SARS-CoV-2 on the structure of the epitope and their interface with paratope using all-atom molecular dynamics (MD) simulation studies.
- Molecular dynamics simulations and dielectric relaxation (DR) measurements to explore the heterogeneous reorientation dynamics in deep eutectic solvents
- Nonequilibrium thermodynamic signatures of various dynamical instabilities in open and nonlinear systems
- Understanding the H–D isotopic exchange reaction in a liquid droplet via surface plasmon resonance (SPR).
- Observation of Imbert–Fedorov (IF) shift in monolayer MoS2 via quantum weak measurement (QWM).
- Structural and dynamical heterogeneity of water trapped inside Na+-pumping KR2 rhodopsin.
- Water structure and dynamics near molecules and surfaces.
- Water dynamics during protein phase transition. Modulation of such transition using excipients.
- Application of 2-photon absorption spectroscopy as a novel tool to understand ligand-surfactant interaction.
- Design and Fabrication of washable all-cotton 3 or 4-layer mask with controlled super-hydrophilic/hydrophobic surface modifications.
- Development of nanomedicines and nanohybrids for treating different diseases.
- Investigation on the role of Magnesium Ions in the DNA-Scissoring activity of the Restriction Endonuclease Biochemical reactions occurring inside cells
- Basic studies on energy harvesting materials.
- Development of nanomedicines and nanohybrids for treating different diseases.

Summary of research activities

The department consists of faculty members with a wide variety of expertise including theory, simulation and experiments. The department hosts some of the very quince experimental facilities (e.g., fs-resolved spectroscopy, THz spectroscopy, ring-down spectroscopy etc.). Following are some key findings from different faculty members:

The group of Prof. Jaydeb Chakrabarti has looked upon the mutations drive viral evolution and genome variability that causes viruses to escape host immunity and to develop drug resistance. SARS-CoV-2 has considerably higher mutation rate. SARS-CoV-2 possesses a RNA dependent RNA polymerase (RdRp) which helps to replicate its genome. The mutation P323L in RdRp is associated with the loss of a particular epitope (321-327) from this protein. They further observe that the mutations cause conformational changes in the epitope region by opening up the region associated with increase in the radius of gyration and intramolecular hydrogen bonds, making the region less accessible.

The group of Prof. Manik Pradhan have utilized the surface plasmon resonance (SPR) technique to explore the real-time kinetics of the H–D isotope exchange reaction between the hygroscopic D2O droplet and atmospheric water (H2O) vapour. These SPR experiments revealed new insights into the rate of exchange of D atoms (□1017 atoms per s) and the time-scale for a single H–D exchange (□few milliseconds) in a D2O/H2O medium under the experimental conditions. This group has also explored the IF shift on MoS2 for a fundamental Gaussian beam. Using Jones vector formalism, they have shown a novel pathway to apply the quantum weak measurement (QWM) technique for easy and accurate determination of the IF shift.

Prof. Gautam Gangopadhyay and co-workers are involved in analyzing nonlinear instances from a thermodynamic viewpoint, they have established a strong correspondence between thermodynamic and dynamic entities in a nonequilibrium environment through a series of works. The principal methodology involves capturing and characterizing the nonequilibrium steady state of a complex dynamical system and in this context they have utilized complex Ginzberg Landau equation which plays an essential role to focus on predicting some emerging nonlinear phenomena. Their work also involves investigation on the role of Magnesium Ions in the DNA-Scissoring activity of the Restriction Endonuclease Biochemical reactions occurring inside cells have significant stochastic signatures due to the low copy number of reacting species.

Prof. Ranjit Biswas and co-workers have used Molecular dynamics simulations and dielectric relaxation (DR) measurements in the frequency window, $0.2 \leq \nu/\mathrm{GHz} \leq 50$ to explore the heterogeneous reorientation dynamics in [f choline chloride + (1-f) urea] deep eutectic solvents (DESs) at $f = 0.33$ and 0.40 in the temperature range $293 \leq T/\mathrm{K} \leq 333$. The simulated ratios between the average rotation and translation timescales for both urea and choline correctly reduce to the appropriate hydrodynamic limit at high temperature. This group has recently reported temperature dependent

(293≤T(K)≤336) dielectric relaxation (DR) measurements of (acetamide + LiBr/NO3-/ClO4-) deep eutectic solvents (DESs) in a frequency window, 0.2≤ν(GHz)≤50, and explore, via molecular dynamics simulations, the relative roles for the collective single particle reorientational relaxations, and the H-bond dynamics of acetamide in the measured DR response.

By employing several microseconds long atomistic molecular dynamics simulation of this trans-membrane protein system, the group of Prof. Suman Chakrabarty has demonstrated the presence of five distinct water containing pockets/cavities separated by gateways controlled by protein side-chains. There exists a strong hydrogen bonded network involving these buried water molecules and functionally important key residues. They present evidence of significant structural and dynamical heterogeneity in the water molecules present in these cavities, with very rare exchange between them. This group has also demonstrated that although for spherical hydrophobic solutes water undergoes a nanometer scale order-disorder crossover (as predicted earlier by David Chandler), for linear and flexible hydrophobic polymers this crossover is either weak or does not exist due to presence of a sub-nanometer length scale along the cross-section of the polymer.

The group of Prof. Samir Kumar Pal is involved in basic studies on energy harvesting materials, development of nanomedicines and nanohybrids for treating different diseases, basic experimental photophysical studies on bio-mimetic systems, development of biomedical instruments, development of point of care diagnosis.

Prof. Rajib Kumar Mitra and co-workers have investigated the hydration of protein microdroplets formation (LLPS) using THz spectroscopy. They have also found that such a process can be modulated by the addition of external agents like sucrose, bovine serum etc. This group has also study the interaction between the cationic dye rhodamine 6G (R6G) with surfactants of different charge types: anionic SDS, cationic CTAB, and nonionic Tx 100 using two-photon absorption (TPA) spectroscopy. They calculate the Δμ and observe that it passes through a maximum at a surfactant concentration half of the critical micelle concentration of SDS. This observation imparts support to earlier quantum mechanical calculation, which infers deviation from the parallel orientation of the dye during surfactant-induced aggregation.

Rajib Kumar Mitra
Head, Department of Chemical,
Biological & Macro-Molecular Sciences

Ali Hossain Khan
Ramanujan Fellow
CBMS
alikhan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Rudra Chowdhury; Application of 2D nanoplatelets in optoelectronic devices; Under progress; Co-supervisor: Prof. Abhijit Biswas (Professor & HOD, Department of Radio Physics and Electronics, University of Calcutta)

b) External Project Students / Summer Training

1. Sukanta Das (Summer Training); Synthesis and Characterization of Gold Nanoparticle and CdSe Quantum Dot; Institute of Nano Science and Technology (INST), Mohali, Punjab
2. Soumyadeep De (Project Student); Co-doping in CdSe nanoplatelets; S. N. Bose National Centre for Basic Sciences, Kolkata, West Bengal

Teaching

1. August 2021-2022; IDC 601: Seminar Course, INST, Mohali; Ph.D. course work; 43 students; Co-teachers: Dr. Bhanu Prakash and Dr. Deepika Sharma

Talks / Seminars Delivered in reputed conference / institutions

1. 1st Annual Meeting of Energy & Environment Unit; 10-11 September 2021; INST, Mohali; 30 minutes

Areas of Research

Material Science, colloidal 2D nanocrystals

The main objective of my Ramanujan Fellowship research proposal is the synthesis of doped 2D nanocrystals for photonic applications. For this purpose, we have chosen 2D nanocrystals of cadmium selenide (CdSe), often known as the CdSe nanoplatelets (NPLs) as hosts. The synthesis of CdSe NPLs needs a reaction system, called Schlenk line setup, where we usually synthesize colloidal nanoparticles at high temperature (up to 400°C) maintaining vacuum and inert gas atmosphere. We have purchased the various parts of the Schlenk line setup and assembled them (Figure 1a). We have standardized the synthesis procedure of cadmium myristate precursor, CdSe NPLs, CdSe/CdS core/shell and core-crown nanostructures. Those nanostructures will be used as the host for the doping. Firstly, we have planned to dope two metal atoms simultaneously in the CdSe NPLs. In this way we can introduce a localized donor and an acceptor states within the CdSe bandgap to tune the dopant emission

spectrum towards the NIR region. For this purpose, we chose two hetero valent metal ion Ag^{+} and In^{3+} as the dopant, the charge compensation by the heterovalent co-dopants can also enhance the stability of the dopants inside the host. We have doped Ag^{+} in the CdSe NPLs via partial cation exchange procedure which gives emission around 700 nm (Figure 1b). The In^{3+} doping in CdSe NPLs was done via growth doping procedure, which gives emission at around 600 nm. But the In-dopant emission intensity reduces with time, most probably because of the self-purification of NPLs and so In is coming out from the host. We are trying to stabilize the dopant emission of In. So, silver doping and indium doping in CdSe NPLs is done separately. The next step is to introduction of both the dopants simultaneously.

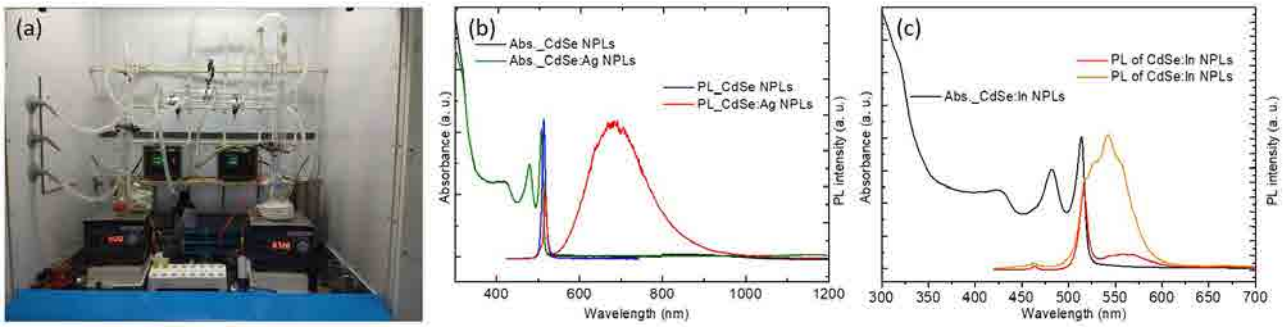


Figure1 (a) Picture of the newly assembled Schlenk line setup for the synthesis of colloidal nanocrystals. (b) Absorption and PL spectra of CdSe NPLs and CdSe:Ag NPLs respectively. (c) Absorption and PL spectra of CdSe:In NPLs.

Plan of Future Work Including Project

We have almost established the individual doping of Ag^{+} or In^{3+} in CdSe NPLs. So, the next plan is to doping these ions together in the same host. We need to do work on the co-doping strategies. Once the co-doping method is established, next we will explore the combination of other possible metal ions, like Ag^{+}/Cu^{+} with $In^{3+}/Ga^{3+}/Al^{3+}$. Crown or shell deposition will be employed on the co-doped system to improve the PL QY and optical stability. The structural and optical characterization will be done to identify the dopant states and then to reveal their effect on the optoelectronic properties of the host. Later, heavy lanthanide ions such as Gd^{3+}, will be used as dopant in CdSe NPLs, this material can be used for ultrafast time-resolved scintillation.

Gautam Gangopadhyay
Senior Professor
CBMS
gautam@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Premashis Kumar; Nonequilibrium Thermodynamics of some nonlinear dynamical systems; Under progress
2. Jayarshi Bhattacharyya; Quantum entropy dynamics of nonlinear systems; Under progress; Prof. Sunandan Gangopadhyay (Co-supervisor)

b) Post-Docs

1. Prasanta Kundu; Dynamic Disrder in single molecule enzyme kinetics

c) External Project Students / Summer Training

1. Sayantan Das; Bichemical understanding of repressilator; Department of Biophysics Molecular Biology & Bioinformatics; Rajabazar Science College; University of Calcutta
2. Nirabindu Ganguly; Study of Cyclic Oscillations in a Synthetic Oscillatory Network of Transcriptional Regulators; Department of Physics, University of Delhi

Teaching

1. Spring semester; Stochastic Processes in Physics and Chemistry, CB-528; Integrated Ph.D.; 8 students

Publications

a) In journals

1. Premashis Kumar and **Gautam Gangopadhyay**, *Nonequilibrium thermodynamic characterization of chimeras in a continuum chemical oscillator system*, Physical Review E, 105, 034208, 2022
2. Sandip Saha, **Gautam Gangopadhyay** & Deb Shankar Ray, *Universality in bio-rhythms: A perspective from nonlinear dynamics*, Journal of Biosciences, 47, 16, 2022
3. Souma Mazumdar, **Gautam Gangopadhyay**, *Centre Manifold Analysis of 3-D Nonlinear System and Kinetic Stability of Protein Assembly*, Journal of Applied Nonlinear Dynamics, 11(1), 139-152, 2022
4. Premashis Kumar and **Gautam Gangopadhyay**, *Nonequilibrium thermodynamics of glycolytic traveling wave: Benjamin-Feir instability*, Physical Review E, 104, 014221, 2021

5. Prasanta Kundu, Soma Saha, and **Gautam Gangopadhyay**, *A Revisit to Turnover Kinetics of Individual Escherichia coli β-Galactosidase Molecules*, The Journal of Physical Chemistry B, 125, 8010-8020, 2021
6. Biswajit Das, Kinshuk Banerjee, and **Gautam Gangopadhyay**, *On the Role of Magnesium Ions in the DNA-Scissoring Activity of the Restriction Endonuclease ApaI: Stochastic Kinetics from a Single Molecule to Mesoscopic Paradigm*, The Journal of Physical Chemistry B, 125, 4099-4107, 2021
7. Anirban Karmakar and **Gautam Gangopadhyay**, *Electron-Vibration Entanglement of Resonating Dimers in Quantum Transport*, The Journal of Physical Chemistry A, 125, 3122-3134, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. 17th Theoretical Chemistry Symposium (TCS - 2021), 11-14Dec'2021, IISER Kolkata; Dec 12, 2021; Online, IISER Kolkata; 11-14th December'2021
2. 13th Conference on Nonlinear Systems and Dynamics (CNSD-2021) Sastra Deemed UniversityThanjavur-613401, India; Dec 15, 2021; Online Sastra Deemed UniversityThanjavur- 613401, India; 17-22 December'2021

Administrative duties

1. Transparency Officer
2. Convener, Medical Cell
3. Member, Project and Patent Cell

Membership of Learned Societies

1. Life Member, Indian Physical Society, Kolkata
2. Life Member, Indian Association for the Cultivation of Science, Kolkata

Scientific collaborations with other national / international institutions (based on joint publications)

1. Dr. Soma Saha, Presidency University; Sl. No. 5; National
2. Dr. Kinshuk Banerjee, AJC Bose College, Kolkata West Bengal; Sl. No. 6; National
3. Dr. Anirban Karmakar, Taldi College, Kolkata West Bengal; Sl. No. 7; National
4. Prof. Deb Shankar Ray, IACS, Kolkata; Sl. No. 2; National

Areas of Research

Stochastic processes in Physics, Chemistry and Biology

(a) Nonequilibrium thermodynamic signatures of various dynamical instabilities in open and nonlinear systems: Analyzing nonlinear instances from a thermodynamic viewpoint, we have established a strong correspondence between thermodynamic and dynamic entities in a nonequilibrium environment through a series of works. The principal methodology involves capturing and characterizing the nonequilibrium steady state of a complex dynamical system and in this context we have utilized complex Ginzberg Landau equation which plays an essential role to focus on predicting some emerging nonlinear phenomena. For example, a significant and challenging task is to systematically develop nonequilibrium forces, fluxes, and energies on top of the dynamics of the complex system within different regimes to capture the system characteristics and understand the priorities and trade-off strategies of natural complex system. We have quantified the entropic and energetic consumption of pattern generation due to three simple possible scenarios of Turing-Hopf overlap in various chemical models (for example, Brusselator, Selkov model of chemical oscillations) in the presence of cross-diffusion terms . Like the chemical oscillation model, we have formulated nonequilibrium energetics of the kinetic proofreading model in response to the change in ATP concentration, and this response profile correlates to the error profile of the system. These observations provide a strong basis for revisiting the trade-off between error, external force, and dissipation and quantifying this trade-off by taking concentrations of chemostatted elements and chemical affinity as control parameters.

(b) Investigation on the role of Magnesium Ions in the DNA-Scissoring activity of the Restriction Endonuclease Biochemical reactions occurring inside cells have significant stochastic signatures due to the low copy number of reacting species. Kinetics of DNA cleavage by restriction endonucleases are no exception as established by single-molecule experiments. Here, we propose a simple reaction scheme to understand the role of the cofactor magnesium ion in the action of the

endonuclease ApaI. The methodology is based on the waiting time distribution of cleavage product formation that enables us to determine the corresponding rate both analytically and numerically. The theory is developed at the single-molecule level and then generalized to the biologically relevant case of a population of DNA–endonuclease complexes present inside a cell which is supported by a recent experimental result.

(c) Dynamic disorder and conformational fluctuations in reaction kinetics: The decay of the nonexponential kinetics at the microsecond timescale, points to the relevance of having possible influence of dynamic disorder on the reaction kinetics. To rationalize the experimental results by the microscopic dynamics of aprotein molecule is described in terms of the anomalous diffusion of a Brownian particle in a harmonic well under the action of fractional Gaussian noise.

Plan of Future Work Including Project

1. Quantum entanglement in Energy funneling of light harvesting complexes through Exciton Transport: effect of vibrational dynamics Capturing sunlight with a highly efficient light-harvesting apparatus, where molecular aggregate serving as antenna transfers the excitation energy to the reaction center via exciton transport mechanism. The exciton transport dynamics in a naturally occurring bacterial photosynthetic system have been studied by utilizing a quantum optical master equation in an electron transport setup where the system is coupled to two fermionic reservoirs with a hugely different chemical potentials. We have demonstrated that an interplay between the excitonic and vibronic coupling actually controls and modulates the excitonic current and hence the associated energy funneling mechanism. Here we have two ways to show the qualitative distinction of transport properties. In the first instance it shows that the current peaks at the multiples of the vibration energy. Secondly the quantum entanglement replicates the current with excitonic coupling. Both the mechanisms are thermally induced so they support energy transfer in current through exciton transport complexes, however, the back action of coupling on the vibrational mode is counterintuitive where we plan to study the nontrivial temperature dependence and other interplays of exciton-vibration coupling scenario.

Goutam De
Emeritus Professor
CBMS
g.de@bose.res.in

Teaching

(i) A Course on "Chemical Synthesis, Characterization & Application of Nanomaterials (NANO1)" has been designed for the Ph.D. students of SNBNCBS who are working in the area of nanomaterials. The course has been submitted to the Dean (Academic Program) for necessary action.

(ii) Preliminary work related to the embedment of CdSe nanosheets in TiO2/SiO2 coating-matrices has been initiated during the reporting period.

Publications

a) In Journals

1. Atin Pramanik, Shreyasi Chattopadhyay, Sandipan Maiti, **Goutam De**, Sourindra Mahanty, *Hollow-porous nanospheres of $ZnMn_2O_4$ spinel: A high energy density cathode for rechargeable aqueous battery*, Materials Chemistry and Physics, 263, 124373, 2021
2. Sourav Pramanik, Shreyasi Chattopadhyay, Sandip Bysakh, Anindita Mukhopadhyay, **Goutam De**, *Alloy formation and composition partitioning of plasmonic-magnetic Au–Fe nanoparticles embedded in sol-gel SiO_2 films*, Journal of Alloys and Compounds, 873, 159793, 2021
3. Atin Pramanik, Sandipan Maiti, Shreyasi Chattopadhyay, **Goutam De**, Sourindra Mahanty, *'Cotton-ball' shaped porous iron-nickel sulfide: A high-rate cathode for long-life aqueous rechargeable battery*, Materials Research Bulletin, 140, 111307, 2021
4. Atin Pramanik, Shreyasi Chattopadhyay, **Goutam De** and Sourindra Mahanty, *Efficient energy storage in mustard husk derived porous spherical carbon nanostructures*, Materials Advances, 2, 7463-7472, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. An invited lecture entitled "Recent Advances on the Development of Superhydrophobic Surfaces" was delivered at the International Hybrid Meeting on Physics and Chemistry of Advanced Materials (PCAM-2021) held in IIT Delhi during October 24-27, 2021; 25/12/2021; IIT Delhi; 12:45 - 13:05

Awards, Recognitions

1. External Member of CRNN (Calcutta University) Ph.D. committee (continued)

Scientific collaborations with other national / international institutions (based on joint publications)

1. CSIR-Central Glass & Ceramic Research Institute, Kolkata; Sl. No. 1-4; National

Outreach program organized / participated

1. Attended several Webinars

Areas of Research

Synthesis & evaluation of functional nanomaterials and coatings

Project: Design and Fabrication of washable all-cotton 3 or 4-layer mask with controlled super-hydrophilic/ hydrophobic surface modifications

Experimental work on the synthesis and characterization of SiO2-ZnO nanoparticles-based superhydrophobic coatings (single layer) on cotton fabrics has been completed under the above activity. Water droplets permeability (mimicking human sneeze) of the coated and uncoated fabrics has been done at IIT Mandi. Analysis of data is under progress. It has been observed that when water droplets (average size 265 μm) with a speed of 7-10 m/s impacted on uncoated cotton fabrics (superhydrophilic) it absorbs the water and a fraction of absorbed water blob emits secondary droplets of >50 μm in size; on the contrary, the coated fabric (superhydrophobic) repels most of the droplets after the impact with penetration of a very small fraction of droplets of ~20 μm in size.

Other activities:

Work related to the analysis of data, manuscript preparation and further data analysis/acquisition (for revision) are going on for the following work:

1. "Plasmon Mediated Electron Transfer and Temperature Dependent Electron-Phonon Scattering in Gold Nanoparticles Embedded in Dielectric Films" (with INST Mohali).
2. "In situ CsPbBr3 Architecture Engineered in the Electrospun Fibers and Its Ultrafast Charge Transfer Dynamics" (with INST Mohali)
3. "Weather Sustainable Low-Reflective Ordered Mesoporous Silica Coatings on Solar Cover Glasses for Enhancement of Photocurrent and Easy Maintenance" (with CSIR-CGCRI).
4. "FeNi2S4-rGO-MWCNT composite for high-rate conversion anode in lithium-ion battery" (with CSIR-CGCRI).

Plan of Future Work Including Project

(i) The ongoing activity on the development of superhydrophobic coatings on cotton fabrics.

(ii) Some ongoing collaborative research activities on metal nanoparticle doped films, abrasion resistant refractive index-controlled coatings, antireflecting cum hydrophobic coatings on solar cover glass etc. will be continued.

(iii) Supervision of a Summer Intern from IT-BHU on a project "Au nanoparticle doped Aluminium Titanate films on Glass".

Any other Relevant Information including social impact of research

i) Evaluated the work-report for "Faculty assessment & promotion" program of Institute of Advanced Study in Science & Technology (IASST), Guwahati (December 2021).

ii) Acted as an external examiner of a Ph.D. thesis "Engineering Fragility of Hybrid Organic-Inorganic Perovskite for Diverse Applications" submitted by Anindita Mahapatra of CSIR-IICB under AcSIR (August 2021).

iii) Attended the CRNN (Calcutta University) Ph.D. committee meetings as an external member.

iv) Attended the Editorial Board Meetings of RSC journals 'Journal of Materials Chemistry A' & 'Materials Advances' as Board member on 21/06/2021.

v) Manuscript handling of the Royal Society of Chemistry (RSC) journals, Journal of Materials Chemistry A and Materials Advances as Associate Editor.

vi) Nominated several names of Indian researchers to the RSC as 'Emerging Investigators', 'Lectureship award', 'Fellowship (FRSC)' etc.

vii) Setting-up of a small chemical lab at TRC-2, SNBNCBS.

Jaydeb Chakrabarti
Senior Professor
CBMS
jaydeb@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Sasthi Charan Mandal; Biomolecular systems; Thesis submitted
2. Edwin Tendong; Soft matter physics; Under progress; Tanusri Saha Dasgupta
3. Abhik Ghosh Moulik; Biomolecular systems; Under progress
4. Rahul Karmakar; Soft matter physics; Under progress
5. Anirban Pal; Biomolecular systems; Under progress
6. Suravi Pal; Soft matter physics; Under progress
7. Kanika Kole; Biomolecular systems; Under progress
8. Avik Sasmal; Soft matter physics; Under progress

b) Post-Docs

1. Ayatti Mallik Gupta; Biomolecular systems

Publications

a) In journals

1. Aayatti Mallick Gupta, SasthiCharan Mandal, Sukhendu Mandal, **Jaydeb Chakrabarti**, *Immune escape facilitation by mutations of epitope residues in RdRp of SARS-CoV-2*, Journal of Biomolecular Structure and Dynamics, DOI: 10.1080/07391102.2022.2051746
2. E Tendong, T Saha-Dasgupta, **J Chakrabarti**, *Viscoelastic response of fluid trapped between two dissimilar van der Waals surfaces*, Journal of Physics: Condensed Matter, 34, 195101, 2022
3. Mausumi Raya, Sasthi Charan Mandal, **Jaydeb Chakrabarti**, *Quantum chemical studies on chelation in nano-bio conjugate between ZnO nanoparticles and cellular energy carrier molecules*, Materials Chemistry and Physics, 279, 125744, 2022
4. Rahul Karmakar and **J. Chakrabarti**, *A long-range order in a thermally driven system with temperature-dependent interactions*, Soft Matter, 18, 867-876, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. From atoms to protein functions-Molecular dynamics as a tool; Dec 21, 2021; Amity University, Kolkata

2. Tracer motion through an entangled polymeric network within a confined asymmetric geometry in presence of a driving force, StatPhys, Kolkata; Mar 21, 2022; IISER, Kolkata; 5 days

Administrative duties

1. Head of the Department, CBMS
2. Chairman, Faculty Search Committee

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. TRC; DST; Co-PI

Areas of Research

Soft condensed matter physics

We highlight a couple of important works done in our group:

1. Mutations drive viral evolution and genome variability that causes viruses to escape host immunity and to develop drug resistance. SARS-CoV-2 has considerably higher mutation rate. SARS-CoV-2 possesses a RNA dependent RNA polymerase (RdRp) which helps to replicate its genome. The mutation P323L in RdRp is associated with the loss of a particular epitope (321-327) from this protein. We consider the effects of mutations in some of the epitope region including the naturally occurring mutation P323L on the structure of the epitope and their interface with paratope using all-atom molecular dynamics (MD) simulation studies. We observe that the mutations cause conformational changes in the epitope region by opening up the region associated with increase in the radius of gyration and intramolecular hydrogen bonds, making the region less accessible. Moreover, we study the conformational stability of the epitope region and epitope:paratope interface under the mutation from the fluctuations in the dihedral angles. We observe that the mutation renders the epitope and the epitope:paratope interface unstable compared to the corresponding wild type ones. Thus, the mutations may help in escaping antibody mediated immunity of the host.
2. Aggregation of macro-molecules under an external force is far from being understood. An important driving situation is achieved by temperature difference. Inter-particle interactions in metallic nanoparticles with ligand capping are reported to be sensitive to temperature and the zeta potential of the particles being reduced in the cold region. Such particles form aggregates in the cold region of the system in the presence of temperature difference. Here we study the aggregation of particles in the presence of temperature difference with temperature-dependent interaction parameters using Brownian dynamics simulation. The particle interaction and particle diffusion are considered to be sensitive to the local temperature. We identify a long-range structural order in the cold region of the system using the Avrami equation for crystal growth kinetics. Our observations might be useful in designing ordered structures with macro-molecules under non-equilibrium steady-state conditions.

Plan of Future Work Including Project

1. Biomolecular systems: A. Understanding metastability in molten globule proteins:on This is to investigate function of proteins out of their conventional structure B. Understanding DNA functions when they lack the traditional Watson-Crick pairing structure C.
2. Tracer motion through polymeric network to understand physics of face mask and reverse osmosis.

Manik Pradhan
Professor
CBMS
manik.pradhan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Akash Das; Quantum Weak Measurements; Thesis submitted
2. Biswajit Panda; High Resolution Molecular Spectroscopy; Under progress
3. Ardhendu Pal; Cavity Ring-down Spectroscopy; Under progress
4. Soumen Mandal; Optical Beam Shifts; Under progress
5. Vishal Agarwal; Nano Materials and Spectroscopy; Under progress; Prof. Arup K. Raychaudhuri (Co-supervisor)
6. Soumyadipta Chakraborty; Cavity Ring-down Spectroscopy; Under progress

b) Post-Docs

1. Jayeta Banerjee; Surface Plasmon Resonance

Teaching

1. Spring semester; Methods in Experimental Physics (PHY 391); Integrated Ph.D.; 5 students
2. Spring semester; Project Research III (PHY 401); Integrated Ph.D.; 1 student

Publications

a) In journals

1. Biswajit Panda, Ardhendu Pal and **Manik Pradhan**, *Direct and 2f-wavelength modulation spectroscopy of NO and OCS using an astigmatic multipass cell coupled with a mid-IR 5.2 μm cw-QCL*, Laser Physics, 32, 035702, 2022
2. Ardhendu Pal, Biswajit Panda, Sanchi Maithani, **Manik Pradhan**, *l-doublet splittings in Δ vibrational state of $^{15}N^{14}N^{16}O$ isotopomer*, Chemical Physics Impact, 3, 100049, 2021
3. Ardhendu Pal, Biswajit Panda, Sanchi Maithani, **Manik Pradhan**, *Cavity ring-down spectroscopy of l-type doubling in ^{15}N-β-site N_2O isotopomer near 7.8 μm*, Journal of Molecular Spectroscopy, 381, 111523, 2021
4. Akash Das, Soumen Mandal, and **Manik Pradhan**, *Observation of Imbert–Fedorov shift in monolayer MoS_2 via quantum weak measurement*, Optics Letters, 46, 5826-5829, 2021

5. Sanchi Maithani, Abhijit Maity and **Manik Pradhan**, *Probing the H–D isotopic exchange reaction in a liquid droplet via surface plasmon resonance*, Journal of Analytical Atomic Spectrometry, 37, 544-550, 2022
6. Biswajit Panda, Ardhendu Pal, Sanchi Maithani, Abhijit Maity, **Manik Pradhan**, *Ro-vibrational spectral features and pressure broadening dynamics of dideutero-methane ($^{12}CH_2D_2$) in the $\nu_9(B_2)$ fundamental band*, Journal of Molecular Spectroscopy, 384, 111572, 2022
7. Sanchi Maithani, Abhijit Maity and **Manik Pradhan**, *A perspective on the evolving role of stable isotope analysis and the emergence of cavity enhanced spectroscopy as a potent tool*, Journal of Analytical Atomic Spectrometry, 36, 1813-1825, 2021
8. Saptarshi Pal, Puspendu Barik, **Manik Pradhan**, *Tunable plasmon assisted enhancement of green light emission from ZnO nanoparticles*, Materials Today Communications, 28, 102713, 2021
9. Puspendu Barik, Saptarshi Pal, **Manik Pradhan**, *On-demand nanoparticle-on-mirror (NPoM) structure for cost-effective surface-enhanced Raman scattering substrates*, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 263, 120193, 2021
10. Sayoni Bhattacharya, Mithun Pal, Biswajit Panda, **Manik Pradhan**, *Spectroscopic investigation of hydrogen and triple-oxygen isotopes in atmospheric water vapor and precipitation during Indian monsoon season*, Isotopes in Environmental and Health Studies, 57, 368-385, 2021
11. Arun Bera, Arpan Maiti, Abhijit Maity & **Manik Pradhan**, *Exploring C, H and O isotope-specific adsorption of CO_2 and H_2O vapour in nanostructured polyaniline*, MRS Communications, 11, 843-849, 2021
12. Chiranjit Ghosh, Debashis Patra, Niranjan Bala, Indira Majumder, Nayim Sepay, Prabuddha Mukhopadhyay, Sukhen Das, Rita Kundu, Michael G. B. Drew, Armando Rafael León, Tapas Ghosh, **Manik Pradhan**, *A family of amphiphilic dioxidovanadium(V) hydrazone complexes as potent carbonic anhydrase inhibitors along with anti-diabetic and cytotoxic activities*, BioMetals, 2022, https://doi.org/10.1007/s10534-022-00384-7
13. Puspendu Barik and **Manik Pradhan**, *Selectivity in trace gas sensing: recent developments, challenges, and future perspectives*, Analyst, 147, 1024-1054, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. 6th International Diabetes Summit (Virtual)-2022: Pune, India; Mar 4, 2022; Pune (Virtual); March 4-6, 2022
2. Chemistry Lecture Series: School of Chemical and Materials Sciences; 2021, IIT Goa, India; Dec 3, 2021; IIT Goa (Virtual); December, 3, 2021
3. Spectroscopy and Dynamics of Molecules and Clusters (SDMC)-Webinar; Jan 29, 2022; Virtual; January, 29, 2022

Administrative duties

1. Member of Works Committee
2. Member of Reservation Cell Committee
3. Member of various Interview and Thesis Committee

Patents Taken and Process Developed with Details

1. "ADVANCEMENT IN METHODOLOGY AND SYSTEM TO CONTROL ISOTOPIC FRACTIONATIONS IN CARBON CONTAINING GASES": FER Submitted on 16/03/2022; E-91/838/2022/KOL; Applied
2. "SYSTEM AND KIT FOR MONITORING BLOOD GLUCOSE PROFILE BASED ON BREATH ANALYSIS": FER Submitted on 08/03/2022; E-91/722/2022/KOL; Applied

Awards, Recognitions

1. Elected Fellow of the Institute of Physics (FInstP), London, UK
2. Chellaram Foundation Diabetes Research Award (First Prize), India

Membership of Learned Societies

1. Fellow of the Royal Society of Chemistry (FRSC), London, UK
2. Fellow of the Institute of Physics (FInstP), London, UK
3. Fellow of Linnean Society of London (FLS), UK
4. Member of American Chemical Society (ACS)
5. Member of Chemical Research Society of India
6. Member of Indian Physics Association
7. Member of Indian Laser Association
8. Member of Indian Society of Chemists and Biologists
9. Member of Research Society for the Study of Diabetes in India

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Understanding of growth of vertically aligned nanowires or nanotubes of binary oxides and physics of isotopic fractionation of gases by them; SERB; 2017-2021; Co-PI

Scientific collaborations with other national / international institutions (based on joint publications)

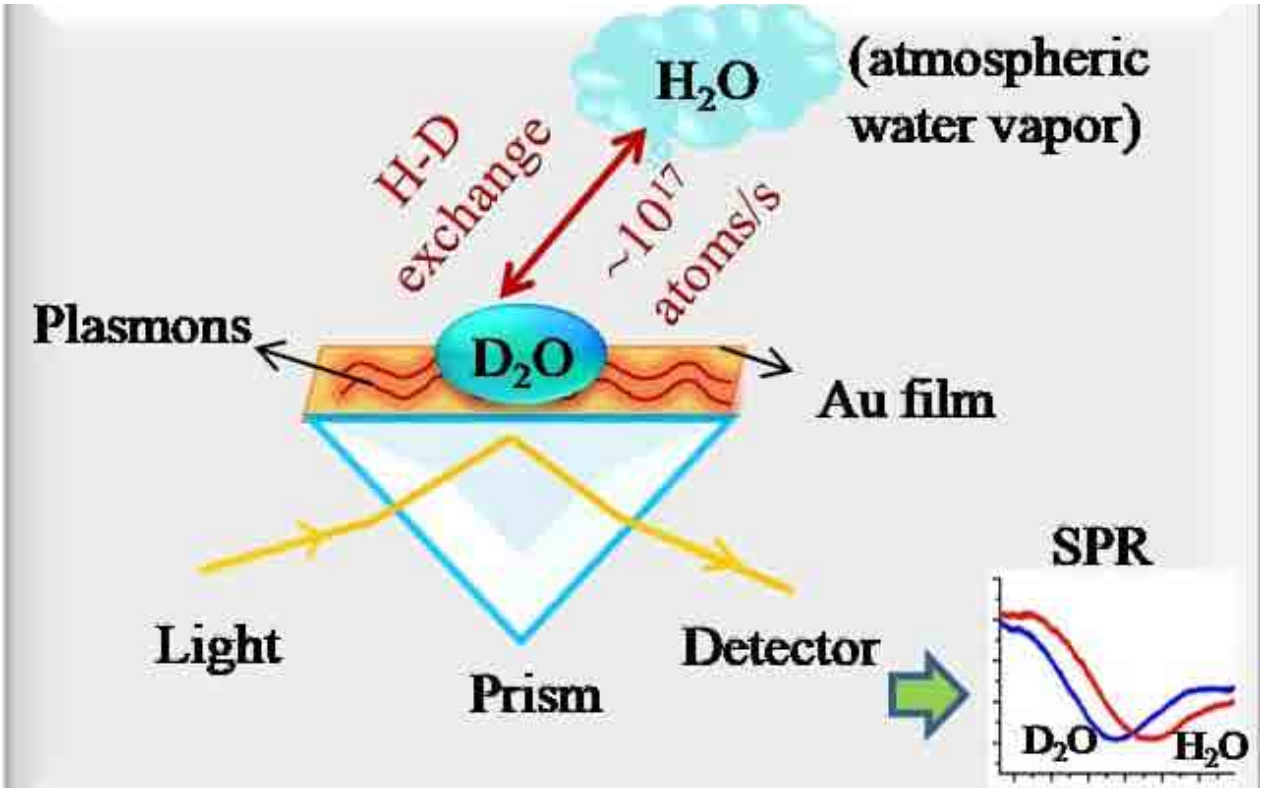
1. C. Ghosh, D. Patra, N. Bala, I. Majumder, N. Sepay, P. Mukhopadhyay, S. Das, R. Kundu, M. Drew, A. Leon, T. Ghosh and M. Pradhan, "A family of amphiphilic dioxidovanadium (V) hydrazone complexes as potent carbonic anhydrase inhibitors along with anti-diabetic and cytotoxic activities": BioMetals (2022); Sl. No. 12; International

Areas of Research

Quantum Cascade Laser Spectroscopy, High-Resolution Molecular Spectroscopy, Applied Optics and Photonics, Biomedical Science and Environmental Sensing

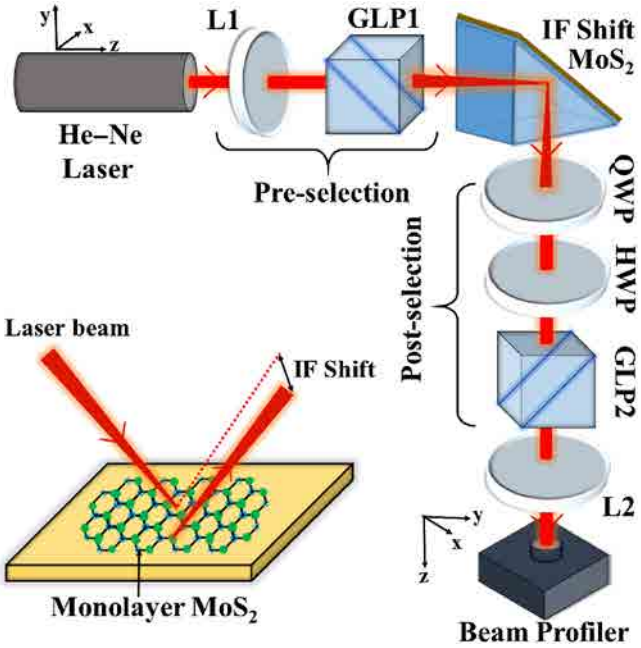
Understanding the H–D isotopic exchange reaction in a liquid droplet *via* surface plasmon resonance (SPR):

The optical excitation of plasmonic oscillation at the metal–dielectric interface has widely been utilized for selective detection of molecules by tracking the change of the refractive index (RI) of the medium above the metal film. In this work, we have utilized the surface plasmon resonance (SPR) technique to explore the real-time kinetics of the H–D isotope exchange reaction between the hygroscopic D2O droplet and atmospheric water (H_2O) vapour. These SPR experiments revealed new insights into the rate of exchange of D atoms (~1017 atoms per s) and the time-scale for a single H–D exchange (~few milliseconds) in a D2O/H2O medium under the experimental conditions of the present study as shown in the following Figure. Unique SPR profiles were obtained for different mixtures of H2O and D2O, which were supported by respective RI measurements of the mixtures using a standard refractometer. The study also demonstrated the feasibility of SPR as a powerful method for real-time monitoring of temporal degradation of D2O and detecting the impurity of water content in D2O and vice versa.



Observation of Imbert–Fedorov (IF) shift in monolayer MoS_2 via quantum weak measurement (QWM):

We have explored the IF shift on MoS2 for a fundamental Gaussian beam. Using Jones vector formalism, we have shown a novel pathway to apply the quantum weak measurement (QWM) technique for easy and accurate determination of the IF shift as shown in the Figure below. We have revealed the dependence of IF shift over a large range of angles of incidence along with the mode of polarization of the incident light. Our experimental findings via the weak value amplification scheme are in good agreement with the theoretical analysis. The present method is a general one and can also be implemented for other materials to observe such tiny transverse shifts.



Plan of Future Work Including Project

1. Development of a LED based cavity enhanced absorption spectroscopic technique for trace detection of atmospheric pollutants and highly-reactive species.
2. Development of a new quantum weak measurement (QWM) technique for studying angular momentum dependent optical beam shifts in various 2D-materials
3. Understanding the spin-chemistry in gas phase molecular species

Any other Relevant Information including social impact of research

1. Pyro-Breath technology has already transferred to a startup company for commercialization. This device will explore H. pylori bacterial infection and various gastric disorders by means of human exhaled breath analysis.

Manoj Mandal
Ramalingaswami Re-entry Fellow
CBMS
m.mandal@bose.res.in

Publications

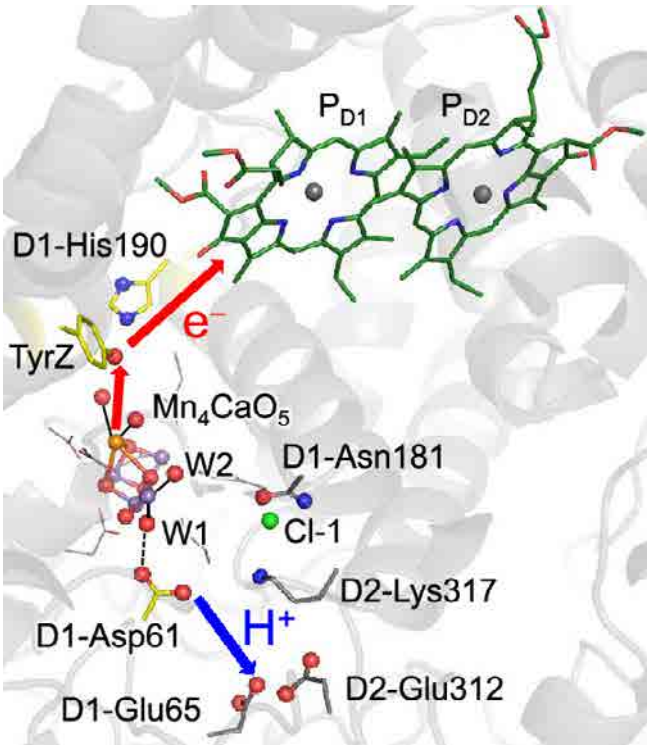
a) In Journals

1. **Manoj Mandal**, Keisuke Saito, Hiroshi Ishikita, *Requirement of Chloride for the Downhill Electron Transfer Pathway from the Water-Splitting Center in Natural Photosynthesis*, The Journal of Physical Chemistry B, 126, 123-131, 2022

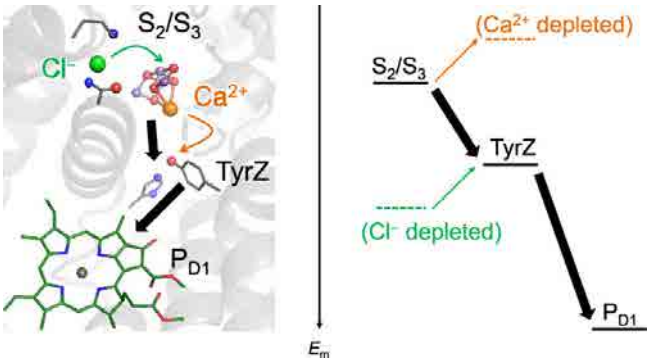
Areas of Research

i. proton-coupled electron transfer
ii. redox potential calculation
iii. natural water oxidation catalysis

The water-splitting enzyme photosystem II (PSII) uses the Mn_4CaO_5 cluster as the catalytic center. To oxidize substrate water molecules, PSII also uses the electron transfer pathway that proceeds from the Mn_4CaO_5 cluster via redox active D1 - yr161 (TyrZ) to the oxidized chlorophyll pair, $[P_{D1}P_{D2}]^{\bullet+}$. The subproduct protons are removed by proton acceptor groups and transferred along the proton transfer pathway toward the lumenal bulk region. As electron transfer occurs, the oxidation state of the oxygen-evolving complex, S_n, increases from S_0 to S_4, in the order: $S_0 \rightarrow S_1 \rightarrow S_2 \rightarrow S_3 \rightarrow S_4 \rightarrow S_0$, and O_2 evolves during the S_4 to S_0 transition.



The PSII crystal structure shows that a chloride ion, Cl-1, is located at D1-Asn181 and D2-Lys317. Cl-1 isolates the H-bond network of the Mn_4CaO_5 cluster and TyrZ from the H-bond network of the D1-Glu65/D2-Glu312 channel. When Cl^- is depleted, the S-state transition is inhibited at the $S_2TyrZ^•$ formation, that is, electron transfer occurs from TyrZ to $PD_1^{•+}$, but subsequent electron transfer from S_2 to $TyrZ^•$ does not occur, which resembles the inhibition of the S_2 to S_3 transition in Ca^{2+}-depleted PSII. The presence of Cl^- may be crucial for the redox potential (E_m) of S_2/S_3 and electron transfer from S_2. However, the functional role of Cl^-remains obscure, partly because the S_2 to S_3 transition involves both electron and proton transfer. We investigate the energetic of proton transfer and electron transfer in Cl^--depleted PSII by adopting a quantum mechanical/molecular mechanical (QM/MM) approach based on the PSII crystal structure. For proton transfer, we analyze the potential energy profiles of the H-bond between W1 and D1-Asp61 and proton transfer. For electron transfer, we calculate the redox potential (E_m) of the cofactors in the electron transfer pathway. The most significant change in response to Cl^- depletion is the increase in the E_m values along the electron transfer pathway, $E_m(S_2/S_3)$, leading to the formation of the energetically uphill electron transfer pathway from S_2/S_3, in contrast with the energetically downhill pathway from S_1/S_2. The formation of the salt bridge between D1-Asp61 and D2-Lys317 is likely to inhibit the release of the proton from W1 via D1-Asp61 by restricting the D1-Asp61 side-chain rotation, and not by disrupting the low-barrier H-bond between W1 and D1-Asp61. The inhibition of electron transfer owing to the significant increase in $E_m(S_2/S_3)$ is primarily responsible for the inhibition of the S_2 to S_3 transition upon the depletion of Cl^-; Cl^- is used to stabilize the higher oxidation states (e.g., S_2/S_3) and facilitate proton-coupled electron transfer from the substrate water molecules in native PSII. Remarkably, **the redox potential (E_m) of S_2/S_3 increased significantly, making electron transfer from S_2 to TyrZ energetically uphill**, as observed in Ca^{2+}-depleted PSII. The uphill electron transfer pathway was induced by the significant increase in $E_m(S_2/S_3)$ caused by the loss of charge compensation for D2-Lys317 upon the depletion of Cl^-, whereas it was induced by the significant decrease in E_m(TyrZ) caused by the rearrangement of the water molecules at the Ca^{2+} binding moiety upon the depletion of Ca^{2+}.



Plan of Future Work Including Project

The recent improved understanding of Mn_4CaO_5 cluster creates a more complex picture and no consensus about the mechanistic understanding of water oxidation and the proton coupled electron transfer in PSII. Whether the proton release from OEC precede electron transfer or occur simultaneously, is under debate. How the electron and proton transfer is supported by fluctuating biological scaffold? What is role of a specific residue in proton and electron transfer? Does the electron flow follow static one-dimensional pathways or dynamic three-dimensional networks? Considering the structure, E_m values and comparing them with experimental results, one can expect to have the exact structure of S_2, S_3 and S_4 states of OEC which are very poorly understood. **The findings of S_2 to S_3 transition mechanism and S_3 state will have a direct impact on possible solution towards the unobserved intermediate states between S_3 and S_0.** TryZ and P_{D1} are far from each other and do not coupled electronically, the same is true for OEC and TyrZ but the **intermediate electron carriers** (pathway) and mechanism are still unknown. Is there super-exchange electron transfer? Why electron transfer predominantly occurs along with D1-branches, not the D2-branches, irrespective of the pseudo-C_2 symmetry between the two branches? We would like to try our best to answer these questions in near future.

Pradip S Pachfule
Assistant Professor
CBMS
ps.pachfule@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Bikash Chandra Mishra; Functionalised Covalent Organic Frameworks (COFs) for Visible Light Induced Photocatalysis; Under progress

Awards, Recognitions

1. Highly cited researcher (World's Top 2% Scientists) published by Stanford University.

Areas of Research

Porous Materials, Covalent Organic Frameworks, Photocatalysis, Electrocatalysis, Hydrogen Generation, Energy Storage, CO_2 Reduction

Hydrogen is a clean fuel that, when burnt, produces only water as a byproduct. However, the production of hydrogen in the first place is mostly accomplished by reforming hydrocarbons, leading to substantial CO_2 generation. A sustainable alternative with minimal greenhouse gas evolution is hydrogen production from water using solar, thermochemical, or photocatalytic water splitting and electrolysis. In my research group, we focus on the development of organic frameworks and carbon-based porous materials, as the catalysts for efficient and recyclable water splitting and CO_2 reduction, of particular interest to the renewable energy industry and transportation sector.

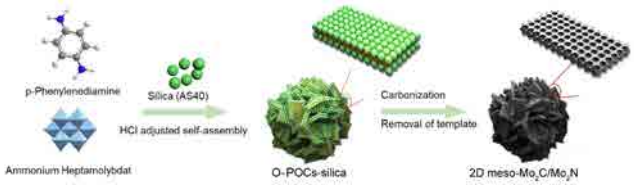


Figure 1. Scheme of synthesis of two-dimensional (2D) Mo-based carbides/nitrides.

For the efficient hydrogen evolution reaction (HER), molybdenum-based carbides and nitrides have been considered as promising catalysts. However, one of the challenges in using Mo-based HER electrocatalysts is establishing well-defined precursors that can be transformed into Mo-based carbides/nitrides with controllable structure, defined reactive sites and porosity. In these regards, we have reported the synthesis of a series of precursors consisting of organic–polyoxometalate co-crystals (O-POCs) as a new type of metal–organic precursor to synthesize Mo-based carbides/nitrides in a controlled fashion and to use them for efficient

catalytic hydrogen production (Figure 1). This protocol enables to create electrocatalysts composed of abundant nano-crystallites and heterojunctions with tunable micro- and nano-structure and mesoporosity. The best performing electrocatalyst shows high HER activity and stability with a low overpotential of 162 mV at 100 mA cm^{-2} (in comparison to Pt/C with 263 mV), which makes it one of the best non-noble metal HER catalysts in alkaline media and seawater. The cheap and bulk production of the catalyst with high catalytic activity show the promise of Mo-based carbides/nitrides for efficient water splitting.

Also, the electrochemical CO_2 reduction is a potential approach to convert CO_2 into valuable chemicals using electricity as feedstock. Abundant and affordable catalyst materials are needed to upscale this process in a sustainable manner. Transition metal-based catalysts, especially, nickel-nitrogen-doped carbon (Ni-N-C) is considered as an efficient catalyst for CO_2 reduction to CO, where the single-site Ni–Nx motif is believed to be the active site.

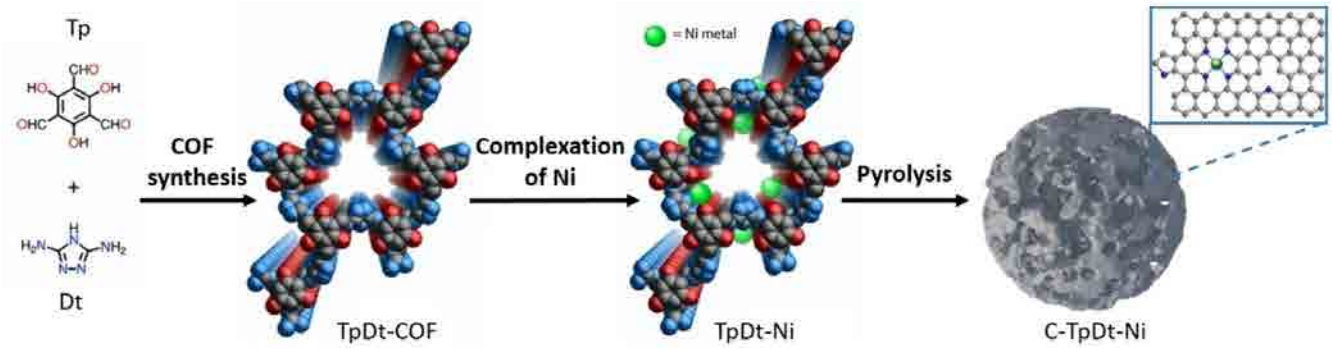


Figure 2. Scheme for the synthesis of C-TpDt-N (Ni-N-C catalysts).

In these regards, we prepared a set of covalent organic framework (COF)-derived Ni-N-C catalysts, where the Ni–Nx content could be adjusted by the pyrolysis temperature. The combination of high-angle annular dark-field scanning transmission electron microscopy and extended X-ray absorption fine structure evidenced the presence of Ni single-sites, and quantitative X-ray photoemission addressed the relation between active site density and turnover frequency. As a result of presence of Ni–Nx single sites in porous Ni-N-C catalysts, the highly efficient electrochemical CO_2 reduction activity was achieved.

Plan of Future Work Including Project

1. Solar-driven water-splitting for hydrogen generation is considered to be of fundamental importance in the push towards clean energy, but inefficiencies in current materials necessitate the development of improved photocatalysts. The future work aims to synthesise ordered organic network materials – such as microporous and hierarchically structured covalent organic frameworks (COFs) – with special suitability for photocatalytic water splitting. In expected outcomes and benefits, these advanced semiconducting materials will enhance visible light absorption and overcome substrate diffusion issues that currently limit water splitting performance, representing a key step towards the novel applications of COFs in the water splitting process. Considering these facts, in our group, we are exploring the synthesis of crystalline and porous COFs with following objectives: 1. Utilization of the heterojunction design strategy for the synthesis of donor-acceptor COFs for efficient light absorption. 2. Synthesis of two-dimensional (2D) sp2 carbon–conjugated olefin-linked COFs using Aldol and Knoevenagel condensation reaction. 3. Applications of COFs for efficient photocatalytic water splitting targeting hydrogen (H2) generation.

Rajib Kumar Mitra
Professor
CBMS
rajib@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Sk. Imadul Islam; Studies on ultrafast dynamics and spectroscopic investigations on fluorescent probes in bimolecular and biomimetic recognition; Thesis submitted
2. Saikat Pal; Studies on the Effects of Different Crowding agents on Protein FoldingUnfolding Process and its Kinetics as well as Activity; Thesis submitted
3. Anulekha De; Nanomagnetism; Thesis submitted; Prof. Anjan Barman
4. Partha Pyne; Studies of Some Biophysical Processes Using Ultrafast Spectroscopic Techniques; Under progress
5. Didhiti Bhattacharya; Opto-electronic, Electrical and Spectroscopic studies of two dimensional materials; Under progress; Prof. S.K. Ray
6. Sumana Pyne; Application of Ultrafast Spectroscopy in Biological Systems; Under progress
7. Ria Saha; Studies on the Effects of Different Crowding agents on Protein FoldingUnfolding Process and its Kinetics as well as Activity; Under progress
8. Sudip Majumder; Nanomagnetism; Under progress; Prof. Anjan Barman
9. Subhajit Singha; Application of Ultrafast Spectroscopy in Chemical/Biological Systems; Under progress

b) Post-Docs

1. Subhadip Chakraborty; Protein folding under stressed environments

Teaching

1. Autumn semester; PHY 301 (Atomic and Molecular Physics); Integrated Ph.D.; 5 students; with 1 (Prof. Anjan Barman) co-teacher
2. Autumn semester; CB 527 (Molecular Physics & Spectroscopy); Ph.D.; 1 student; with 1 (Prof. Anjan Barman) co-teacher
3. Spring semester; PHY491 (Methods of Experimental Physics); Integrated Ph.D.; 5 students; with 3 (Prof. Kalyan Mandal, Prof. Manik Pradhan, and Prof. T Setti) co-teachers

Publications

a) In journals

1. Didhiti Bhattacharya, Sayan Bayan, **Rajib Kumar Mitra** and Samit K. Ray, *2D WS_2 embedded PVDF nanocomposites for photosensitive piezoelectric nanogenerators with a colossal energy conversion efficiency of ~25.6%*, Nanoscale, 13, 15819-15829, 2021
2. Sonali Mondal, Partha Pyne, Animesh Patra, **Rajib Kumar Mitra**, and Soumen Ghosh, *Effect of Surfactant Tail Length on the Hydroxypropyl Cellulose-Mediated Premicellar Aggregation of Sodium n-Alkyl Sulfate Surfactants*, Langmuir, 37, 6168-6177, 2021
3. Partha Pyne and **Rajib Kumar Mitra**, *Excipients Do Regulate Phase Separation in Lysozyme and Thus Also Its Hydration*, The Journal of Physical Chemistry Letters, 13, 931-938, 2022
4. Sk Imadul Islam, Partha Pyne, Dipak Kumar Das, Shounak Mukherjee, Suman Chakrabarty, and **Rajib Kumar Mitra**, *Molecular Insight into Dye–Surfactant Interaction at Premicellar Concentrations: A Combined Two-Photon Absorption and Molecular Dynamics Simulation Study*, Langmuir, 38, 3105-3112, 2022
5. Shubhrasish Mukherjee, Didhiti Bhattacharya, Sumanti Patra, Sanjukta Paul, **Rajib Kumar Mitra,** Priya Mahadevan, Atindra Nath Pal, and Samit Kumar Ray, *High-Responsivity Gate-Tunable Ultraviolet–Visible Broadband Phototransistor Based on Graphene–WS_2 Mixed-Dimensional (2D-0D) Heterostructure*, ACS Applied Materials & Interfaces, 14, 5775-5784, 2022

b) Conference proceedings / Reports / Monographs / Books

1. RK Mitra, DK Palit "Probing Biological Water Using Terahertz Absorption Spectroscopy" Terahertz Technology, Ed. Dr. Borwen You and Dr. Ja-Yu Lu, IntechOpen, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. "A new spectroscopic window to investigate collective vibrational dynamics in chemistry and biology" in International Conference on "Frontiers in Terahertz Technologies and Applications (FTTA-2021)" December 09-11, 2021, CSIR-National Physical Laboratory, New-Delhi; Dec 10, 2021; Online
2. "THz spectroscopy: A potential window to explore solvation in biologically important molecules" Ultrafast Science (UFS) - 2021 Organized by: UM-DAE Centre for Excellence in Basic Sciences, Mumbai; Nov 13, 2021; Online

Administrative duties

1. Head, CBMS Department
2. Chairman, Covid Task Force, SNBNCBS
3. Faculty in-charge, students affairs
4. Chairman, SCOLP Committee
5. Chairman, Internal Standing Technical Committee; Convener, External Technical Committee
6. Member, Admission committee
7. Member, Students' Curriculum & Research Evaluation (SCREC) Committee

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Application of TeraHertz Spectroscopy to Membrane Hydration Dynamics, Complemented by Time Resolved Fluorescence Approaches; CSIR; 2019-2022; PI
2. Investigation on the Changes in Protein Hydration During Aggregation in Crowded Environment by THz Time Domain and Optical Time Resolved Spectroscopy; SERB-DST; 2020-2023; PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Collaboration with Prof. Dipal Palit, UM-DAE Centre for Excellence in Basic Sciences, Mumbai; Book chapter; National
2. Collaboration with Prof. Soumen Ghosh, Jadavpur University; Sl. No. 2; National

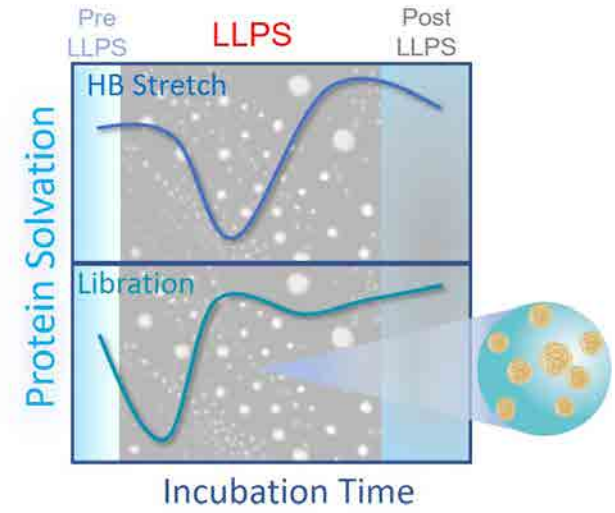
Outreach program organized / participated

1. Delivered a talk at Surendranath College, Kolkata (online) on 30.12.2021 at 3:00 PM, topic: "Spectroscopy: A tool to investigate molecules - recent advancements and challenges"

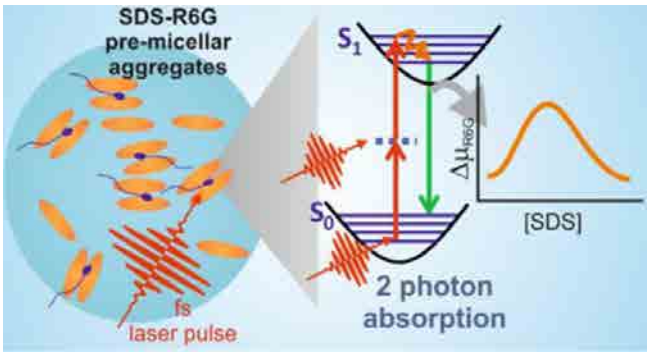
Areas of Research

Experimental biophysical chemistry, spectroscopy

We have prepared LLPS of a model protein, Lysozyme, Lys form chicken egg white and aimed to study the stability of LLPS in presence of different excipients (molecular crowders). We first characterise the LLPS by monitoring the turbidity of the solution as the turbid solution is the primary step towards formation of phase separation. Temperature induced phase plot of Lys (dissolved in 200 mM buffer (NaOH and KCl) of pH 12.6) with varying the temperature and the concentration suggests where the solution gets turbid. As solution turbidity is the preliminary measure of the phase separation, we employ differential interference contrast (DIC) microscope to observe the droplets (droplet formation is the crucial in LLPS process). Here we observe droplets of different size (sub-μm to μm) appeared (Lysozyme concentration: 600 μM, incubation temperature 50 C) . Finally we measured thioflavin-T (ThT) induced fluorescence upon different time of incubation to verify whether any aggregated species appears. Small change of relative intensity (compared to the native protein) ensures that within our experimental time range no aggregated species do produce. We measure the explicit change in hydration using ATR-FTIR measurements in the THz region and we found that hydration gets modulated as the LLPS are formed.



We study the interactionbetween the cationic dye rhodamine 6G (R6G) with surfactants of different charge types: anionic SDS, cationic CTAB, and nonionic Tx 100 using absorption and emission spectroscopy. We identify that R6G forms dimeric aggregates at a premicellar concentration of SDS. Formation of aggregates is also confirmed from classical simulation measurements. CTAB and Tx 100 do not form any such aggregate, presumably owing to unfavorable electrostatic interactions. For a molecular-level understanding, we perform two-photon absorption (TPA) spectroscopy for the same systems. TPA allows us to calculate the two-photon absorption cross section and subsequently the change in the dipole moment (Δμ) between ground and excited states of the dye. We calculate the Δμ and observe that it passes through a maximum at a surfactant concentration half of the critical micelle concentration of SDS. This observation imparts support to earlier quantum mechanical calculation, which infers deviation from the parallel orientation of the dye during surfactant-induced aggregation. We extended our measurements and varied the carbon chain length of the anionic surfactant, and we found that all of them exhibit a maximum in Δμ, while their relative magnitude is dependent on the surfactant carbon chain length.



Multivalent (specifically trivalent) metal ions are known to induce microscopic phase separation (commonly termed as ***liquid-liquid phase separation*** (LLPS)) in negatively charged globular proteins even at ambient temperatures, the process being mostly driven by protein charge neutralization followed by aggregation. Recent simulation studies have revealed that such self-aggregation of protein is entropy driven, however, associated with a solvation effect which could as well be different from the usual notion of ***hydrophobic hydration***. In this contribution we have experimentally probed the explicit change in the hydration associated with ion-induced LLPS formation of a globular protein bovine serum albumin (BSA) at ambient temperature using FIR-THz FTIR spectroscopy (50-750 cm^{-1}; 1.5-22.5 THz). We have used ions of different charges: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, La^{3+}, Y^{3+}, Ho^{3+} and Al^{3+}. We found that all the trivalent ions induce LLPS; formation of large aggregates has been evidenced from dynamic light scattering (DLS) measurements, however, without perturbing the protein structure as confirmed from circular dichroism (CD) measurements. From the frequency dependent absorption coefficient measurements in the

THz frequency domain we estimate the various stretching/ vibrational modes of water and we found that ions, forming LLPS, produce definite perturbation in the overall hydration, the extent of which is ion specific, invoking the definite role of hydrophilic (electrostatic) hydration of ions in the observed LLPS process.

Plan of Future Work Including Project

1. We would continue our study to understanding how molecular crowders (salts, amino acids, solvents etc.) 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 spectroscopic as well as thermodynamic analysis of the processes involved using differential scanning calorimetry measurements. This study will include both experimental as well as simulation measurements
2. 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. Among the self-aggregated systems we would study protein aggregation (with a special reference to liquid-liquid phase separation in proteins), fibril formation and on amphiphilic self-aggregates like micelles, vesicles, liposomes etc. We also plan to extend this idea towards intrinsically disordered protein (IDP) also.
3. We plan to explore the effect of cholesterol and its biosynthetic precursors on hydration dynamics in membranes and vesicles of different phases and its implications in the complex, evolutionarily fine-tuned biology of cholesterol in membranes and vesicles 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. We also plan to carry out atomic force microscopy measurements on vesicles (made by lipids and surfactants) in absence and in presence of cholesterol to underline the elastic properties of the interface.

Ranjit Biswas
Senior Professor
CBMS
ranjit@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Narayan Maity; Experimental Studies of Metastable and Self-Organised Systems; Under progress
2. Jayanta Mondal; Experimental Studies of Ionic and Neutral Deep Eutectics; Under progress
3. Dhrubajyoti Maji; Computer Simulations of Deep Eutectics; Under progress
4. Amrita Mondal; Experimental Studies of Complex Chemical Systems; Under progress
5. Sudipta Mitra; Computer Simulations of Relaxation Dynamics in Condensed Phases; Under progress
6. Rik N Mukherjee; Computer Simulations of Ionic Deep Eutectic and Other Systems; Under progress

Teaching

1. Autumn semester; Physical Chemistry: Experiments & Theory (CB524); Ph.D.; 5 students

Publications

a) In journals

1. Atanu Baksi and **Ranjit Biswas**, *Dynamical Anomaly of Aqueous Amphiphilic Solutions: Connection to Solution H-Bond Fluctuation Dynamics?*, ACS Omega, 7, 10970-10984, 2022
2. Sirshendu Dinda, Arnab Sil, Anuradha Das, Ejaj Tarif, **Ranjit Biswas**, *Does urea modify microheterogeneous nature of ionic amide deep eutectics? Clues from non-reactive and reactive solute-centered dynamics*, Journal of Molecular Liquids, 349, 118126, 2022
3. Kallol Mukherjee, Suman Das, Juriti Rajbangshi, Ejaj Tarif, Anjan Barman, and **Ranjit Biswas**, *Temperature-Dependent Dielectric Relaxation in Ionic Acetamide Deep Eutectics: Partial Viscosity Decoupling and Explanations from the Simulated Single-Particle Reorientation Dynamics and Hydrogen-Bond Fluctuations*, The Journal of Physical Chemistry B, 125, 12552-12567, 2021
4. Juriti Rajbangshi, **Ranjit Biswas**, *Heterogeneous dynamics in [BMIM][PF_6] + Cosolvent binary Mixtures: Does It depend upon cosolvent Polarity?*, Journal of Molecular Liquids, 341, 117342, 2021

5. Dhrubajyoti Maji, Sandipa Indra & **Ranjit Biswas**, *Dielectric relaxations of molten acetamide: dependence on the model interaction potentials and the effects of system size*, Journal of Chemical Sciences, 133, 104, 2021
6. Juriti Rajbangshi, Kallol Mukherjee, and **Ranjit Biswas**, *Heterogeneous Orientational Relaxations and Translation–Rotation Decoupling in (Choline Chloride + Urea) Deep Eutectic Solvents: Investigation through Molecular Dynamics Simulations and Dielectric Relaxation Measurements*, The Journal of Physical Chemistry B, 125, 5920-5936, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Deep Eutectic Solvents: New Excitements in Old Applications; Jul 3, 2021; Online, hosted jointly by IIT, Tirupati & SNBNCBS; 60 minutes

Membership of Learned Societies

1. Chemical Research Society of India
2. Indian Society for Radiation and Photochemical Sciences

Scientific collaborations with other national / international institutions (based on joint publications)

1. Journal of Physical Chemistry B, 2021, 125, 12552–12567, Sl. No. 3; National

Areas of Research

Physical Chemistry: Theory, Experiments and Simulations

Molecular dynamics simulations and dielectric relaxation (DR) measurements in the frequency window, 0.2 ≤ν/GHz≤50, have been performed to explore the heterogeneous reorientation dynamics in [f choline chloride + (1-f) urea] deep eutectic solvents (DESs) at f = 0.33 and 0.40 in the temperature range 293≤T/K≤333. The solution viscosity varies by more than an order of magnitude. DR measurements in these DESs reveal multiple relaxation timescales - τ_1~ 500 ps, τ_2~ 100 ps, τ_3~ 30 ps and τ_4~ 5 ps. Simulated rank-dependent collective single particle reorientational (C_l (t),l being the rank) and structural H-bond (C_HB (t)) relaxations can explain the microscopic origin of all these DR timescales. The average DR times, ⟨τ_DR ⟩, exhibit a pronounced fractional viscosity dependence, ⟨τ_DR ⟩∝(ηⲩT)^p, with p = 0.1. This experimental evidence of pronounced heterogeneous reorientation dynamics in these DESs is supported by a strong translation-rotation decoupling and a significant deviation of the average reorientational correlation times (⟨τ_l ⟩) from the Debye's l(l+1) law. The simulated ratios between the average rotation and translation timescales for both urea and choline correctly reduce to the appropriate hydrodynamic limit at high temperature. The stretched exponential relaxations of the simulated self-dynamic structure factors and the non-Gaussian single particle displacement distributions further support strong temporal heterogeneity in these DESs. Dynamic susceptibilities from the simulated four-point correlations exhibit long correlated timescales. The results are summarized in the following publication: Journal of Physical Chemistry B, 2021, 125, 5920–5936.

We have recently reported temperature dependent (293≤T(K)≤336) dielectric relaxation (DR) measurements of (acetamide + LiBr/NO_3^-/ClO_4^-) deep eutectic solvents (DESs) in a frequency window, 0.2≤ν(GHz)≤50, and explore, via molecular dynamics simulations, the relative roles for the collective single particle reorientational relaxations, and the H-bond dynamics of acetamide in the measured DR response. In addition, DR measurements of neat molten acetamide have been performed. Recorded DR spectra of these DESs require multi-Debye fits and produce well-separated DR timescales spreading over several picoseconds to about a nanosecond. Simulations suggest DR timescales derive contributions from both the collective reorientational (C_l (t)) relaxation and structural H-bond (C_HB (t)) dynamics of acetamide. A good correlation between the measured and simulated activation energies further reveals a strong connection between the measured DR, and the simulated C_l (t) and C_HB (t). Average DR times exhibit a strong fractional viscosity dependence, suggesting substantial microheterogeneity in these media. Simulations of C_l (t) and C_HB (t) reveal strong stretched exponential relaxations with stretching exponent, 0.4≤β≤0.7. Importantly, a pronounced translation-rotation decoupling between the simulated reorientation and centre-of-mass diffusion times has been observed. These results are described in the following publication: Journal of Physical Chemistry B, 2021, 125, 12552–12567.

Plan of Future Work Including Project

1. Ionic amide deep eutectic solvents are known to exhibit deep depression of freezing points in presence of ions and a dependence of the extent of depression ('supercooling') on the identity of ions present in those systems. In addition, experiments have recvealed signatures of ion dependent spatio-temoporal heterogeneity features. We would like to focus next on to investigate and provide microscopic explanations

of these experimentally observed macroscopic system properties. In order to gain microscopic insight of this differing 'supercooling' phenomenon, extensive molecular dynamics simulations would be carried out at different temperatures employing (acetamide + Na/KSCN) deep eutectics as representative ionic systems. The individual translational motions of acetamide and the ions would be followed and their connections to solution heterogeneity explored. This would then be generalized for other systems as well.

2. Heterogeneity aspects in cryoprotectant mixtures and their relations to presentation is an interesting area of research that demands a serious attention of experimentalists and theoreticians alike. We would like to investigate these systems by considering a model system, such as , glucose/glycerol system. This system would be investigated through temperature (T= 300-333 K) and glucose concentration (0, 5, 15 and 25 wt% glucose) dependent dielectric relaxation spectroscopy (DRS) measurements in the frequency window 20 Hz to 10 MHz and 200 MHz to 50 GHz. These studies would be supplemented by steady state and time-resolved fluorescence measurements. The heterogeneity aspects would be established first experimentally, and then would be followed up by suitable computer simulations for interpreting the experimental data in terms of microscopic picture.

Samir Kumar Pal
Senior Professor
CBMS
skpal@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Tuhin K. Maji; Combined experimental and computational investigation on optical and catalytic properties of functionalized metal oxides; Awarded
2. Aniruddha Adhikari; Studies on Therapeutic Potential of Various Nanomaterials and Ethnobotanical Ingredients in Preclinical Disease Model; Awarded
3. Soumendra Singh; Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications; Awarded
4. Animesh Halder; Development and Validation of Optical Methodologies for Potential Biomedical and Environmental Applications; Awarded; Dr. Rajib Chakraborty
5. Arka Chatterjee; Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis; Awarded
6. Dipanjan Mukherjee; Microfluidic-Assisted Optical Spectroscopic Studies on Biomolecular Recognition in Physiologically Relevant Engineered Environments; Thesis submitted; Prof. Ranjan Das (Co-supervisor)
7. Arpan Bera; Spectroscopic Studies on Functional Nanohybrids and their Potential Biological Application; Under progress
8. Md Nur Hasan; Optical spectroscopy and Ab-initio study on biocompatible nanohybrids for their potential biomedical and environmental applications; Under progress
9. Susmita Mondal; Studies on Biochemical and Molecular aspects of Redox Modulatory Theranostic Nanomaterials in Preclinical Disease Model; Under progress
10. Arnab Samanta; Synthesis and Characterization of Nanoscale Alloys and Metal Oxides for Potential Application in Catalysis; Thesis submitted; Dr. Subhra Jana
11. Amrita Banerjee; Multi-parameter detection using optical spectroscopy for monitoring and control of bio medical anomalies, food adulteration and environmental; Under progress; Dr. Subhadipta Mukhopadhyay

12. Loapamudra Roy; Exploration of Optical Methodologies for the Development of Prototypes in the Real-world Application; Under progress; Professor Kallol Bhattacharya
13. Nivedita Pan; Photophysical Studies on Hybrid Nanomaterials for manifold application; Under progress

b) External Project Students / Summer Training

1. Neha Bhattacharya; Development of an industrial process for the large-scale production of retro reflective material for potential applications in display labels; Holoflex Limited
2. Ria Ghosh; Development of Nano Sensor and its Application through Cloud Based Network for Real Time Irrigation to Soil and Plant; Indian Council of Agricultural Science Fund (ICAR)

Teaching

1. Spring semester; PHY191; Integrated Ph.D.; 10 students; with 1 (Prof. Soumen Mondal) co-teacher

Publications

a) In journals

1. Nivedita Pan, Neha Bhattacharyya, Amrita Banerjee, Pritam Biswas, Lopamudra Roy, Arka Chatterjee, Rama Bhattacharjee, Soumendra Singh, Saleh A. Ahmed, Arpita Chattopadhyay, Mala Mitra and **Samir Kumar Pal**, *Paper-based plasmonic nanosensor monitors environmental lead pollution in real field*, New Journal of Chemistry, 46, 8177-8184, 2022
2. Ria Ghosh, Soumendra Singh, Dipanjan Mukherjee, Susmita Mondal, Monojit Das, Uttam Pal, Aniruddha Adhikari, Aman Bhushan, Surajit Bose, Siddharth Sankar Bhattacharyya, Debasish Pal, Tanusri Saha-Dasgupta, Maitree Bhattacharyya, Debasis Bhattacharyya, Asim Kumar Mallick, Ranjan Das, **Samir Kumar Pal**, *Host-Assisted Delivery of a Model Drug to Genomic DNA: Key Information from Ultrafast Spectroscopy and in silico Study*, ChemBioChem, e202200109, 2022
3. Saleh A. Ahmed, Md. Nur Hasan, Hatem M. Altass, Arpan Bera, Reem I. Alsantali, Nivedita Pan, Abdullah Y. A. Alzahrani, Damayanti Bagchi, Jabir H. Al-Fahemi, Abdelrahman S. Khder, and **Samir Kumar Pal**, *Tetracycline Encapsulated in Au Nanoparticle-Decorated ZnO Nanohybrids for Enhanced Antibacterial Activity*, ACS Applied Nano Materials, 5, 4484-4492, 2022
4. Neha Bhattacharyya, Soumendra Singh, Dipanjan Mukherjee, Nairit Das, Arka Chatterjee, Aniruddha Adhikari, Susmita Mondal, Pulak Mondal, Asim Kumar Mallicke and **Samir Kumar Pal**, *Picosecond-resolved fluorescence resonance energy transfer (FRET) in diffuse reflectance spectroscopy explores biologically relevant hidden molecular contacts in a non-invasive way*, Physical Chemistry Chemical Physics, 24, 6176-6184, 2022
5. Dipanjan Mukherjee, Md. Nur Hasan, Ria Ghosh, Gourab Ghosh, Arpan Bera, Sujanthi Easwara Prasad, Ankita Hiwale, Praveen K. Vemula, Ranjan Das, and **Samir Kumar Pal**, *Decoding the Kinetic Pathways toward a Lipid/DNA Complex of Alkyl Alcohol Cationic Lipids Formed in a Microfluidic Channel*, The Journal of Physical Chemistry B, 126, 588-600, 2022
6. Md. Nur Hasan, Arpan Bera, Tuhin Kumar Maji, Dipanjan Mukherjee, Nivedita Pan, Debjani Karmakar, **Samir Kumar Pal**, *Functionalized nano-MOF for NIR induced bacterial remediation: A combined spectroscopic and computational study*, Inorganica Chimica Acta, 532, 120733, 2022
7. Dipanjan Mukherjee, Debashish Paul, Sushmita Sarker, Md. Nur Hasan, Ria Ghosh, Sujanthi Easwara Prasad, Praveen K. Vemula, Ranjan Das, Arghya Adhikary, **Samir Kumar Pal** and Tatini Rakshit, *Polyethylene Glycol-Mediated Fusion of Extracellular Vesicles with Cationic Liposomes for the Design of Hybrid Delivery Systems*, ACS Applied Bio Materials, 4, 8259-8266, 2021
8. Arpan Bera, Md. Nur Hasan, Uttam Pal, Damayanti Bagchi, Tuhin Kumar Maji, Tanusri Saha-Dasgupta, Ranjan Das, **Samir Kumar Pal**, *Fabrication of nanohybrids toward improving therapeutic potential of a NIR photo-sensitizer: An optical spectroscopic and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 424, 113610, 2022
9. Arnab Samanta, **Samir Kumar Pal**, and Subhra Jana, *Synthesis of Template-Free Iron Oxyhydroxide Nanorods for Sunlight-Driven Photo-Fenton Catalysis*, ACS Omega, 6, 27905-27912, 2021

10. Susmita Mondal, Ria Ghosh, Aniruddha Adhikari, Uttam Pal, Dipanjan Mukherjee, Pritam Biswas, Soumendra Darbar, Soumendra Singh, Surajit Bose, Tanusri Saha-Dasgupta, **Samir Kumar Pal**, *In vitro and Microbiological Assay of Functionalized Hybrid Nanomaterials To Validate Their Efficacy in Nanotheranostics: A Combined Spectroscopic and Computational Study*, ChemMedChem, 16, 3739-3749, 2021

11. Neha Bhattacharyya, Soumendra Singh, Animesh Halder, Aniruddha Adhikari, Ria Ghosh, Deep Shikha, Santanu Kumar Tripathi, Asim Kumar Mallick, Pulak Mondal, **Samir Kumar Pal**, *An Energy-Resolved Optical Non-invasive Device Detects Essential Electrolyte Balance in Humans at Point-of-Care*, Transactions of the Indian National Academy of Engineering, 6, 355-364, 2021

12. Susmita Mondal, Aniruddha Adhikari, Ria Ghosh, Manali Singh, Monojit Das, Soumendra Darbar, Siddhartha Sankar Bhattacharya, Debasish Pal & **Samir Kumar Pal**, *Synthesis and spectroscopic characterization of a target-specific nanohybrid for redox buffering in cellular milieu*, MRS Advances, 6, 427-433, 2021

13. Aniruddha Adhikari, Susmita Mondal, Tanima Chatterjee, Monojit Das, Pritam Biswas, Ria Ghosh, Soumendra Darbar, Hussain Alessa, Jalal T. Althakafy, Ali Sayqal, Saleh A. Ahmed, Anjan Kumar Das, Maitree Bhattacharyya & **Samir Kumar Pal**, *Redox nanomedicine ameliorates chronic kidney disease (CKD) by mitochondrial reconditioning in mice*, Communications Biology, 4, 1013, 2021

14. Aniruddha Adhikari, Susmita Mondal, Monojit Das, Ria Ghosh, Pritam Biswas, Soumendra Darbar, Soumendra Singh, Anjan Kumar Das, Siddhartha Sankar Bhattacharya, Debasish Pal, Asim Kumar Mallick, and **Samir Kumar Pal**, *Redox Buffering Capacity of Nanomaterials as an Index of ROS-Based Therapeutics and Toxicity: A Preclinical Animal Study*, ACS Biomaterials Science & Engineering, 7, 2475-2484, 2021

15. Sayan Bayan, Aniruddha Adhikari, Uttam Pal, Ria Ghosh, Susmita Mondal, Soumendra Darbar, Tanusri Saha-Dasgupta, Samit Kumar Ray, and **Samir Kumar Pal**, *Development of Triboelectroceutical Fabrics for Potential Applications in Self-Sanitizing Personal Protective Equipment*, ACS Applied Bio Materials, 4, 5485-5493, 2021

16. Aniruddha Adhikari, Uttam Pal, Sayan Bayan, Susmita Mondal, Ria Ghosh, Soumendra Darbar, Tanusri Saha-Dasgupta, Samit Kumar Ray, and **Samir Kumar Pal**, *Nanoceutical Fabric Prevents COVID-19 Spread through Expelled Respiratory Droplets: A Combined Computational, Spectroscopic, and Antimicrobial Study*, ACS Applied Bio Materials, 4, 5471-5484, 2021

17. Mamta Kumari, Manisha Sharma, Swati Rani, Damayanti Bagchi, Arpan Bera, Dipanjan Mukherjee, **Samir Kumar Pal**, Subho Mozumdar, *Solvent dependent photophysical study of stable and medicinally active diketone modified pyrazole derivatives of curcumin: A spectroscopic study*, Journal of Photochemistry and Photobiology A: Chemistry, 416, 113337, 2021

18. Arka Chatterjee, Nivedita Pan, Tuhin Kumar Maji, Sheik Saleem Pasha, Soumendra Singh, Saleh A. Ahmed, Jalal T. Al-Thakafy, and **Samir Kumar Pal**, *Highly Sensitive Optical Sensor for Selective Detection of Fluoride Level in Drinking Water: Methodology to Fabrication of Prototype Device*, ACS Sustainable Chemistry & Engineering, 9, 7160-7170, 2021

19. Md. Nur Hasan, Arpan Bera, Tuhin Kumar Maji, **Samir Kumar Pal**, *Sensitization of nontoxic MOF for their potential drug delivery application against microbial infection*, Inorganica Chimica Acta, 523, 120381, 2021

20. Saleh A. Ahmed, Nivedita Pan, Hatem M. Altass, Jayita Patwari, Rami J.Obaid, Hussain Alessa, Rabab S. Jassas, **Samir Kumar Pal**, *Broad light harvesting under restricted environment: Photophysical understanding leading to enhanced reactive oxygen species generation*, Journal of Photochemistry and Photobiology A: Chemistry, 418, 113422, 2021

21. Essam M.Hussein, Nizar ElGuesmi, Tuhin K. Maji, Rabab S. Jassas, Abdulrahman A. Alsimaree, Hatem M. Altass, Ziad Moussa, **Samir Kumar Pal**, Saleh A. Ahmed, *Synthesis and photophysical properties of benzimidazoles grafted pyrazole-containing pyrene or fluorene moiety: A combined spectroscopic and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 419, 113465, 2021

22. Manisha Sharma, Uttam Pal, Mamta Kumari, Damayanti Bagchi, Swati Rani, Dipanjan Mukherjee, Arpan Bera, **Samir Kumar Pal**, Tanusree Saha Dasgupta and Subho Mozumdar, *Effect of solvent on the photophysical properties of isoxazole derivative of curcumin: A combined spectroscopic and theoretical study*, Journal of Photochemistry and Photobiology A: Chemistry, 410, 113164, 2021

23. Dipanjan Mukherjee, Priya Singh, Soumendra Singh, Debanjona Singh Roy, Subhankar Singha, Uttam Pal, Jhimli Sengupta, Rami J. Obaid, Saleh A. Ahmed, Tanusri Saha Dasgupta, Ranjan Das, **Samir Kumar Pal**, *Host assisted molecular recognition by human serum albumin: Study of molecular recognition controlled protein/drug mimic binding in a microfluidic channel*, International Journal of Biological Macromolecules, 176, 137-144, 2021

b) Conference proceedings / Reports / Monographs / Books

1. N. Bhattacharyya, A. Halder, S. Singh, A. Adhikari, R. Ghosh, P. Mondal and S. K.Pal "Detection of Lithium in Real World using Optical Emission Spectroscopy: Caution to E-Waste Management", 6th International Conference for Convergence in Technology (I2CT) 2021 pp. 1-5

Talks / Seminars Delivered in reputed conference / institutions

1. "Application-driven Basic Research: The Need of the Hour " Invited Talk, The Department of Physics, Pabna University of Science and Technology, Pabna Bangladesh; May 19, 2021; online; 2 hours
2. "Application-driven Biophotonics for the Development of Indigenous Scientific Devices and Nanomedicines: The need of the hour" IProgram of BRICS Workshop on Biophotonics -2021 SEPTEMBER 27 –29, 2021, SARATOV, RUSSIA; Sep 24, 2021; online; 1 hour

Administrative duties

1. Chairman of Technical cell
2. Chaiman of Pest control committee
3. Chairman of Security monitoring committee
4. Member of internal technical committee

Awards, Recognitions

1. Abdul Kalam Technology Innovation National Fellowship 2018 (Indian National Academy of Engineering: INAE) Extension for another two years
2. Core Committee Member of Electrical, Electronics & Computer Engineering 2021 (SERB) onwards
3. Chairman of Expert Committee of Global Innovation & Technology Alliance (GITA)
4. Member of Governing Council Indian National Academy of Engineering: INAE

Membership of Learned Societies

1. American Chemical Society
2. Indian Association for the Cultivation of Science, Life Member
3. Indian Physical Society
4. Member of Governing Council Indian National Academy of Engineering: INAE

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Development of Nano Sensor and its Application through Cloud Based Network for Real Time Irrigation to Soil and Plant; Indian Council of Agricultural Science Fund (ICAR); 3 years; Co-PI
2. Development of an industrial process for the large-scale production of retro reflected material for potential application in display labels; Holoflex Limited; 1 year; PI
3. Emergent Phenomena in 2D Heterostructures; DST India; 5 years; Co-PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Professor Tanusri Saha-Dasgupta, Director and Senior Professor at SNBose National Centre for Basic Sciences; Sl. No. 2,8,10,15,16 and 22; National
2. Professor Samit Kumar Ray, Department of Physics, Indian Institute of Technology, Kharagpur; Sl. No. 15 and 16; National

3. Professor Ranjan Das, Department of Chemistry, West Bengal State University; Sl. No. 2, 5, 7, 8 and 23; National
4. Professor Asim Kumar Mallick, NRS Medical College; Sl. No. 2,4,11 and 14; National
5. Dr. Debjani Karmakar, Bhabha Atomic Research Centre, Trombay, Mumbai, India; Sl. No. 6; National
6. Professor Saleh Ahmed, Umm Al-Qura University · Department of Chemistry, Saudi Arabia; Sl. No. 1, 3, 13, 18, 20, 21 and 23; International

Outreach program organized / participated

1. Scientific Creativity, inspirational talk at J.B Centre of Excellence (JBNSTS), 1300, Rajdanga Main Road, Kolkata-700107

Areas of Research

Femtosecond and Picosecond time resolved Laser spectroscopy, Biomolecules, Bio-Nano Interface and Self-organized molecular assembly, Light Harvesting, Dye Sensitized solar cells, Instrumentation

One of our researches is focused on Ultrafast Spectroscopy of Molecules and Materials for the potential applications in Environments, Energy and Health.

Plan of Future Work Including Project

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

Suman Chakrabarty
Associate Professor
CBMS
sumanc@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Abhinandan Das; Rational design and mechanism of action of inhibitors for Acetylcholinesterase; Under progress
2. Krishnendu Sinha; Phosphorylation code in RhoGDI regulation; Under progress
3. Dibyendu Maity; Molecular mechanism of nucleation and growth during crystallization; Under progress

b) Post-Docs

1. Ipsita Basu; Rational design of allosteric inhibitors for PCSK9-LDLR interaction

c) External Project Students / Summer Training

1. Vikram S. Gaikwad; Quantitative Calculation of Solvation Free Energy of Small Organic Molecules From Atomistic Simulations; Savitribai Phule Pune University
2. Diptatanu Das; Protein-ligand interaction: Conformational selection or induced fit?; IISER Kolkata
3. Sutanu Mukhopadhyay; Rigid Docking and Molecular Dynamics Simulation Studies of Natural Products as Potent Inhibitors again SARS-COV-2 Main Protease (Mpro); Ramakrishna Mission Vivekananda Centenary College
4. Sudipta Chakraborty; Solvation Free Energy of Lennard-Jones Sphere and Cavity Thermodynamics Using Scaled Particle Theory; University of Calcutta

Teaching

1. Autumn semester; Computational Methods in Physics I; Integrated Ph.D.; 9 students

Publications

a) In journals

1. Mantu Santra, Aniruddha Seal, Kankana Bhattacharjee, and **Suman Chakrabarty**, *Structural and dynamical heterogeneity of water trapped inside Na^+-pumping KR2 rhodopsin in the dark state*, The Journal of Chemical Physics, 154, 215101, 2021

2. J. B. Deshpande, **S. Chakrabarty**, A. A. Kulkarni, *Heterogeneous nucleation in citrate synthesis of AgNPs: Effect of mixing and solvation dynamics*, Chemical Engineering Journal, 421, 127753, 2021
3. Vrushali Hande and **Suman Chakrabarty**, *Size-Dependent Order–Disorder Crossover in Hydrophobic Hydration: Comparison between Spherical Solutes and Linear Alcohols*, ACS Omega, 7, 2671-2678, 2022
4. Vrushali R. Hande and **Suman Chakrabarty**, *How Far Is "Bulk Water" from Interfaces? Depends on the Nature of the Surface and What We Measure*, The Journal of Physical Chemistry B, 126, 1125-1135, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. Workshop on Advanced Molecular Dynamics Simulations; Jul 5, 2021; Online; 1 day
2. Statistical Mechanics in Chemistry and Biology (SMCB) Seminar Series; Aug 7, 2021; Online 1 day
3. Physical Chemistry Physical Biology (PCPB – 2021); Sep 24, 2021; Online; 5 days
4. Current Trends in Theoretical Chemistry (CTTC-2020); Sep 23, 2021; Online; 3 days
5. 17th Theoretical Chemistry Symposium (TCS 2021); Dec 11, 2021; Online; 4 days
6. International conference on rare event simulation (RARE 2022); Dec 15, 2021; Online; 4 days
7. Lecture series in Amity Institute of Biotechnology, Amity University, Kolkata; Dec 23, 2021; Online; 1 day

Administrative duties

1. Chairman, Library Committee
2. Chairman, Media Cell
3. Member, Seminar & Colloquia Programme (SCOLP)
4. Member, Computer Services Cell Advisory Committee (CSC-AC)
5. Member, Website Design and Maintenance Committee
6. Member, Equity Committee
7. Member, Committee for implementation of Vigyan Jyoti Programme
8. Member of Internal Standing Technical Committee

Awards, Recognitions

1. Editorial Board member of DIALOGUE: Science, Scientists, and Society published by the Indian Academy of Sciences, Bengaluru
2. Review Editor on the Editorial Board of Biophysics (specialty section of Frontiers in Physics, Frontiers in Physiology and Frontiers in Molecular Biosciences)

Membership of Learned Societies

1. Biophysical Society, USA
2. American Chemical Society (ACS), USA
3. Chemical Research Society of India (CRSI), India

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Molecular mechanism of regulation of Rho GTPases through phosphorylation of RhoGDI: Towards unraveling the "phosphorylation code"; SERB, India; 3 years; PI
2. Development of Artificial Neural Network (ANN) based models for rapid prediction of physicochemical properties of drug-like molecules; SERB, India; 3 years; PI

Conference / Symposia / Schools organized

1. Physical Chemistry Physical Biology (PCPB – 2021); Sep 24, 2021; Online; 5 days
2. 17th Theoretical Chemistry Symposium (TCS 2021); Dec 11, 2021; Online; 4 days

Scientific collaborations with other national / international institutions (based on joint publications)

1. Collaboration with Dr. Amol Kulkarni from CSIR-National Chemical Laboratory (NCL), Pune on mechanism of heterogeneous nucleation in citrate synthesis of silver nanoparticles; Sl. No. 2; National

Outreach program organized / participated

1. Invited lecture in the Celebration of National Science Day: Pathways of Modern Research, Jagannath Kishore College, Purulia

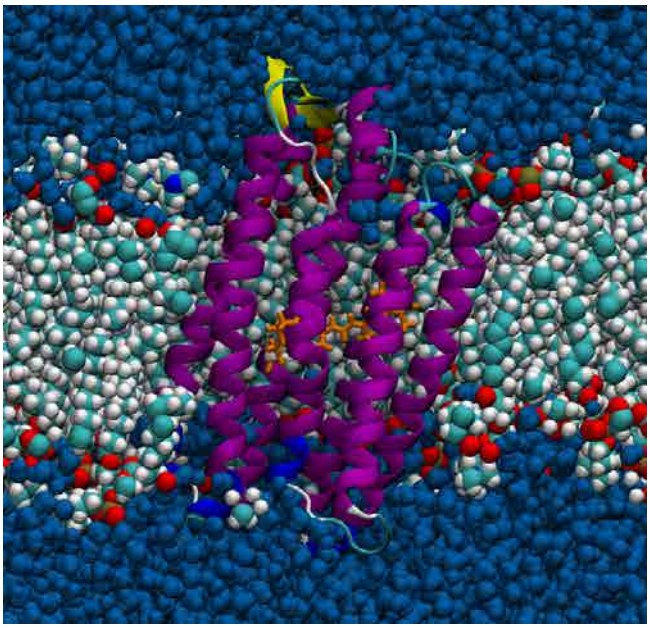
Areas of Research

Theoretical and computational physical chemistry, computational molecular biophysics

We use a combination of classical molecular dynamics simulation and enhanced sampling methods to understand the connection between structure, interaction, dynamics and function of complex (bio)molecular systems and phase transition related phenomena in soft condensed matter systems. A few representative examples where we have made significant progress recently are:

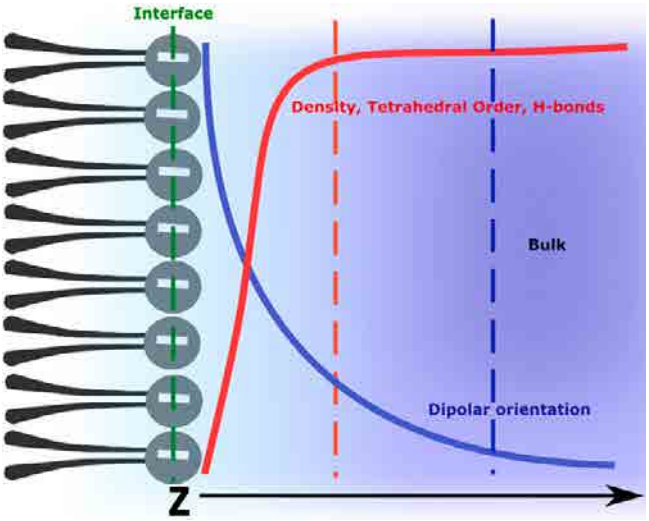
1. Structural and dynamical heterogeneity of water trapped inside Na+-pumping KR2 rhodopsin:

Photoisomerization in the retinal leads to a channel opening in rhodopsins that triggers translocation or pumping of ions/protons. Crystal structures of rhodopsins contain several structurally conserved water molecules. It has been suggested that water plays an active role in facilitating the ion pumping/translocation process by acting as a lubricant in these systems. By employing several microseconds long atomistic molecular dynamics simulation of this trans-membrane protein system, we demonstrate the presence of five distinct water containing pockets/cavities separated by gateways controlled by protein side-chains. There exists a strong hydrogen bonded network involving these buried water molecules and functionally important key residues. We present evidence of significant structural and dynamical heterogeneity in the water molecules present in these cavities, with very rare exchange between them. The exchange time scale of such buried water with the bulk has an extremely wide range, from tens of nanoseconds to >1.5 μs. The translational and rotational dynamics of buried water are found to be strongly dependent on the protein cavity size and local interactions with a classic signature of trapped diffusion and rotational anisotropy. (J. Chem. Phys., 154, 215101 (2021))



2. Water structure and dynamics near molecules and surfaces

We have demonstrated that although for spherical hydrophobic solutes water undergoes a nanometer scale order-disorder crossover (as predicted earlier by David Chandler), for linear and flexible hydrophobic polymers this crossover is either weak or does not exist due to presence of a sub-nanometer lengthscale along the cross-section of the polymer (ACS Omega, 7, 2671 (2022)).



In a different study (J. Phys. Chem. B, 126, 1125 (2022)), we have revisited an old question: At what distance

from an interface do the properties of "bulk water" get recovered? Our analysis highlights that not only the length-scale of perturbation depends on the nature of the interfaces and specific interactions but also the type of water property that we measure/calculate. Different water properties seem to have widely different length-scale of perturbation. Orientational order parameters seem to be perturbed to a much longer length-scale as compared to translational order parameters particularly for polar/charged interfaces due to long range electrostatic interactions. This observation has significant implication toward the interpretation of experimental measurements as well since different spectroscopic techniques would probe different parameters or water properties with possible mutual disagreement and inconsistency between different types of measurements.

3. Heterogeneous nucleation in citrate synthesis of AgNPs

In collaboration with the group of Dr. Amol Kulkarni from CSIR-NCL, Pune, we have investigated the molecular mechanism of heterogeneous nucleation and growth of silver nanoparticles in a citrate based synthesis route. The morphology and kinetics strongly depend on the conditions under which the precursors are formed.

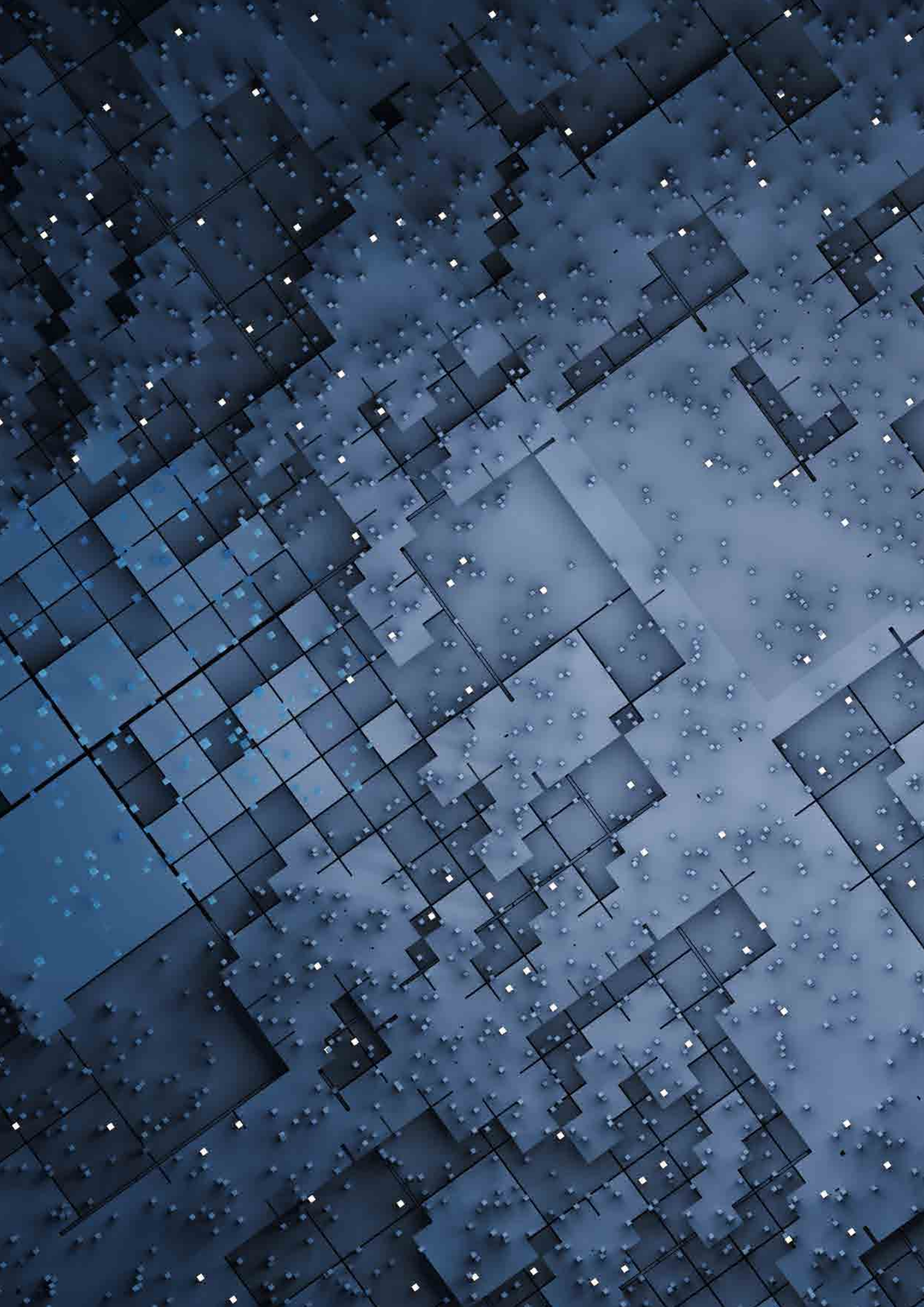
Plan of Future Work Including Project

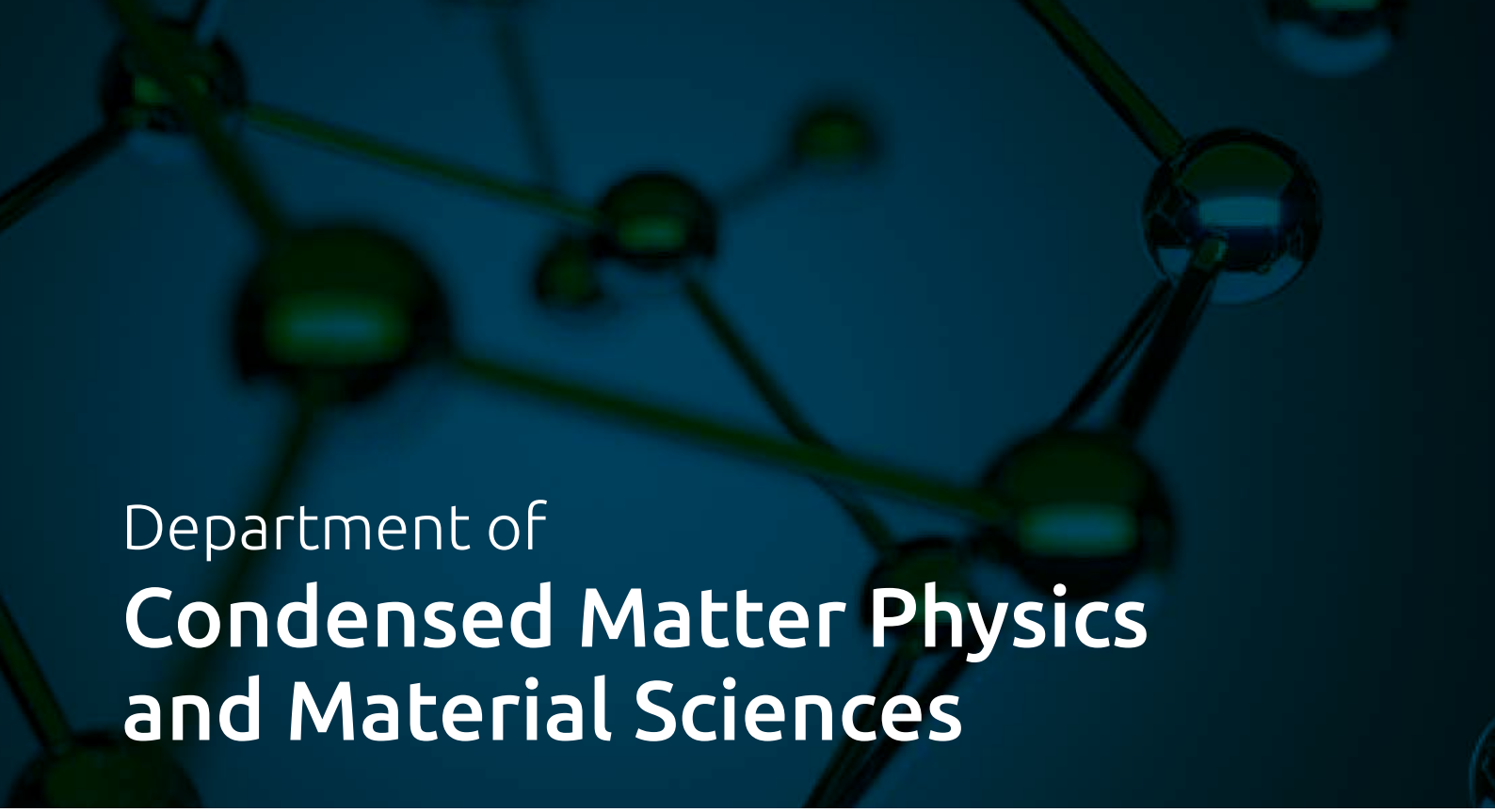
1. Energetics and dynamics of various steps in the photo-activation of Rhodopsin class of proteins. It would involve a combination of QM/MM multi-scale modelling approach as well as enhanced sampling methods like metadynamics and transition path sampling.
2. Development of Markov State Models (MSM) and machine learning (ML) based tools towards elucidating the thermodynamics and kinetics of biomolecular recognition and signalling processes, and prediction of physicochemical properties of molecules.

Any other Relevant Information including social impact of research

1. Collaboration with a pharmaceutical company (Sarfez Cure, India) is on-going. The know-how generated through our computational studies would potentially be translated towards development of novel allosteric inhibitors for hypercholesterolemia.

Condensed Matter Physics and Material Sciences





Department of
Condensed Matter Physics and Material Sciences

Priya Mahadevan

Department profile indicators

Table A: Manpower and resources

Number of faculty members	11
Number of Post –doctoral research associate (centre+project)	8
Number of Ph.D students	70
Number of other project staff	2
Number of summer students	3
Projects (ongoing)	14

Table B: Research Activities indicators

Number of research papers in Journals	104
Number of Book-chapters/books	3
Number of other publications	4
Number of Ph.D students graduated (submitted+degree awarded)	10+9
Number of M.Tech/M.Sc projects	1

Table C: Academic activities and linkage

Number of courses taught by faculty members	12
Number of Visitors (non –associates)	
Number of associates	
Number of Seminars organized	
Number of Conference/Symposia/Advanced Schools organized	1
Number of talks delivered by members of department in conferences/Symposia	National
	International

Most important research highlights

- Using an all-optical method, the group of Anjan Barman has observed a giant interfacial spin transparency in W/Co20Fe60B20/SiO2 heterostructures in beta-tungsten phase.
- The group of Anup Ghosh have studied DMSO in various solvation environments to decipher the environment-dependent dimerization and hydrogen bonding propensity.
- The group of Atindra Nath Pal have demonstrated a super large (~0.75 mm2), UV-Vis broadband (365-633 nm), phototransistor made of WS2 quantum dots decorated graphene as active channel in the 2D-0D configuration.
- The group of Avijit Chowdhury has shown that ternary nanocomposites surpass the individual merits of their building blocks by augmenting the catalytic performances many-fold through their synergistic interfacial effects.
- The group of Barnali Ghosh-Saha have developed a low cost, wearable, portable solid state gamma ray detectors using paper electronics based halide perovskites.
- The group of Kalyan Mandal have observed unusual dielectric behavior in hollow magnesium ferrite nanospheres, with negative refractive index like behavior near a meta-magnetic transition.
- The group of Manoranjan Kumar has proposed a hybrid Exact Diagonalization (ED) and Density Matrix Renormalization Group (DMRG) approach which is based on combining exact diagonalization to study the high temperature and DMRG method for low temperature.
- The group of Nitesh Kumar has found an extraordinary anomalous Hall effect in LaCrSb3
- The group of Priya Mahadevan have provided a route of improved optical absorption by examining how doping Mn on different facets of CsPbBr3 behaves.
- The group of Tanusri Saha-Dasgupta has found the ZT of monolayer Te to reach a value of 6.07 at 800 K under tensile strain, being larger than 2 for temperature greater than 400 K.
- The group of T. Setti has found that cubic PtBi2 hosts a sixfold band touching point – a triple Dirac point near the Femi level.

Summary of research activities

The group of Anjan Barman have measured coherent spin waves within a three-dimensional artifical spin ice structure for the first time, using Brillouin light scattering. Two spin-wave modes were observed whose frequencies showed nearly monotonic variation with the applied field strength. The simulated mode profiles revealed spatial quantization with varying mode quantization numbers.

The group of Atindra Nath Pal have studied the formation of a metal-molecule bond by studying charge transport through single molecular junctions at room temperature and provided a detail mechanism of metal/molecule bond formation.

The group of Avijit Chowdhury has been developing various layered 2D materials such as GOs, rGO, g-C3N4, TMDCs, etc., including their hybrid composites, mainly for solar photocatalysis and resistive memory applications. The aim is to exploit the interfacial features of the organic-inorganic layered heterostructures embedded with/ or without the polymer matrices to modulate the carrier transport.

The group of Barnali Ghosh-Saha has explored a paper-based photodetector made from mixed cation organic perovskite halide MA1−xFAxPbI3 (MA = methylammonium; FA = formamidium). The detector shows a substantial photogain and photoresponse at low illumination intensity and a broad band response that extends from 300 to 800 nm.

The group of Kalyan Mandal has shown that the construction of dual co-catalysts modified Fe2O3 nanorods photoanode by strategically incorporating CoPi and Co(OH)x for photoelectrochemical water oxidation, enhances the light-harvesting efficiency, surface photovoltage and hole transfer kinetics of the hybrid photoanode.

The group of Manoranjan Kumar has studied the quantum phases in spin-1 model of the 5/7 skewed ladder. This system shows a high spin magnetic state in large rung bond interaction limit. The system also shows the presence of spin current due to simultaneous breaking of both reflection and spin parity symmetries.

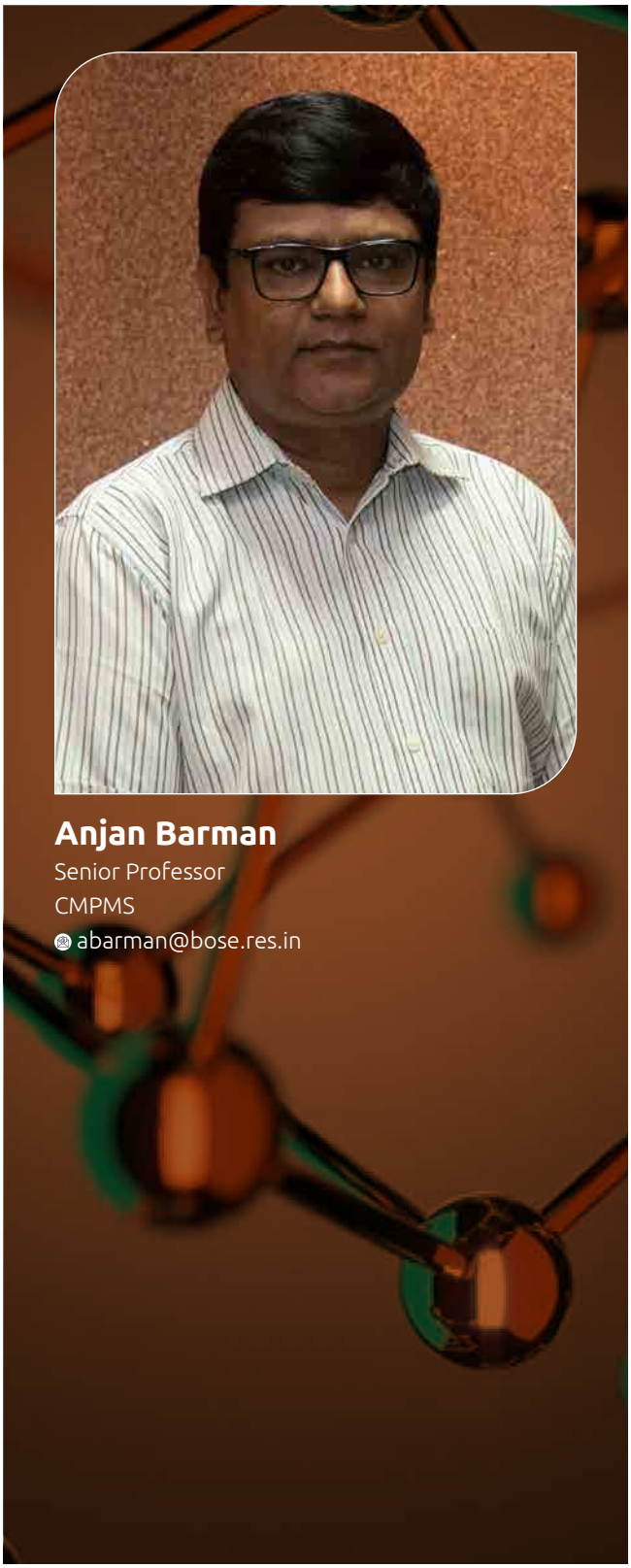
The group of Nitesh Kumar has examined MnAlGe, a layered ferromagnet in which the magnetic layers of Mn are separated by nonmagnetic AlGe spacers. They find that the nodal lines are quite close to the Fermi energy. Upon application of spin orbit coupling the nodal lines are gapped out and functions as a source of large Berry curvature. We observe a correspondingly large AHE of 700-800 S/cm at low temperature which is dominated by intrinsic mechanism.

The group of Priya Mahadevan has examined the unusual ferromagnetic insulating state in Cr doped VO2, in which experiments find a ferromagnetic insulating state which is also charge ordered. A ferromagnetic insulating state is found in the dopant range consistent with experiments. The doped Cr atoms are found to be in the +3 valence state instead of +4 which is expected for an isovalent substitution. This is achieved by the transfer of an electron from one of the neighboring V sites, rendering the latter with a valency of +5. The large Hund's intra-atomic exchange on Cr favoring a d3 configuration as well as the attractive Coulomb interactions between Cr+3-V+5 ions help in stabilizing this charge order.

The group of Tanusri Saha-Dasgupta has explored magnetism in a class of double perovskites with the organic group methylammonium (MA+) at the A site and polyatomic cyanide, (CN)−, as the molecular linker. Fixing Cu as the choice of cation at the B site, they have scanned the elemental space of the 3d, 4d, and 5d transition metal series. Their study reveals an interesting interplay of electronegativity, crystal field, and filling effect in structural, electronic, and magnetic properties of these yet-to-be synthesized compounds.

The group of T. Setti has examined the low-energy electronic structure of K0.65RhO2 .using the high-resolution angle-resolved photoemission spectroscopy (ARPES) technique and density functional theory (DFT) calculations. We observe a highly correlated hole pocket on the Fermi surface. Based on systematic analysis of their experimental data, they propose high frequency bosonic excitations as a plausible origin of the high energy anomaly, which plays a role in the colossal thermoelectric power.

Priya Mahadevan
Head, Department of Condensed Matter Physics and Material Sciences



Anjan Barman
Senior Professor
CMPMS
abarman@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Anulekha De; Ultrafast Spin Dynamics in Ferromagnetic Patterned Nanostructures and Multilayers; Thesis submitted; Prof. Rajib Kumar Mitra (Co-supervisor)
2. Sourav Kumar Sahoo; Spin Dynamics in 2D And 3D Confined Magnetic Structure and Thin Film Heterostructures; Thesis submitted
3. Kartik Sdhikari; Spin Dynamics in Ferromagnetic Nanostructures; Thesis submitted
4. Suryanarayan Panda; All-Optical Investigation of Spin- Orbit Effects in Ferromagnet/Nonma gnet Heterostructures; Under progress
5. Sudip Majumdar; Ferromagnetic Resonance of Magnetic Thin films and Nanostructures; Under progress; Prof. Rajib Kumar Mitra (Co-supervisor)
6. Koustuv Dutta; Femto and Picosecond Spin Dynamics of Low Dimensional Magnetic Structures; Under progress
7. Amrit Kumar Mondal; Spin Wave Propagation and Localization in Continuous and Confined Magnetic Thin Film; Under progress
8. Arundhati Adhikari; Quasistatic and Ultrafast Magnetization Dynamics in Ferromagnetic Nanostructures; Under progress
9. Pratap Kumar Pal; Spin Dynamics in Ferromagnetic Thin Film and Nanostructures; Under progress
10. Sreya Pal; Spin Dynamics in Quantum Materials; Under progress
11. Soma Dutta; Ultrafast Magnetization Dynamics in Thin Film Heterostructures; Under progress
12. Suchetana Mukhopadhyay; Ultrafast Spin Dynamics in Topological and Quantum Materials; Under progress; Prof. Chiranjib Mitra, IISER Kolkata (Co-supervisor)
13. Chandan Kumar; Magnetization Dynamics in Magnetic Thin Films, Nanostructures and Heterostructures; Under progress

b) Post-Docs

1. Arpan Bhattacharyya; Spin-Orbit Effects in Magnonics; Centre PDRA

c) External Project Students / Summer Training

1. Smridhi Chawla; Stabilization of skyrmions in patterned magnetic heterostructures and their dynamics; University of Delhi
2. Krishnanjana P. J.; Study of field controlled dynamics of nanodot arrays with varying areal densities; IIT Hyderabad
3. Rajdwip Bhar; Ultrafast Spin Dynamics of Ferromagnetic Thin Films; S. N. Bose National Centre for Basic Sciences

Teaching

1. Autumn semester; PHY301: Atomic and Molecular Physics; Integrated Ph.D.; 5 students; with 1 (Prof. Rajib Kumar Mitra,) co-teacher
2. Autumn semester; CB 527: Molecular Physics and Spectroscopy; Ph.D.; 1 student; with 1 (Prof. Rajib Kumar Mitra,) co-teacher
3. Autumn semester; PHY304: Project Course II; Integrated Ph.D.; 1 student

Publications

a) In journals

1. Raisa Fabiha, Jonathan Lundquist, Sudip Majumder, Erdem Topsakal, **Anjan Barman**, Supriyo Bandyopadhyay, *Spin Wave Electromagnetic Nano-Antenna Enabled by Tripartite Phonon-Magnon-Photon Coupling*, Advanced Science, 9, 2104644, 2022
2. Amrit Kumar Mondal, Sudip Majumder, Sourav Sahoo, Surya Narayan Panda, Sumona Sinha, and **Anjan Barman**, *Defect-Density- and Rashba-Shift-Induced Interfacial Dzyaloshinskii–Moriya Interaction and Spin Pumping in Single-Layer Graphene/$Co_{20}Fe_{60}B_{20}$ Heterostructures: Implications for New-Generation Spintronics*, ACS Applied Nano Materials, 5, 5056-5063, 2022
3. Anulekha De, Sri Sai Phani Kanth Arekapudi, Leopold Koch, Fabian Samad, Surya Narayan Panda, Benny Böhm, Olav Hellwig, and **Anjan Barman**, *Magnetic Configuration Driven Femtosecond Spin Dynamics in Synthetic Antiferromagnets*, ACS Applied Materials & Interfaces, 14, 13970-13979, 2022
4. Sajid Husain, Sreya Pal, Xin Chen, Prabhat Kumar, Ankit Kumar, Amrit Kumar Mondal, Nilamani Behera, Nanhe Kumar Gupta, Soumyarup Hait, Rahul Gupta, Rimantas Brucas, Biplab Sanyal, **Anjan Barman**, Sujeet Chaudhary, and Peter Svedlindh, *Large Dzyaloshinskii-Moriya interaction and atomic layer thickness dependence in a ferromagnet-WS_2 heterostructure*, Physical Review B, 105, 064422, 2022
5. Md Rejaul Karim, Surya Naryan Panda, **Anjan Barman** and Indranil Sarkar, *Strain and crystallite size controlled ordering of Heusler nanoparticles having high heating rate for magneto-thermal application*, Nanotechnology, 33, 235701, 2022
6. Santanu Pan, Fabian Ganss, Suryanarayan Panda, Gabriel Sellge, Chandrima Banerjee, Jaivardhan Sinha, Olav Hellwig & **Anjan Barman**, *Mechanism of femtosecond laser induced ultrafast demagnetization in ultrathin film magnetic multilayers*, Journal of Materials Science, 57, 6212-6222, 2022
7. Payal Bhattacharjee, **Anjan Barman**, Saswati Barman, *Operation of Magnetic Vortex Transistor by Spin-Polarized Current: A Micromagnetic Approach*, Physica Status Solidi (a): applications and materials science, 219, 2100564, 2022
8. Supriyo Bandyopadhyay, Jayasimha Atulasimha, and **Anjan Barman**, *Magnetic straintronics: Manipulating the magnetization of magnetostrictive nanomagnets with strain for energy-efficient applications*, Applied Physics Reviews, 8, 041323, 2021
9. Avinash Kumar Chaurasiya, Amrit Kumar Mondal, Jack C. Gartside, Kilian D. Stenning, Alex Vanstone, Saswati Barman, Will R. Branford, and **Anjan Barman**, *Comparison of Spin-Wave Modes in Connected and Disconnected Artificial Spin Ice Nanostructures Using Brillouin Light Scattering Spectroscopy*, ACS Nano, 15, 11734-11742, 2021
10. Sourav Sahoo, Andrew May, Arjen van Den Berg, Amrit Kumar Mondal, Sam Ladak, and **Anjan Barman**, *Observation of Coherent Spin Waves in a Three-Dimensional Artificial Spin Ice Structure*, Nano Letters, 21, 4629-4635, 2021
11. Kallol Mukherjee, Suman Das, Juriti Rajbangshi, Ejaj Tarif, **Anjan Barman**, and Ranjit Biswas, *Temperature-Dependent Dielectric Relaxation in Ionic Acetamide Deep Eutectics: Partial Viscosity Decoupling and Explanations from the Simulated Single-Particle Reorientation Dynamics and Hydrogen-Bond Fluctuations*, The Journal of Physical Chemistry B, 125, 12552-12567, 2021

12. Bivas Rana, Amrit Kumar Mondal, Supriyo Bandyopadhyay and **Anjan Barman**, *Applications of nanomagnets as dynamical systems: I*, Nanotechnology, 33, 062007, 2022
13. Bivas Rana, Amrit Kumar Mondal, Supriyo Bandyopadhyay and **Anjan Barman**, *Applications of nanomagnets as dynamical systems: II*, Nanotechnology, 33, 082002, 2022
14. Avinash Kumar Chaurasiya, Jaivardhan Sinha, Samiran Choudhury & **Anjan Barman**, *Influence of variation of tungsten layer thickness on interfacial Dzyaloshinskii–Moriya interaction in W/CoFeB/SiO_2 heterostructures*, Bulletin of Materials Science, 44, 277, 2021
15. Bipul Kumar Mahato and **Anjan Barman**, *Magnetization reversal mechanism of chemically synthesized linear chains of α-Fe nanospheres*, Journal of Materials Science, 56, 19476-19483, 2021
16. Arundhati Adhikari, Chandrima Banerjee, Amrit Kumar Mondal, Avinash Kumar Chaurasiya, Samiran Choudhury, Jaivardhan Sinha, Saswati Barman, **Anjan Barman**, *Anisotropic spin-wave propagation in asymmetric width modulated $Ni_{80}Fe_{20}$ nanostripes*, Materials Science and Engineering: B, 272, 115385, 2021
17. Surya Narayan Panda, Sudip Majumder, Samiran Choudhury, Arpan Bhattacharya, Sumona Sinha and **Anjan Barman**, *Femtosecond laser-induced spin dynamics in single-layer graphene/CoFeB thin films*, Nanoscale, 13, 13709-13718, 2021
18. Sudip Majumder, Samiran Choudhury, Saswati Barman, Yoshichika Otani, **Anjan Barman**, *Reconfigurable spin-wave dynamics in two-dimensional quasiperiodic magnonic crystals*, Physica E: Low-dimensional Systems and Nanostructures, 134, 114901, 2021
19. Koustuv Dutta, Anulekha De, Sucheta Mondal, Saswati Barman, Yoshichika Otani, **Anjan Barman**, *Dynamic configurational anisotropy in $Ni_{80}Fe_{20}$ antidot lattice with complex geometry*, Journal of Alloys and Compounds, 884, 161105, 2021
20. Kartik Adhikari, Samiran Choudhury, Saswati Barman, Yoshichika Otani and **Anjan Barman**, *Observation of magnon–magnon coupling with high cooperativity in $Ni_{80}Fe_{20}$ cross-shaped nanoring array*, Nanotechnology, 32, 395706, 2021
21. Anulekha De, Justine Lynn Drobitch, Sudip Majumder, Saswati Barman, Supriyo Bandyopadhyay and **Anjan Barman**, *Resonant amplification of intrinsic magnon modes and generation of new extrinsic modes in a two-dimensional array of interacting multiferroic nanomagnets by surface acoustic waves*, Nanoscale, 13, 10016-10023, 2021
22. Md Rejaul Karim, Arundhati Adhikari, Surya Narayan Panda, Purbasha Sharangi, Soubhik Kayal, Gouranga Manna, P. S. Anil Kumar, Subhankar Bedanta, **Anjan Barman**, and Indranil Sarkar, *Ultrafast Spin Dynamics of Electrochemically Grown Heusler Alloy Films*, The Journal of Physical Chemistry C, 125, 10483-10492, 2021
23. Surya Narayan Panda, Sudip Majumder, Arpan Bhattacharyya, Soma Dutta, Samiran Choudhury, and **Anjan Barman**, *Structural Phase-Dependent Giant Interfacial Spin Transparency in W/CoFeB Thin-Film Heterostructures*, ACS Applied Materials & Interfaces, 13, 20875-20884, 2021
24. **Anjan Barman**, Gianluca Gubbiotti, S Ladak, A O Adeyeye, M Krawczyk, J Gräfe, C Adelmann, S Cotofana, A Naeemi, V I Vasyuchka, B Hillebrands, S A Nikitov, H Yu, D Grundler, A V Sadovnikov, A A Grachev, S E Sheshukova, J-Y Duquesne, M Marangolo, G Csaba, W Porod, V E Demidov, S Urazhdin, S O Demokritov, E Albisetti, D Petti, R Bertacco, H Schultheiss, V V Kruglyak, V D Poimanov, S Sahoo, J Sinha, H Yang, M Münzenberg, T Moriyama, S Mizukami, P Landeros, R A Gallardo, G Carlotti, J-V Kim, R L Stamps, R E Camley, B Rana, Y Otani, W Yu, T Yu, G E W Bauer, C Back, G S Uhrig, O V Dobrovolskiy, B Budinska, H Qin, S van Dijken, A V Chumak, A Khitun, D E Nikonov, I A Young, B W Zingsem and M Winklhofer, *The 2021 Magnonics Roadmap*, Journal of Physics: Condensed Matter, 33, 413001, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Magnonics in Artificial Spin Ice System, A. Barman, APS March Meeting (Invited); Mar 16, 2022; Chicago, Illinois, USA; 30 min
2. Ultrafast Spin Dynamics and Spin Waves in 2D Material/ Ferromagnet Thin Film Heterostructures, A. Barman, Indo-Japan Workshop on Interface Phenomena for Spintronics (IJW-IPS 2022) (Invited); Mar 8, 2022; NISER, BHubaneswar; 30 min

3. Emergent Novel Phenomena in Magnonics and Spintronics, A. Barman, MRSI AGM and 3rd Indian Materials Conclave (Invited); Dec 22, 2021; IIT Madras; 30 min
4. Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Heterostructures: Towards Ultrahigh Speed Spintronics, A. Barman, International Workshop on the Physics of Semiconductor Devices (IWPSD 2021) (Invited); Dec 14, 2021; IIT Delhi; 30 min
5. Emergent Phenomena in Nanoscale Magnonics, A. Barman, Symposium on Magnetism and Spintronics 2021 (SMS-2021) (Invited); Nov 25, 2021; NISER Bhubaneswar; 30 min
6. Femtosecond Laser Induced Spin Dynamics in Ferromagnetic Thin Films and Heterostructures: Towards Ultrahigh Speed Spintronics, A. Barman, Ultrafast Science (Plenary Lecture); Nov 12, 2021; UM-DAE Centre for Excellence in Basic Mumbai; 45 min
7. Ultrafast Spin Dynamics and Spin Waves in Graphene/ Ferromagnetic Thin Film Heterostructures, A. Barman, Symposium on Spintronics and Quantum Information (Invited); Oct 22, 2021; Adam Mickiewicz University, Poznan, Poland; 30 min
8. Spin-Orbit Effect: A New Wing of Spintronics, A. Barman, Plasma and Nanoscale Magnetism (Keynote Lecture); Oct 21, 2021; West Bengal State University; 120 min
9. Interfacial spin-orbit effects in magnonics and spintronics, A Barman, International Conference on Materials for Humanity (MH-21), Materials Research Society Singapore (Invited); Jul 7, 2021; Materials Research Society Singapore; 30 min

Administrative duties

1. Dean Faculty
2. Chairman and Member of Various Committees

Awards, Recognitions

1. Elected Fellow of Institute of Physics, UK in 2021

Membership of Learned Societies

1. Member of Institute of Physics, UK. Member of American Physical Society. Life Member of MRSI

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Center for Nanomagnetics for Energy Efficient Computing, Communications and Data Storage; Indo-US Virtual Networked Centre; 2019-22; PI
2. Development of strongly spin orbit coupled topological quantum hetero-structures for spintronic application; DST, Nano Mission; 2021-2026; PI

Conference / Symposia / Schools organized

1. Symposium on Magnetism and Spintronics 2021 (SMS-2021) - Co Organizer; Nov 25, 2021; NISER Bhubaneswar (Online Mode); 3 days

Scientific collaborations with other national / international institutions (based on joint publications)

1. Prof. Supriyo Bandyopadhyay, Virginia Commonwealth University, USA; Sl. No. 1, 8, 12, 13, 21; International
2. Prof. Olav Hellwig, TU Chemnitz and HZDR, Germany; Sl. No. 3, 6; International
3. Prof. Yoshichika Otani, RIKEN and University of Tokyo, Japan; Sl. No. 18, 19, 20; International
4. Prof. Peter Svedlindh, Uppsala University, Sweden; Sl. No. 4; International
5. Dr. William R. Branford, Imperial College London, UK; Sl. No. 18, 19, 20; International
6. Dr. Sam Ladak, Cardiff University, UK; Sl. No. 10; International
7. Dr. Indranil Sarkar, INST Mohali; Sl. No. 5, 22; National
8. Prof. Ranjit Biswas, SNBNCBS; Sl. No. 11; National
9. Prof. Saswati Barman, IEM Kolkata; Sl. No. 7; National

Outreach program organized / participated

1. Resource Person in AICTE Sponsored Short Term Training Programme (STTP) : Recent Trends in Emerging Devices and Nanotechnology, NIST, Odisha, June 17th and 19th, 2021. Delivered two hour online lectures with demonstrations and subsequently interacted with the participants for 30 min. Title: "Magnetization Dynamics from Theory to Experiment – Part I and part 2".

Areas of Research

Experimental Condensed Matter Physics; Nanomagnetism; Spintronics; Magnonics; Ultrafast and THz Spectroscopy; Micromagnetic Simulations

A. We have investigated ultrafast spin dynamics of single-layer graphene(SLG)/CoFeB thin films with varying CoFeB thickness. Gilbert damping variation with CoFeB thickness is modelled to extract spin-mixing conductance for SLG/CoFeB interface and isolate two-magnon scattering contribution from spin pumping. We have established an inverse relationship between ultrafast demagnetization time(τm) and Gilbert damping parameter(α) induced by interfacial spin accumulation and pure spin currents transport via spin pumping mechanism. This systematic study of ultrafast demagnetization in SLG/CoFeB heterostructure and its connection with magnetic damping can help to design graphene-based ultrahigh-speed spintronic devices.

B. An efficient mechanism for generation of pure spin current is spin pumping, and high effective spin-mixing conductance (Geff) and interfacial spin transparency (T) are essential for its higher efficiency. Using an all-optical method, we have observed a giant T in W(t)/Co20Fe60B20(d)/SiO2(2 nm) heterostructures in beta-tungsten phase. The spin-diffusion length of W and spin-mixing conductance of W/CoFeB interface was extracted from the modulation of damping with W and CoFeB thickness, which gives a giant value of T = 0.81±0.03 for the β-W/CoFeB interface. A stark variation of Geff and T is observed in accordance with the structural phase transition and resistivity variation of W with its thickness. The spin memory loss and two-magnon scattering were found to be negligible. The giant interfacial spin transparency and its strong dependence on crystal structures of W will be important for future spin-orbitronic devices based on pure spin current.

C. We have investigated femtosecond laser-induced ultrafast demagnetization in synthetic antiferromagnets (SAFs) where [Co/Pt]n-1/Co multilayer blocks are separated by Ru or Ir spacers. Our investigation conclusively shows that the spin transport (ST) of optically excited carriers have a significant contribution to the ultrafast demagnetization, in addition to spin-flip scattering (SFS) processes. Moreover, we have achieved an active control over the individual mechanisms by specially designing the SAF samples, and altering the external magnetic field and excitation fluence. Our study provides a vital understanding of the underlying mechanism of ultrafast demagnetization in synthetic antiferromagnets.

D. We have studied reconfigurable magnonics in two kagome artificial spin ices (ASIs) via Brillouin light scattering (BLS), a continuously connected system and a disconnected system with vertex gaps. We have observed distinct high-frequency dynamics and magnetization reversal regimes between the systems, with key distinctions in spin-wave localization and mode quantization, microstate-trajectory during reversal and internal field-profiles. These observations are pertinent for the fundamental understanding of artificial spin systems and broader design and engineering of reconfigurable functional magnonic crystals.

E. Measurement of spin dynamics in complex 3D structures remains exceptionally challenging. We have measures coherent spin waves within a 3D-ASI structure for the first time, using BLS. The 3D-ASI was fabricated by using a combination of two-photon lithography and thermal evaporation. Two spin-wave modes were observed whose frequencies showed nearly monotonic variation with the applied field strength. Numerical simulations qualitatively reproduced the observed modes. The simulated mode profiles revealed the collective nature of the modes extending throughout the complex network of nanowires while showing spatial quantization with varying mode quantization numbers.

Plan of Future Work Including Project

1. We will investigate spin pumping in ferromagnetic Heusler alloy ($Co_2Fe_xMn_{1-x}Si$)/Pt heterostructures considering the ultralow damping and stable spin-polarized band structure at the Fermi level of the CFMS and excellent spin-sink property of Pt. By modelling the thickness-dependent Gilbert damping using ballistic and diffusive spin transport framework we will study the spin-diffusion length, spin-mixing conductance and spin transparency.

2. We will systematically study the role of spin-orbit coupling strength on ultrafast spin dynamics in nonmagnet(NM)/ferromagnet heterostructures, by using Cu, Ta, W, Pt, Ta/Ru/Ta, and Si/SiO_2 as NM layer. We will attempt to establish a relationship between α and τm, τe and investigate the contributions of spin current transport in ultrafast demagnetization and fast remagnetization process.

3. We will study the effects of damping-like and field-like spin-orbit torque due to spin-Hall effect induced pure spin current and the ensuing control over Gilbert damping in β-Ta/CoFeB/SiO_2 heterostructures with widely varying Ta thickness having stable β-phase. We will thereby estimate the efficiencies of these torques with and without Joule heating.
4. We will investigate the effects of dimensional confinements and the ensuing variation in the static and dynamic magnetic properties of ferromagnetic nanostripes (spin-wave nano-waveguides) by the geometric parameters and external field. Using a combined experimental and numerical study we will study the reconfigurable spin-wave dynamics in such systems and investigate different uniform, localized and standing spin waves and their variation with these parameters.

Any other Relevant Information including social 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 unique 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 some of 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 Ph.D. students and Postdoctoral scientists for the development of future science and technology in India.

Anup Ghosh
Inspire Faculty
CMPMS
anup.ghosh@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) External Project Students / Summer Training

1. Suranjana Chakrabarty (Project Student)

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

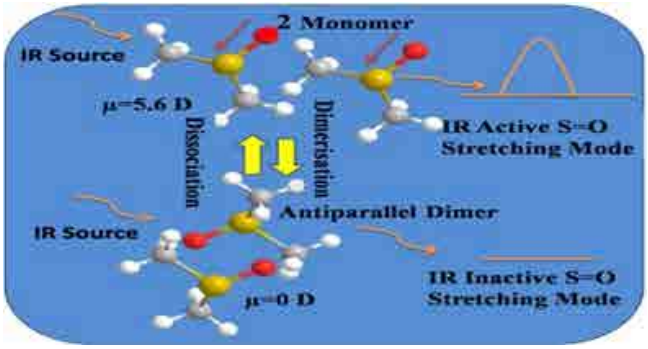
1. DST Inspire; DST; 5; PI

Areas of Research

i. On-Off Infrared Absorption of S=O Vibrational Probe of Dimethyl Sulfoxide

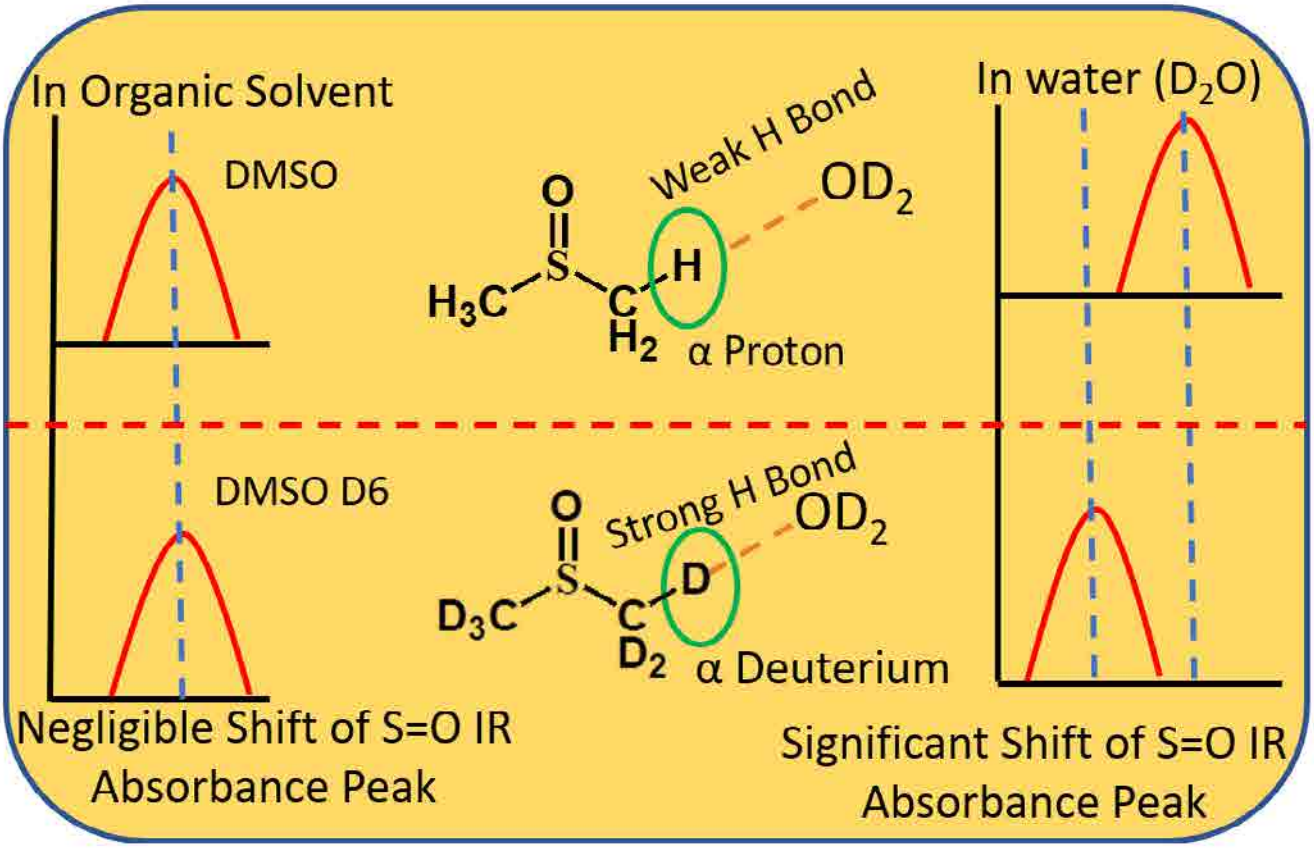
ii. Anomalous Infrared Absorbance of S=O: A Perturbation Study of α C-H/D

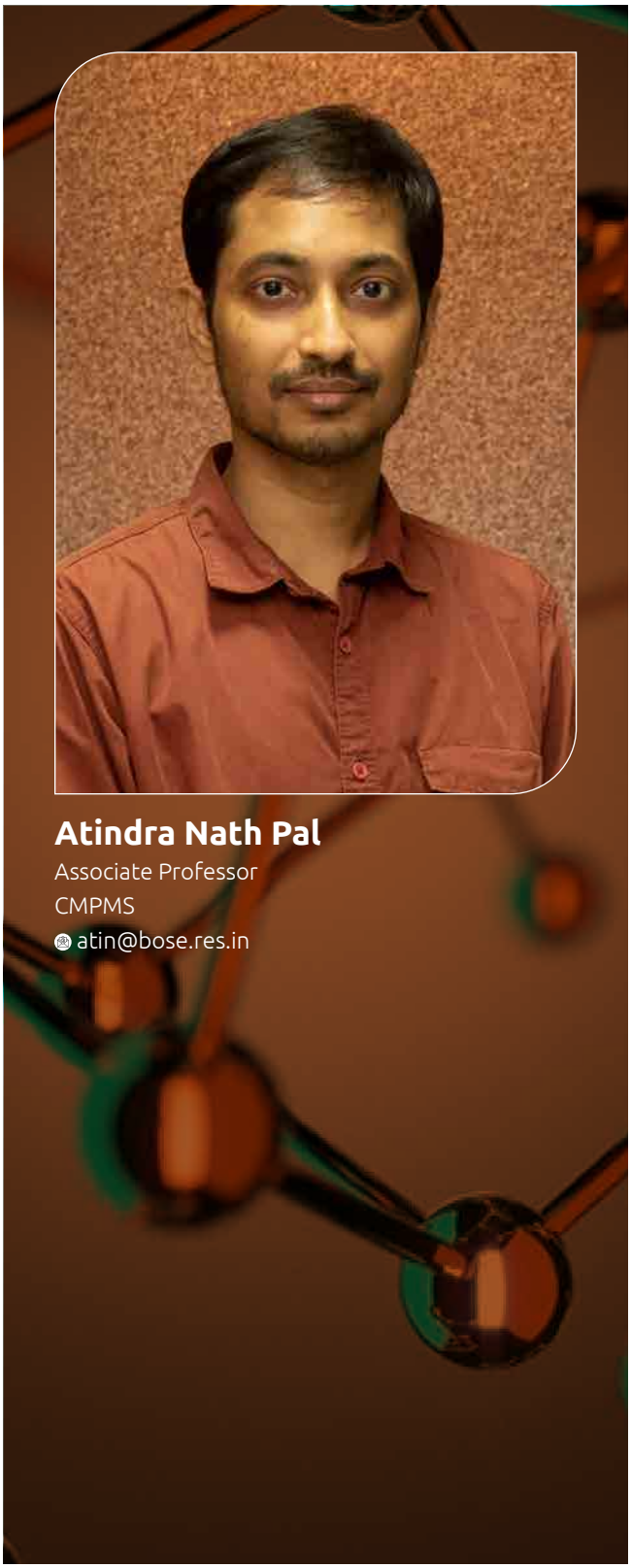
Dimethyl sulfoxide (DMSO), a polar solvent molecule, is used in a wide range of therapeutic and pharmacological applications. Different intermolecular interactions, such as dimerization and hydrogen bonding with water, are crucial to understanding the role of DMSO in applications. Herein, we have studied DMSO in various solvation environments to decipher the environment-dependent dimerization and hydrogen bonding propensity. We have used a combination of infrared spectroscopy, quantum mechanical calculations, and molecular dynamics simulations to reach our conclusions. Although DMSO can exist in a dynamic equilibrium between monomers and dimers, our results show that the relative intensity of the S=O stretch and the CH_3 rocking modes is a spectroscopic indicator of the extent of DMSO dimerization in solution. The dimerization (self-association) is seen to be maximum in neat DMSO. When dissolved in different solvents, the dimerization propensity decreases with increasing solvent polarity. In the presence of a protic solvent, such as water, DMSO forms hydrogen bond with the solvent molecules, thereby reducing the extent of dimerization. Further, we



have estimated the hydrogen bond occupancy of DMSO. Our results show that DMSO predominantly exists as doubly hydrogen-bonded in water.

Solvatochromic shifts of S=O vibrational probes describe the strength of the surrounding electric fields and the hydrogen bonding status. Herein, we demonstrated how the solvents alter the IR spectra of S=O vibrating mode. Experimental measurement of the involvement of α H/D isotopic interaction with different solvents and their effects on IR absorbance spectra of the vibrational probe provides detailed knowledge on the micro-solvation environment despite the complexity of overlapping bands in the spectra. Herein we discover how the solvents interact differently with DMSO and DMSO D6 while they are electronically and structurally same. Interestingly the IR spectrum of the S=O mode remains unaltered during α isotopic replacement in attendance of aprotic solvents (acetone, acetonitrile, and dichloromethane) but in strong coordinating polar solvents (D_2O) it is altered remarkably. We have explored that α C-D of DMSO-D6 forms a stronger hydrogen bond with D_2O than α C-H of DMSO which tends to the more C-D bond delocalization over S=O bond than C-H bond. Subsequently, S=O IR absorbance of DMSO D6 shifted lower in frequency than DMSO in D_2O. Parallelly we also identified that the IR spectrum of S=O mode in Hexafluroisopropanol is more red-shifted than in D_2O due to the stronger α H-bond interaction of 'F' atom of HFIP. There is a lack in the literature of quantitative information about the influence of α H atom or α isotopic substitution on the vibrational probe. Our experiments provide a detailed molecular understanding of the structure of DMSO in DMSO-solvent binary mixtures as DMSO plays an important role in virtually all sub-disciplines of chemistry and biology, we believe that our work will be of interest to the large diversity of the community.





Atindra Nath Pal
Associate Professor
CMPMS
atin@bose.res.in

Guidance of Students/Post-Docs/ Scientists

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. Shubhrasish Mukherjee; An investigation of electronic and optical properties in 2D semiconductors and their heterostructures; Under progress; S. K. Ray (Supervisor)
4. Rafiqul Alam; An investigation of transport phenomena in topological materials; Under progress
5. Riju Pal; Spintronics with layered materials; Under progress

b) Post-Docs

1. Buddhadeb Pal; Spintronics with 2d materials and superconductor

Teaching

1. Spring semester; PHY 291- Laboratory; Integrated Ph.D.; 5 students; with 1 (Prof. P. K. Mukhopadhyay) co-teacher

Publications

a) In Journals

1. Biswajit Pabi, Debayan Mondal, Priya Mahadevan, and **Atindra Nath Pal**, *Probing metal-molecule contact at the atomic scale via conductance jumps*, Physical Review B, 104, L121407, 2021
2. Shubhrasish Mukherjee, Didhiti Bhattacharya, Sumanti Patra, Sanjukta Paul, Rajib Kumar Mitra, Priya Mahadevan, **Atindra Nath Pal,** and Samit Kumar Ray, *High-Responsivity Gate-Tunable Ultraviolet–Visible Broadband Phototransistor Based on Graphene–WS_2 Mixed-Dimensional (2D-0D) Heterostructure*, ACS Applied Materials & Interfaces, 14, 5775-5784, 2022

Administrative duties

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

4. In charge of Ellipsometry system
5. Member of Project & Patent Cell
6. Member of purchase sub committee

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. CRG/2020/004208 - Project Title - Probing orbital hybridization and structural asymmetry in atomic and molecular nano-contact via inelastic electron spectroscopy and shot noise; SERB-DST; 3 years (since 2020); PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Collaborated with Prof. Priya Mahadevan (SNBNCBS) on the single molecular break junction work published in PRB Letter; Phys. Rev. B 104, L121407 (2022); National
2. Collaborated with Prof. S K Ray and Prof. Priya Mahadevan on the 2D optoelectronics work published in ACS AMI; ACS Appl. Mater. Interfaces 14, 5775, (2022); National

Areas of Research

Experimental condensed matter physics

A. Transport through single molecular junction: we have developed a unique set up using a mechanically controllable break junction technique to study the electron and spin transport through a single molecule suspended between two electrodes. This can work from room temperature down to 4.2K. As the transistor size going down below 10 nm scale, conventional lithographic techniques are limited to create molecular scale (~ 1 nm) devices. Fortunately, break junction technique can be relevant for understanding the details of the metal/molecule interface at the single molecule level, important for futuristic technology. At this atomic scale, the orbital hybridization between the metal and molecule becomes important as well as the quantum effects become dominant. In our recent work (*PRB 104 (12), L121407, 2021*), we studied the formation of a metal-molecule bond by studying charge transport through single molecular junctions at room temperature and provided a detail mechanism of metal/molecule bond formation. At present he is focussing on studying organometallic molecule to create a highly conducting molecular junction by tuning quantum interference between the orbitals and already he has very interesting experimental result.

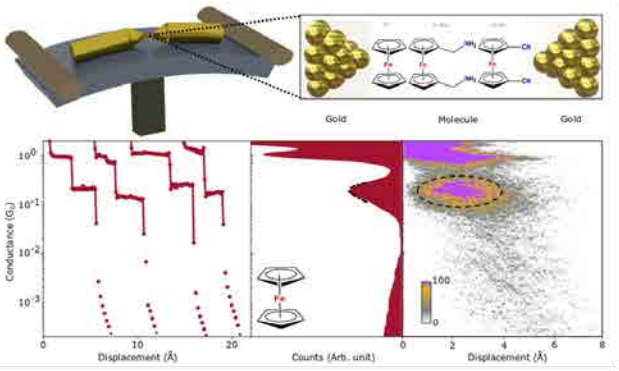


Figure 1: Characterization of Gold-Ferrocene junction - Schematic illustration of MCBJ set up along with the molecular structure (ferrocene, 1, 1'- bis(aminomethyl)ferrocene, 2, 2'-dicyanoferrocene) used here. Typical breaking conductance distance traces of ferrocene molecular junction (attached to the gold electrode) in semi-logarithmic scale, with traces shifted in electrode separation axis for clarity. One dimensional conductance histogram of same junction, constructed from 1800 molecular traces using 35 bins per decade. Black dash-dot line represents the Gaussian fitting of the corresponding molecular peak which yields the most probable value - 0.11 ± 0.01 G_0. Conductance distance density plot of ferrocene molecular junction based on the same 1800 molecular traces (breaking), constructed using logarithmic binning (50 bins per decade), where black circle shows the data cloud of molecular plateaus.

B. Optoelectronics with 2D materials: Our primary aim was to create hybrid optoelectronic devices for broadband applications and to understand the underlaying physics. With our custom made set up, recently (ACS Appl. Mater. Interfaces 2022, 14, 5775) we have demonstrated a super large (~0.75 mm2), UV-Vis broadband (365-633 nm), phototransistor made of WS2 QDs decorated CVD graphene as active channel in the 2D-0D configuration, with extraordinary stability and durability in ambient condition. In line with this, they are focusing on new heterostructure for accessing the even broader range with higher responsivity, important for future technological applications.

C. Transport through emerging quantum materials: In a recent collaborative work (*arXiv:2111.14525*), we have found a new quasi one dimensional materials (Ta(Se4)3I) where a rare coexistence of superconductivity and magnetism was observed at temperature below 10K. We investigated in details about the nature of superconductivity in this new materials. In an another work, we are focusing on the electronic transport on LaAgSb2, a topological semimetal having charge density wave. Buy studying planar Hall effect we try to understand the nature of Fermi surface and its relation with topology at various temperature.

D. Hybrid Graphene-Spin crossover system: Here, we focused on creating hybrid device of spin crossover molecule and graphene to understand the the nature of spin transition in these hybrid devices and if it can be used for memory application. We created hybrid with

both rGO and large area CVD graphene, and detected the spin state transition through a sudden change in conductance. More interestingly, we see that the effect is magnetic field dependent, indicating the presence of magneto-elastic coupling in these system.

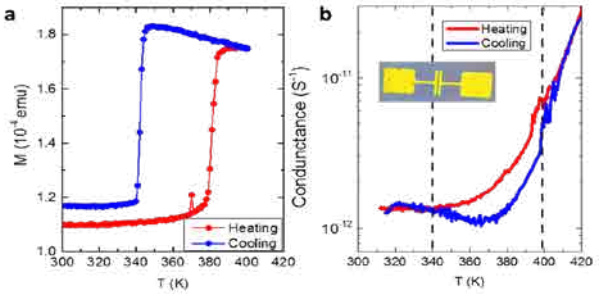
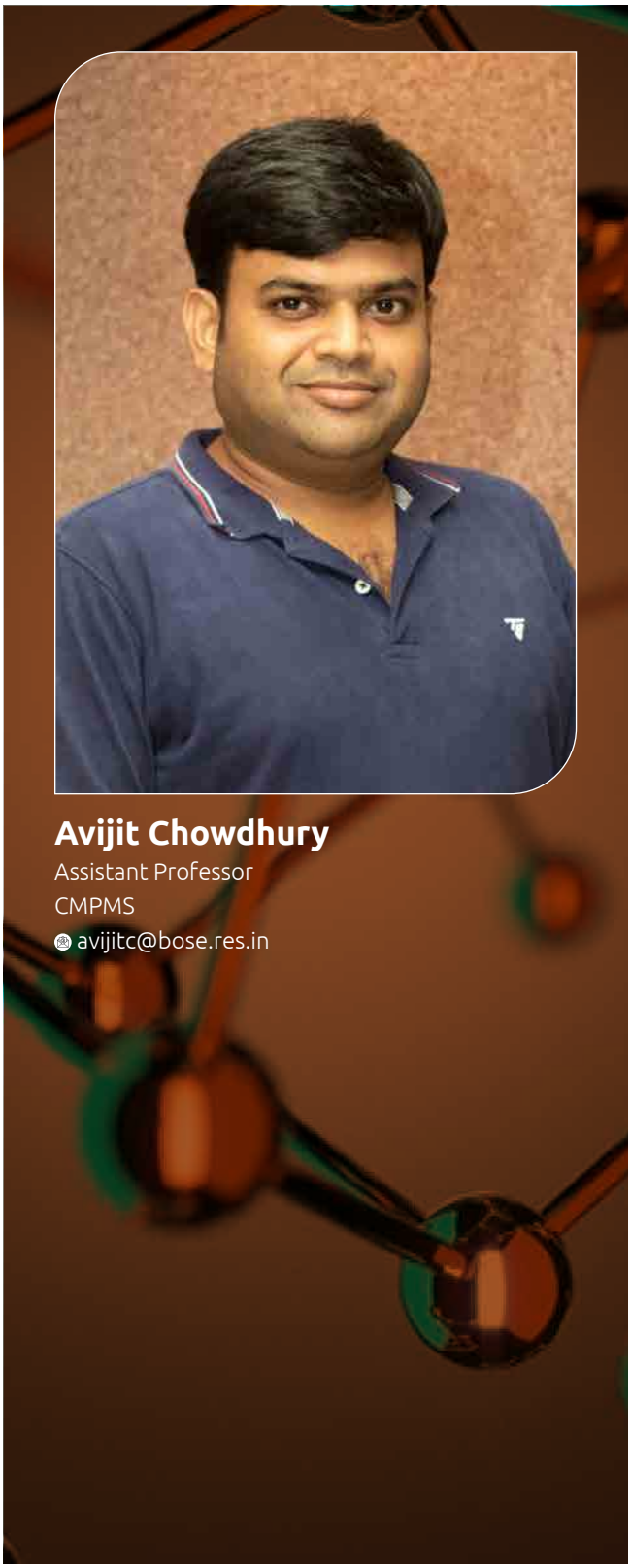


Figure 2: (a) M-T curve for the bare SCO nanoparticle showing a thermal hysteresis. (b) Conductance measurement of bare nanoparticle showing similar thermal hysteresis.

E. Transport through 2D Ferromagnet: In an another ongoing project, we are investigating the new low dimensional van der Waal Ferromagnet (FGT family) through magnetization and transport measurements. In our recent experiment with F4GT, we do observe Anomalous Hall effect and unusual spin transition at low temperature.

Plan of Future Work Including Project

1. Transport through Single molecular junction: We have already developed the transport measurement set up to measure single molecular junction from room temperature to 4.2K. Ferrocene based molecular junction seems to be a promising candidate for creating highly conducting molecular junction and we plan to explore this new direction in more details. A new dipstick s being prepared to do shot noise measurement to understand the number of conduction channels. A SERB CRG project has been granted for three years on "Probing orbital hybridization and structural asymmetry in atomic and molecular nano-contact via inelastic electron spectroscopy and shot noise". We plan to investigate 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. Optoelectronics with vander Waal hybrid: Another direction which was developed is the optoelectronic set up. It seems to be technologically appealing apart from basic understanding. We have already shown new result in CVD graphene and WS2 quantum dots, which show broadband photo response. We are going have new CVD machine for producing large area TMD materials. This will certainly provide us advantage to explore different large area hybrid including flexible devices.
3. Proximity induced effect in quasi-two dimensional heterostructure: The following work is the proposed as a part of the multi-institutional projects under the special call for Thematic unit of Excellence - Quantum materials, Nanomission, DST: CONsortium for Collective and Engineered Phenomena in Topology (CONCEPT). In this proposal we wish to explore two-dimensional heterostructure based on 2D magnetic materials for spintronic application. Also, we plan to investigate triplet Cooper pair proximity effects in a variety of superconductor-ferromagnet (S-F) hybrid systems. The interface between superconductors (S) and ferromagnets (F) can offer the opportunity to find a new class of superconducting spintronic devices.



Avijit Chowdhury
Assistant Professor
CMPMS
avijitc@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Anupriya Nyayban; Theoretical studies on the Rb-based all inorganic halides toward photovoltaic applications; Under progress; Dr. Subhasis Panda, Department of Physics, NIT Silchar, Assam 788010 (Supervisor)
2. Nipom Sekhar Das; Organic-Inorganic Layered Nanohybrid Dispersed Ferroelectric Polymer Blend For Bipolar Analog Memristors; Under progress; Prof. Asim Roy, Department of Physics, NIT Silchar, Assam 788010 (Supervisor)
3. Suma Das; Development of g-C3N4-based magnetic nanomaterials for photocatalysis applications; Under progress; Dr. Ranjith G. Nair, Department of Physics, NIT Silchar, Assam 788010 (Supervisor)
4. Saikat Mitra; Studies of growth and physical properties of perovskite halides; Under progress; Dr. Barnali Ghosh (Saha), CMPMS, SNBNCBS, Salt Lake City, Kolkata 700106 (Supervisor)
5. Soumik Das; Layered nanohybrid based devices for optoeletronic synapses; Under progress
6. Koustav Kashyap Gogoi; Studies on semiconductor-grafted layered nanohybrid embedded polymer composites for non-volatile resistive memory applications; Awarded

b) External Project Students / Summer Training

1. Siddhant Manna; A mini-review on the synthesis, structural modification ofgraphitic carbon nitride based magnetic nanocomposite and their applications for environmental remediation; National Institute of Technology Silchar, 2021
2. Subhankar Pandit; A Brief Study on Wearable Technology Using Ferroelectric Polymer and It's Application in Cardiovascular Care; National Institute of Technology Silchar, 2021

Teaching

1. Autumn semester; Basic Laboratory I (PH191); Integrated Ph.D.; 9 students; with 1 (Prof. Pratip Kr. Mukhopadhyay) co-teacher

2. Spring semester; Electronics & Instrumentation (PHY204); Integrated Ph.D.; 9 students; with 1 (Prof. Kalyan Mandal,) co-teacher
3. Spring semester; Basic Laboratory II (PHY291); Integrated Ph.D.; 9 students; with 1 (Prof. Kalyan Mandal,) co-teacher

Publications

a) In journals

1. Suma Das and **Avijit Chowdhury**, *Recent advancements of g-C_3N_4-based magnetic photocatalysts towards the degradation of organic pollutants: a review*, Nanotechnology, 33, 072004, 2021

(b) Conference proceedings / Reports / Monographs / Books

1. Nipom Sekhar Das, Avijit Chowdhury and Asim Roy, Facile one pot hydrothermal synthesis of reduced graphene oxide-tin disulfide (rGO-SnS2) nanohybrid material and their optical and structural investigation, IOP Conf. Series: Materials Science and Engineering 1233, 012007, 2022.

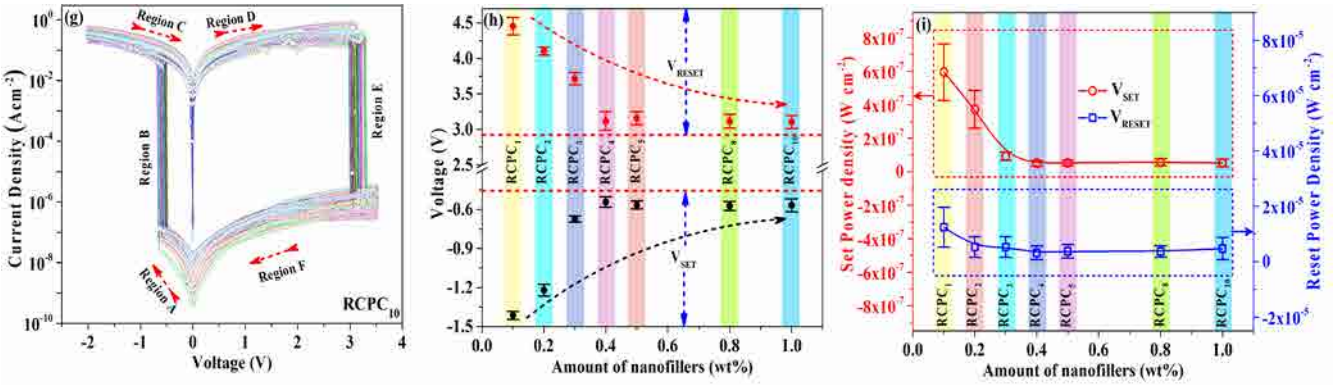
Membership of Learned Societies

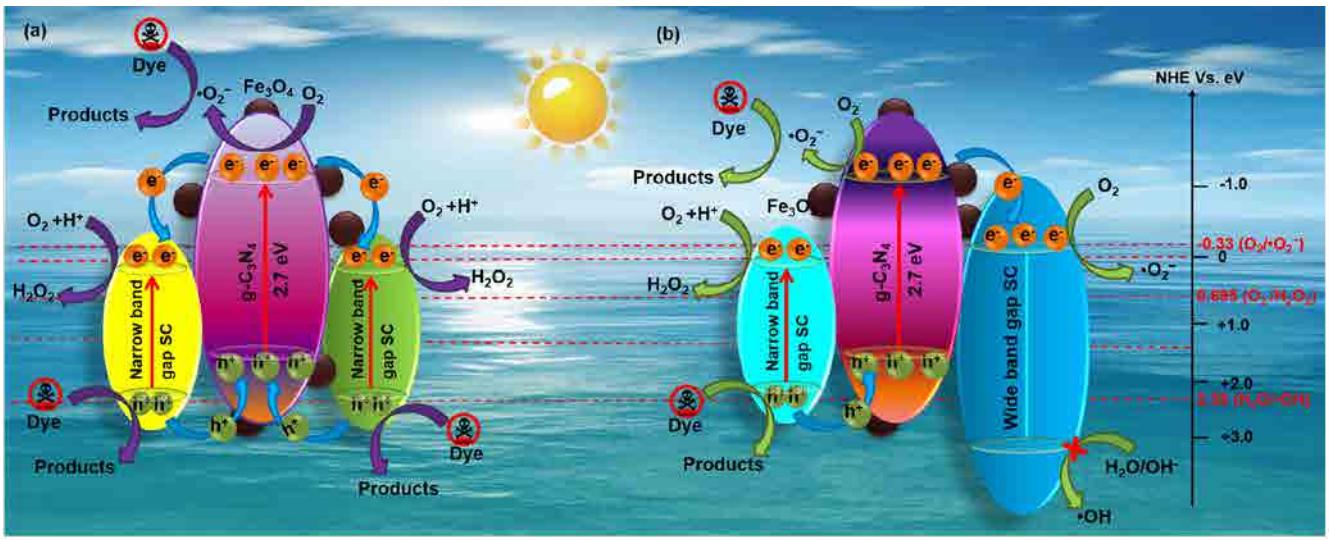
1. Life Member of MRSI
2. Life Member of Indian Association for the Cultivation of Science

Areas of Research

Experimental Condensed Matter Physics and Materials Science

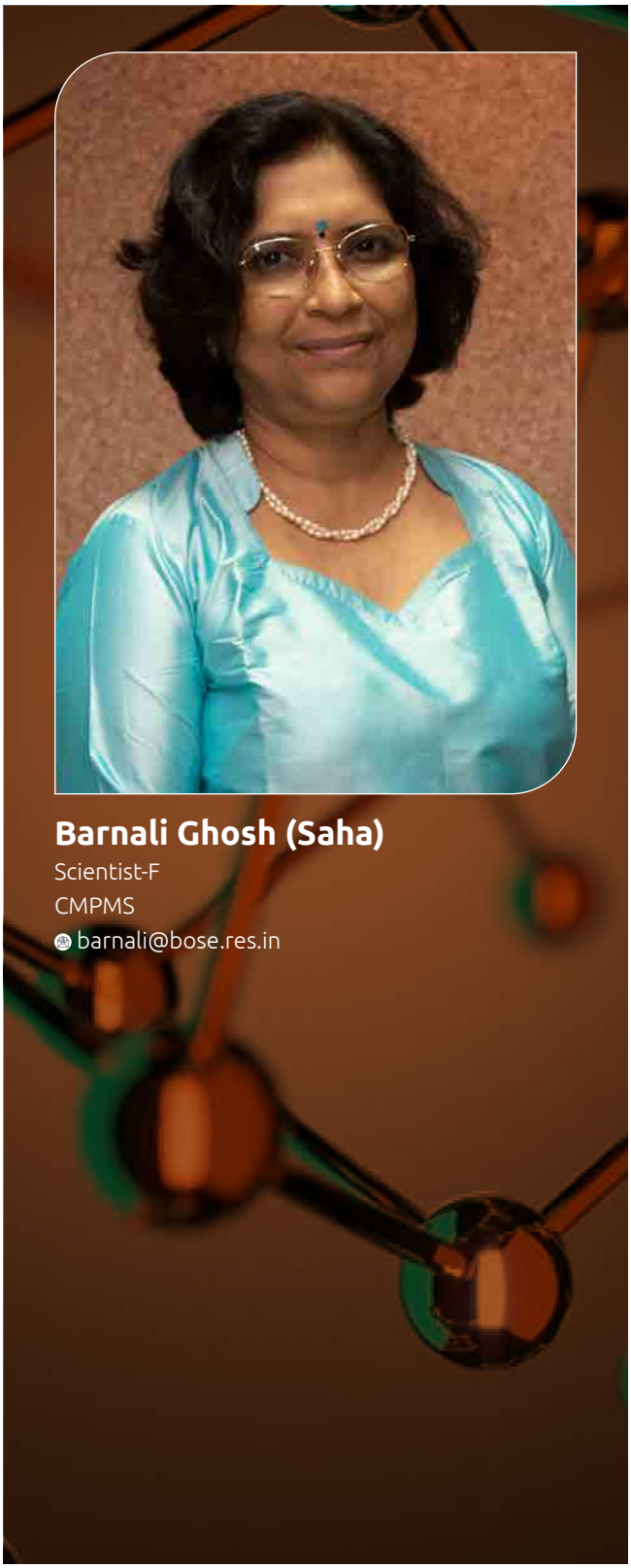
Our research group is currently developing various layered 2D materials such as GOs, rGO, g-C3N4, TMDCs, etc., including their hybrid composites, mainly for solar photocatalysis and resistive memory applications. Our primary goal is to exploit the interfacial features of the organic-inorganic layered heterostructures embedded with/ or without the polymer matrices to modulate the carrier transport. Eventually, the hybrid composite displays outstanding performances not observed in their bulk phases or pristine counterparts. In addition, we are further looking into the development of magnetic binary and ternary composites as recyclable and reusable catalysts for solar photocatalysis applications. Our recent study demonstrates that the ternary nanocomposites surpass the individual merits of their counterparts by augmenting the catalytic performances many-fold through their synergistic interfacial effects. Besides, our group is also involved in the theoretical studies of the structural, electronic, and optical properties of lead-free perovskites using Density Functional Theory (DFT).





Plan of Future Work Including Project

1. The modern technique used in neurobiology to control the activity of the neurons using light is optogenetics, where an optoelectronic synaptic device is employed to integrate visual sensing, data storage, and signal processing. A neuromorphic chip premised on analog memristive devices can store and process information, like the brain, with massive parallelism and energy efficiency. Therefore, our future plan is to develop a novel active layer-based memtransistors comprising a ferroelectric polymer blend/ photoelectric 2D material hybrid system. The key functionalities of synapses and neurons will be emulated via a combination of electronic and photonic pulses. Eventually, the synergy between the electrical (compact footprint, high density) and optical (high bandwidth and low communication energy) domains will be harnessed to emulate the optoelectronic synapses with better energy efficiency and greater tunability.



Barnali Ghosh (Saha)
Scientist-F
CMPMS
barnali@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Chandan Samanta; "Synthesis, Physical Properties And Applications Of Metal Oxide Semiconductor Nanostructures And Thin Films"; Awarded
2. Avisek Maity; "Synthesis, Characterization, Physical Property Studies & Applications of Perovskite Halide; Thesis submitted
3. Parushottam Majhi; "Structure And Physical Properties Of Strained Metal Oxide Films"; Under progress; Prof. A.K.Raychaudhuri (Co-supervisor)
4. Snehamoyee Hazra; Investigation on Nanostructured Piezoelectric and Ferroelectric materials"; Under progress
5. Sudipta Chatterjee, Institute fellow since March 2021; Investigation On Transort And Magneto-Transport Properties of Transition Metal Based Oxides And Alloys; Under progress; Prof. Kalyan Mandal (Supervisor)
6. Saikat Mitra, Institute fellowship since Jan 2022; Studies of Growth and Physical Properties of Perovskite Halides; Under progress; Dr. Avijit Chowdhury (Co-supervisor)

b) Post-Docs

1. Mustaque Ali Khan; 2D Materials Based Advanced Photodetectors and Effect of ALD Grown Dielectric Gate Oxide on the Device performance

c) External Project Students / Summer Training

1. Saikat Mitra, SERB project student till Dec 2021; Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them
2. Sudipta Chatterj, SERB project till Feb 2021; An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films
3. Sohel Siraj TRC Project Student; Development of programming and packaging of prototypes
4. Chandni Das, TRC Project Student; Growth of Sensing materials and their characterization
5. Ayan Ghosh, TRC project Assistant; Prototype development of gas sensor

Teaching

1. Autumn semester; Project Research(PHY591); Ph.D.; 1 student; with 1 (Prof. Kalyan Mondal) co-teacher

Publications

a) In journals

1. Snehamoyee Hazra, Subhamita Sengupta, Soumyaranjan Ratha, Ankita Ghatak, A K Raychaudhuri and **Barnali Ghosh**, *Piezoelectric Nanogenerators based on Lead Zirconate Titanate nanostructures: an insight into the effect of potential barrier and morphology on the output power generation*, Nanotechnology, 33, 155403, 2022
2. Avisek Maity, Chandni Das, A K Raychaudhuri, Abhijit Saha and **Barnali Ghosh**, *Highly radiation resistant room temperature organic perovskite halide ($FAPbI_3$) crystal for direct detection of gamma-ray photons down to nano curie activity*, Journal of Physics D: Applied Physics, 54, 455104, 2021
3. Subarna Datta, Ankita Ghatak, **Barnali Ghosh**, *Effect of structural deformations on the transport properties of half-doped manganite nanowires: An insight through high resolution image simulation*, Materials Science and Engineering: B, 272, 115300, 2021
4. Parushottam Majhi, Sudipta Chatterjee, Ravindra Singh Bisht, V. Raghavendra Reddy, **Barnali Ghosh** and A. K. Raychaudhuri, *Diffused metal-insulator transition in $NdNiO_3$ film grown on $BaTiO_3$: Likely evidence of electronic Griffiths phase*, Physical Review Materials, 5, 085005, 2021
5. Avisek Maity, A. K. Raychaudhuri, and **Barnali Ghosh**, *Paper-Based Stable Broad Band Optical Detector Made from Mixed Cation Organic Perovskite Halides*, The Journal of Physical Chemistry C, 125, 10646-10652, 2021
6. Avisek Maity, Saikat Mitra, Chandni Das, Sohel Siraj, A.K.Raychaudhuri and **Barnali Ghosh**, *Universal sensing of ammonia gas by family of lead halide perovskites based on paper sensors: Experiment and molecular dynamics*, Materials Research Bulletin, 136, 111142, 2021
7. Arnab Ghosh, Milon Miah, Arun Bera, Shyamal Kumar Saha, **Barnali Ghosh**, *Synthesis of freestanding 2D CuO nanosheets at room temperature through a simple surfactant free co-precipitation process and its application as electrode material in supercapacitors*, Journal of Alloys and Compounds, 862, 158549, 2021

b) Conference proceedings / Reports / Monographs / Books

1. In the Coffee table book: A journey Towards Excellence (June 1986 to May 2021): Published on the occasion of Golden Jubilee Celebration of Department of Science & Technology , GOI, May 2021. Published by S. N. Bose National Centre For Basic Sciences, Year 2021. topic title: "On Application potential in environment protection and medical diagnosis using Different Gas sensors, Piezoelectric nanowires for Sensitive motion and Energy harvesting nanogenerators. Also on Optical detectors"

Talks / Seminars Delivered in reputed conference / institutions

1. Invited Evening Lecture and Session Chair in Research Scholars Workshop (RSW-2021) during 23-24 Nov 2021, at UGC-DAE-CSR, Indore (online); Nov 23, 2021; UGC-DAE-CSR Indore; 1hr
2. Invited lecture in Two-day National Conference on Frontiers in Modern Physics (NCFMP 2021) during 26-27 November, 2021, Department of Physics, Adamas university (online); Nov 27, 2021; Adamas University , Kolkata; 1hr
3. Invited lecture in Discussion meeting on Contemporary Aspects of Radiation Based Material & Chemical Sciences: The Macro, The Nano & The Lights, on 28th January, 2022 UGC-DAE CSR, Kolkata Centre (online); Jan 28, 2022; UGC-DAE-CSR, Kolkata; 30 min

Administrative duties

1. Purchase, up-gradation site preparation and installation of common facility equipment s under TRC
2. Scientist - in charge of few Central equipment facilities under TRC 3Maintainance as In-charge of common facility equipments under Technical Cell
3. Garden and plumbing
4. Various thesis committee
5. Purchase committee
6. Committees related to TRC
7. Various evaluation committees
8. Interview committee

9. Member of Internal Complaints Committee of the Centre

Patents Taken and Process Developed with Details

1. Flexible Thin Film Transistor Using Electric Double Layer as Gate Dielctric and a Method of Fabricating Thereof: The present invention discloses a flexible thin film transistor using a polymer electrolyte based gate dielectric (that forms an electric double layer at the gate region), configured to operate in small threshold gate voltage and having high channel ON/OFF current ratio and sharp switching. The present flexible thin film transistor comprises a flexible substrate, a semiconductor channel disposed over said flexible substrate; and a polymer electrolyte based operating gate dielectric disposed over said semiconductor channel facilitating transistor operation. The polymer electrolyte based operating gate dielectric(G) form electric double layers which act as a nano-gap capacitor having capacitance fixed by atomic distance of constituent elements of the double layer facilitating transistor operation at small threshold gate voltage. " The First Examination Report (FER) submitted on April 2021"; 201731015268; Applied
2. Advancement in Methodology and System to Control Isotopic Fractionations in Carbon Containing Gases: A methodology and system for preferential adsorption of isotope of carbon containing gases involving a selective nanostructured material having specific porosity and large aspect ratio. In particular the advancement can selectively control the isotope fractionations of CO2 (12C 16O2, 13C 16O2) i.e. δ 13C in gases. Importantly, the advancement provides a physical process based isotope selective adsorption of carbon containing gas exploiting a simple nanostructured material having specific porosity and large aspect ratio to selectively adsorb isotopic CO2 from environment. The selective adsorption of isotopes of carbon containing gas (12CO2) takes place from an environment having minimum ppm of 300 at a temperature above 25oC. The preferential isotopic adsorption of carbon containing gas finds application in medical diagnostic devices, gas fractionation isotopically and similar fields. "The First Examination report (FER) has been submitted on 15/03/2022"."; 201731017087; Applied
3. A paper based ammonia gas selective sensor with electrical read out and a method for manufacturing the same: The present invention relates to sensing of ammonia gas at room temperature. More specifically, the present invention is directed to develop a stand-alone low cost portable high sensitivity room temperature operated ammonia gas sensor with electrical read out for rapid, easy and selective detection of the ammonia gas in any open or closed environment and immediate generation of electrical response indicating presence of the ammonia gas. The developed ammonia gas sensor is configured to detect very low concentration of the ammonia gas down a level of 1 ppm in the sensing environment and operatively integrate with other peripheral electronics/applications/systems. "The First Examination report (FER) has been submitted on 06/08/2021."; 201831001993; Applied

Membership of Learned Societies

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

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; SERB-DST; 6/7/2018-5/4/2022; PI
2. An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films; SERB-DST; 24/3/2017- 23/7/2021; Co-PI
3. Technical Research Centre (TRC), Centre Project, One of the activity leader among others; DST; 01/1/2016-30/6/2022; PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. UGC-DAE-CSR Indore; Sl. No. 4; National
2. CGCRI, Kolkata; Sl. No. 1, 2, 4, 5, 6; National
3. IACS, Kolkata; Sl. No. 7; National
4. UGC-DAE-CSR Kolkata; Sl. No. 2; National

Outreach program organized / participated

1. The 24th National Science Exhibition held during 28 - 31 October 2021 at Science City Ground, Kolkata Showcasing of Prototypes

Areas of Research

Experimental Nanoscience & Nanotechnology, Physics of Perovskite Oxides & Halides Nanofabrication using Lithography, Semiconductor Optoelectronics, Gas Sensor & Energy devices, Electron Microscopy /Crystallographic Structural Analysis, Materials growth using wet chemistry, Pulsed laser deposition, Atomic layer deposition

1) **Direct detection of Gamma Ray photons using Highly radiation resistant room temperature organic perovskite halide ($FAPbI_3$) crystal down to nano curie activity:**

   This work is based on a simple room temperature gamma (γ)-ray detector with electrical read out made using as-grown highly textured crystals of organic perovskite halide formamidium lead iodide (FAPI) prepared by solution method. The detector uses electronics that measure resistance changes, similar to those used in optical detectors. Although it does not have energy resolution, the detector can be used as a quick tool to detect the presence of γ-ray in wide energy range, from the 100 to the 1250 keV range, with noise limited sensitivity capable of detecting activity down to 50 nCi. The FAPI detector has a reasonable μτ ≈ 5.2 × 10−3 cm2V −1 and has been tested for shelf-life of at least six months. The crystal detector was found to have stability toward long term sustained exposure to γ-ray making it useful in applications needing such long exposure. Also, a proof of concept has been established toward wearable, low cost, portable solid state gamma ray detectors using paper electronics based halide perovskites. This work has been published in **J. Phys. D: Appl. Phys. 54, 455104 (2021).**

2) **Paper electronics Based Stable Broad Band Optical Detector Made from Mixed Cation Organic Perovskite Halides:**

   This work is based on a paper-based photodetector made from mixed cation organic perovskite halide MA1−xFAxPbI3 (MA = methylammonium (CH3NH3); FA = formamidium CH(NH2)2). The detector shows a substantial photogain and photoresponse at low illumination intensity (<10 μW/ cm2) and a broad band response that extends from 300 to 800 nm at the optimum substitutional level with x = 0.4. A peak responsivity of 0.27 A/W in the paper photodetector was observed at a wavelength of ~775 nm at a bias of 5 V. The responsivity stayed above 0.1 A/W for a broad optical wavelength range of 550 to 825 nm that covers a good range of the visible spectra. The detector has a low dark current (<10−9 A) at highest bias of operation and an rms current noise of ≤10 pA. The mixed halide detector was grown on conventional paper using a one-pot chemical process. The detector reported here is stable at a room ambience and does not deteriorate under prolonged exposure to illumination. It combines the high response of MAPbI3 and the stability of FAPbI3. The paper photodetector is useful in a number of applications needing flexible and disposable detectors, and the power requirement even at full operation is <0.5 μW at a low bias (<5 V) making it compatible with battery-powered operation. This work has been published in **The Journal of Physical Chemistry C, 125, 10646, 2021.**

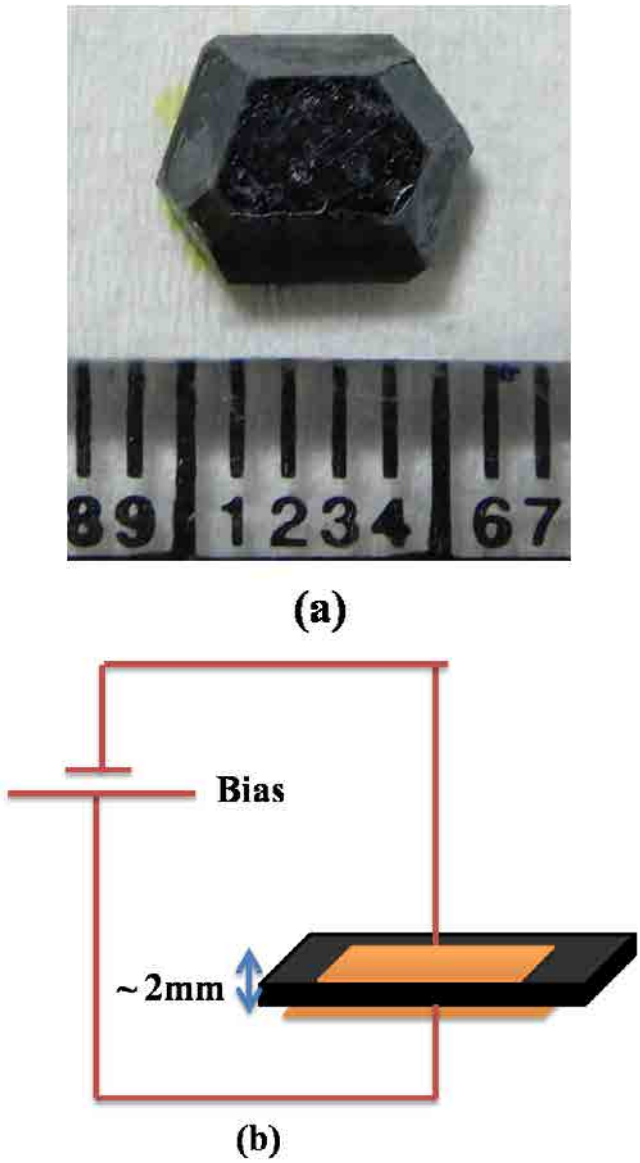


Figure1 : a) Photograph of single crystal FAPbI3 for gamma ray detector b) Schematic of the device.

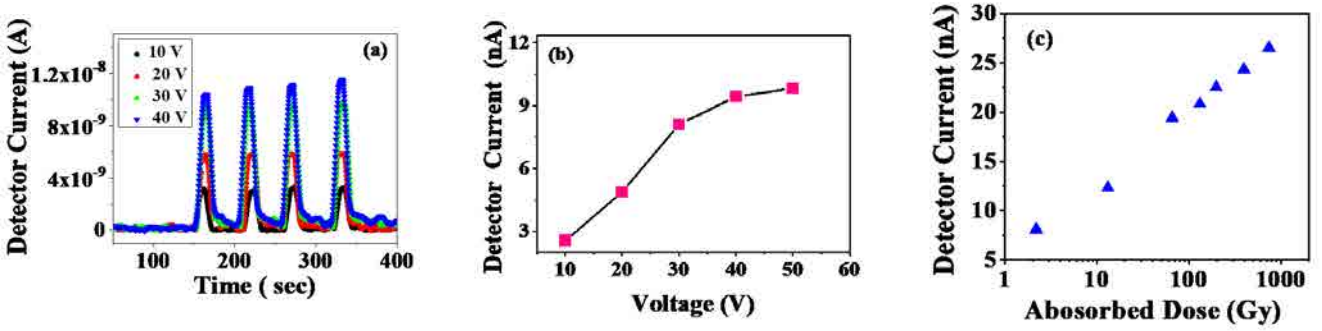
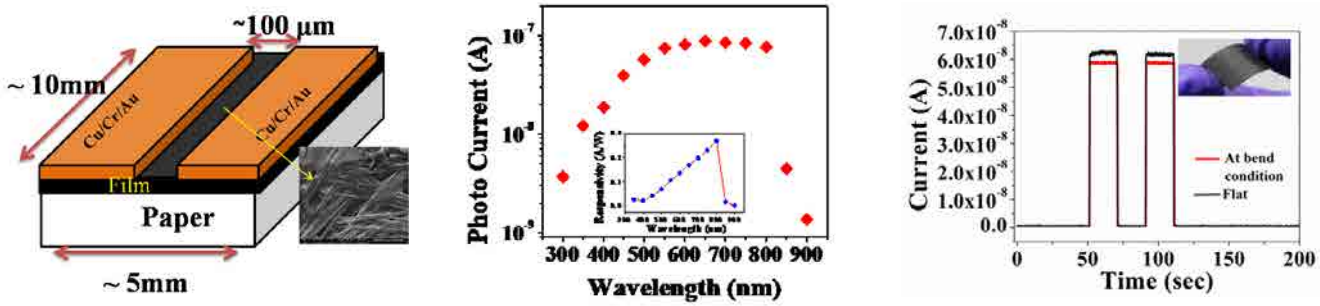


Figure 2: a) Current Response by γ ray detector (using Co-60 source) b) Voltage dependent current response by the detector c) Detector Current as function of absorbed dose



3.(a)Schematic of the wearable electronics based flexible photo detector, b) Spectral Response of the photo current (illumination intensity 120 µW/cm2) Inset :Spectral dependence of the Responsivity. (C) Comparison of response of flexible photo detector in flat/bend condition

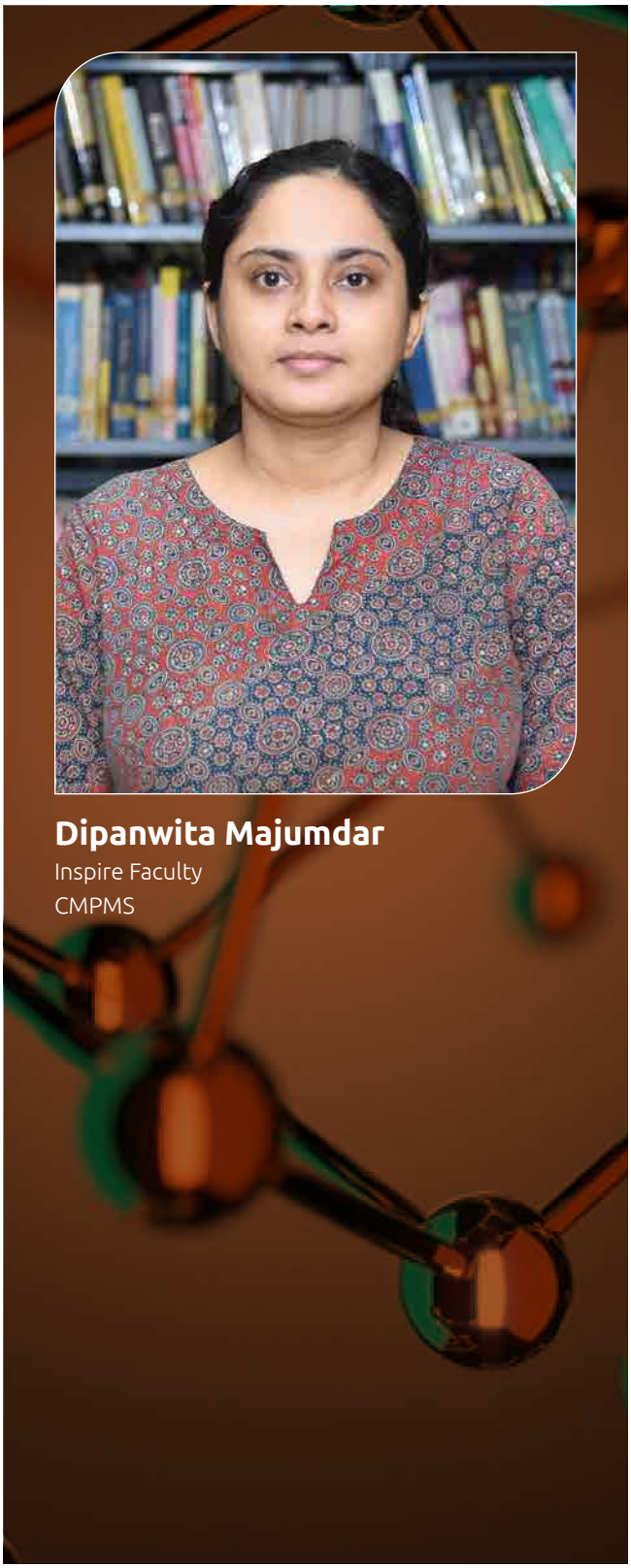
Plan of Future Work Including Project

1. A) Basic research: i))Synthesis & optical properties, crystallographic structure microstructural study on Perovskite halide systems ii)Physics of Perovskite Oxides: understanding of growth, crystallographic and low temperature transport and magneto transport property iii) Optoelectronics property study on semiconductors iv) Growth and Physical property study on piezoelectric nanostructures iii) Study of interface physics of complex and binary Oxide thin films and multilayers B).Work under Project: SERB ref no: EMR-2016/002855 dated 20/3/2017 Synchrotron and Neutron Diffraction study on perovskite oxides 2) 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:. Further work is under study.

B) Technology development related work: under TRC: 1) Gas Sensors & Energy devices: i)Development of Hazards gas sensors: It works as visual as well as electrical sensing mode. It could have potential to detect sub ppm capability for real time practical usage will be useful. It is extremely useful for Environment protection as well as health care sector. Modification of prototypes is under process. ii) Development of Energy Devices: Portable power generation system as nanogenerator using piezoelectric nanostructures: publication: Snehamoyee Hazra, Subhamita Sengupta, Soumyaranjan Ratha, Ankita Ghatak, A K Raychaudhuri and Barnali Ghosh* Nanotechnology 33 (2022) 155403 iii) Development of Radiation detectors: A detector for real time quick monitoring of gamma radiation at work places as well as medical Sciences.

Any other Relevant Information including social impact of research

1. Social Impact research: Engineering emerging materials as new Generation Detectors, Sensors and Energy Devices: 1) Radiation Detector , 2) Hazardas (Ammonia) gas detector, 3) Nanogenerator 1)Radiation Detector: A detector for real time quick monitoring of gamma radiation Novelty of our invention, application areas &social impact: There are several areas like nuclear imaging; cancer therapy; security checking, where needs radiation detector just as a quick tracer of presence of gamma radiation. Conventional techniques are not easy to use. A deviated approach for gamma ray detection not by energy resolution rather via electrical read out method at room temperature using this novel solid state radiation detector as a quick marker of gamma radiation. This Detection technique could be extremely useful in radiation prone areas, in a quick and cost effective way - where fine energy resolution is not a primary concern. Moreover the detector is Highly Radiation Resistant. 2)Gas Sensors: We developed a visual sensor Based on colour change grown on paper. It could have potential to detect sub ppm capability for real time practical usage. It is extremely useful for Environment protection as well as health care sector. Application areas: Refrigeration industry, Agricultural (fertilizer) industries, Food Beverage and cold storage industries, Medical diagnosis (as marker for renal diseases), chronic kidney diseases (CKD), can be used to check the efficacy of the dialysis. 3) Nanogenerator: Generation of power from waste energy : Application 1)Charging of Mobile, Smart watch, Blue tooth devices etc.



Dipanwita Majumdar
Inspire Faculty
CMPMS

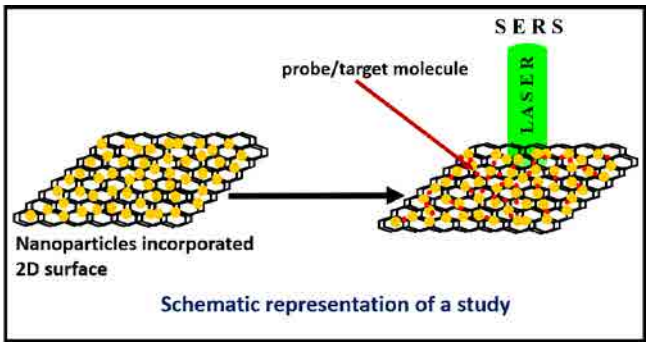
Awards/ Recognitions

1. DST Inspire Faculty Award

Areas of Research

Experimental Condensed Matter Physics

Graphene and its analogues have an atomic-scale flat surface that can be integrated with different nanostructures (NSs) for extending their functionalities. Hybridization changes the vibrational and optical properties significantly. The effects of hybridization have been investigated via structural, vibrational, optical and electronic properties of the composite systems. Surface enhanced Raman scattering (SERS) is a finger-print like spectral technique which offers an increase in Raman signal and is highly dependent on the substrate materials. The utility of the nanohybrid structures as an efficient SERS substrate has been studied by performing concentration-dependent SERS measurements of a highly fluorescent dye. A schematic representation of the study is shown in the adjacent figure. The hybrid systems are found to exhibit promising detection capabilities.



Schematic representation of a study

Plan of Future Work Including Project

- 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

Any other Relevant Information including social impact of research

1. Training for Raman measurements has been given to Mr. Joy Bandopadhyay (Technical Assistant).
2. Member, Users Committee for Micro-Raman Facility.

Kalyan Mandal
Senior Professor
CMPMS
kalyan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Sourav Sarkar; Multiferroic materials; Under progress
2. Ishita Jana; Multiferroic materials; Under progress
3. Soham Saha; Photoelectrochemical water splitting; Under progress
4. Sudipta Chatterjee; Topology; Under progress
5 Saheli Samanta; Magnetocaloric materials; Under progress
6. Anupam Gorai; Microwave properties of transition metal oxides; Under progress
7. Swarnali Hait; Multiferroic materials; Under progress
8. Dipanjan Maity; Photoelectrochemical water-splitting; Thesis submitted
9. Priyanka Saha; Magnetic nanostructures and rheology; Thesis submitted
10. J. Sridhar Mohanty; Magnetocaloric materials; Under progress

Teaching

1. Spring semester; Magnetism and Superconductivity; Integrated Ph.D.; 2 students; with 1 (Ranjan Chaudhury) co-teacher
2. Spring semester; Advanced Laboratory; Integrated Ph.D.; 5 students; with 4 (Rajib Mitra, Manik Pradhan, Ramkrishna Das, Nitesh Kumar) co-teachers
3. Spring semester; Electronics and Instrumentations; Integrated Ph.D.; 9 students; with 1 (Avijit Chaudhury) co-teacher
4. Spring semester; Basic laboratory II; Integrated Ph.D.; 9 studens; with 1 (Avijit Chaudhury) co-teacher
5. Spring semester; Advanced condensed matter I; Ph.D.; 7 students; with 1 (Ranjan Chaudhury) co-teacher

Publications

a) In journals

1. Dipika Mandal and **Kalyan Mandal**, *Tuning of structural, magnetic and dielectric properties of TFe_2O_4 (T = Mn, Fe, Co, Ni, Cu, and Zn) Nano-Hollow Spheres: Effect of cation substitution*, Journal of Alloys and Compounds, 851, 156898, 2021

2. Priyanka Saha, Rupali Rakshit, and **Kalyan Mandal**, *Shear response of magnetorheological fluid with $Zn_{0.2}Fe_{2.8}O_4$ sub-micron hollow spheres*, Journal of Applied Physics, 129, 033901, 2021
3. Mahebub Alam and **Kalyan Mandal**, *Origin of ferroelectricity in multiferroic $ErFeO_3$*, Physica B: Condensed Matter, 612, 412935, 2021
4. Dipika Mandal and **Kalyan Mandal**, *Enhancement of electromagnetic wave absorption in $MnFe_2O_4$ nano-hollow spheres*, Journal of Applied Physics 129, 074902, 2021
5. Arka Chaudhuri, Rupali Rakshit, Kazunori Serita, Masayoshi Tonouchi, and **Kalyan Mandal**, *Electromagnetic Response of $SiO_2@Fe_3O_4$ Core–Shell Nanostructures in the THz Regime*, IEEE Transactions on Magnetics, 57, 2300206, 2021
6. Anupam Gorai, Dipika Mandal and **Kalyan Mandal**, *Multi-layered nano-hollow spheres for efficient electromagnetic wave absorption*, Nanotechnology, 32, 345707, 2021
7. Dipika Mandal, **Kalyan Mandal**, *Electromagnetic wave attenuation properties of MFe_2O_4 (M = Mn, Fe, Co, Ni, Cu, Zn) nano-hollow spheres in search of an efficient microwave absorber*, Journal of Magnetism and Magnetic Materials, 536, 168127, 2021
8. Indranil Chakraborty, Deblina Majumder, Rupali Rakshit, Mahebub Alam, Suprabhat Mukherjee, Anupam Gorai, and **Kalyan Mandal**, *Magnetic Field-Dependent Photoluminescence of Tartrate-Functionalized Gadolinium-Doped Manganese Ferrite Nanoparticles: A Potential Therapeutic Agent for Hyperbilirubinemia Treatment*, ACS Applied Nano Materials, 4, 4379-4387, 2021
9. Ritwik Maity, Alo Dutta, Saswata Halder, Santiranjan Shannigrahi, **Kalyan Mandal** and T. P. Sinhaa, *Enhanced photocatalytic activity, transport properties and electronic structure of Mn doped $GdFeO_3$ synthesized using the sol–gel process*, Physical Chemistry Chemical Physics, 23, 16060-16076, 2021
10. Saheli Samanta, Subrata Ghosh and **Kalyan Mandal**, *Observation of giant exchange bias effect in Ni–Mn–Ti all-d-metal Heusler alloy*, Journal of Physics: Condensed Matter, 34, 105801, 2022
11. Subrata Ghosh, Saheli Samanta, Jayee Sinha, and **Kalyan Mandal**, *Measurement protocols dependent giant magnetocaloric effect in MnNiSi-based system*, Applied Physics Letters, 119, 183901, 2021
12. Alo Dutta, Anupam Gorai, Dipika Mandal & **Kalyan Mandal**, *Dielectric and microwave absorption properties of $Na_{0.5}Bi_{0.5}TiO_3$–$SrTiO_3$ system*, Ferroelectrics, 583, 252-263, 2021
13. Dipanjan Maity, Keshab Karmakar, Debashish Pal, Soham Saha, Gobinda Gopal Khan, and **Kalyan Mandal**, *One-Dimensional p-$ZnCo_2O_4$/n-ZnO Nanoheterojunction Photoanode Enabling Photoelectrochemical Water Splitting*, ACS Applied Energy Materials, 4, 11599-11608, 2021

b) Conference proceedings / Reports / Monographs / Books

1. D. Maity, K. Mandal, "One-Dimensional p-ZnCo2O4/n-ZnO Nanoheterojunction Photoanode Enabling Photoelectrochemical Water Splitting", Proceedings of Recent Advances in Catalysis Science and Engineering (RACSE) , 26-28 October 2021
2. Saheli Samanta, Subrata Ghosh, and Kalyan Mandal, "Large plateau-like Magnetic entropy change in Sn doped Ni-Co-Mn-Ti all d metal Heusler alloy", Proceedings of Joint MMM - Intermag Conference, 10-14 January 2022
3. Anupam Gorai, Rohan Mandal, Dipika Mandal, "Anupam Gorai, Rohan Mandal, Dipika Mandal, "Enhanced Electromagnetic Wave Absorption by Bi-layered Nano-hollow Spheres", Proceedings of Joint MMM - Intermag Conference, 10-14 January 2022
4. K. Mandal, S. Ghose, M. Mandal, D. Majumder, S. Talukdar, I. Chakraborty, S. K Panda, "Chapter 2-Notes on useful materials and synthesis through various chemical solution techniques" in the book "Chemical Solution Synthesis for Materials Design and Thin Film Device Applications" Ed: S. Das and S. Dhara, (Elsevier, 2021) Pages: 29-78

Administrative duties

1. Vigilance Officer

Membership of Learned Societies

1. Executive committee member, Kolkata chapter, Materials Research Society of India
2. Life member, Magnetics Society of India
3. Life member, Non-destructive Society of India
4. Executive committee member, Indian Physics Teachers Association

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Study of magneto-structural transitions and magneto-caloric effects in inter-metallic compounds: a search for eco-friendly magnetic refrigerant; DST, Govt. of India; 3 years; Co-PI
2. Transition metal oxides and photocatalytic effect; CSIR, Govt of India; 3 years; Co-PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Dr. Gobinda Gopal Khan, Assistant Professor, Tripura Central University, Agartala, Tripura; Sl. No. 13; National

Areas of Research

Magnetism and magnetic materials, Nanoscience and nanotechnology, Energy materials

1. Unusual dielectric properties of hollow magnesium ferrite nanospheres: a potential lightweight microwave absorber:

We observed a combination of dielectric and magnetic experimental signatures on $Mg_xFe_{3-x}O_4$ (x = 0.0, 0.2, 0.3, 0.4 and 1.0) nano-hollow spheres (NHSs) magnetic semiconductor system. Interestingly, $Mg_{0.3}Fe_{2.7}O_4$ NHSs with the maximum value of room temperature dielectric permittivity behave as negative index material in the vicinity of metamagnetic transition. Detailed study reveals that high dipolar fluctuation-assisted back-scattering under strong spin–polaron coupling results in negative dielectric index, while metamagnetic transition takes place due to the ferromagnetic arrangement of spins by overcoming the super-exchange interaction in $Mg_{0.3}Fe_{2.7}O_4$ NHSs. Finally, an excellent electromagnetic wave absorbing efficiency with reflection loss (RL)= 53.8 dB in the 1–20 GHz range is achieved by utilizing high room temperature dielectric and magnetic loss, and the hollow interior of $Mg_{0.3}Fe_{2.7}O_4$ NHSs, opening up a plethora of interesting possibilities in lightweight shielding devices, and waveguides for microwave applications.

2. Dual co-catalysts activated hematite nanorods with low turn-on potential and enhanced charge collection for efficient solar water oxidation

Hematite (α-Fe_2O_3) photoanode suffers from significant photocarrier recombination and sluggish water oxidation kinetics for photoelectrochemical water splitting. To address these challenges, this work demonstrates the construction of dual co-catalysts modified Fe_2O_3 nanorods photoanode by strategically incorporating CoPi and Co(OH)x for photoelectrochemical water oxidation. The Fe_2O_3/CoPi/Co(OH)x nanorods photoanode exhibits the lowest ever turn on potential of 0.4 VRHE (versus reversible hydrogen electrode) and a photocurrent density of 0.55 mA cm−2 at 1.23 VRHE, 358% higher than that of pristine Fe2O3 nanorods. The dual cocatalysts modification enhances the light-harvesting efficiency, surface photovoltage and hole transfer kinetics of the hybrid photoanode. The dual co-catalyst coupling also increases the carrier density and significantly reduces the depletion width (1.9 nm), resulting in improved conductivity and favorable band bending, boosting photogenerated hole transfer efficiency for water oxidation.

3. Observation of giant exchange bias effect in Ni–Mn–Ti all-d-metal Heusler alloy

We observed a giant exchange bias (EB) field of about 3.68 kOe during field cooled process in all-d-metal Ni 40 (FeCo) 4 Mn 36 Ti 20 Heusler alloy. The study of magnetic memory effect and isothermal magnetic relaxation processes suggest that the giant EB field arises due to the possible coexistence of antiferromagnetic (AFM) and ferromagnetic (FM) phase exchange interaction in the studied system at temperatures below 35 K. Furthermore, the temperature and cooling field dependence of EB effect are analyzed which are related to the change in unidirectional anisotropy at FM/AFM interface. The study of a well-established training effect confirms the intrinsic nature of the observed EB behavior. This result will open up a new way toward the development of EB materials considering all-d-metal Heusler alloy systems.

Plan of Future Work Including Project

1. Effort will be made to prepare Low-cost energy efficient environment-friendly materials with giant magnetocaloric effect. Magnetic refrigeration using those materials is also planned.
2. Light-weight multilayered nano-hollow-spheres with efficient microwave absorbing properties will be developed.
3. Various nano-sized heterojunctions will be attempted to develop highly efficient cost-effective materials for photoelectrochemical water splitting.

Manoranjan Kumar
Associate Professor
CMPMS
manoranjan.kumar@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Sk Saniur Rahaman; Quantum Phases in Quasi-One Dimensional Frustrated Spin Systems; Under progress; M Sanjay Kumar (Co-supervisor)
2. Koushik Mandal; Theoretical investigation of the properties of correlated fermionic systems in low dimension; Under progress; Ranjan Chaudhury (Supervisor)
3. Monalisa Chatterjee; Topological aspect of Frustrated low dimensional Spin Systems; Under progress
4. Jyotirmoy Sau; Topology in Correlated Systems; Under progress
5. Sudip Kumar Saha; Thermodynamics of Low-Dimensional Interacting Quantum Systems: A Hybrid Exact Diagonalization and Density Matrix Renormalization Group Study; Thesis submitted
6. Sayan Ghosh; Ground state quantum phase diagram for a Kagome Stripe; Under progress
7. Manodip Routh; Thermal and quantum fluctuations in low dimensional strongly correlated systems; Under progress
8. Sourabh Saha; The study of triangular lattice Hubbard model by the Density Matrix Renormalization Group Method; Under progress

b) Post-Docs

1. Sumit Halder; Principal component analysis to study the phase behaviour and phase transitions in several classical spin models and quantum systems using the data generated from the classical Monte Carlo and determinant quantum Monte Carlo methods
2. Santanu Pal; Frustrated spin system on Shastry-Sutherland Lattice

c) External Project Students / Summer Training

1. Khush Dave; Origin and Introduction to Spin-system Models: Study of Ising and Heisenberg spin-1/2 models; IISER Bhopal

Teaching

1. Autumn semester; Advanced Quantum Mechanics and Applications (2021); Ph.D.; 6 students; with 1 (Prof. M Sanjay Kumar) co-teacher

2. Spring semester; Correlated systems and disorder (2022); Ph.D.; 9 students
3. Spring semester; Advanced Condensed Matter Physics II (2021); Ph.D.; with 1 (Prof. Tanushri Saha Dasgupta) co-teacher

Publications

a) In journals

1. Gaurav K. Shukla, Jyotirmoy Sau, Nisha Shahi, Anupam K. Singh, **Manoranjan Kumar**, and Sanjay Singh, *Anomalous Hall effect from gapped nodal line in the Co_2FeGe Heusler compound*, Physical Review B, 104, 195108, 2021
2. Sambunath Das, Dayasindhu Dey, **Manoranjan Kumar**, and S. Ramasesha, *Quantum phases of a frustrated spin-1 system: The 5/7 skewed ladder*, Physical Review B, 104, 125138, 2021
3. Sudip Kumar Saha, Manodip Routh, **Manoranjan Kumar**, and Zoltán G. Soos, *Low-temperature thermodynamics of the antiferromagnetic J_1–J_2 model: Entropy, critical points, and spin gap*, Physical Review B, 103, 245139, 2021
4. Sambunath Das, Dayasindhu Dey, S. Ramasesha and **Manoranjan Kumar**, *Quantum phases of spin-1 system on 3/4 and 3/5 skewed ladders*, Journal of Applied Physics, 129, 223902, 2021
5. Sk Saniur Rahaman, Shaon Sahoo, **Manoranjan Kumar**, *Quantum phases and thermodynamics of a frustrated spin-1/2 ladder with alternate Ising-Heisenberg rung interactions*, Journal of Physics: Condensed Matter, 33, 265801, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. National conference on Quantum Condensed Matter (QMAT - 2021); Dec 8, 2021; TIFR Mumbai (virtual); 4 days

Administrative duties

1. Hostel Warden
2. Member of computer center working committee
3. Member of library purchase committee
4. Member of VASP
5. Jest coordinator from S. N. Bose National Centre for Basic Sciences, Kolkata

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Exploring Quantum and Thermal fluctuations in Frustrated Magnets at Low Temperature; SERB, DST; 30.12.2020-29.12.2023; PI

Conference / Symposia / Schools organized

1. Theoretical Chemistry Symposium (TCS 2021); Dec 11, 2021; IISER Kolkata (virtual); 4 days
2. International Conference on the Topology in Condensed Matter Systems; Feb 21, 2022; SNBNCBS (Hybrid); 3 days
3. Young Investigators Meet on Quantum Condensed Matter Theory-2021; Nov 16, 2021; NISER, Bhubaneswar (virtual); 4 days

Scientific collaborations with other national / international institutions (based on joint publications)

1. Zoltán G. Soos, Department of Chemistry, Princeton University, Princeton, New Jersey 08544, USA; International
2. Sanjay Singh, Department of Physics, Indian Institute of Technology (BHU), Varanasi 221005, India; National
3. S. Ramasesha, Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore 560012, India; National
4. Shaon Sahoo, Indian Institute of Technology, Tirupati, Andhra Pradesh, 517 506, India; National

Outreach program organized / participated

1. Organizer of colloquium series ("Quantum materials and devices") by distinguished scientist around the world

Areas of Research

Quantum condensed matter theory, Non-equilibrium phenomena in classical and quantum systems, Development of numerical techniques in quantun many-body systems, Topology in low dimensional quantum systems

The focus of our group is mostly in ground state properties, such as exotic phases and quantum phase transitions in strongly correlated low dimensional systems with frustrated interactions and their fate at finite temperature. The study of the condensed matter systems with quantum many body

models has been a frontier area of research in quantum condensed matter physics. The main challenge lies in its rapid increase of Hilbert space size with system size. The well known numerical methods exists with their own limitations. For example, quantum Monte Carlo methods often fail due to sign-problems in presence of frustration in spin systems or fermionic systems away from half filling. Exact numerical solutions of quantum many body systems are limited to small systems. Solving finite temperature (T) is even more challenging than at T = 0 as it involves Boltzmann distribution of all available enegy states.

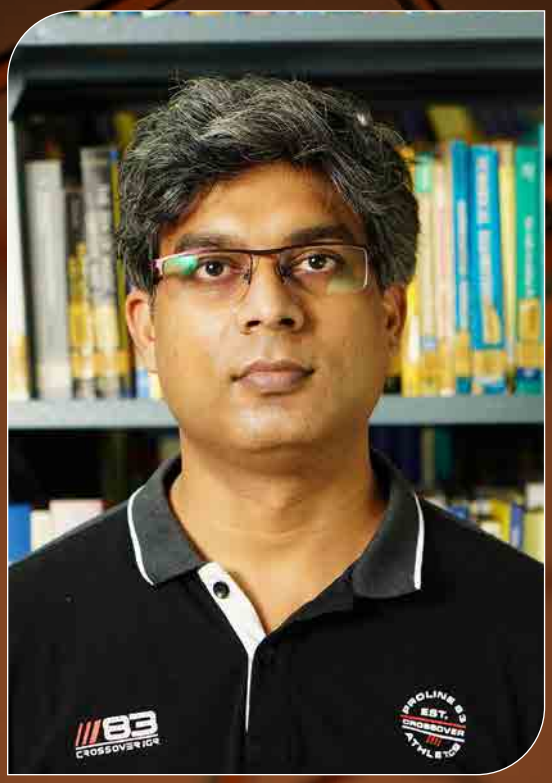
Our group has proposed a hybrid Exact Diagonalization (ED) and Density Matrix Renormalization Group (DMRG) approach [1-4] which is based on combining the ED to study the high temperature and DMRG method for low temperature. Exact diagonalization (ED) can access ground state or a few excited states only for small systems. This is used in the hybrid method to access the high temperature properties since large thermal fluctuation suppress the correlation length and large system size is irrelevant. To obtain low temperature thermodynamics, we solve low energy spectrum using of larger systems using the density matrix renormalization group (DMRG) method, i.e., a state of art method, based on the systematic truncation of irrelevant degrees of freedom in the system. This procedure is very effective in studying the effect of thermal fluctuations on the exotic phases and their robustness at low temperature where thermal and quantum fluctuations are competing.

Recent research output from our group are the following:

1. We have extended the application of the Hybrid ED/ DMRG method to fermionic Hubbard and extended Hubbard model. The thermodynamics of quarter filled extended Hubbard model is extensively calculated which is rare is literature.
2. The quantum phases of frustrated antiferromagnetic Heisenberg spin-1 systems on the 3/4 and 3/5 skewed two leg ladder geometries is extensively studied.
3. We study the quantum phases in spin-1 model of the 5/7 skewed ladder. This system shows a high spin magnetic state in large rung bond interaction limit. The system also shows the presence of spin current due to simultaneous breaking of both reflection and spin parity symmetries.
4. Full Heusler compounds with cobalt as a primary element show anomalous transport due to the Weyl fermions and broken time-reversal symmetry. We present here the study of anomalous Hall effect (AHE) in the Co_2FeGe Heusler compound. The experimental analysis of anomalous Hall resistivity suggests the scattering independent intrinsic mechanism dominates the overall behavior of anomalous Hall resistivity. The first-principles calculation reveals that the Berry curvature originated by a gapped nodal line near E_F is the primary source of AHE in the Co_2FeGe Heusler compound.
5. We study a quasi-one dimensional spin-1/2 ladder with alternate rung interactions as Ising and HB type. We report four different exotic phases in the ground state using ED method. Taking advantage of the fact that Hamiltonians of each of the units in the ladder commute, we use the Transfer Matrix method for studying the thermodynamic properties for the different ground state phases.

Plan of Future Work Including Project

1. Frustrated magnetism has been a frontier area of research in condensed matter research, and these systems host varieties of exotic phase. These systems has experienced a tremendous push on both theoretical and experimental fronts since couple of decades. The exotic quantum phases like spin liquid phase, the dimer phase, the vector chiral phase, multipolar phase have unique feature and may be exploited for various technological applications . Recently, kagome lattice, a corner sharing triangle type of structure, is a highly promising material with geometrically frustrattion, Shastri-Shutherland lattice with ferromagnetic exchange interaction is another interesting system and exhibits many interesting quantum phases. Our group is also interested in topological aspect of low dimensional frustrated magnetic systems. The competition between the thermal and quantum fluctuations are another area of research interest.
2. The origin of ferromagnetism in Hubbard model is quite interesting and it can be observed in flat band systems. Nagaoka and Thouless showed for the first time that the Hubbard model can generate ferromagnetism and it satisfies the Stoner criterion because of the large Coulomb interaction U. The mechanism in various systems like ladder and quasi-one dimensional systems are still not well understood. We plan to study some realistic flat band model systems and tries to see the instabilities in the interacting limit. We will also study if the superconducting and magnetic states can coexist in these systems. If yes, what is the mechanism to stabilize the coexistence.



Nitesh Kumar
Assistant Professor
CMPMS
nitesh.kumar@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Banik Rai; Transport studies of magnetic topological quantum materials; Under progress
2. Arunanshu Panda; Single crystal growth and transport properties of layered topological systems; Under progress

b) External Project Students / Summer Training

1. Rajdwip Bhar; Investigation of Kagome topological systems

Teaching

1. Autumn semester; Condensed Matter Physics; Integrated Ph.D.; 16 students

Publications

a) In Journals

1. Subhajit Roychowdhury, Sukriti Singh, Satya N. Guin, **Nitesh Kumar**, Tirthankar Chakraborty, Walter Schnelle, Horst Borrmann, Chandra Shekhar, and Claudia Felser, *Giant Topological Hall Effect in the Noncollinear Phase of Two-Dimensional Antiferromagnetic Topological Insulator* $MnBi_4Te_7$, Chemistry of Materials, 33, 8343-8350, 2021
2. Sukriti Singh, Jonathan Noky, Shaileyee Bhattacharya, Praveen Vir, Yan Sun, **Nitesh Kumar**, Claudia Felser, Chandra Shekhar, *Anisotropic Nodal-Line-Derived Large Anomalous Hall Conductivity in ZrMnP and HfMnP*, Advanced Materials, 33, 2104126, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. International Conference on the Topology in Condensed Matter Systems; Feb 23, 2022; S N Bose National Centre for Basic Sciences; 30 minutes

Administrative duties

1. Member of CWEP committee
2. Member of VASP webinar series on Quantum Materials and Devices
3. Member of the Media Cell

Awards, Recognitions

1. Awarded as a Leader of Max Planck-India Partner Group

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. From three-dimensional to two-dimensional quantum anomalous Hall effect in ferromagnetic topological quantum materials; SERB DST, CRG; 3 years; PI
2. Max Planck India Partner Group; Max Planck Society; 5 years; PI

Conference / Symposia / Schools organized

1. International Conference on the Topology in Condensed Matter Systems; Feb 21, 2022; S. N. Bose National Centre for Basic Sciences; 3 days

Scientific collaborations with other national / international institutions (based on joint publications)

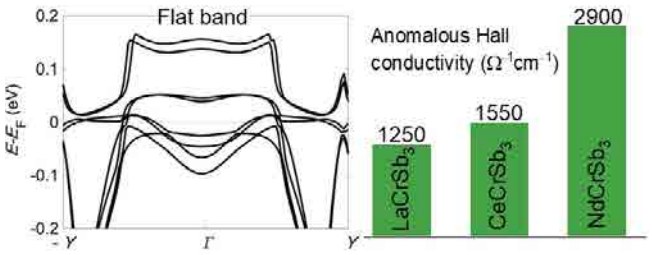
1. Prof. Claudia Felser, Max Planck Institute for Chemical Physics of Solids, Dresden; Sl. No. 2; International

Areas of Research

Single crystal growth and transport properties of quantum materials

Anomalous Hall effect is a characteristic of all ferromagnetic metals and is now established to arise intrinsically from the band structure. Certain features of the band structure such as nodal line crossings or Weyl crossings upon spin orbit coupling are known to facilitate large Berry curvature effect along with large anomalous Hall conductivity (AHE). In MnAlGe, a layered ferromagnet wherein the magnetic layers of Mn are separated by nonmagnetic AlGe spacers, we find that the nodal line is quite close to the Fermi energy. Upon application of spin orbit coupling the nodal lines is gapped out and functions as a source of large Berry curvature. We observe a correspondingly large AHE of 700-800 S/cm at low temperature which is dominated by intrinsic mechanism. Moreover, we show that the anomalous Hall conductance per Mn-layer is equivalent to conductance quanta i.e. e^2/h, which means that it behaves as a 3D quantum anomalous Hall system.

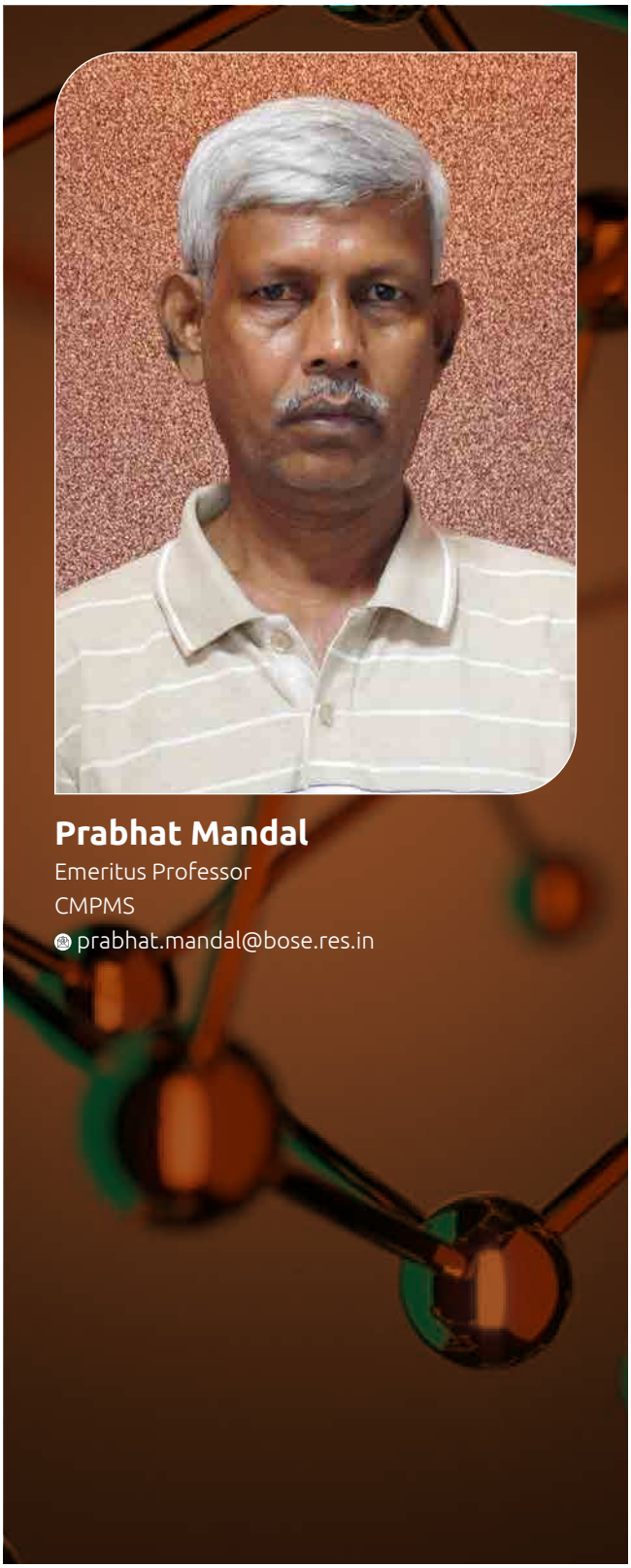
In another ferromagnetic system $LaCrSb_3$, we have found extraordinary anomalous Hall effects. Our investigations suggest that flat bands in $LaCrSb_3$ generates a strong Berry curvature by abundant momentum-space crossings and narrow energy-gap openings, which are the primary sources of the anomalous Hall conductivity. The rather two-dimensional nature of the magnetic subunit in $LaCrSb_3$ imparts huge anisotropy in the anomalous Hall effect. After introducing f-electrons, anomalous Hall conductivity experiences more than two-fold increase and reaches 2900 S/cm in $NdCrSb_3$.



We have studied topological Hall effect (THE) in $MnBi_4Te_7$. $MnBi_4Te_7$ is a two-dimensional Z2 antiferromagnetic (AFM) topological insulator with a Néel temperature of ~13 K. In AFM materials, the THE is observed owing to the existence of nontrivial spin structures. A material with noncollinearity that develops in the AFM phase rather than at the onset of the AFM order is particularly important. In this study, we observed that such an unanticipated THE starts to develop in a $MnBi_4Te_7$ single crystal when the magnetic field is rotated away from the easy axis (c-axis) of the system. Furthermore, the THE resistivity reaches a giant value of ~7 μΩ-cm at 2 K when the angle between the magnetic field and the c-axis is 75°. This value is significantly higher than the values for previously reported systems with noncoplanar structures. The THE can be ascribed to the noncoplanar spin structure resulting from the canted state during the spin-flip transition in the ground AFM state of $MnBi_4Te_7$.

Plan of Future Work Including Project

1) Single crystals growth of topological materials by methods such as chemical vapor transport, metal-flux and Bridgman technique
2) Investigation of magnetic and electrical transport properties at ambient and high magnetic field and low temperature and pressure.
3) Establishing the facility for piston based high pressure electrical transport measurement.
4) Electronic properties of quasi-one dimensional systems via transport studies
5) 3D quantum anomalous Hall effect in bulk layered ferromagnets
6) Establishing setup for thermoelectric measurements
7) Electrical transport properties under extremely high pressure using diamond anvil cell.



Prabhat Mandal
Emeritus Professor
CMPMS
prabhat.mandal@bose.res.in

Conference / Symposia / Schools organized

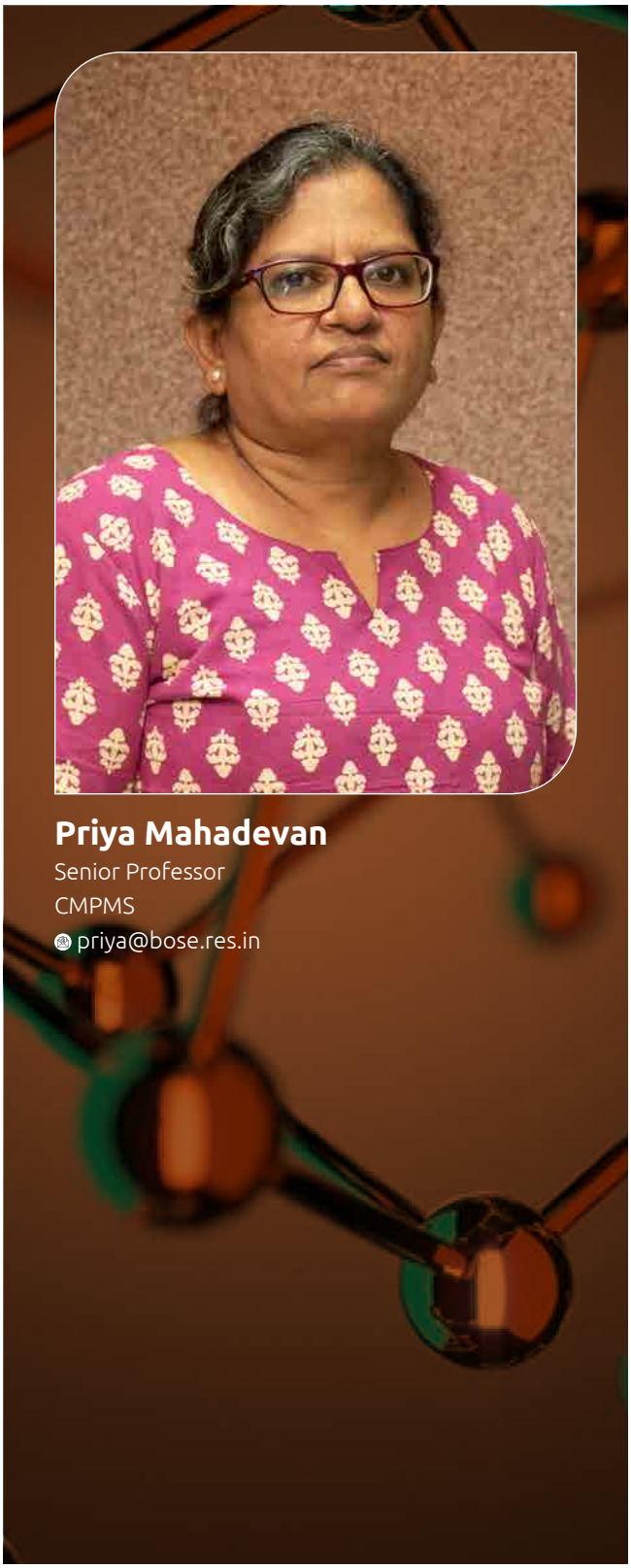
1. International conference on the topology in condensed matter systems; February; 21-23, 2022; 3 days

Areas of Research

Topological Insulator, Dirac/Weyl Semimetals, Charge Density Wave, magnetic and non-magnetic van der Waals systems.

We grow very high-quality single crystals of several Dirac/Weyl semimetals and van der Waals compounds and investigated their magnetic, structural and transport properties as functions of temperature, magnetic field and crystallographic directions. Recently we have studied the magnetotransport properties of CaAuAs and $CaAu_{0.5}Cu_{0.5}As$ compounds.

The electrical resistivity of both CaAuAs and $CaAu_{0.5}Cu_{0.5}As$ shows metallic behavior. Nonsaturating quasilinear magnetoresistance (MR) behavior is observed in CaAuAs whereas the MR of $CaAu_{0.5}Cu_{0.5}As$ shows a pronounced cusp-like feature in the low-field regime due to the weak antilocalization (WAL) effect. The WAL effect is analyzed using different theoretical models, including the semiclassical ~√B one and the modified Hikami-Larkin-Nagaoka model. A strong WAL effect is also observed in the longitudinal MR, which is well described by the generalized Altshuler-Aronov model. Our study suggests that the WAL effect originates from weak disorder and the spin-orbit coupled bulk state. Interestingly, we have also observed the signature of chiral anomaly in longitudinal MR when both the current and field are applied along the ***c*** axis. The charge conduction mechanism in these compounds is dominated by the holes with a concentration ~10^{20} cm^{-3} and mobility ~10^{2} cm^{2} V^{-1} s^{-1}.



Priya Mahadevan
Senior Professor
CMPMS
priya@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Poonam Kumari; The effect of spin-orbit coupling on electronic structure, magnetism and optical properties of transition metal compounds; Awarded
2. Joydeep Chatterjee; Electronic and structural properties of semiconductor heterostructures; Thesis submitted
3. Sumanti Patra; Electronic, structural and optical properties of transition metal dichalcogenide heterostructures; Thesis submitted
4. Prasun Boyal; Role of spin-orbit interactions in layered semiconductors; Under progress
5. Debayan Mondal; Investigating electronic and structural properties of hybrid materials; Under progress
6. Shivam Mishra; Growth mechanism and electronic properties of semiconductor nanoplatelets; Under progress
7. Krishnendu Patra; Re-examining metal-insulator transitions in transition metal compounds; Under progress
8. Shinjini Paul; Electronic, structural and magnetic properties of few layer transition metal compounds; Under progress
9. Sanuja Khuntia; Electronic structure of low-dimensional hybrid perovskites; Under progress
10. Shivam Jani; Electronic structure of twisted heterostructures of transition metal compounds; Under progress
11. Madhurita Das; Electronic structure of twisted heterostructures of magnetic semiconductors; Under progress

b) Post-Docs

1. Priyanka Garg; Catalysis
2. Sanjukta Paul; Electronic structure of twisted bilayers of transition metal dichalcogenides

c) External Project Students / Summer Training

1. K.M. Sougandh; Electronic structure of semiconducting quantum dots - the role of stoichiometry; Centre for Basic Science, Mumbai
2. Abhishek Sharma; Spin-lattice relaxation times of single donors and cluster donors in silicon; IIT Dhanbad, Dhanbad

Teaching

1. Autumn semester; Quantum Mechanics 1; Integrated Ph.D.; 9 students

Publications

a) In journals

1. Feng Liu, Debayan Mondal, Kai Zhang, Ying Zhang, Keke Huang, Dayang Wang, Wensheng Yang, **Priya Mahadevan** and Renguo Xie, *Zero-dimensional plate-shaped copper halide crystals with green-yellow emissions*, Materials Advances, 2, 3744-3751, 2021
2. Rohit Kumar Rohj, Akmal Hossain, **Priya Mahadevan** and D. D. Sarma, *Band Gap Reduction in Ferroelectric $BaTiO_3$ Through Heterovalent Cu-Te Co-Doping for Visible-Light Photocatalysis*, Frontiers in Chemistry, 9, 682979, 2021
3. Feng Liu, Tongjin Zhang, Debayan Mondal, Shiyong Teng, Ying Zhang, Keke Huang, Dayang Wang, Wensheng Yang, **Priya Mahadevan**, Yong Sheng Zhao, Renguo Xie, Narayan Pradhan, *Light-Emitting Metal-Organic Halide 1D and 2D Structures: Near-Unity Quantum Efficiency, Low-Loss Optical Waveguide and Highly Polarized Emission*, Angewandte Chemie, 60, 13548-13553, 2021
4. Debayan Mondal and **Priya Mahadevan**, *Shape Control of Emissive Properties of Mn-Doped $CsPbBr_3$ Nanocrystals*, The Journal of Physical Chemistry C, 125, 11462-11467, 2021
5. Shishir Kumar Pandey, Abhinav Kumar, Sagar Sarkar, and **Priya Mahadevan**, *Understanding the ferromagnetic insulating state in Cr-doped VO_2: Density functional and tight binding calculations*, Physical Review B, 104, 125110, 2021
6. Biswajit Pabi, Debayan Mondal, **Priya Mahadevan**, and Atindra Nath Pal, *Probing metal-molecule contact at the atomic scale via conductance jumps*, Physical Review B, 104, L121407, 2021
7. Shubhrasish Mukherjee, Didhiti Bhattacharya, Sumanti Patra, Sanjukta Paul, Rajib Kumar Mitra, **Priya Mahadevan**, Atindra Nath Pal, and Samit Kumar Ray, *High-Responsivity Gate-Tunable Ultraviolet–Visible Broadband Phototransistor Based on Graphene–WS_2 Mixed-Dimensional (2D-0D) Heterostructure*, ACS Applied Materials & Interfaces, 14, 5775-5784, 2022
8. Yutaka Nikaido, Tom Ichibha, Kenta Hongo, Fernando A. Reboredo, K. C. Hari Kumar, **Priya Mahadevan**, Ryo Maezono, and Kousuke Nakano, *Diffusion Monte Carlo Study on Relative Stabilities of Boron Nitride Polymorphs*, The Journal of Physical Chemistry C, 126, 6000-6007, 2022
9. Suman Bera, Biswajit Hudait, Debayan Mondal, Sanjib Shyamal, **Priya Mahadevan**, and Narayan Pradhan, *Transformation of Metal Halides to Facet-Modulated Lead Halide Perovskite Platelet Nanostructures on A-Site Cs-Sublattice Platform*, Nano Letters, 22, 1633-1640, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. Invited speaker at International virtual conference on Functional Materials and Applied Physics (FMAP 2021), SVNIT Surat; May 15, 2021; online; 14-15 May, 2021
2. Invited talk at International Physics webinar at Pabna University of Science and Technology, Pabna Bangladesh; Jun 21, 2021; online; 21 June, 2021
3. Invited talk at QMAT 2021, TIFR Mumbai; Dec 9, 2021; online; 8-11 December, 2021
4. Invited talk at J. Physics (Materials) webinar; Dec 17, 2021; online; 17 December, 2021
5. Invited talk at International Conference on the Topology in Condensed Matter Physics, SN Bose centre, Kolkata, February (2022); Feb 21, 2022; online; 21-23 February, 2022
6. Invited talk at NanoGe Spring meeting in Semiconductor Nanocrystals: Basic Science session; Mar 7, 2022; online; 7-11 March, 2022
7. Talk at American Physical Society March meeting; Mar 16, 2022; online; 14-18 March, 2022

Administrative duties

1. Head of the Department of CMPMS
2. Member of the Advisory group of the computer centre

Awards, Recognitions

1. Elected TWAS Fellow in 2022.
2. SERB-POWER Fellow (2021-2024)
3. Editorial advisory board member (2021-2025), Journal of Magnetism and Magnetic Materials
4. Editorial advisory board member (2021-2023), ACS Energy Letters

Membership of Learned Societies

1. Member of American Physical Society

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Twistronics with transition metal dichalcogenides; SERB; 2020-2025; PI
2. Electronic structure of semiconductor Nanoplatelets; DST-Nanomission; 2018-2022; PI
3. DST Indo-Sweden; DST International Division; 2020-2023; PI
4. SERB POWER; SERB; 2021-2024; PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Explained the large quantum yield for optical transitions as well as the formation of the self-trapped exciton.; Sl. No. 1, 3; International
2. Explored co-doping of ferroelectric BaTiO3 as a route to reducing the band gap while retaining the insulating ground state; Sl. No. 2; National
3. Explained the unusual observations of jumps in the conductivity in molecular junctions; Sl. No. 6; National
4. Explained the larger photoresponse in nanosheets as compared to multilayers of WSe2-graphene photodetectors; Sl. No. 7; National
5. The relative stability of various polymorphs of BN was examined; Sl. No. 8; International
6. Some basic rules for growth of one material over another were examined; Sl. No. 9; National

Outreach program organized / participated

1. Invited talk at RRCAT student seminar, March 4, 2022

Areas of Research

Electronic, structural and magnetic properties of materials, growth of semiconductors, modelling transport in single molecule devices

Changing the growth conditions from halide rich to halide poor conditions, allows the stabilization of certain facets in $CsPbBr_3$ nanocrystals. In J. Phys. Chem. C 125, 11462 (2021), we have examined Mn doping into the low-energy facets that are realised. While doping into the cubic facets leads to the Mn-dopant-induced states arising in the band gap of the host material, we find that doping into the noncubic facets results in the minority spin Mn d states lying in the conduction band of the host material. Although the majority spin Mn d states lie in the band gap, the transition of a photoexcited electron takes place from the host conduction band to the majority spin Mn d states. Hence it is non-emissive in contrast to the case of a Mn internal transition for the cubic facets. This study therefore provides us with a route to enhanced optical properties by tuning the surface area, as well as the specific facet that is stabilised, in addition to explaining how the same dopant atom in different shapes of the same material could have different emissive properties.

There are some empirical observations on the nature of the electronic ground state in magnetic materials. Most examples of ferromagnets are metals, while antiferromagnets are insulators. Considering the case of Cr doping into the rutile phase of VO_2, experiments find a ferromagnetic insulating state which is also charge ordered. In Phys. Rev. B 104, 125110 (2021), we have investigated the origin of this unusual ground state at 12.5% as well as 25% Cr doping using a combination of ab initio electronic structure calculations as well as microscopic modeling. A ferromagnetic insulating state is found at 12.5% which is consistent with the dopant range in experiments where it has been seen. The doped Cr atoms are found to be in the +3 valence state instead of +4 which is expected for an isovalent substitution. This is achieved by the transfer of an electron from one of the neighboring V sites, rendering the latter with a valency of +5. While the distortion of the Cr-O and V-O bond lengths involves a large component of strain energy to stabilize the unusual valencies of Cr^{+3} and V^{+5}, the large Hund's intra-atomic exchange on Cr favoring a d^3 configuration as well as the attractive Coulomb

interactions between Cr^{+3}-V^{+5} ions help in stabilizing it. The charge ordering of Cr^{+3}-V^{+5} ions also facilitates hopping if the spins are aligned ferromagnetically and is reminiscent of a "frozen-in" double-exchange configuration.

We carry out a mapping of the ab initio band structure onto a tight binding model for the ferromagnetic case as well as the closest lying antiferromagnetic state at 12.5% doping. Within the model we determine the energy gain from the Cr^{+3}-V^{+5} pathway as well as Cr^{+3}-V^{+4} pathway and show for the first time how charge ordering can stabilize a ferromagnetic insulating state. This mechanism has to compete with other pathways present, and so at larger doping concentrations, we find an antiferromagnetic insulator to be favoured.

Plan of Future Work Including Project

1. The puzzling observation of room temperature ferromagnetism in double perovskites (A2BB'O6), despite having the magnetic lattice of B-ions diluted by non-magnetic B'-ions, have been examined for Sr_2FeReO_6. Ab-initio spin spiral electronic structure calculations along various high symmetry directions in reciprocal space are used to determine the exchange interactions entering an extended Heisenberg model, which is then solved classically using Monte Carlo simulations to determine the ferromagnetic transition temperature Tc. We find that one must consider onsite Coulomb interactions at the nonmagnetic Re sites (U) in order to obtain a Tc close to the experimental value. Analysis of the ab-initio electronic structure as well as an appropriate model Hamiltonian trace the origin of enhancement in Tc with U to the enhanced exchange splitting that is introduced at these sites. This in turn destabilizes the antiferromagnetic exchange channels, thereby enhancing the Tc. The role of occupancy at the non-magnetic sites is examined by contrasting with the case of Sr_2FeMoO_6.

Prosenjit Singha Deo
Professor
CMPMS
deo@bose.res.in

Guidance of Students/Post-Docs/ Scientists during the period under review

a) Ph.D. Students

1. Kanchan Meena; Mesoscopic physics; Under progress
2. Sayan Routh; Condensed matter; Under progress (with Thirupathaiah Setti)

Teaching

1. Spring semester; Mesoscopic physics; Ph.D.; 10 students

Publications

a) Conference proceedings / Reports / Monographs / Books

1. Author - Prosenjit Singha Deo, title of book - Mesoscopic route to time travel, publisher - Springer, October 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Indirect evidence of time travel. Talk delivered at 5th international congress on Physics at Paris, France; Mar 3, 2022; Paris, France, online; 20 minutes

Areas of Research

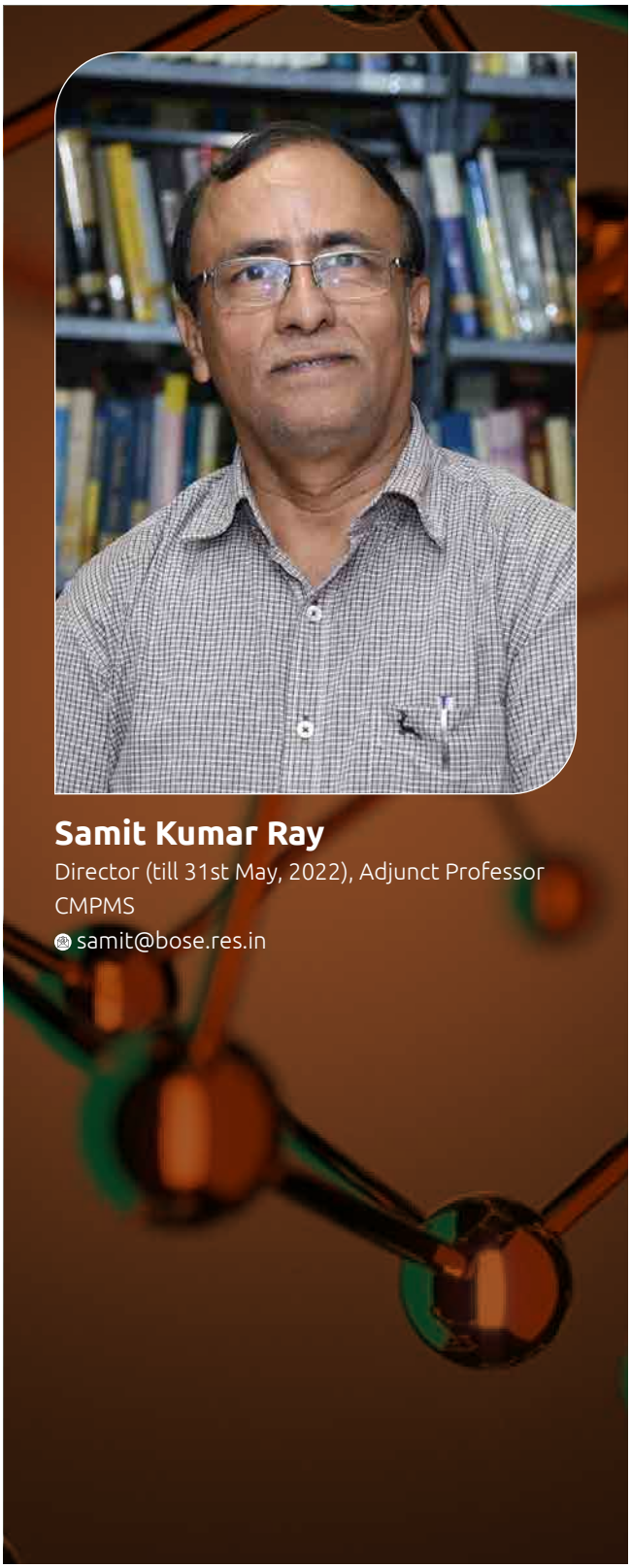
Mesoscopic physics

We have proved that time travel is possible wherein one can send information to the past. Definite experimental situation is provided wherein one can achieve it and it has been indirectly observed too.

We have also studied the role of evanescent modes in determing thermodynamic properties of mesoscopic systems.

Plan of Future Work Including Project

1. Electron-electron interaction in mesoscopic systems



Samit Kumar Ray
Director (till 31st May, 2022), Adjunct Professor
CMPMS
samit@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Didhiti Bhattacharya; 2D materials based piezotronic devices; Under progress; Rajib Kumar Mitra (Co-supervisor)
2. Subhrasish Mukherjee; Electronic and optical properties of 2D semiconductors; Under progress; Atindra Nath Pal (Co-supervisor)

Publications

a) In journals

1. Shubhrasish Mukherjee, Didhiti Bhattacharya, Sumanti Patra, Sanjukta Paul, Rajib Kumar Mitra, Priya Mahadevan, Atindra Nath Pal, and **Samit Kumar Ray**, *High-Responsivity Gate-Tunable Ultraviolet–Visible Broadband Phototransistor Based on Graphene–WS_2 Mixed-Dimensional (2D-0D) Heterostructure*, ACS Applied Materials & Interfaces, 14, 5775-5784, 2022
2. Didhiti Bhattacharya, Sayan Bayan, Rajib Kumar Mitra and **Samit K. Ray**, *2D WS_2 embedded PVDF nanocomposites for photosensitive piezoelectric nanogenerators with a colossal energy conversion efficiency of ~25.6%*, Nanoscale, 13, 15819-15829, 2021
3. Sourabh Pal, Arup Ghorai, Dipak K.Goswami, **Samit K. Ray**, *Strain mediated light emission using heterojunctions of all-inorganic mixed-halide perovskite nanocrystals via piezo-phototronic effect*, Nano Energy, 87, 106200, 2021
4. Janardhan Rao Gadde, Anasuya Karmakar, Tuhin Kumar Maji, Subhrajit Mukherjee, Rajath Alexander, Anjanashree M. R. Sharma, Sarthak Das, Anirban Mandal, Kinshuk Dasgupta, Akshay Naik, Kausik Majumdar, Ranjit Hawaldar, K. V. Adarsh, **Samit Kumar Ray**, and Debjani Karmakar, *Two-dimensional ReS_2: Solution to the unresolved queries on its structure and inter-layer coupling leading to potential optical applications*, Physical Review Materials, 5, 054006, 2021
5. Subhendu Sinha Sarkar, Susnata Bera, Md. Samim Hassan, Sameer Sapra, Ravinder K. Khatri, and **Samit K. Ray**, *$MoSe_2$–$Cu_{2-x}S$/GaAs Heterostructure-Based Self-Biased Two Color-Band Photodetectors with High Detectivity*, The Journal of Physical Chemistry C, 125, 10768-10776, 2021

6. Sayan Bayan, Aniruddha Adhikari, Uttam Pal, Ria Ghosh, Susmita Mondal, Soumendra Darbar, Tanusri Saha-Dasgupta, **Samit Kumar Ray**, and Samir Kumar Pal, ***Development of Triboelectroceutical Fabrics for Potential Applications in Self-Sanitizing Personal Protective Equipment***, ACS Applied Bio Materials, 4, 5485-5493, 2021

7. Aniruddha Adhikari, Uttam Pal, Sayan Bayan, Susmita Mondal, Ria Ghosh, Soumendra Darbar, Tanusri Saha-Dasgupta, **Samit Kumar Ray**, and Samir Kumar Pal, ***Nanoceutical Fabric Prevents COVID-19 Spread through Expelled Respiratory Droplets: A Combined Computational, Spectroscopic, and Antimicrobial Study***, ACS Applied Bio Materials, 4, 5471-5484, 2021

Areas of Research

Developed a sustainable, self-driven UV photodetection system using ternary TMDC alloy ($Mo_xW_{1-x}S_2$) by coupling a photodetector as a light intensity sensor and a piezoelectric nanogenerator (PENG) as a power source. The optimized $Mo_{0.5}W_{0.5}S_2$ ternary alloy nanosheets are used as fillers in PVDF matrix to fabricate flexible self-polled PENGs, exhibiting piezoelectric open-circuit output ~50 V under finger tapping and a record high piezo-voltage ~187 V under impact of 12 kPa. By coupling the two devices, the output voltage of the PENG is tuned by the resistance of the photodetector, exhibiting superior voltage sensitivity (~ 0.75 V $\mu W^{-1}cm^{-2}$) with UV illumination. This self-powered, portable ternary TMD alloy device is attractive for future real-time monitoring of UV radiation and smart health sensors for IOT applications.

The photo response properties of three terminal hybrid devices using ternary alloy $MoS_{2x}Se_{2(1-x)}$ decorated large area graphene in 2D-2D configurations have been studied. The MoSSe device exhibits extremely high photoresponsivity (>10^4 A/W), low noise equivalent power (~10^{-14} W/$Hz^{0.5}$), higher specific detectivity (~ 10^{11} Jones) in the wide UV-NIR (365-810 nm) range with excellent gate tunability. The broadband light absorption of MoSSe, ultrafast charge transport in graphene, along with controllable defect engineering in MoSSe makes this device extremely attractive. The work demonstrates the large area scalability with wafer-scale production of $MoS_{2x}Se_{2(1-x)}$ alloys, having important implication towards facile and scalable fabrication of high-performance optoelectronic devices.

Tanusri Saha Dasgupta
Senior Professor & Director
CMPMS
tanusri@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Shreya Das; Electronic Structure of Oxides; Thesis submitted
2. Shiladitya Kamakar; First-principles study of technologically indigenous materials; Under progress
3. Samir Rom; Study of Heterostructures; Under progress
4. Aishwaryo Ghosh; Application of machine learning in Materials; Under progress
5. Manoj Gupta; Study of topological phases; Under progress
6. Koushik Pradhan; Correlated Electron systems; Under progress
7. Arnab Paul; Correlated Electrons in Oxides; Under progress
8. Rajdeep Biswas; 2D materials; Under progress
9. Edwine Tandong; Properties at interfaces; Under progress

b) Post-Docs

1. Soumendu Dutta; Nano materials
2. Dipayan Sen; Hybrid materials
3. Tanmoy Das; Battery

c) External Project Students / Summer Training

1. Varun R P; Machine learning

Publications

a) In journals

1. Uttam Pal, Kartikey K.Yadav, D.K.Singh, **Tanusri Saha-Dasgupta**, *Extraction behavior of yttrium with Aliquat336 from nitrate and thiocyanate media: A microscopic view from computational analysis*, Materials Today Communications, 28, 102603, 2021
2. Shreya Das, Sreekar Voleti, **Tanusri Saha-Dasgupta**, and Arun Paramekanti, *XY magnetism, Kitaev exchange, and long-range frustration in the J_{eff} = 1/2 honeycomb cobaltates*, Physical Review B, 104, 134425, 2021
3. Anita Halder, Shreya Das, Prabuddha Sanyal & **Tanusri Saha-Dasgupta**, *Understanding complex multiple sublattice magnetism in double double perovskites*, Scientific Reports, 11, 21764, 2021

4. **Tanusri Saha-Dasgupta**, *Understanding and prediction of quantum materials via modelling and computation*, Bulletin of Materials Science, 44, 270, 2021

5. Susmita Mondal, Ria Ghosh, Aniruddha Adhikari, Dr. Uttam Pal, Dipanjan Mukherjee, Pritam Biswas, Dr. Soumendra Darbar, Soumendra Singh, Dr. Surajit Bose, **Prof. Tanusri Saha-Dasgupta**, Prof. Samir Kumar Pal, *In vitro and Microbiological Assay of Functionalized Hybrid Nanomaterials To Validate Their Efficacy in Nanotheranostics: A Combined Spectroscopic and Computational Study*, ChemMedChem, 16, 3739-3749, 2021

6. Hena Das, Alejandro F. Rébola, and **Tanusri Saha-Dasgupta**, *Exploring the possible origin of the spin reorientation transition in $NdCrO_3$*, Physical Review Materials, 5, 124416, 2021

7. Shiladitya Karmakar and **Tanusri Saha-Dasgupta**, *High-performance thermoelectric properties of strained two-dimensional tellurium*, Physical Review Materials, 5, 124006, 2021

8. Samir Rom, Aishwaryo Ghosh, Anita Halder, and **Tanusri Saha Dasgupta**, *Machine learning classification of binary semiconductor heterostructures*, Physical Review Materials, 5, 043801, 2021

9. Aniruddha Adhikari, Susmita Mondal, Monojit Das, Pritam Biswas, Uttam Pal, Soumendra Darbar, Siddhartha Sankar Bhattacharya, Debasish Pal, **Tanusri Saha-Dasgupta**, Anjan Kumar Das, Asim Kumar Mallick, Samir Kumar Pal, *Incorporation of a Biocompatible Nanozyme in Cellular Antioxidant Enzyme Cascade Reverses Huntington's Like Disorder in Preclinical Model*, Advanced Healthcare Materials, 10, 2001736, 2021

10. Soumendu Datta, Uttam Pal, and **Tanusri Saha-Dasgupta**, *Effect of Mg Doping on Structural, Alloying, Electronic, Optical, and Bactericidal Properties of Cu_nAg_{25-n} Nanoclusters: A Computational Study*, The Journal of Physical Chemistry C, 125, 11066-11074, 2021

11. A. Bhattacharyya, T. K. Bhowmik, D. T. Adroja, B. Rahaman, S. Kar, S. Das, **T. Saha-Dasgupta**, P. K. Biswas, T. P. Sinha, R. A. Ewings, D. D. Khalyavin, and A. M. Strydom, *Dynamic spin fluctuations in the frustrated spin chain compound $Li_3Cu_2SbO_6$*, Physical Review B, 103, 174423, 2021

12. Aniruddha Adhikari, Uttam Pal, Sayan Bayan, Susmita Mondal, Ria Ghosh, Soumendra Darbar, **Tanusri Saha-Dasgupta,** Samit Kumar Ray, and Samir Kumar Pal, *Nanoceutical Fabric Prevents COVID-19 Spread through Expelled Respiratory Droplets: A Combined Computational, Spectroscopic, and Antimicrobial Study*, ACS Applied Bio Materials, 4, 5471-5484, 2021

13. Sayan Bayan, Aniruddha Adhikari, Uttam Pal, Ria Ghosh, Susmita Mondal, Soumendra Darbar, **Tanusri Saha-Dasgupta,** Samit Kumar Ray, and Samir Kumar Pal, *Development of Triboelectroceutical Fabrics for Potential Applications in Self-Sanitizing Personal Protective Equipment*, ACS Applied Bio Materials, 4, 5485-5493, 2021

14. Dipanjan Mukherjee, Priya Singh, Soumendra Singh, Debanjona Singh Roy, Subhankar Singha, Uttam Pal, Jhimli Sengupta, Rami J. Obaid, Saleh A. Ahmed, **Tanusri Saha Dasgupta**, Ranjan Das, Samir Kumar Pal, *Host assisted molecular recognition by human serum albumin: Study of molecular recognition controlled protein/drug mimic binding in a microfluidic channel*, International Journal of Biological Macromolecules, 176, 137-144, 2021

15. Pritam Biswas, Dr. Uttam Pal, Aniruddha Adhikari, Susmita Mondal, Ria Ghosh, Dipanjan Mukherjee, **Prof. Dr. Tanusri Saha-Dasgupta**, Dr. Sudeshna Shyam Choudhury, Prof. Dr. Ranjan Das, Prof. Dr. Samir Kumar Pal, *Essential Loop Dynamics Modulates Catalytic Activity in a-Chymotrypsin*, ChemistrySelect, 7, e202104262, 2022

16. Arpan Bera, Md. Nur Hasan, Uttam Pal, Damayanti Bagchi, Tuhin Kumar Maji, **Tanusri Saha-Dasgupta**, Ranjan Das, Samir Kumar Pal, *Fabrication of nanohybrids toward improving therapeutic potential of a NIR photo-sensitizer: An optical spectroscopic and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 424, 113610, 2022

17. Dipayan Sen and **Tanusri Saha-Dasgupta**, *Rational Design of Magnetic Hybrid Transition Metal Double Perovskites in Polyatomic Anionic Systems*, Chemistry of Materials, 34, 1821-1828, 2022

18. K.Denisova, P.Lemmens, D.Wulferding, P.Berdonosov, V.Dolgikh, A.Murtazoev, E.Kozlyakova, O.Maximova, A.Vasiliev, I.Shchetinin, F.Dolgushin, A.Iqbal, B.Rahaman, **T.Saha-Dasgupta**, *$Cu_9O_2(SeO_3)_4Cl_6$ revisited: Crystal structure, Raman scattering and first-principles calculations*, Journal of Alloys and Compounds, 894, 162291, 2022

19. Ria Ghosh, Soumendra Singh, Dipanjan Mukherjee, Susmita Mondal, Monojit Das, Uttam Pal, Aniruddha Adhikari, Aman Bhushan, Surajit Bose, Siddharth Sankar Bhattacharyya, Debasish Pal, **Tanusri Saha-Dasgupta**, Maitree Bhattacharyya, Debasis Bhattacharyya, Asim Kumar Mallick, Ranjan Das, Samir Kumar Pal, *Host-Assisted Delivery of a Model Drug to Genomic DNA: Key Information from Ultrafast Spectroscopy and in silico Study*, ChemBioChem, e202200109, 2022
20. E Tendong, **T Saha-Dasgupta**, J Chakrabarti, *Viscoelastic response of fluid trapped between two dissimilar van der Waals surfaces*, Journal of Physics: Condensed Matter, 34, 195101, 2022
21. Abhisek Bandyopadhyay, A. Chakraborty, S. Bhowal, Vinod Kumar, M. M. Sala, A. Efimenko, F. Bert, P. K. Biswas, C. Meneghini, N. Büttgen, I. Dasgupta, **T. Saha Dasgupta**, A. V. Mahajan, and Sugata Ray, *Breakdown of atomic spin-orbit coupling picture in an apparently isolated pseudo-one-dimensional iridate: Sr_3NaIrO_6*, Physical Review B, 105, 104431, 2022

Talks / Seminars Delivered in reputed conference / institutions

1. Understanding Quantum Materials by Computation : Challenges and Opportunities; Dec 14, 2021; INSA; 45 mins
2. Magnetism in two dimension; Dec 12, 2021; IIT B; 1 hour
3. Magnetism and Spintronics Symposium, Engineering two dimensional ferromagnetism; Nov 25, 2021; NISER, Bhubaneswar; 35 mins
4. Women in Science - Breaking the Glass Ceiling; Mar 8, 2022; UM-DAE Center for Excellence in Basic Sciences; 1 hour
5. IIT Delhi Physics Symposium, Quantum Science and Technology; Dec 3, 2021; IIT Delhi Physics Symposium, Quantum Science and Technology; 1 hour
6. "Interdisciplinary Topics in Advanced Materials" Tale of two nickelates; Jul 27, 2021; IISc; 35 mins
7. Conference on Physics of Nano Materials:PNM20; Aug 20, 2021; INST; 35 mins

Administrative duties

1. Director, S.N.Bose Centre

Awards, Recognitions

1. Elected fellow of Indian National Science Academy

Membership of Learned Societies

1. American Physical Society

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. J C Bose National Fellowship; SERB; Until 2025; PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. Hena Das (Tokyo Institute of Technology); Sl. No.6; International
2. Samir K Pal (S.N.Bose Centre); Sl. No. 5,9,12,13,14,15,16,19; National
3. Arun Paramekanti (Univ Toronto); Sl. No.2; International
4. Alexandre Vasiliev (Moscow State Univ); Sl. No. 18; International
5. Sugata Ray (IACS); Sl. No. 21; National
6. J Chakrabarti (S.N.Bose Centre); Sl. No. 20; National

Outreach program organized / participated

1. Women in Science program; National Science day program, popular talk at Bangiyo Bigyan Parishad

Areas of Research

Computational Materials Physics

Rational Design of Magnetic Hybrid Transition Metal Double Perovskites in Polyatomic Anionic Systems

Motivated by the exciting magnetic properties exhibited by inorganic transition metal based double perovskites $A_2BB'O_6$, we computationally explore designing of hybrid double perovskites with transition metal elements at the B sublattice. We focus our attention on compounds with the organic group methylammonium (MA^+) at the A site and polyatomic cyanide, $(CN)^-$, as the molecular linker. This restricts our search to the monovalent/divalent cation at the B site and trivalent/divalent cations at the B′ site. Fixing Cu as the choice of cation at the B site, we scan the elemental space of the 3d, 4d, and 5d transition metal series. Our study reveals an interesting interplay of electronegativity, crystal field, and filling effect in structural, electronic, and magnetic

properties of these yet-to-be synthesized compounds. Several of the proposed compounds are found to be strongly magnetic with antiferromagnetic coupling and moderately high Neél temperature. Our computational study involving Ag in place of Cu provides rare examples of Ag(II) compounds. *Dipayan Sen and Tanusri Saha-Dasgupta, Chem. Mater.* 2022, 34, 4, 1821–1828

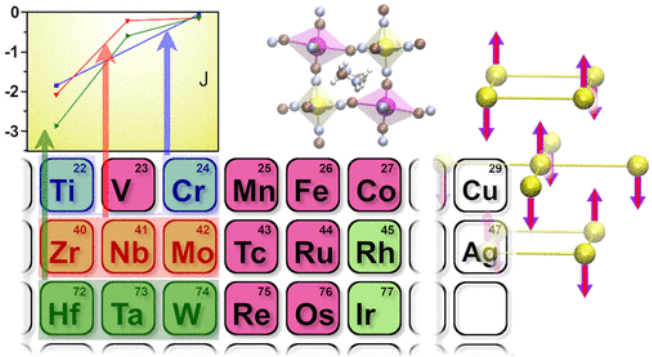


Figure 1: Schematics on study of proposed (MA)2CuM(CN)6 double perovskites.

High-performance thermoelectric properties of strained two-dimensional tellurium

Elemental two-dimensional (2D) materials in monolayer form are attractive due to their simplicity and indigenous properties. In the present study, we investigate the influence of biaxial strain on group VI elemental 2D material of tellurium, which has been discussed for its potential in various applications. Considering realistic estimates of strain that may be imposed to monolayer Te through van der Waals heterostructing with other known 2D materials, we demonstrate that the structural, electrical, and thermal transport properties can get strongly influenced by strain. Importantly, through strain engineering, the thermoelectric performance of elemental 2D Te in p-type doping can be made comparable to that of the known binary or ternary layered compound at room temperature, and can outperform the known binary or ternary layered compounds at high to moderate temperature. The ZT of monolayer Te is found to reach a value of 6.07 at 800 K under tensile strain, being larger than 2 for temperature greater than 400 K. Our study provides a way to tune the thermoelectric properties of 2D Te for future applications. Shiladitya Karmakar and Tanusri Saha-Dasgupta, Phys. Rev. Materials (2021) **5**, 124006

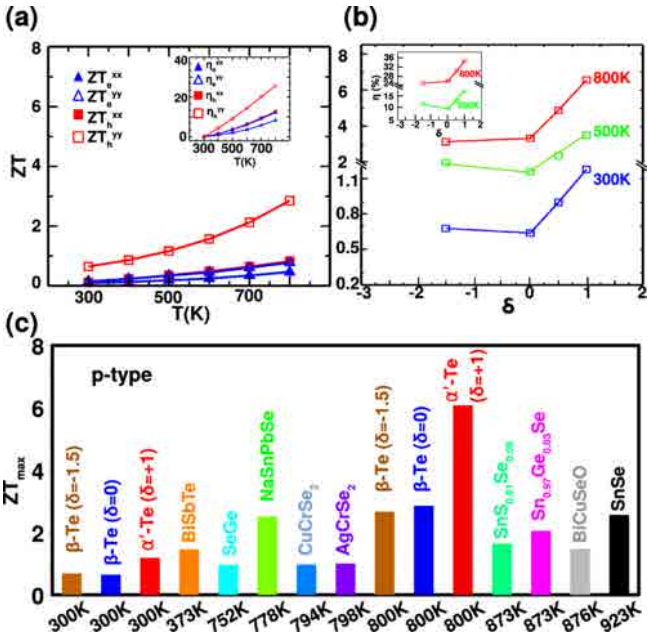
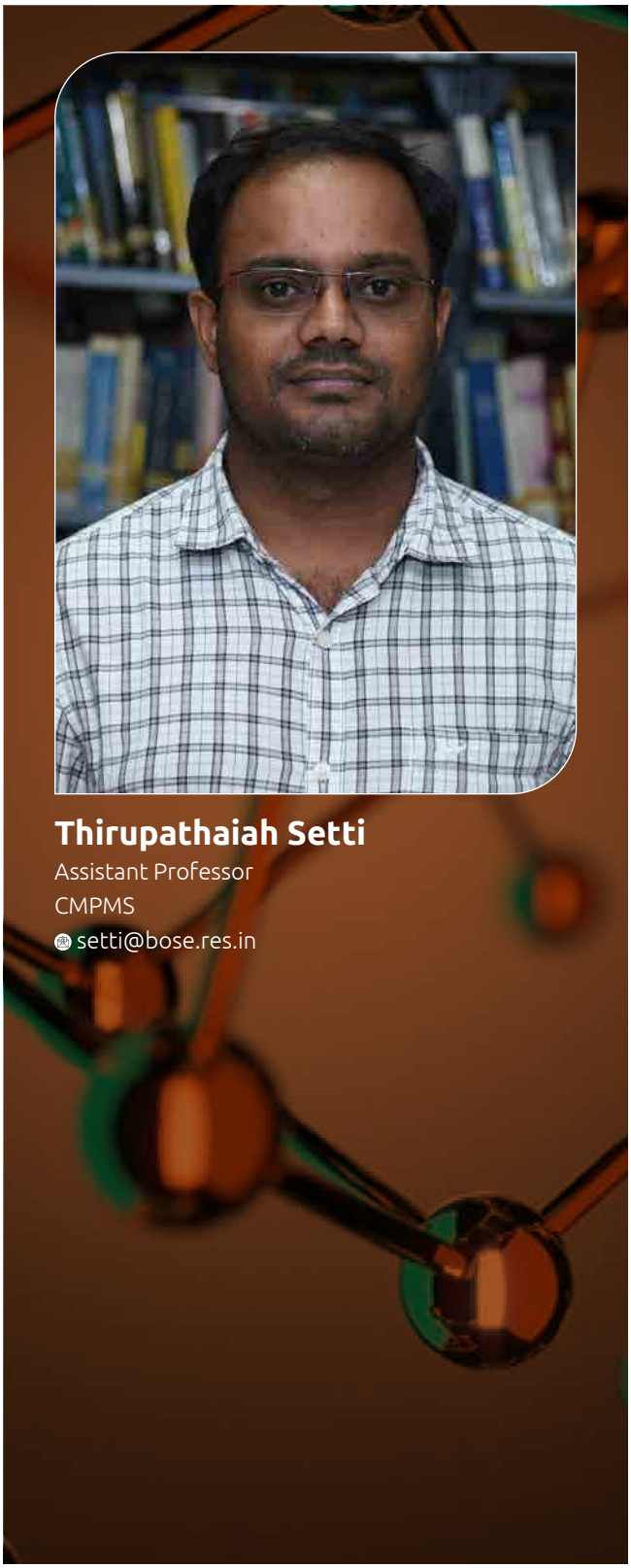


Figure 2: (a) The temperature variation of ZT and TE efficiency (inset) of unstrained Te monolayer, for chosen carrier concentration of 1013cm−2. (b) The variation of ZTyyh with strain at T=300 K, 500 K, and 800 K. The inset shows the corresponding variation of TE efficiency at 500 K and 800 K. (c) Comparison of TE perfomance of strained and unstrained Te monolayer with other known p-type layered materials.

Plan of Future Work Including Project

1. Application of Machine learning in generation of force field
2. Unusual superconductivity in $IrTe_2$
3. Application of machine learning in understanding structural patterns of binary nanoclusters



Thirupathaiah Setti
Assistant Professor
CMPMS
setti@bose.res.in

Guidance of Students/Post-Docs/ Scientists

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; Prof. Prosenjit Singha Deo (Supervisor)
5. Shubham Purwar; 2D Magnetism; Under progress
6. Susanta Ghosh; Topological Quantum Materials; Under progress; Prof. Kalyan Mandal (Supervisor)
7. Soumya Ghorai; Strongly Correlated Systems; Under progress

b) Post-Docs

1. Pankaj Maheswari; Single crystal growth of Topological Systems

Teaching

1. Autumn semester; Project Research; Ph.D.; 1 student
2. Spring semester; PHY203: Electromagnetic Theory; Integrated Ph.D.; 9 students

Publications

a) In journals

1. Sayan Routh and **Setti Thirupathaiah**, *Observation of Exchange Bias in Antiferromagnetic $Cr_{0.79}Se$ Due to the Coexistence of Itinerant Weak Ferromagnetism at Low Temperatures*, ACS Omega, 6, 28012-28018, 2021
2. Susmita Changdar, Grigory Shipunov, Nesta B. Joseph, Nicholas C. Plumb, Ming Shi, Bernd Büchner, Awadhesh Narayan, Saicharan Aswartham, and **Setti Thirupathaiah**, *Anomalous band renormalization due to a high-energy kink in $K_{0.65}RhO_2$ with colossal thermoelectric power factor*, Physical Review Materials, 5, 055402, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Interdisciplinary Topics in Materials Science (ITAM-2021); Jul 29, 2021; IISc & JNCASR; 27th – 30th July, 2021

2. DAE Symposium on Solid State Physics, 2021; Dec 17, 2021; BARC, Mumbai; 15th – 19th Dec, 2021

Membership of Learned Societies

1. American Chemical Society

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Start-up Research Grants; DST; 2 years; PI

Conference / Symposia / Schools organized

1. Invitation for International Conference on the Topology in Condensed Matter Systems; Feb 21, 2022; SNBNCBS; 21st -23rd Feb, 2022

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. SCCU, IISc, India; Sl. No. 2; National
2. IFW Dresden (Germany), PSI (Switzerland); Sl. No. 2; International.

Areas of Research

Experimental Condensed Matter Physics

1. **Large Room-Temperature Pure Topological Hall Effect (THE) in Kagome Antiferromagnet Mn3Sn, and Induced Giant Low-Temperature THE with Fe Doping [A. Low *et al.*, arXiv:2112.15409 (2021)]**

   Mn_3Sn is a fascinating magnetic topological system, showing topological characteristics within the Kagome lattice network due to the non-vanishing Berry phase in the momentum space. For the first time, we find a large pure room-temperature topological Hall effect (THE) in the xy-plane (0001), while the anomalous Hall effect (AHE) has been noticed in the zx-plane (01-10) of Mn_3Sn. With Fe doping, we can induce a giant xy-plane THE in addition to AHE at low temperatures, while still preserving the pure room-temperature THE in $Mn_{2.8}Fe_{0.2}Sn$. Moreover, the AHE in the zx-plane has been increased with Fe doping. Our studies indicate that the topological properties are highly anisotropic in these systems. Most importantly, the novel observation of large room-temperature pure THE observed in Mn_3Sn is quite promising for the realization of room-temperature topotronic-based applications.

2. **Sixfold fermion near the Fermi level in cubic $PtBi_2$ [S. Thirupathaiah *et al.*, SciPost Phys. 10, 004 (2021)]**

   We identify cubic $PtBi_2$ as an ideal candidate for transport studies on topological semimetals. We used a combination of angle-resolved photoemission spectroscopy (ARPES) and density functional theory (DFT) to map the band structure of the system. We found that cubic $PtBi_2$ hosts a sixfold band touching point – a triple Dirac point – in close proximity (10- 20 meV) to the Femi level. To study the essential topological features of the crossing, we use a low-energy effective Hamiltonian which reproduces the ab-initio data. Upon including a weak Zeeman field in the model, we find that the sixfold point can split into a total of twenty type-II Weyl cones.

3. **Anomalous band renormalization due to high energy kink in the colossal thermoelectric material $K_{0.65}RhO_2$ [Susmita Changdar *et al.*, Physical Review Materials 5, 055402 (2021)]**

   We studied the low-energy electronic structure and electronic correlations of $K_{0.65}RhO_2$ using the high-resolution angle-resolved photoemission spectroscopy (ARPES) technique and density functional theory (DFT) calculations. We observe a highly correlated hole pocket on the Fermi surface. We further notice that the correlations are momentum-dependent. Most importantly, two kinks at binding energies of 75 meV and 195 meV have been observed from the band dispersion in the vicinity of the Fermi level. While the low energy kink at 75 meV can be understood as a result of the electron-phonon interaction, the presence of high energy kink at 195 meV is totally a new discovery of this system leading to an anomalous band renormalization. Based on systematic analysis of our experimental data, we propose high frequency bosonic excitations as a plausible origin of the high energy anomaly. Further, we notice that the high energy anomaly has important implications in obtaining the colossal thermoelectric power of $K_{0.65}RhO_2$.

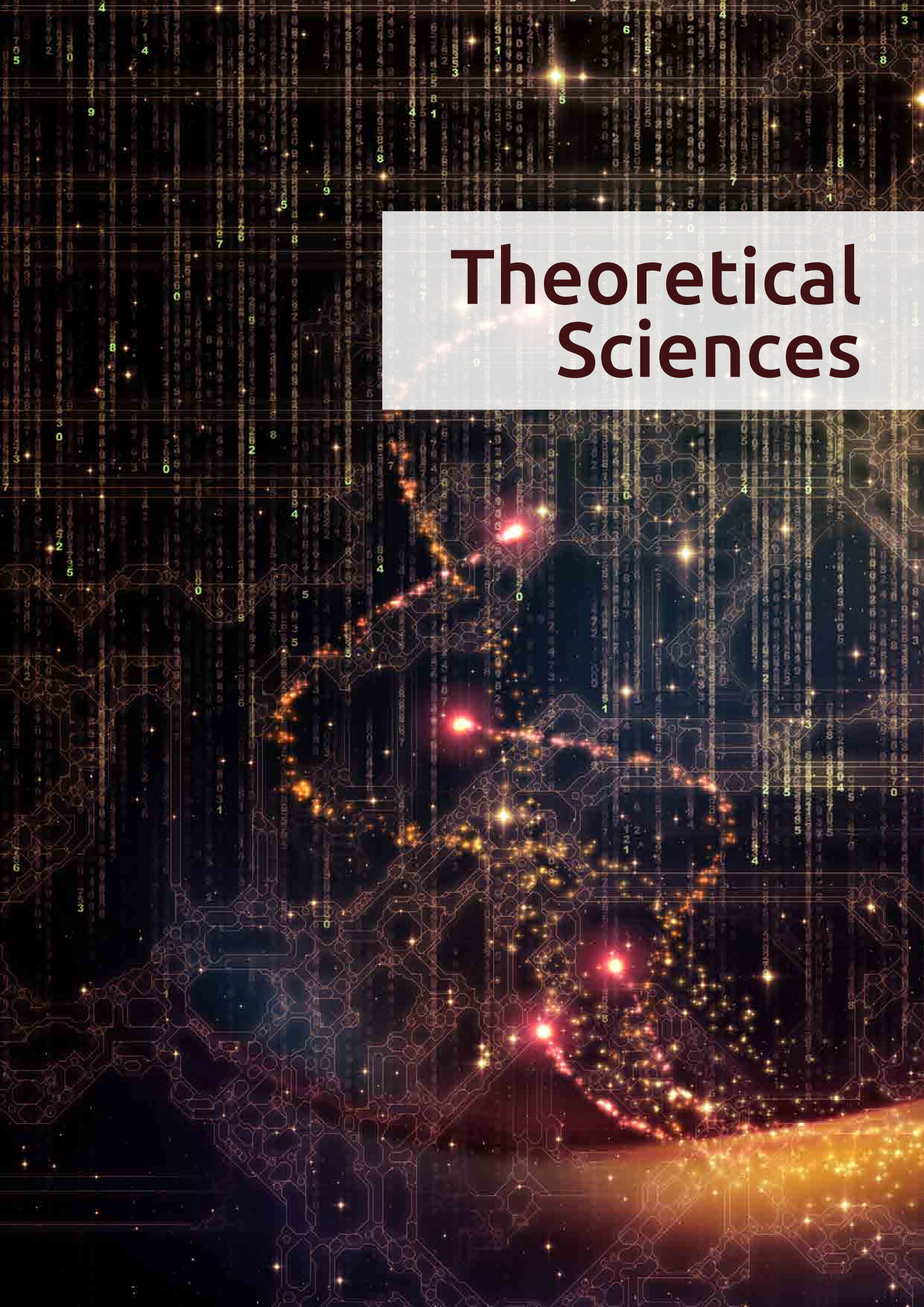
Plan of Future Work including Project

1. Growing high-quality single crystals of Dirac and Weyl semimetals, Transition metal dichalcogenides (TMDC), Quantum spin liquids (QSL), and Two-dimensional (2D) magnetic materials using the solid-state reaction route of molten-growth, flux-growth, and chemical vapor

transport (CVT) techniques. As grown samples will be extensively studied for their electrical, magnetic properties and electronic band structure to understand the underlying physics of these exotic materials.

Any other Relevant Information including social impact of Research

1. Manuscript Submitted/Under Review: Large Room-Temperature Pure Topological Hall Effect (THE) in Kagome Antiferromagnet Mn3Sn, and Induced Giant Low-Temperature THE with Fe Doping, Achintya Low, Susanta Ghosh, S. Thirupathaiah, arXiv:2112.15409 (2021)
2. Conference papers submitted/accepted 1. Effect of Mo doping on the electrical and magnetic properties of antiferromagnetic CrSe, Sayan Routh, P. K. Maheswari, P. Singha Deo, and Setti Thirupathaiah, Materials Today Proceedings 2. Crossover from linear to quadratic magnetoresistance in NiTe2, Indrani Kar, Setti Thirupathaiah, Materials Today Proceedings
3. Awards and Recognitions: 1. Indrani got the "Best Oral Presentation" prize at the International Conference on Advanced Materials and Mechanical Characterization (ICAMMC 2021) 2. Susmita has been awarded the "Materials Advances" Poster Prize at Interdisciplinary Topics in Materials Science (ITAM-2021) conference.


Theoretical
Sciences

Department of
Theoretical Sciences

Punyabrata Pradhan

Department Profile Indicators

Table A: Manpower and Resources

Number of faculty members	11
Number of Post –doctoral research associate (centre+project)	3
Number of Ph.D students	29
Number of other project staff	0
Number of summer students	8
Projects (ongoing)	3

Table B: Research Activities Indicators

Number of research papers in Journals	29
Number of Book-chapters/books	0
Number of other publications	2
Number of Ph.D students graduated (submitted+degree awarded)	4+5=9
Number of M.Tech/M.Sc projects	0

Table C: Academic Activities and Linkage

Number of courses taught by faculty members	11
Number of Visitors (non –associates)	0
Number of associates	0
Number of Seminars organized	11
Number of Conference/Symposia/Advanced Schools organized	3
Number of talks delivered by members of department in conferences/Symposia/ others	National : 7 International : 2

Most important Research Highlights

- The dynamics of electrons in the presence of magnetic flux strings in the Abelian Higgs model has been studied.
- Transport and fluctuations in mass aggregation processes has been studied and a novel type of phase transition characterized by mobility-driven clustering has been found.
- A covariant formulation for the Newton-Hooke particle is presented by following an algorithm developed by us termed galilean gauge theory.
- Hamiltonian formulation of higher rank symmetric gauge theories has been developed.
- Highly nontrivial dependence of the methylation dynamics on the receptor cluster size has been explained through the interplay between the sensing and adaptation modules of the signaling network.
- A class of percolation processes have been shown to be a self-organized critical dynamical process with spatial and temporal manifestations having long-range correlations.
- Entanglement and complexity for mixed states have been holographically quantified by following the prescription of purification.
- The signature of noncommutativity in various measures of entanglement has been uncovered by computing the holographic entanglement entropy corresponding to a strip like subsystem of length l.
- A novel vortex solutions in a rotating holographic superfluid have been obtained by considering a static disc at the AdS boundary and letting the superfluid rotate around it.
- The generalized uncertainty principle (GUP) through quantum noises in optomechanical systems have been probed.
- The exact eigenstates of a two dimensional damped harmonic oscillator, in the presence of an external magnetic field varying with respect to time in time dependent noncommutative space, has been obtained.
- Authors have analytically deduced the frequency dependent expression of conductivity and the band gap energy in AdS_4 Schwarzschild background for p-wave holographic superconductors.
- Authors show that, for a direction reversing active Brownian particle in a harmonic potential in two dimensions, the presence of the two time scales set by the rotational diffusion constant and the reversal rate gives rise to four distinct dynamical regimes.
- The construction of a real structure on a fuzzy sphere in its spin-1/2 representation has been carried out.
- Authors show the emergence of Berry phase in a forced harmonic oscillator system placed in the quantum space-time of Moyal type, where the time 't' is also an operator.
- Authors construct an SU(N) toric code model describing the dynamics of SU(N) electric and magnetic fluxes on a two-dimensional torus.

Summary of Research Activities

A dualized picture of the Abelian Higgs model containing flux tubes (e.g. in a type-II superconductor) in the presence of itinerant electrons has been considered. We found that the dual field had a nonlocal interaction with the electrons. If these strings condense in a stringy Higgs mechanism, there is linear potential between the electrons. The semi-classical picture is a pair of magnetic dipoles (electrons) being joined by a pair of magnetic flux tubes.

The bulk-diffusion coefficient and the mobility in nonequilibrium conserved-mass aggregation processes on a ring have been calculated. When the aggregation dominates over chipping, the mobility of masses is greatly enhanced, resulting in large mass fluctuations and inducing a mobility-driven clustering in the systems. Indeed, in a certain parameter regime, the mobility, along with the mass fluctuation, diverges beyond a critical density, thus characterizing the previously observed nonequilibrium condensation transition.

A covariant formulation for the Newton-Hooke particle is presented by following an algorithm developed by us termed galilean gauge theory. It naturally leads to a coupling with the Newton-Cartan geometry. From this result we provide an understanding of gravitation in a Newtonian geometric background.

Fractons are objects with restricted mobility brought about by the conservation of symmetries that go beyond usual charge conservation. Theory of fractons naturally requires the presence of higher rank tensor theories. Recent discussions of fractons have evolved around higher rank symmetric gauge theories with emphasis on the role of Gauss constraints. This has prompted thauthors to study where a detailed hamiltonian analysis of such theories was presented. Besides a general treatment, the traceless scalar charge theory is considered in details.

Methylation dynamics of the chemoreceptors have been studied in the context of an Escherichia coli cell moveing around in a spatially varying chemoattractant environment. For weak gradient, both for uphill and downhill runs, after the initial demethylation, it has been found that methylation

level increases steadily with time for all cluster sizes. Similar qualitative behavior was observed for strong gradient during uphill runs as well. However, the methylation dynamics for downhill runs in strong gradient show highly nontrivial dependence on the receptor cluster size. We explained this behavior as a result of interplay between the sensing and adaptation modules of the signaling network.

In the chemotactic motion of Escherichia coli, the switching of transmembrane chemoreceptors between active and inactive states is one of the most important steps of the signaling pathway. Authors have studied the effect of this switching time-scale on the chemotactic performance of the cell. We quantified performance by the chemotactic drift velocity of the cell. Simulations on a detailed theoretical model showed that as the activity switching rate increases, the drift velocity increases and then saturates. Also the mean duration of a downhill run decreases strongly with the switching rate, while that of an uphill run decreases relatively slowly.

We have studied a few social inequality measures associated with the sub-critical dynamical features of four self-organized critical models while the corresponding systems approach their respective stationary critical states. It has been observed that these inequality measures (specifically the Gini and Kolkata indices) exhibit nearly universal values though the models studied here are widely different, namely the Bak-Tang-Wiesenfeld sandpile, the Manna sandpile and the quenched Edwards-Wilkinson interface, and the fiber bundle interface. These observations suggest that the self-organized critical systems have broad similarity in terms of these inequality measures. A comparison with similar earlier observations in the data of socio-economic systems with unrestricted competitions suggest the emergent inequality as a result of the possible proximity to the self-organized critical states.

Authors have probed the generalized uncertainty principle (GUP) through quantum noises in optomechanical systems. In this work a simple mechanical oscillator interacting with a single mode optical field inside a cavity has been considered in the generalized uncertainty principle framework (GUP). The commutation relation considered has an extra linear order momentum term along with a quadratic order term. Confronting the theoretical results with the observational results, one gets a much tighter bound on the GUP parameters from the noise spectrum using the values of the system parameters from different experiments.

Holographically quantified entanglement and complexity for mixed states have been considered by following the prescription of purification. The bulk theory considered is a hyperscaling violating solution, characterized by two parameters, hyperscaling violating exponent and dynamical exponent. This geometry is dual to a non-relativistic strongly coupled theory with hidden Fermi surfaces. The holographic analogy of entanglement of purification (EoP), denoted as the minimal area of the entanglement wedge cross section, has been computed. Then in order to probe the mixed state complexity, authors computed the mutual complexity for the well-known BTZ black hole and the hyperscaling violating geometry by incorporating the holographic subregion complexity conjecture.

Authors analytically studied a simple model of active Brownian motion with intermittent direction reversals, common in a class of bacteria like Myxococcus xanthus and Pseudomonas putida. For such a motion in two dimensions, the presence of the two time scales set by the rotational diffusion constant and the reversal rate gives rise to four distinct dynamical regimes showing distinct behaviors. These behaviors are characterized by analytically computing the position distribution and persistence exponents. Most interestingly, when reversal rate is much higher than the rotational diffusion constant, the position distribution in the intermediate regime shows two different scaling behaviours along the direction orthogonal (ballistic scaling) and parallel (diffusive scaling) to the initial orientation.

Authors construct SU(N) toric code model which provides a natural setting for fault tolerant or topological quantum computing. We show that this SU(N) model is exactly solvable and has nonabelian anyons. The braiding statistics of these nonabelian anyons is shown to be encoded in the SU(N) Wigner rotation matrices. All the above features are the general prerequisites for quantum computers.

Punyabrata Pradhan
Head, Department of Theoretical Sciences

Amitabha Lahiri
Senior Professor
Theoretical Sciences
amitabha@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Subhasish Chakrabarty; Field theoretic approach to gravity; Awarded
2. Shantonu Mukherjee; Some applications of quantum field theory to superconductivity and superfluidity; Under progress
3. Indrajit Ghosh; Fermions in curved spacetime (tentative); Under progress
4. Riya Barik; Neutrino interactions induced by torsion (tentative); Under progress
5. Arnab Chakraborty; P and CP violations in gravity (tentative); Under progress
6. Saurav Kantha; Electron-vortex interactions (tentative); Under progress
7. Sagar Maity; Gravitational collapse in first order gravity (tentative); Under progress

b) Post-Docs

1. Soumya Chakrabarti; Cosmology, gravitation

c) External Project Students / Summer Training

1. Payal Roy; C, P, and T in four-fermion interactions; University of Calcutta
2. Sudip Chakrabarty; Symmetries and group representations in particle physics; SNBNCBS

Teaching

1. Autumn semester; Research Methodology (PHY 501); Ph.D.; 36 students; with 1 (P. K. Mukhopadhyay) co-teacher
2. Spring semester; Advanced Statistical Physics (PHY 408); Integrated Ph.D.; 4 students
3. Spring semester; Statistical Physics (PHY 603); Ph.D.; 6 students

Publications

a) In journals

1. Shantonu Mukherjee & **Amitabha Lahiri**, *Spin gauge theory, duality and fermion pairing*, Journal of High Energy Physics, 2022, 68, 2022

b) Conference proceedings / Reports / Monographs / Books

1. Ambalika Biswas, Amitabha Lahiri, "Naturalness and Two Higgs Doublet Models," (with A. Biswas) Proceedings of the 23rd DAE-BRNS High Energy Physics Symposium (hepbrns2018), Chennai, India 10-14 Dec, 2018, Published in Springer Proc. Phys. 261, 187 (2021)

Talks / Seminars Delivered in reputed Conference / Institutions

1. Chiral Torsion and its quantum effects, talk given at "Future Trends in Gravitational Physics"; Feb 10, 2022; SNBNCBS

Administrative Duties

1. Head, Dept. of Theoretical Sciences, Feb 2021 -- Oct 2021
2. Dean (Academic Programme), June 2021 -- present

Conference / Symposia / Schools organized

1. Future Trends in Gravitational Physics; Feb 8, 2022; SNBNCBS; 8-10 February, 2022

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. Vivekananda College, Kolkata; Conf. Proc. Sl. No.1; National

Outreach Program organized / participated

1. "An Invitation to Quantum Field Theory" talk given online to undergraduate students of Panjab University, 28th May, 2021

Areas of Research

Quantum Field Theory, General Relativity, Mathematical Physics

I studied, with a student, the dynamics of electrons in the presence of magnetic flux strings in the Abelian Higgs model. This can be thought of a model of itinerant electrons in a type-II superconductor. Similar models have been considered for describing high-T_c superconductors. We applied a duality transformation on the fields in the path integral formulation, which resulted in a dual description of the system. Using that, we showed that vortex strings carrying magnetic flux interacted with one another via the mediation of an emergent tensor gauge field. The dual description also led to the interaction between the strings and electrons. It was found that this interaction, which coupled the tensor gauge field with the spin current of the electron, had the unusual characteristic of being non-local. We showed that if the system allowed a condensation of strings and thus a stringy Higgs mechanism, there would be a linear interaction potential between pairs of electrons. This can be interpreted as the electrons being connected by the string. But the string carries magnetic flux, while the electrons carry electric charge! This is unlike previously known models in which magnetic flux tubes join magnetic charges, or electric flux tubes (in dual superconductivity) join electric charges. Joining electric charges by magnetic flux tubes has never been proposed in the literature before. We achieved this by noting that it is the spin of the electron, and thus its magnetic dipole moment, which takes part in the interaction. Thus it is the flux of the dipole which enters the flux tube, as in Fig. 1. (The dots represent electrons, the arrows on them represent their magnetic dipole moments. The lines are flux tubes, with the arrows showing the direction of magnetic field inside.) This is a localized pair, unlike usual Cooper pairs. The energy and angular momentum of such pairs are related, as is known from String Theory. The binding energy is plotted against the angular momentum in Fig. 2. It would be interesting to search for such localized pairs in type II superconductors which allow itinerant electrons.

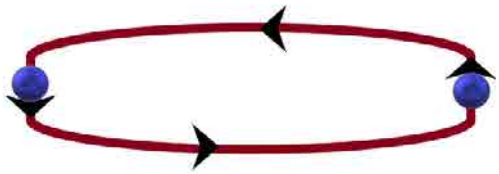


Figure1

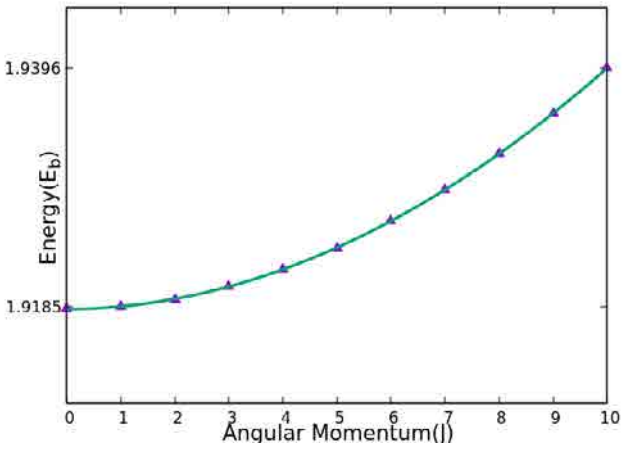


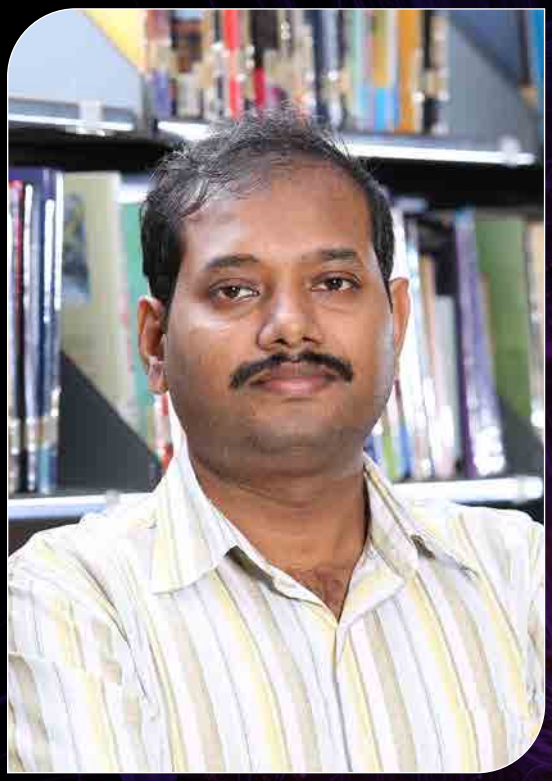
Figure2

Plan of Future Work including Project

1. Quantum field theory: I plan to extend our earlier work on the electron-vortex interaction in 3+1 dimensions. According to existing literature, electrons form bound states with vortices in 2+1 dimensions, in a process known as flux attachment. I plan to investigate, with students, if our mathematical description of electron-string interactions, when restricted to two dimensions, results in the same process. This is expected to be useful in theories of fractional quantum Hall effect. I also plan to extend earlier work on the dynamics of fermions on curved spacetime, which led to the discovery of a novel four-fermion interaction. With students, I plan to investigate the effect of these interactions on neutrino oscillations and compare our results with experimental observations.
2. Gravitation and Cosmology: I plan to study, with collaborators, the late time cosmology of the Friedmann-LeMaitre-Robertson-Walker universe, taking into account quantum gravitational effects in the renormalization group flow approach to quantum gravity. I also plan to study, with collaborators, the effect on cosmology of a fermionic field with a Yukawa-type interaction with a scalar, as well as self interactions. We plan to investigate whether there are parameter regions for which the solutions are consistent with observations.
3. Mathematical Physics: I plan to continue, with colleagues elsewhere, a long running programme of investigation of categorical geometry, in particular categorical fiber bundles based on fiber bundles on the space of directed paths on a manifold, and connections on them.

Any other Relevant Information including social impact of Research

1. Member, Editorial Board, Physics News (Indian Physical Association)
2. 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 an understanding of the interaction of electrons with magnetic flux tubes in type-II superconductors and may also help in understanding the confinement of quarks inside mesons and baryons. 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.



Punyabrata Pradhan
Professor
Theoretical Sciences
punyabrata.pradhan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Dhiraj Tapader; Studies of hydrodynamics and fluctuations in mass transport processes; Under progress
2. Anirban Mkherjee; Studies of hydrodynamics and fluctuations in sandpiles; Under progress
3. Tanmoy Chakraborty; Studies of fluctuations and transport in active matter systems; Under progress
4. Deepshikha Das; Transport in manyparticle system with time-dependent drive; Under progress; Sakuntala Chatterjee (Co-supervisor)
5. Animesh Hazra; Studies of absorbing phase transition; Under progress

Teaching

1. Spring semester; PHY 204; Integrated Ph.D.; 5 students
2. Spring semester; PHY 202; Integrated Ph.D.; 9 students

Publications

a) In journals

1. Subhadip Chakraborti, Tanmoy Chakraborty, Arghya Das, Rahul Dandekar, and **Punyabrata Pradhan**, *Transport and fluctuations in mass aggregation processes: Mobility-driven clustering*, Physical Review E, 103, 042133, 2021
2. **Punyabrata Pradhan**, *Time-Dependent Properties of Sandpiles*, Frontiers in Physics, 9, 641233, 2021

Talks / Seminars Delivered in reputed Conference / Institutions

1. Invited Talk entitled "Hydrodynamics and fluctuations in models of self-propelled particles", presented in the international conference "Statistical Physics: Recent advances and Future directions" (14-15 February 2022); Feb 15, 2022; Online presentation at the International Centre for Theoretical Sciences (ICTS), Bengaluru); 15 minutes

Administrative Duties

1. HOD of the DTS, Faculty Selection Committee, Chairperson of Newsletter Committee, Library Committee, Media Cell Committee, Admission committee, interview committee, etc.

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Fluctuation and transport in the models of self-propelled particles; SERB (DST); 3 years; PI

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. Rahul Dandekar; Sl. No. 1; National
2. Arghya Das; Sl. No. 1; National
3. Subhadip Chakraborti; Sl. No. 1; National

Areas of Research

Nonequilibrium statistical physics, hydrodynamics of sandpiles, active matter and mass aggregation processes

1. We calculate the bulk-diffusion coefficient and the conductivity in nonequilibrium conserved-mass aggregation processes on a ring. These processes involve chipping and fragmentation of masses, which diffuse on a lattice and aggregate with their neighboring masses on contact, and, under certain conditions, they exhibit a condensation transition. We find that, even in the absence of microscopic time reversibility, the systems satisfy an Einstein relation, which connects the ratio of the conductivity and the bulk-diffusion coefficient to mass fluctuation. Interestingly, when aggregation dominates over chipping, the conductivity or, equivalently, the mobility of masses, is greatly enhanced. The enhancement in the conductivity, in accordance with the Einstein relation, results in large mass fluctuations and can induce a mobility-driven clustering in the systems. Indeed, in a certain parameter regime, we show that the conductivity, along with the mass fluctuation, diverges beyond a critical density, thus characterizing the previously observed nonequilibrium condensation transition [Phys. Rev. Lett. 81, 3691 (1998)] in terms of an instability in the conductivity.
2. We have been studing time-dependent properties of the conserved stochastic Manna sandpile model in terms of density and current fluctuations. We propose a truncation scheme in the BBGKY hierarchy of the n-point correlations, which could help us calculate the cumulant generating function for various time-dependent quantities and thus characterize the transport properties not only in sandpiles, but driven systems in general. We also computed the diffusion (self) coefficient for a tagged particle in sandpiles and elucidate its relationship with the other hydrodynamic transport coefficients. We also derived hydrodynamics of a variant of the Manna sandpiles with multi-toppling dynamics and with continuous mass, which could shed some light into determining the universality classes in sandpile.
3. We obtain hydrodynamics of a class of interacting self-propelled particles, which interestingly have power-law relaxation times as a function of density. We find that the broad range of relaxation times emerge dynamically through the intriguing interplay between persistence and correlations and gives rise to anomalous (i.e., non-Gaussian and super-diffusive) spread of density profiles in the systems.

Plan of Future Work including Project

1. Hydrodynamics of sandpiles and active matter systems. We plan to study various time-dependent properties in these nonequilibrium systems and characterize the time-dependent correlation functions analytically through a new truncation schemes proposed earlier by us.

Any other Relevant Information including social impact of research

1. Man-power development through teaching and training of graduate students.

Rabin Banerjee
Raja Ramanna Fellow
Theoretical Sciences
rabin@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Post-Docs

1. Soumya Bhattacharjee; Gauge and gravitational symmetries in nonrelativistic theories: Formalism and applications

Publications

a) In journals

1. **Rabin Banerjee**, *Covariant formulation of the Newton-Hooke particle and its canonical analysis*, Physical Review D, 103, 125009, 2021
2. **Rabin Banerjee**, *Hamiltonian formulation of higher rank symmetric gauge theories*, The European Physical Journal C, 82, 22, 2022

Administrative Duties

1. Member of the committee looking into the publication of the third volume of S.N. Bose's life and works.

Awards, Recognitions

1. Awarded (DAE) Raja Ramanna Fellowship for a period of three years from 3 May, 2021
2. Mentioned in Stanford University's list of two percent of world's most influential scientists in my area of research (Nuclear and Particle Physics)

Outreach Program organized / participated

1. Wrote an invited (popular) article "Satyendranath Bose : A Rare Polymath" that appeared in the Bulletin of the Ramakrishna Mission Institute of Culture, Kolkata, January 2022 issue, on the occasion of the centenary of Dacca University

Areas of Research

Quantum Field Theory, Gravity

A covariant formulation for the Newton-Hooke particle is presented by following an algorithm developed by us termed galilean gauge theory. It naturally leads to a coupling with the Newton-Cartan geometry. From this result we provide an understanding of gravitation in a Newtonian geometric background.

Fractons are objects with restricted mobility brought about by the conservation of symmetries that go beyond usual charge conservation. For example a typical case is the conservation of dipole moment, called dipole symmetry. Obviously a single dipole is immobile. However, a set of dipoles may move in a restricted manner such that the net dipole moment is conserved. Theory of fractons naturally requires the presence of higher rank tensor theories. Recent discussions of fractons have evolved around higher rank symmetric gauge theories with emphasis on the role of Gauss constraints. This has prompted my study where a detailed hamiltonian analysis of such theories was presented. Besides a general treatment, the traceless scalar charge theory is considered in details. A new form for the action is given which, in 2 + 1 dimensions, yields area preserving diffeomorphisms. Investigation of global symmetries reveals that this diffeomorphism invariance induces a noncommuting charge algebra that gets exactly mapped to the algebra of coordinates in the lowest Landau level problem. Connections of this charge algebra to noncommutative fluid dynamics and magnetohydrodynamics are shown.

Plan of Future Work Including Project

I plan to continue my work done in the preceding period. Recently I have found some interesting results related to global symmetries. These symmetries contain all n-pole symmetries like dipole, quadrupole etc. and generalise usual charge symmetry. There are a couple of ways to exploit these findings. One is to construct specific models to display such symmetries. These models generally involve higher rank tensor fields which may find applications in different contexts. Indeed preliminary research has shown the duality between higher rank tensor theories and theories of elasticity. We wish to push this duality further and explore other avenues.

Another possibility is to exploit galilean gauge theory to embed such flat space theories in a curved background. I hope to expand my research on other frontier areas, especially fluid-gravity correspondence in a nonrelativistic context. This correspondence is expected to illuminate features of one aspect (say gravity) by a knowledge of fluid dynamics and vice-versa. It is known that such theories involve Newton-Cartan structures which is an essential element of Galilean gauge theory. Thus my proposal of galilean gauge theory should be enriched by this analysis.

Sakuntala Chatterjee
Associate Professor
Theoretical Sciences
sakuntala.chatterjee@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Shobhan Dev Mandal; Sensing adaptation interplay in bacterial chemotaxis; Under progress
2. Deepsikha Das; Periodically driven interacting particle systems; Under progress; Punyabrata Pradhan, SNBNCBS (Co-supervisor)
3. Chandradip Khamrai; Coupled driven systems; Under progress
4. Ramesh Pramanik; Bacterial chemotaxis in ligand environments with spatio-temporal variation; Under progress
5. Rupayan Saha; Dynamics of receptor activity in noisy intracellular environment; Under progress
6. Ajay Sharma; Study of Blazars in High Energy Regime; Under progress; (jointly with Debanjan Bose, SNBNCBS)

Teaching

1. Spring semester; Statistical Mechanics; Integrated Ph.D.; 9 students

Publications

a) In journals

1. Shobhan Dev Mandal and **Sakuntala Chatterjee**, *Effect of receptor cooperativity on methylation dynamics in bacterial chemotaxis with weak and strong gradient*, Physical Review E, 105, 014411, 2022
2. Shobhan Dev Mandal & **Sakuntala Chatterjee**, *Effect of switching time scale of receptor activity on chemotactic performance of Escherichia coli*, Indian Journal of Physics, Special Issue: Physical Views of Cellular processes, 96, Issue 9, 2619-2627, 2022

Talks / Seminars Delivered in reputed Conference / Institutions

1. Theory Physics Colloquium in Department of Theoretical Physics, TIFR Mumbai on the topic "Dynamics of coupled modes for sliding particles on a fluctuating landscape", Sep 21, 2021, TIFR Mumbai (Online), 1.5 hour
2. "STATISTICAL PHYSICS: RECENT ADVANCES AND FUTURE DIRECTIONS (ONLINE)" hosted by ICTS Bangalore, Talk title: "Sensing vs adaptation in bacterial chemotaxis", Feb 14, 2022, ICTS Bangalore (Online), 3 days

Administrative Duties

1. Served in a number of internal committees of the center

Awards, Recognitions, if any

1. Invited by European Physical Society to act as co-editor for the journal Europhysics Letters

Membership of Learned Societies

1. Invited to be a member of European Physical Society

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Theoretical investigation of run-and-tumble motion in a noisy environment; SERB-Matrics; 3years; PI

Conference / Symposia / Schools organized

1. "Statiscal Physics: Recent advances and future directions (Online)", Feb 14, 2022, ICTS Bangalore (Online), 3 days
2. StatPhys Kolkata XI (Online), Mar 21, 2022, SNBNCBS and IISER Kolkata (online), 5 days

Outreach Program organized / participated

1. Organized Role model interaction with Prof. Sudipta Sengupta
2. Organized online seminars for young girl students from East Midnapore schools to encourage them to choose STEM field in their future career. This initiative was under Vigyan Jyoti scheme of DST.

Areas of Research

Statistical Physics, Biological Physics

Study of methylation dynamics during chemotaxis in weak and strong gradient:

We have studied methylation dynamics of the chemoreceptors as an Escherichia coli cell moves around in a spatially varying chemoattractant environment. We have considered attractant concentration with strong and weak spatial gradient. During the uphill and downhill motion of the cell along the gradient, the temporal variation of average methylation level of the receptor clusters was measured and it was found to depend sensitively on the size of the receptor clusters and also on the strength of the gradient. At short times after the beginning of a run, the methylation dynamics is mainly controlled by short runs which are generally associated with high receptor activity. This results in demethylation at short times. But for intermediate or large times, long runs play an important role and depending on receptor cooperativity or gradient strength, the qualitative variation of methylation can be completely different in this time regime. For weak gradient, both for uphill and downhill runs, after the initial demethylation, we found methylation level increases steadily with time for all cluster sizes. Similar qualitative behavior was observed for strong gradient during uphill runs as well. However, the methylation dynamics for downhill runs in strong gradient show highly nontrivial dependence on the receptor cluster size. We explained this behavior as a result of interplay between the sensing and adaptation modules of the signaling network.

Effect of switching time scale of receptor activity on chemotactic performance of Escherichia coli

In the chemotactic motion of Escherichia coli, the switching of transmembrane chemoreceptors between active and inactive states is one of the most important steps of the signaling pathway. We have studied the effect of this switching time-scale on the chemotactic performance of the cell. We quantified performance by the chemotactic drift velocity of the cell. Our extensive numerical simulations on a detailed theoretical model showed that as the activity switching rate increases, the drift velocity increases and then saturates. Our data also showed the mean duration of a downhill run decreases strongly with the switching rate, while that of an uphill run decreases relatively slowly. We explained this effect from temporal variation of activity along uphill and downhill trajectories. We showed that for large and small switching rates the nature of activity variation show qualitatively different behaviors along a downhill run but similar behavior along an uphill run. This results in a stronger dependence of downhill run duration on the switching rate and relatively milder dependence for uphill run duration.

Plan of Future Work Including Project

1. Investigating details of sensing-adaptation interplay in bacterial chemotaxis in presence of extra-cellular environment with spatio-temporal variation
2. Study of dynamics in disordered phase for coupled driven systems

Sunandan Gangopadhyay
Associate Professor
Theoretical Sciences
sunandan.gangopadhyay@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Debabrata Ghorai; Holographic superconductors; Awarded; Biswajit Chakraborty (Co-supervisor)
2. Ankur Srivastav; Gauge/gravity correspondence applications; Under progress
3. Anish Das; Black hole shadow; Under progress
4. Neeraj Kumar; Black hole thermodynamics; Under progress
5. Rituparna Mandal; Asymptotic safe gravity and its applications; Under progress
6. Manjari Dutta; Noncommutative quantum mechanics; Under progress
7. Anirban Roy Chowdhury; Gauge/gravity duality; Under progress
8. Soham Sen; Quantum gravity phenomenology; Under progress

b) Post-Docs

1. Dharmesh Jain; String theory; Centre PDRA

Teaching

1. Autumn semester; Mathematical Methods (PHY 102); Integrated Ph.D.; 10 students
2. Spring semester; General Relativity and Cosmology (PHY 417); Integrated Ph.D.; 4 students; with 1 (Prof. Archan S Majumdar) co-teacher
3. Spring semester; General Relativity and Cosmology (PHY 617); Ph.D.; 5 students; with 1 (Prof. Archan S Majumdar) co-teacher

Publications

a) In journals

1. Ashis Saha and **Sunandan Gangopadhyay**, *Holographic study of entanglement and complexity for mixed states*, Physical Review D, 103, 086002, 2021
2. Riddhi Chatterjee, **Sunandan Gangopadhyay** & A. S. Majumdar, *Resonance interaction of two entangled atoms accelerating between two mirrors*, The European Physical Journal D, 75, 179, 2021
3. Sukanta Bhattacharyya and **Sunandan Gangopadhyay**, *Path-integral action in the generalized uncertainty principle framework*, Physical Review D, 104, 026003, 2021

4. Anirban Roy Chowdhury, Ashis Saha and **Sunandan Gangopadhyay**, *Entropy function from the Einstein boundary term*, Europhysics Letters, 134, 60003, 2021
5. Riddhi Chatterjee, **Sunandan Gangopadhyay** and A. S. Majumdar, *Violation of equivalence in an accelerating atom-mirror system in the generalized uncertainty principle framework*, Physical Review D, 104, 124001, 2021
6. Debabrata Ghorai, **Sunandan Gangopadhyay**, *Analytical study of holographic superconductor with backreaction in 4d Gauss-Bonnet gravity*, Physics Letters B, 822, 136699, 2021
7. Ankur Srivastav and **Sunandan Gangopadhyay**, *Novel vortices and the role of a complex chemical potential in a rotating holographic superfluid*, Physical Review D, 104, 126004, 2021
8. Manjari Dutta, Shreemoyee Ganguly and **Sunandan Gangopadhyay**, *Investigation of a harmonic oscillator in a magnetic field with damping and time dependent noncommutativity*, Physica Scripta, 96, 125224, 2021
9. Diganta Parai, Debabrata Ghorai and **Sunandan Gangopadhyay**, *Holographic insulator/ superconductor phase transition via matching method and thermodynamic geometry approach*, International Journal of Modern Physics A, 37, 2150249, 2022
10. Anish Das, Ashis Saha and **Sunandan Gangopadhyay**, *Study of circular geodesics and shadow of rotating charged black hole surrounded by perfect fluid dark matter immersed in plasma*, Classical and Quantum Gravity, 39, 075005, 2022
11. Soham Sen, Sukanta Bhattacharyya and **Sunandan Gangopadhyay**, *Probing the generalized uncertainty principle through quantum noises in optomechanical systems*, Classical and Quantum Gravity, 39, 075020, 2022
12. Suchetana Pal, Diganta Parai, and **Sunandan Gangopadhyay**, *Analytical approach to compute conductivity of p-wave holographic superconductors*, Physical Review D, 105, 065015, 2022
13. Anirban Roy Chowdhury, Ashis Saha & **Sunandan Gangopadhyay**, *Entanglement wedge cross-section for noncommutative Yang-Mills theory*, Journal of High Energy Physics, 2022, 192, 2022
14. Saumya Ghosh, **Sunandan Gangopadhyay** and Prasanta K. Panigrahi, *Noncommutative quantum cosmology with perfect fluid*, Modern Physics Letters A, 37, 2250009, 2022

Talks / Seminars Delivered in reputed Conference / Institutions

1. Invited Talk given in "5th International Conference on Holography, String Theory and Discrete Approach, 2021", Talk Title: Information Theoretic Quantities from gauge/ gravity correspondence; Aug 3, 2021; Online, Organized by Phenikaa University, Hanoi, Vietnam; 1 hour

Administrative Duties

1. Member of SCOLP committee, organizing departmental seminars, conferences
2. Member of Canteen Committee

Conference / Symposia / Schools organized

1. Future Trends in Gravitational Physics; Feb 8, 2022; S.N. Bose National Centre for Basic Sciences; 3 days

Scientific collaborations with other National / International Institutions (based on Joint Publications)

1. Department of Physics, University of Kalyani; Sl. No. 1, 10; National
2. Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata (IISER-K); Sl. No. 9, 12, 14; National

Areas of Research

Quantum gravity phenomenology, applications of gauge/ gravity correspondence, asymptotic safe gravity

My research work during this assessment year has been in the following areas :

1. We have holographically quantified entanglement and complexity for mixed states by following the prescription of purification. The bulk theory we considered our investigation is a hyperscaling violating solution, characterized by two parameters, hyperscaling violating exponent and dynamical exponent. This geometry is dual to a non-relativistic strongly coupled theory with hidden Fermi surfaces. We first computed the holographic analogy of entanglement of purification (EoP), denoted

as the minimal area of the entanglement wedge cross section and observe the effects of the exponents. Then in order to probe the mixed state complexity we compute the mutual complexity for the well-known BTZ black hole and the hyperscaling violating geometry by incorporating the holographic subregion complexity conjecture. We have carried this out for two disjoint subsystems separated by a distance and also when the subsystems are adjacent with subsystems making up the full system. Furthermore, various aspects of holographic entanglement entropy such as entanglement Smarr relation, Fisher information metric and the butterfly velocity has also been discussed. This work got published in Physical Review D 103, 086002, 2021.

2. I have also focussed in studying the signature of noncommutativity in various measures of entanglement by considering the holographic dual of noncommutative super Yang-Mills theory. We have followed a systematic analytical approach in order to compute the holographic entanglement entropy corresponding to a strip like subsystem of length l. The relationship between the subsystem size and the turning point introduces a critical length scale which leads to three domains in the theory, namely, the deep UV domain, deep noncommutative domain and deep IR domain. We have carried out the holographic study of entanglement entropy for each of these domains by employing both analytical and numerical techniques. The broken Lorentz symmetry induced by noncommutativity has motivated us to redefine the entropic c--function. We have obtained the noncommutative correction to the c--function upto leading order in the noncommutative parameter. We have also looked at the behaviour of this quantity over all the domains of the theory. We then move on to compute the minimal cross-section area of the entanglement wedge by considering two disjoint subsystems A and B. On the basis of E_p=E_w duality, this leads to the holographic computation of the entanglement of purification. The correlation between two subsystems, namely, the holographic mutual information I(A : B) has also been computed. This work got published in Journal of High Energy Physics 02, 192, 2022.

3. I have also looked at the application of the gauge/gravity correspondence to vortex solutions. We have analytically devised novel vortex solutions in a rotating holographic superfluid. To achieve this result, we have considered a static disc at the AdS boundary and let the superfluid rotate relative to it. This idea has been numerically exploited earlier where formation of vortices in such a setting was reported. We have found that these vortex solutions are eigenfunctions of angular momentum. We have also shown that vortices with higher winding numbers are associated with higher quantized rotation of the superfluid. We have, then, analysed the equation of motion along bulk AdS direction using Stürm-Liouville eigenvalue approach. A surprising outcome of our study is that the chemical potential must be purely imaginary. We have then observed that the winding number of the vortices decreases with the increase in the imaginary chemical potential. We conclude from this that imaginary chemical potential leads to less dissipation in such holographic superfluids. This work got published in Physical Review D 104, 126004, 2021.

4. I have also looked at circular geodesics and shadow of rotating charged black hole surrounded by perfect fluid dark matter immersed in plasma. In this work, we have considered a rotating charged black hole surrounded by perfect fluid dark matter. We consider the system to be immersed in non-magnetised, pressureless plasma. First, we have evaluated the null geodesics in order to study the co-rotating and counter rotating photon orbits. Further, we analyse the null geodesics to calculate the celestial coordinates. The celestial coordinates are used to determine the black hole shadow radius.Thereafter, we observe and analyse the effects of black hole spacetime, perfect fluid dark matter and plasma parameters on the black hole shadow in detail. Finally, we study the effect of plasma distribution on the effective potential of the black hole spacetime as encountered by the photons. We also present bounds on the plasma parameter from the observational data from M87* central supermassive black hole. This work got published in Classical and Quantum Gravity 39, 075005, 2022.

5. I have also probed the generalized uncertainty principle (GUP) through quantum noises in optomechanical systems. In this work we have considered a simple mechanical oscillator interacting with a single mode optical field inside a cavity in the generalized uncertainty principle framework (GUP). Our aim has been to calculate the modified noise spectrum and observe the effects of the GUP. The commutation relation that we have considered has an extra linear order momentum term along with a quadratic order term. Confronting our theoretical results with the observational results, we observe that we get a much tighter bound on the GUP parameters from the noise spectrum using the values of the system parameters from different experiments. This work got published in Classical and Quantum Gravity 39, 075020, 2022.

6. I have also looked at the violation of the equivalence principle in an accelerating atom-mirror system in the generalized uncertainty principle framework. We studied the spontaneous excitation of a two-level atom in the presence of a perfectly reflecting mirror, when the atom, or the mirror, is uniformly accelerating in the framework of the generalised uncertainty principle (GUP). The quantized scalar field obeys a modified dispersion relation leading to a GUP deformed Klein-Gordon equation. The solutions of this equation with suitable boundary conditions are obtained to calculate the spontaneous excitation probability of the atom for the two separate cases. We show that in the case when the mirror is accelerating, the GUP modulates the spatial oscillation of the excitation probability of the atom, thus breaking the symmetry between the excitation of an atom accelerating relative to a stationary mirror, and a stationary atom excited by an accelerating mirror. An explicit violation of the equivalence principle seems to be thus manifested. We further obtain an upper bound on the GUP parameter using standard values of the system parameters. This work got published in Physical Review D 104, 124001, 2021.

7. I have looked at the entropy function formalism developed by Sen. In particular, we have shown that the boundary term which arises from the Einstein-Hilbert action is sufficient to yield the Bekenstein-Hawking entropy of a static extremal black hole which is asymptotically flat. However, for asymptotically AdS black holes, the bulk term also plays an important role due to the presence of the cosmological constant. Further, we show that for extremal rotating black holes, both the boundary and the bulk terms contribute non-vanishing pieces to the entropy. This work got published in Euro Physics letters 134, 60003, 2021.

8. We have obtained the exact eigenstates of a two dimensional damped harmonic oscillator in the presence of an external magnetic field varying with respect to time in time dependent noncommutative space. It has been observed that for some specific choices of the damping factor, the time dependent frequency of the oscillator and the time dependent external magnetic field, there exists interesting solutions of the time dependent noncommutative parameters following from the solutions of the Ermakov-Pinney equation. Further, these solutions enable us to get exact analytic forms for the phase which relates the eigenstates of the Hamiltonian with the eigenstates of the Lewis invariant. Then we compute the expectation value of the Hamiltonian. The expectation values of the energy are found to vary with time for different solutions of the Ermakov-Pinney equation corresponding to different choices of the damping factor, the time dependent frequency of the oscillator and the time dependent applied magnetic field. We also compare our results with those in the absence of the magnetic field obtained earlier. This work got published in Physica Scripta 96, 125224, 2021.

9. We have analytically deduced the frequency dependent expression of conductivity and the band gap energy in AdS_4 Schwarzschild background for p-wave holographic superconductors considering Einstein-Yang-Mills theory. We also used the self consistent approach to obtain the expressions of conductivity for different frequency ranges at low temperature. We then compared the imaginary part of conductivity at low frequency region. The band gap energy obtained from these two methods seem to agree very well. This work got published in Physical Review D 105, 065015, 2022.

Plan of Future Work Including Project

1. In future, I would like to extend my ongoing studies further . In particular, I would like to focus on quantum gravity phenomenology and look for its possible effects at low energies. I would like to understand the role played by quantum gravity in gravitational wave detector systems.

Any other Relevant Information including Social Impact of Research

1. The areas of research in which we are engaged are purely theoretical in nature and would probably have practical applications in future. The important thing to note in these kind of investigations is that it gives a fundamental understanding of the working of our universe. History has also shown us that fundamental studies finds applications in technology invariably. Hence the societal impact of these kind of investigations is quite clear. Further, research in the theoretical areas in which I work would also lead to the development of man power who would become the future torch bearers.

Urna Basu
Assistant Professor
Theoretical Sciences
urna@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Ritwick sarkar; Under progress

b) External Project Students / Summer Training

1. Durgesh Ajgaonkar; MS thesis on "Inertial active particle dynamics"; IISER Pune
2. Seemant Mishra; MS thesis on "Symmetric exclusion process under power law resetting"; IISER Pune
3. Adarsh Raghu; Summer project on "Particle current under stochastic resetting"; IISER Kolkata

Teaching

1. Spring semester; CB 535; Ph.D.; 6 students

Publications

a) In journals

1. Ion Santra, **Urna Basu** and Sanjib Sabhapandit, *Direction reversing active Brownian particle in a harmonic potential*, Soft Matter, 17, 10108-10119, 2021
2. Ion Santra, **Urna Basu**, and Sanjib Sabhapandit, *Active Brownian motion with directional reversals*, Physical Review E, 104, L012601, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Invited talk at ICTP program "Statistical Physics of Complex Systems"; Sep 8, 2021; ICTP (online); 3 days
2. Seminar at DAMTP, University of Cambridge, UK; Apr 27, 2021; University of Cambridge (online); 1 day
3. Seminar at IISER-Kolkata; Feb 25, 2022; IISER Kolkata; 1 day

Administrative Duties

1. Member of CWEP
2. Member of Media Cell
3. Chairperson of Main building housekeeping tendering committee
4. Member of Equity committee
5. Hostel warden

6. Member of admission committee
7. Member of the organizing committee of Statistical Physics seminar series under VASP

Awards, Recognitions

1. Associate of ICTS-TIFR, Bengaluru since 2018. The associateship has recently been renewed for 3 more years

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Ramanujan Grant; SERB; 5 years; PI

Conference / Symposia / Schools organized

1. Statphys Kolkata XI; Mar 21, 2022; Online; 1 week

Scientific collaborations with other national / international institutions (based on joint publications)

1. Collaboration with Sanjib Sabhapandit, Raman Research Institute, Bengaluru, India; Sl. No. 1,2; National

Outreach program organized / participated

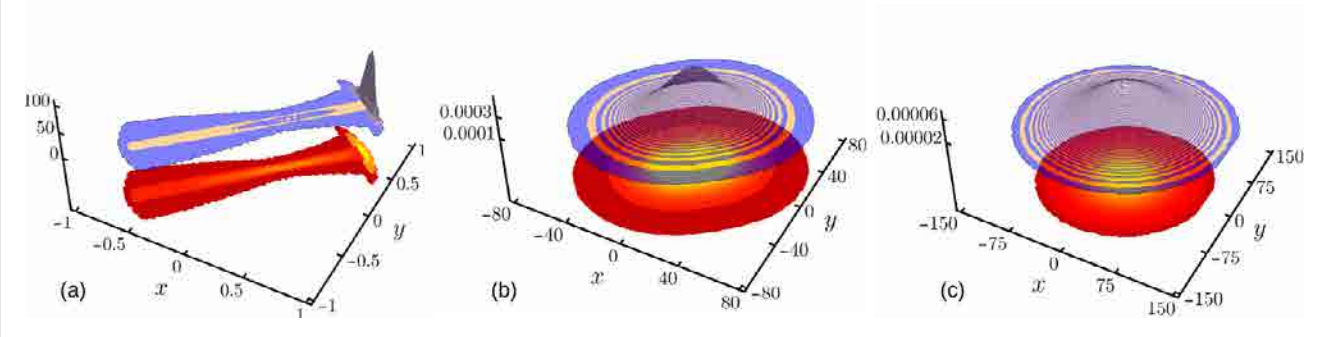
1. Co-organizer of the programs by Equity committee and Statistical Physics seminar series
2. Presented a seminar on "Active particle dynamics" for undergraduate students at the Physics department of Scottish Church College, Kolkata

Areas of Research

Nonequilibrium Statistical Physics

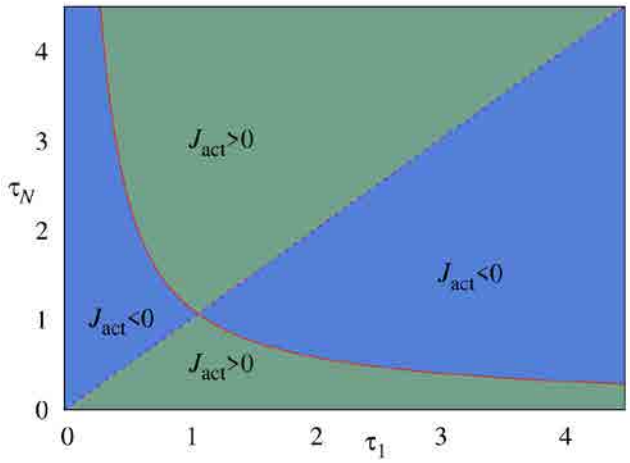
I work in the general area on nonequilibrium statistical physics with current focus in the following areas.

Active particle dynamics: Active particles are self-propelled agents which consume energy from environment and convert it into directed motion. One of my main research interests is to study and characterize the properties of single active particles, using simple, analytically tractable models. Recently, we have analytically studied a simple model of active Brownian motion with intermittent direction reversals which is common in a class of bacteria like Myxococcus xanthus and Pseudomonas putida. We show that, for such a motion in two dimensions, the presence of the two time scales set by the rotational diffusion constant and the reversal rate gives rise to four distinct dynamical regimes showing distinct behaviors. We characterize these behaviors by analytically computing the position distribution and persistence exponents. Most interestingly, when reversal rate is much higher than the rotational diffusion constant, the position distribution in the intermediate regime shows two different scaling behaviours along the direction orthogonal (ballistic scaling) and parallel (diffusive scaling) to the initial orientation.



Activity driven transport: How the transport properties of an extended system is affected by coupling to active reservoirs is a significant, yet virtually unexplored question. In another recent work, we address this issue in the context of energy transport between two active reservoirs connected by a chain of harmonic oscillators. The couplings to the reservoirs, which exert correlated stochastic forces on the boundary oscillators, lead to fascinating behavior of the energy current and kinetic temperature profile, which we compute exactly in the thermodynamic limit. We show that the stationary active current (i) changes non-monotonically as the activity of the reservoirs are changed, leading to a negative differential conductivity (NDC), and (ii) exhibits an unexpected direction reversal at some finite value of the activity drive. For the example of a dichotomous active force, we find the physical origin of the NDC using nonequilibrium

response formalism. It turns out that the kinetic temperature profile remains uniform at the bulk, and can be expressed in a form similar to the thermally driven case. We show that despite this apparent similarity, no effective thermal picture can be consistently built in general.



Colloid in a fluctuating medium: The effective dynamics of a colloidal particle immersed in a complex medium is often described in terms of an overdamped linear Langevin equation for its velocity with a memory kernel which determines the effective friction and the correlations of fluctuations. Recently, it has been shown that this memory may depend on the possible optical confinement the particle is subject to, suggesting that this description does not capture faithfully the actual dynamics of the colloid, even at equilibrium. In a very recent work, we propose a different approach in which we model the medium as a Gaussian field linearly coupled to the colloid. The resulting effective evolution equation of the colloidal particle features a non-linear memory term which explains qualitatively the experimental and numerical evidence in the presence of confinement.

Plan of Future Work Including Project

1. Presently, I am working on various projects which continue to explore the behaviour of active particles. In particular, I am exploring the behaviour of inertial active particles, and the effect of various non-Markovian tumbling protocols which leads a rich array of novel behaviours. Another direction I am actively pursuing with my Ph.D. student is the transport properties of extended systems driven by active reservoirs. As we have recently shown, even a chain of linear oscillators depict a novel set of intriguing behaviours when driven by nonequilibrium reservoirs which do not satisfy fluctuation-dissipation theorem. Currently we are exploring the possibilities these results opened up -- in particular, the transport behaviour of non-linear systems under active and other nonequilibrium reservoirs.

Any other Relevant Information including social impact of research

1. Our recent work on the "Direction reversing active Brownian motion" was extensively covered in news media. In addition to appearing on the DST platform, the PIB press release, it was covered by several leading media outlets, including The Hindu, The Week, Outlook, and Yahoo News.

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 16800 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), Plagiarism checking software (iThenticate) 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

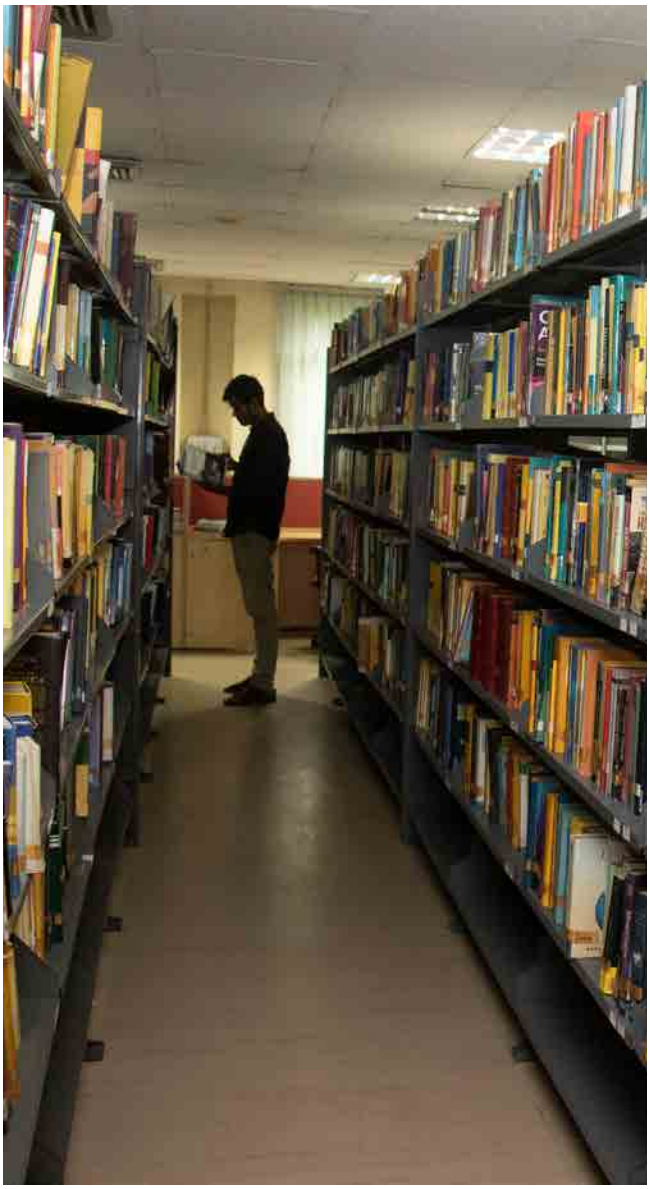
1. **Reading Facility:** Library provides reading facility to its members as well as outside visitors. All the books including reference collections are classified and open-accessed.
2. **Document Lending Service:** Each member is entitled to issue 6 books and 2 bound volumes of journals at a time.
3. **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. **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.
8. **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.

9. **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.
10. **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.
11. **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.
12. **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.
13. **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. 2021-22

1. Based on the demand of Centre's academic members, apart from renewing existing journals, library has added subscription of 11 new online journals from renowned Publishers like - Wiley, AIP, Springer, Nature Publishing Group etc. for the year 2022.
2. Approximately 300 new books and some new journals have been added in the library collection during the above mentioned financial year.
3. 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 2020 have been uploaded in the repository.
4. In the Financial Year 2021-22, the Fiction Section has been enriched by procuring 33 books of classic literature, novel, short story, biography and books of general interests.
5. 35 Hindi books are added in the Library collection the mentioned financial year.

Saumen Adhikari
Librarian – cum – Information Officer



Engineering Section

A. Civil Work

The Faculty Lounge

A new Faculty Lounge was introduced by modifying Room No. 432 on the third floor of the main building with basic amenities and sitting arrangements.


New Faculty Lounge

Providing Roof Treatment of Main Building and Bhaghirathi Guest House of SNBNCBS, Salt Lake:

Roof treatment was executed on roof top of Bhaghirathi Guest House. Initially, the work proposal was for both wings of the building but, after certain progress of the work, it was felt that treatment is also needed at the central portion of roof to protect the building from water leakage from the roof level. Previous weatherized roof treatment layer was dismantled and new treatment has been done.


Roof Treatment of Bhagirathi Building

Library Modification

Modifications have been done inside Library by erecting temporary aluminum partition and one class room has been shifted to better utilization of space.

Class Room inside Library

Library sitting area

B) Estate

1. Maintenance and development of landscape and horticulture to upkeep the aesthetic look of the campus
2. Maintaining "Zero Plastic Green Campus" by preventing the usages of plastic carry bags of less than 75 micron.
3. Providing COVID-19 Special Sanitisation on regular intervals as a part of preventive health measure in the common areas of office and hostel buildings.
4. Installation of tri-lingual name plates on the office room doors in the administrative floor of Main Building of the Centre.

C) Electrical

Street lights near Bhagirathi Building

Refabricated Feeder Pillar

1. Dedicated earthing system was installed at various laboratories to protect the sophisticated research equipments/instruments and also for the proper electrical installation.
2. Electrical installation work for Basundhara Building.
3. Various procurement of electrical items through GeM portal and upkeep the inventory/electrical store.
4. Modification of feeder pillars and new cable laying work from new Substation block.
5. Installation of LED lighting systems replacing the conventional lighting system including street lights.
6. New street lights, bollard lights and area lightning of the Centre were installed that brighten up the Centre.
7. The 750 KVA DG set (make-Captiva), was commissioned in the DG yard of the Centre.
8. Energy Audit of the various buildings, labs and major power consuming instruments were carried out by M/s. PCRA.
9. Industrial grade ducted AC were installed at various places of the Centre in order to replace the old and defunct ACs.

Mithilesh Kumar Pande
Campus Engineer cum Estate Officer

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 Ph.D. in Computer Science and Engineering at National Institute of Technology, Meghalaya on Artificial Intelligence and machine learning, IoT and Edge/Fog Computing.

Ph.D. Progress: Ph.D. registration successfully completed on 10-08-2020 at National Institute of Technology (NIT), Meghalaya.

Apart from my principle technical administrative responsibility, I am working on Edge Computing / Fog Computing research on IoT. Edge/Fog computing provides on-demand access to computing resources for end users across the world. It offers services on a pay-as-you-go model through its environment sites that are scattered across diverse geographies. Cities to harvest renewable energy sources, and prediction of renewable energy to maximize its usage. The key objectives of this research are as follows:

1. Investigating effective solution to deal Virtual Machine's (VM) resource allocation for end user requests under overloaded situation while ensuring QoS.
2. Investigating the interplay QoS and on energy consumption.
3. Investigating novel scheme for reduction of energy consumption while ensuring QoS on Fog environment.
4. Developing sustainable dynamic VM placement algorithms for retaining QoS factors.

   This research work will address the limitations of current fog resource allocation approaches: on the one hand, in dealing with fluctuating demand and supply, and on the other hand, in providing greater control to fog end users. The goal is to ultimately enable a more flexible and efficient allocation through market-based mechanisms ensuring the Energy and QoS factors in fog enabled smart cities.

The **Computer Centre** is a central facility, which caters to the needs of different academic departments and various sections of the institute. The mission of Computer Centre at SNBNCBS is to create and maintain a computing environment for the pursuit of academic excellence. The ultimate aim of the centre is to provide professional services, promote and assist the use of new computing technology among the students, staff, and administration. Computer Centre at SNBNCBS, Kolkata aspires to be a leading computational facility in higher education. Computer Centre manages various computing and communication facilities throughout the campus. 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 Mr. Bapi Tudu 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 2021-22, there were more than 400 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 50Mbps line by Airtel India 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
Polaron	07	32 TB	27

Summary of project sponsored computational facilities

Machine Name	Processor Core	Storage	User
Hybrid System (CPU+GHP)	24 CPU Cores + 14336 GPU cores	4 TB	08
ATHENA	320	-	12
CRAY	7808	255 TB	50
TRC CRAY	960	120 TB	30

CSC-AC Members: Sr. Prof. Amitabha Lahiri (Chairperson), Sr. Prof. Priya Mahadevan, Prof. Soumen Mondal, Dr. Suman Chakrabarty, Deputy Registrar(Finance Mr. Sanjoy Choudhury.

CSC-WG Members: Prof. Jaydeb Chakrabarti (Chairperson), Dr. Manoranjan Kumar, Dr. Sakuntala Chatterjee, Dr. Tapas Baug, Mr. Sanjoy Choudhury, Ms. Nibedita Konar, Dr. Soumen Adhikari, Mr. Abhijit Ghosh, Mr. Sagar S. De, Ms. Deblina Mukherjee,

Central Computational Resources (2021-22):

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

As part of India's ambitious National Super Computing Mission, nine more supercomputers will be installed in top institutes of the country in the coming days. SNBNCBS (S N Bose National Centre for Basic Sciences) will be one institute among those.

S. N. Bose Centre's High Performance Computing facility being listed within top **50 supercomputers** (**CRAY XE6 & CRAY XC50**) India based on the survey carried out by **CDAC Bangalore**. The cluster has a theoretical performance of **222.40 TF** catering the computational need of the vibrant computational activity of the Centre.

The **Computer Services Cell (CSC)** of the S. N. Bose National Centre for Basic Sciences (SNBNCBS) is the leading

Computing Centre having the state-of-the art computing facilities, catering to the ever-increasing demands of high performance computing for scientific and engineering research. The supercomputing facility at SNBNCBS is a symbiosis of computing, network, graphics, and visualization. The Centre housing state-of-the-art computing systems, with sophisticated software packages, is conceived of as a functionally distributed supercomputing environment, and connected by a powerful high- speed network.

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

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

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

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

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

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 and extended various newly created areas 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 2020 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 CO_2 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 designed 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.
31. Up graded 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.
32. Implemented redundant core switch with Next Generation IP Infrastructure features and enhanced back plane and uplink.
33. Implemented 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.
34. All lectures hall and classroom has been modernized as per the Centre's digital needs.

Our Future Vision:

- The Centre future 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.
- Design and Implementation of centralised SAN based storage solution for the Centre.
- Implementation of Multipoint-to-Multipoint Video Conferencing olution.
- WiMax base secure wireless Internet Access in Campus
- Implementation of EDUROAM in the Campus.

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. 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 2021-22:

Prof. Samir Kumar Pal – Convener

Dr. Atindra Nath Pal - Member

Prof. Gautam Gangopadhyay - Member

Prof. Soumen Mondal - Member

Deputy Registrar (Administration) – Member

Deputy Registrar (Finance) - Member

Office Assistant, Office of Dean (Faculty) - Member

Office Assistant, Academic Section - Member

Mr. Achyut Saha, PA to Director renders Secretarial Assistance to the Project & Patent Cell.

Prof. Soumen Mondal acts as the Convener for proposals of Prof. Samir Kumar Pal.

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.)
2017-2018	32	3,04,37,606=00
2018-2019	31	4,62,15,993=00
2019-2020	27	4,15,59,908=00
2020-2021	30	2,21,97,328=00
2021-2022	34	3,22,95,557=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 2021-22

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
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	24-03-2017 to 23-03-2020 Extended for one year till 23-03-2021 Further extension till 23-7-2021	2,12,86,400/-	
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)	1-12-2017 to 30-11-2020 No cost extension till 31-05-2021	30,39,600/-	
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	06-07-2018 to 05-07-2021 Extended for 6 months till 05-01-2022 (No cost extension) Extended by another 3 months till 05-04-2022 (No cost extension)	44,48,969/-	
DST/ASM/17-18/201 – "Quantum Information Technologies with Photonic Devices"	Prof. Archan S. Majumdar	DST DST/ICPS/QuST/ Theme-1/2019 (Proposal-18)	24-04-2019 to 23-04-2022	17,00,000/- (Capital) 97,14,000/- (General)	
DST/PM/17-18/204 – "Electronic, Structural and Optical Properties of Semiconductor Nanoplatelets"	Prof. PriyaMahadevan	DST DST/NM/ NS/2018/18 (G)	28-12-2018 to 27-12-2021 No cost extension till 27-06-2022	30,83,480/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
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	01-08-2018 to 31-07-2021 Extended for 2 Years from 01-08-2021 to 31-07-2023	57,00,000/- (For the first three years) + 19,00,000/- + 19,00,000/-	
IUSSTF/AB/18-19/220 – "Centre for Nanomagnetics for Energy Efficient Computing, Communications and Data Storage"	Prof. Anjan Barman	IUSSTF IUSSTF/JC-030/2018	23-12-2019 to 22-12-2021 No cost extension till 30-09-2022	32,82,850/-	
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	16-03-2019 to 15-03-2022 Granted 3 month no-cost extension	31,96,600/-	
ICAR/SKP/18-19/230 – "Development of nano sensor and its application through cloud based network for real time irrigation to soil and plant"	Prof. S.K. Pal (Co-PI from SNBNCBS) Lead Centre: ICAR–IISS Other Co Centre: ICAR-CIAE	ICAR (NASF) NASF/NRM-8031/2020-21/214 dated 31-05-2021	15-07-2021 to 14-07-2024	41,00,000/- (Non Recurring) 59,04,278/- (Recurring Cost) For SNBNCBS	
Sarfez/SC/19-20/232 – "Tuning electrostatics and dynamics of the flexible areas of PCSK9 protein towards controlling interactions with LDLR: A computational approach"	Dr. Suman Chakrabarty	Sarfez Cure India	19-06-2019 to 18-06-2020 Extended till 18-06-2022	8,24,032/-	
SERB/RKM/19-20/234 – "Investigation on the Changes in Protein Hydration During Aggregation in Crowded Environment by THz Time Domain and Optical Time Resolved Spectroscopy"	Prof. Rajib Kumar Mitra	SERB CRG/20l9/000970	06-02-2020 to 05-02-2023	26,56,800/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
SERB/PP/19-20/237 – "Fluctuation and Transport in the Models of Self Propelled Particles"	Dr. Punyabrata Pradhan	SERB MTR/2019/ 000386	21-02-2020 to 20-02-2023	6,60,000/-	
SERB/TR/19-20/238 – "A Quantitative Study on Single-Chromosome Elasticity and its Relevance to Chromosome Fragility in Cancer"	Dr. Tatini Rakshit	SERB CRG/2019 /007013	27-03-2020 to 26-03-2023 Project closed at SNBNCBS on 10-12-2021 as PI resigned from SNBNCBS	47,43,392/-	
SERB/SC/19-20/240 – "Theoretical Investigation of run-and-tumble Motion in a Noisy Environment"	Dr. Sakuntala Chatterjee	SERB MTR/2019/ 000946	15-02-2020 to 14-02-2023	6,60,000/-	
DST/AB/19-20/246 – "Development of strongly spin orbit coupled topological quantum heterostructures for spintronic applications"	Prof. Anjan Barman	DST DST/NM/ TUE/ QM-3/2019-1G-SNB	21-10-2021 to 20-10-2026	1,28,43,000/-	
PM/SERB/19-20/250 – "Twistronics with Transition Metal Dichalcogenides"	Prof. Priya Mahadevan	SERB IPA/2020/ 000021	30-03-2020 to 29-03-2025	2,17,60,250/-	
DST(SERB)/TS/19-20/251 – "Effect of Magnetic Moment Reorientation on the Physical and Electronic Properties in antiferromagnetic topological systems, (Mn1-xFex)3Sn and (Mn1-xFex)3Ge"	Dr. T. Setti	SERB SRG/2020/ 000393	18-12-2020 to 17-12-2022	26,02,800/-	
SERB/MK/19-20/253 – "Exploring Quantum and Thermal Fluctuations in Frustrated Magnets at Low Temperature"	Dr. Manoranjan Kumar	SERB CRG/2020/ 000754	30-12-2020 to 29-12-2023	58,68,145/-	
SERB(DST)/ANP/19-20/255 – "Probing orbital hybridization and structural asymmetry in atomic and molecular nano-contact via inelastic electron spectroscopy and shot noise"	Dr. Atindra Nath Pal	SERB CRG/2020/ 004208	17-02-2021 to 16-02-2024	36,12,421/-	
SERB/TSD/20-21/260 – "J.C. Bose Fellowship"	Prof. Tanusri Saha Dasgupta	SERB JCB/2020/ 000004 Dairy No. SERB/F/ 3797/2020-2021	12-10-2020 to 11-10-2025	95,00,000/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
SERB(NPDF)/JB/20-21/261 – "Theoretical and experimental investigations on transition metal dichalcogenide based surface plasmon resonance structure with applications in sensing"	Dr. Jayeta Banerjee (Mentor: Dr. Manik Pradhan)	SERB (NPDF) PDF/2020/ 001422	31-12-2020 to 30-12-2022	16,41,600/-	
SERB(NPDF)/DD/20-21/262 – "Characterizing and utilizing quantum resources in the context of information processing tasks"	Dr. Debarshi Das (Mentor: Prof. Archan S. Majumdar)	SERB (NPDF) PDF/2020/ 001358	15-01-2021 to 14-01-2023 Resigned on 31-3-2022	22,36,800 /-	
NASI/RB/20-21/263 – "Gauge and Gravitational Symmetries in Nonrelativistic Theories: Formalism & Applications [NASI Senior Scientist Platinum Jubilee Fellowship]"	Prof. Rabin Banerjee	NASI NASI/291/12/ 2020 dated 30-12-2020 & NASI/51/1/ 2021 dated 28-01-2021 (1st Inst)	06-01-2021 to 05-01-2024 Closed on 02-05-2021	4,60,000/- (1st year)	
SERB/NK/20-21/264 – "From three-dimensional to two-dimensional quantum anomalous Hall effect in ferromagnetic topological quantum materials"	Dr. Nitesh Kumar	SERB CRG/2021/ 002747	10-3-2022 to 09-3-2025	27,26,791/-	
DST/ASM/20-21/265 – "Quantum Heat Engines" (QuEST Project Q-79)	Prof. Archan S. Majumdar (Co PI) PI – Dr. Sibasish Ghosh, IMSc, Chennai	DST DST/ICPS/ QuST/ Theme-1/2019 (Proposal-13)	From 15-03-2021	12,17,000/- (1st Year) 8,07,000/- (2nd Year) 8,66,000/- (3rd Year)	
SERB/SC/20-21/266 – "Development of Artificial Neural Network (ANN) based models for rapid prediction of physicochemical properties of drug-like molecules"	Dr. Suman Chakrabarty	SERB MTR/2021/ 000859	24-02-2022 to 23-02-2025	6,60,000/-	
Holoflex/SKP/21-22/269 – "Development of an industrial process for the large-scale production of retro reflective material for potential applications in display labels"	Prof. S.K. Pal	Holoflex Limited	01-07-2021 to 30-06-2022 Extended till 30-09-2022	7,80,000/- (9,20,400/- including GST) + 2,26,200/-	18% GST on Sanctioned Amount included

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
SERB(NPDF)/DS/21-22/270 – "Self-testing of quantum devices and device-independent information processing"	Dr. Debashis Saha	SERB (NPDF) PDF/2020/ 001682	15-03-2021 to 14-03-2023	22,36,800/-	
"Ab Initio search for topological Mott insulators"	Prof. Priya Mahadevan	DST DST/INT/ SWD/ VR/P-08/2019	12-01-2021 to 11-01-2024	30,30,600/-	
"Electronic structure of free standing films of transition metal oxides".	Prof. Priya Mahadevan	SERB SPF/2021/ 000066	From 24-03-2021	Amount received 12,70,000/-	
SERB/DB/21-22/271 – "Study of Astrophysical Sources in Very High Energy Regime Using Ground Based Gamma – Ray & Neutrino Telescopes" – Ramanujan Fellowship	Dr. Debanjan Bose	SERB SB/S2/RJN-038/2017	Implemented at SNBNCBS from 04-12-2020	Amount received 29,00,000/-	
DBT/MM/21-22/277 – "Exploring the water-oxidation mechanism and proton coupled electron transfer reactions in Photosystem II: an approach towards clean fuel" - Ramalingaswamy Re-entry Fellowship	Dr. Manoj Mandal	DBT BT / RLF / Re-entry / 41 / 2020	15-07-2021 to 14-07-2026	1,13,60,000/-	
SERB/AHK/21-22/278 – "Doped 2D Nanocrystals for Photonic Applications (Ramanujan Fellowship)	Dr. Ali Hossain Khan	SERB RJF/2020/ 000091	01-11-2021 to 31-03-2026	11,62,598/- credited on 9-12-2021	
DAE(RRF)/RB/21-22/279 – "Gauge and Gravitational Symmetries in Nonrelativistic Theories: Formalism & Applications" – DAE Raja Ramanna Fellowship	Prof. Rabin Banerjee	DAE (RRF) 1003/6/2021/ RRF/ R&D-II /10348 Dated 2-9-2021	03-05-2021 to 02-05-2024	13,50,000/- (1st Year)	

*** 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 2021-22

Sl.	Name	Designation	Project Name	P. I. of Project	Joined on	Appt. upto
1	Anuvab Banerjee	RA – I (Ad-hoc), A&C	Study of Astrophysical Sources in Very High Energy Regime using ground based Gamma ray and Neutrino Telescope	Dr. Debanjan Bose	06.09.2021	05.03.2022
2	Dr. Debarshi Das	National Post Doctoral Fellow	Characterizing and utilizing quantum resources in the context of information processing tasks	Self (Mentor - Prof. Archan S Majumdar)	15.01.2021	Resigned on 31-3-2022
3	Dr. Debashis Saha	National Post Doctoral Fellow	Self-testing of quantum devices and device-independent information processing	Self (Mentor - Prof. Archan S Majumdar)	15.03.2021	2 year
4	Dr. Jayeta Banerjee	National Post Doctoral Fellow	Theoretical and experimental investigations on transition metal dichalcogenide based surface plasmon resonance structure with applications in sensing	Self (Mentor - Dr. Manik Pradhan)	31.12.2020	2 year
5	Dr. Sanjukta Paul,	RA – I CMPMS	Twistronics with transition metal dichalogenides	Prof. Priya Mahadevan	07.06.2021	1 year
6	Dr. Soumita Mondal,	RA – I (Ad-hoc) CMPMS	Twistronics with transition metal dichalogenides	Prof. Priya Mahadevan	15.02.2021	31.05.2021
7	Dr. Soumendu Datta	Research Associate – III (Adhoc), CMPMS	J.C. Bose Award (Fellowship) Thematic Unit of Excellence on Computational Material Science	Prof. Tanusri Saha-Dasgupta	01.12.2020	31.05.2021
8	Dr. Soumendu Datta	Research Associate – III, CMPMS	J.C. Bose Award (Fellowship) Thematic Unit of Excellence on Computational Material Science	Prof. Tanusri Saha-Dasgupta	25.08.2021	1 year
9	Dr. Sumit Nandi	Research Associate – I, A&C	Application of Quantum Information	Prof. Archan S Majumdar	05.07.2021	1 year
10	Dr. Sumit Halder	Research Associate – I (Adhoc), CMPMS	Exploring Quantum and Thermal fluctuations in Frustrated Magnets at Low Temperature	Dr. Manoranjan Kumar	01.03.2021	31.08.2021
11	Dr. Sumit Halder	Research Associate – I, CMPMS	Exploring Quantum and Thermal fluctuations in Frustrated Magnets at Low Temperature	Dr. Manoranjan Kumar	01.09.2021	1 year
12	Shreya Das	Research Associate – I (Adhoc), CMPMS	J.C. Bose Award (Fellowship) Thematic Unit of Excellence on Computational Material Science	Prof. Tanusri Saha-Dasgupta	10.01.2022	09.07.2022

Sl.	Name	Designation	Project Name	P. I. of Project	Joined on	Appt. upto
1	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	Resigned on 10.12.2021
2	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
3	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
4	Dr. Saumya Mukherjee	DST INSPIRE Faculty	Search for room-temperature multiferroicity and spin-reorientation in strained thin films	Self	09.11.2020	Resigned on 23.07.2021
5	Dr. Debanjan Bose	Ramanujan Fellow (Transferred from IIT, KGP)	Study of Astrophysical Sources in Very High Energy Regime using Ground based Gamma Ray & Neutrino Telescope	Self	04.12.2020	14.11.2022
6	Prof. Rabin Banerjee	Raja Ramanna Fellow	Gauge and Gravitational Symmetries in Nonrelativistic Theories : Formalism and Applications	Self	03.05.2021	02.05.2024
7	Dr. Manoj Mandal	Ramalingaswami Re-entry Fellow	Exploring the water oxidation mechanism and proton coupled electron transfer reactions in photosystem II : an approach towards clean fuel	Self	15.07.2021	14.07.2026
8	Dr. Ali Hossain Khan	Ramanujan Fellow (Transferred from INST, Mohali)	Doped 2D Nanocrystals for Photonic Applications	Self	01.11.2021	31.03.2026

List of Students under Project (2021-22)

SL	NAME OF THE STUDENT	CURRENT DESIGNATION	PROJECT INSTRUCTOR	DEPT.	NAME OF THE PROJECT	JOINED ON	APPOINTMENT TENURE	NO. OF STUDENTS	DURATION OF THE PROJECT	APPOINTED UPTO	RESIGNED ON
1	Suranjana Chakrabarty	Project Assistant	Anup Ghosh	CMPMS	Ultrafast 2D-IR Spectroscopy on the Structural Dynamics of DNA/G Quadruplex	13.10.2020	31.12.2023		31.12.2023	31.12.2023	
2	Madhurita Das	Project JRF	Priya Mahadevan	CMPMS	Electronic, structural and optical properties of semiconductor nanoplatelets	12.05.2021	27.12.2021		27.12.2021 (No cost extension till 27-06-2022)	27.12.2021	
	Madhurita Das	Project JRF (Ad-hoc)	Priya Mahadevan	CMPMS	Twistronics with transition metal dichalcogenides	14.01.2022	6 Months		29.03.2025	13.07.2022	
3	Sayan Ghosh	Project JRF	Manoranjan Kumar	CMPMS	Exploring Quantum and Thermal Fluctuations in Frustated Magnets at Low Temperature	01.06.2021	Till the end of the project	29.12.2023	29.12.2023		
			DEPT. TOTAL					**3**			
1	Debashish Paul	Project - JRF	Tatini Rakshit	CBMS	Biophysical Characterization of Extracellular Vesicle (Evs) using Single Molecule Detection (SMD) Methods: A Potential Non-invasive Diagnostic Tool	26.10.2020	Initially for One Year + Continued after evaluation	12.08.2023	12.08.2023	10.12.2021	
2	Tina Dey	Project Assistant	Tatini Rakshit	CBMS	Biophysical Characterization of Extracellular Vesicle (Evs) using Single Molecule Detection (SMD) Methods: A Potential Non-invasive Diagnostic Tool	02.08.2021	Initially for Six (6) Months	12.08.2023	01.02.2022	10.12.2021	
3	Neha Bhattacharyya	Project SRF (Ad-hoc)	Samir Kumar Pal	CBMS	Development of an industrial process for the large-scale production of retro-reflective material for potential applications in display labels	08.07.2021	6 Months		30.06.2022 (Extended till 30.09.2022)	07.01.2022	
	Neha Bhattacharyya	Research Staff (Project)	Samir Kumar Pal	CBMS	Development of an industrial process for the large-scale production of retro-reflective material for potential applications in display labels	14.01.2022	30.06.2022		30.06.2022 (Extended till 30.09.2022)	30.06.2022	
4	Ria Ghosh	Project SRF (Ad-hoc)	Samir Kumar Pal	CBMS	Development of nano sensor and its application through cloud based network for real time irrigation to soil and plant	15.07.2021	6 Months		14.07.2024	14.01.2022	13.01.2022
	Ria Ghosh	Project SRF	Samir Kumar Pal	CBMS	Development of nano sensor and its application through cloud based network for real time irrigation to soil and plant	14.01.2022	30.04.2023		14.07.2024	30.04.2023	
5	Soumyadeep De	Project Assistant (Ad-hoc)	Ali Hossain Khan	CBMS	Doped 2D Nanocrystals for Photonic Applications	17.01.2022	6 Months	31.03.2026	16.07.2022	24.04.2022	
			DEPT. TOTAL					**5**			
1	Arun Kumar Das	Project JRF	Archan S Majumdar	AC	Applications of Quantum Information	16.10.2019	Till the end of the project	23.04.2022	23.04.2022		
2	Subhankar Bera	Project JRF	Archan S Majumdar	AC	Applications of Quantum Information	03.10.2019	Till the end of the project	23.04.2022	23.04.2022		
			DEPT. TOTAL					**2**			
			TOTAL					**10**			

Patents Granted:

(1)
Patent No.: 368228
Application No.: 201731036353
Date of Filing: 12/10/2017
Date of Grant: 31/05/2021
A TECHNIQUE TO REGENERATE FERROELECTRIC PHASE BY SURFACE AND SUBSURFACE ENGINEERING OF BaTiO3 THIN FILMS

(2)
Patent No.: 368229
Application No.: 201731027537
Date of Filing: 02/08/2017
Date of Grant: 31/05/2021
(CU)PP-TIO2 -BASED PHOTO-CATALYTIC CONVERTER OF TOXIC METAL
IONS IN WATER INCLUDING CR (VI)

(3)
Patent No.: 370791
Application No.: 201831048458
Date of Filing: 20/12/2018
Date of Grant: 30/06/2021
A METHOD OF FABRICATING MONODISPERSED SILICA NANOFLOWERS FOR CARBON DIOXIDE ADSORPTION

(4)
Patent No.: 377714
Application No.: 201731040027
Date of Filing: 09/11/2017
Date of Grant: 23/09/2021
AN IMPROVED METHOD FOR THE SYNTHESIS OF D-MNO2 NANOCOMPOSITES WITH ENHANCED PHOTOCATALYTIC ACTIVITY

(5)
Patent No.: 393473
Application No.: 201731029433
Date of Filing: 19/08/2017
Date of Grant: 29/03/2022
DIGITAL CAMERA BASED SPECTROMETRIC SYSTEM FOR POINT-OF-CARE ANALYSIS OF ULTRA-LOW VOLUME WHOLE BLOOD SAMPLE

Samir Kumar Pal
Convenor, Project & Patent Cell

Technical Research Centre (TRC)

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.

Major Target Areas of on-going TRC at SNBNCBS

- **Health Care:** Development of Low-cost Non Invasive Medical Diagnostics for Capacity Building for maternal/ child health care & Ulcer detection.
- **Environment:** Development of Low-cost Sensors for sustainable management of Water & Air for life on land and life below water.
- **Food Security:** Development of Low-cost Sensors to provide food security to households.
- **Low-Cost Instrumentation:** Development of low-cost instrumentation for the industries and to enhance employment opportunity.
- **Input through Computation:** High-end computation for the development of technologically Important Indigenous Materials of national need.

Project Investigators :

Prof. Soumen Mondal (Nodal Officer); Prof. Tanusri Saha Dasgupta; Prof. Samir K. Pal; Prof. Ranjit Biswas; Dr. Barnali Ghosh Saha; Dr. Manik Pradhan; Prof. Jaydeb Chakrabarti; Prof. P. K. Mukhopadhyay; Prof. A.K.Raychaudhuri (Nodal Officer till December 2019); Dr. Subhra Jana, Dr. Atindra Nath Pal and Dr. Suman Chakrabarty.

Manpower and Resources up to June 2021 :

- Number of Scientists (C & D): 10
- Number of Project Students: 18
- Number of Project Assistants: 12
- Number of Project Officers: 02

Research Activities :

A. Translational Research Activities undertaken under the TRC Project:

- An active respirator with attached exhalation valve and suspended particulate matter filter for comfortable and hygienic breathing (COVID-19)
- Long-lasting nano-sanitizer with a dispensing antimicrobial layer (COVID-19)
- Non-contact Optial Device Clinical Diagnostics of Anaemia, Jaundice and Oxygen Deficiency (AJO Device)
- Digital Camera Based Spectrometry for the Development of Point-of-Care Anaemia Detection on Ultra-low Volume Whole Blood Sample
- Development of Spectroscopy Based Fluoride Sensor in Drinking Water (FeFlu)
- Development of Optical Emission Spectroscopy (OES) based Sensor for Minimally-invasive Detection of Essential Electrolytes in Human Body (NaLiK)
- A non-invasive breath analysis based detection of Peptic Ulcer disease, nonulcerous dyspepsia and helicobacter pyroli infection
- Development of Flexible paper-based highly sensitive sensor for ammonia gas detection by visual effects.
- Prototype development for spectroscopic based detection of adulteration in Milk (MIL-Q-WAY)
- Fabrication of High Surface Area Silica Nanoflowers for CO2 Capture and Detection of COPD.
- Piezo-electric Nano generator.
- Enzyme Catalysed Bio-degradation of Xenobiotic Compounds: Treatment of Industrial Effluents.
- Development of light operated microactuator using photomechanical actuation of specific alloys.
- Development of sensors and optoelectronic devices using ultrathin layered materials and organic molecules.

- Calorimeter for biochemical and small volume analyzer to be used as an attachment of a microscope: Hand held portable thermal analyzer
- Use of silver nanoparticles to enhance the antifungal properties of natural fiber like Jute.
- Prediction of new magnetic double perovskites and Machine-learning assisted designing of new rare earth based permanent magnets..
- Rare-Earth-Elements (REE) Extraction
- Computation-based understanding and prediction of technologically important materials.
- Machine learning assisted prediction on semiconductor heterostructure
- Designing enhanced thermoelectric properties in 2D Materials
- Microscopic Understanding of Switching and Sensing Devices
- Identification of potential drug targets to control PCSK9-LDLR interaction towards lowering of blood LDL level
- Structure and Dynamics of modulated binary colloid

A. Number of Patent filed and granted during April 2021 to 31st March 2022

Sl.	Title	Inventors	Country	File No.	Status
1.	An Active Respirator with attached exhalation valve and suspended particulate matter filter for Comfortable and Hygienic Breathing	Samir Kumar Pal and others	India	202031026595	Filed on 23/06/2021 (Provisionally on 23/06/2020)
2.	A nano-sanitizer with a dispensing antimicrobial layer	Samir Kumar Pal and others	India	202031026596	Filed on 23/06/2021 (Provisionally on 23/06/2020)
3.	A technique to regenerate ferroelectric phase by surface and subsurface engineering of batio3 thin films	Ankita Ghatak, Shubhamita Sengupta, Shaili Sett, A.K. Raychaudhuri, and Barnali Ghosh	India	201731036353 Granted Patent No. 368228	Filed on 12/10/2017 Granted on 31/05/2021
4.	A method of fabricating monodispersed silica nanoflowers for carbon dioxide adsorption	S. Das, A. Samanta and Subhra Jana INDIA	India	201831048458 Granted Patent No. 370791	Filed on 20/12/2018 Granted on 30/06/2021
5.	An improved method for the synthesis of d-MnO2 nanocomposites with enhanced photocatalytic activity	Sankar Das, Arnab Samanta and Subhra Jana	India	201731040027 Granted Patent No. 377714	Filed on 09/11/2017 Granted on 23/09/2021
6.	Digital camera based spectrometric system for point-of-care analysis of ultra-low volume whole blood sample	Samir Kumar Pal	India	201731029433 Granted Patent No. 393473	Filed on 19/08/2017 Granted on 29/03/2022

B. A few Prototypes developed under TRC ready for Transfer of Technology

C. List of Running Consultancy Projects / Industrial Partners under TRC

S. No	Particulars of Industrial Partner	Name of the Translational Project / Technology	Specific role in Development / Commercialization etc.
1	EzRex Health Tech Pvt. Ltd.	A low-cost non-contact AJO device	Taker of the technology for commercialization
2	Sarfez Cure India	Study the effect of additives on decomposition kinetics of hydrates	Industrial collaboration initiated
3	Dundee University, Scttoland and and EzRex Health Tech Pvt. Ltd (Consultancy project jointly)	A screening device (Spec-U-Lesion) for the detection of bladder cancer using spectroscopic techniques	Consultancy project jointly

D. 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**

Soumen Mondal
Nodal Officer
Technical Research Centre

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 the s e facilities are mentioned in the website: https://newweb.bose.res.in/facilities/TechnicalCell/. The activities of Technical Cell during April 2021 - March 2019 are reported in the following sections:

1. 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)

Sl. No.	Name of the Equipment
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. 13 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 Xray 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 2019. 32 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	DSGS board has been replaced
2. PLD	Replace beam splitter of Instrument

Name of Instrument	Major repair and up-gradation
3. AFM(PFM) *	Installation of Xenon Lamp
4. VSM	Linear amplifier fan has been replaced
5. UV SPECTROMETERE	Installation of D2 Lamp
6. MINI XRD	CPU2DX(communication) board has been replaced

VI. Utilization of Equipment

ITEM	USAGE (Time & Hours)	UP TIME%	DOWN TIME %	No. OF EXTERNAL USERS
PLD	900	75%	25%	NIL
FESEM	900	80%	20%	20
XPERT PRO	700	70%	30%	6
MINI XRD	400	80%	20%	13
TG/DTA	700	97%	3%	25
AFM	815	85%	15%	20
VSM	760	70%	30%	12
DSC	696	70%	30%	11
HRTEM	1080	75%	35%	15
PPMS	7320	75%	25%	NIL
DLS	170	90%	10%	12
HRXRD	2008	90%	10%	1

VII. Revenue Generation

Some revenue was generated from the external users for using the facilities of Technical Cell.

Samir Kumar Pal
In-charge, Technical Cell

Staff Members, Technical Cell

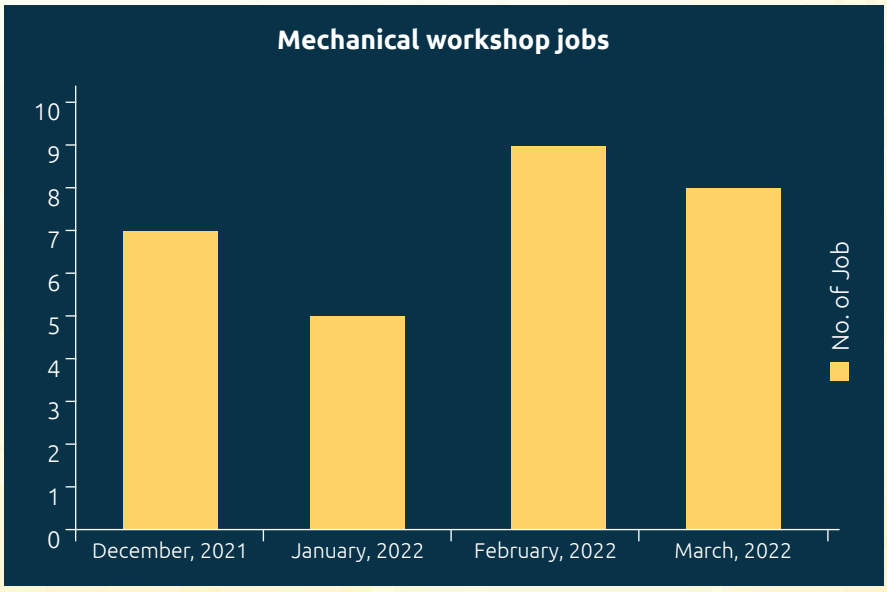
Mechanical Workshop

Mechanical workshop at the center is an important part, particularly to the experimental faculties. Throughout the year mechanical workshop functioned and catered to the demands of different departments and to the outside. It is handled by a mechanic in all days of the week and 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 in mechanical workshop – 29. Month wise breakups are given below: (2021 – 2022). It is to be mentioned that the workshop was closed for a significant time during covid period. Three major equipment were procured during this time: CNC Milling Machine, All Gear Lathe Machine and Welding Machine from Center's TRC project. Also, whole workshop has moved to the old AC plant in the main building premises. With these new facilities will definitely help to make more sophisticated research equipment in future.

All Gear Lathe Machine

CNC Milling Machine

Welding Machine



Total job performed from 15.12.2021 to 31.03.2022

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 and 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 Centre's students. There is a seminar room within the guest house for hosting small conferences, meetings etc with separate dining facilities. The Guest House also hosts the Medical Cell of the Centre where doctor consultations are available to the Centre's staff and students. The Centre's modern cafeteria with a state-of-art kitchen is 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, dinners and high-tea on special occasions. Apart from accommodating Centre's guests and visitors, the Centre extends its guest house facilities to various government departments, organizations, research laboratories, universities etc during normal time. The Centre also extends its guest house facilities for extending accommodation to various academic and research organizations. The guest house provides efficient service and warm hospitality to all the guests staying in it. After the outbreak of the COVID Pandemic, the allotment of guest house rooms to external visitors were done in a very restricted manner as a precautionary measure. Presently, with the improvement in the situation, the guest house rooms are being opened for the visitors in a phased manner.

Majumder

Shohini Majumder
Registrar

Special Days of Celebration

The Centre organized the following events by maintaining COVID-19 restrictions:

- On the occasions of the 73rd Republic Day on 26th January 2022 and 75th Independence Day on 15th August 2021, the Director hoisted the national flag in the premises of the Centre. On both the occasions, national anthem was sung by students and staff present and parade was performed by the Centre's security personnel.
- On 1st January 2022, the Centre celebrated 129th Birth Anniversary of Prof. Satyendra Nath Bose by garlanding the bust of the eminent scientist. The Centre organised 'Open Day' on 4th January 2022 to commemorate the 129th Birth Anniversary of Prof. Satyendra Nath Bose. On the said occasion, Prof. Jayanta Kumar Bhattacharjee, Distinguished Visiting Professor, IACS, Kolkata gave a Popular Science Talk followed by Science Labs visit, SNBose Archive visit and Planet & Star watching.

The Centre also celebrated the following occasions :-

- Rashtriya Ekta Diwas on 31st October 2021 by taking pledge through virtual pledge.
- Constitution Day was celebrated on 26th November 2021 through on-line & physical pledge taking ceremony.
- 'Muktangan' organised the following events:-
- An Intra-Institute Badminton Tournament was organised (both Singles & Doubles) on 26-27 February 2022;
- An Intra-Institute Chess Tournament (Online Game) was organised on 15-16 March 2022 and Intra-Institute Carrom Tournament (both Singles & Doubles) was organised on 22-24 March 2022. Both the events were a grand success;
- An Intra-Institute Cricket Tournament was organised on 26-27 March 2022.

All the above mentioned events were a grand success.

- The Centre celebrated BOSE FEST 2021 during 3-5 August 2021 with 51 short talks delivered by Research Scholars and Post Doctoral Fellows of the Centre.

Sonajumder

Shohini Majumder
Registrar

Flag hoisting on 73rd Republic Day on 26th January 2022

129th Birth Anniversary celebration of Prof. S. N. Bose on 1st January, 2022

Constitution Day celebration on 26th November, 2021

Publications

Publications

List of Journal Publications 2021-2022

Department of Astrophysics & Cosmology

1. Ananda G. Maity, Shiladitya Mal, Chellasamy Jebarathinam, and **A. S. Majumdar**, *Self-testing of binary Pauli measurements requiring neither entanglement nor any dimensional restriction*, Physical Review A, 103, 062604, 2021
2. Shashank Gupta, Debarshi Das, and **A. S. Majumdar**, *Distillation of genuine tripartite Einstein-Podolsky-Rosen steering*, Physical Review A, 104, 022409, 2021
3. Bihalan Bhattacharya, Suchetana Goswami, Rounak Mundra, Nirman Ganguly, Indranil Chakrabarty, Samyadeb Bhattacharya and **A S Majumdar**, *Generating and detecting bound entanglement in two-qutrits using a family of indecomposable positive maps*, Journal of Physics Communications, 5, 065008, 2021
4. Shashank Gupta, Debarshi Das, Chellasamy Jebarathinam, Arup Roy, Shounak Datta & **A. S. Majumdar**, *"All-versus-nothing" proof of genuine tripartite steering and entanglement certification in the two-sided device-independent scenario*, Quantum Studies: Mathematics and Foundations, 9, 175-198, 2022
5. J. Abhir, R. Prince, J. Joseph, **D. Bose** and N. Gupta, *Study of Temporal and Spectral variability for Blazar PKS 1830-211 with Multiwavelength Data*, The Astrophysical Journal, 915, 26, 2021
6. K. Abe, P. Adrich, H. Aihara, R. Akutsu, I. Alekseev, A. Ali, F. Ameli, I. Anghel, L. H. V. Anthony, M. Antonova, A. Araya, Y. Asaoka, Y. Ashida, V. Aushev, F. Ballester, I. Bandac, M. Barbi, G. J. Barker, G. Barr, M. Batkiewicz-Kwasniak, M. Bellato, V. Berardi, M. Bergevin, L. Bernard, E. Bernardini, L. Berns, S. Bhadra, J. Bian, A. Blanchet, F. d. M. Blaszczyk, A. Blondel, A. Boiano, S. Bolognesi, L. Bonavera, N. Booth, S. Borjabad, T. Boschi, **D. Bose**, et al. *Supernova Model Discrimination with Hyper-Kamiokande*, The Astrophysical Journal, 916, 15, 2021
7. **D. Bose**, V. R. Chitnis, P. Majumdar & B. S. Acharya, *Ground-based gamma-ray astronomy: history and development of techniques*, The European Physical Journal Special Topics, 231, 3-26, 2022
8. **D. Bose**, V. R. Chitnis, P. Majumdar & A. Shukla, *Galactic and extragalactic sources of very high energy gamma rays*, The European Physical Journal Special Topics, 231, 27-66, 2022
9. **Ramkrishna Das**, *Elemental abundances in novae*, Journal of Astrophysics and Astronomy, 42, 13, 2021
10. Rahul Bandyopadhyay, **Ramkrishna Das, Soumen Mondal**, *Compact planetary nebulae MaC 2-1 and Sp 4-1: photoionization models and dust characteristics*, Monthly Notices of the Royal Astronomical Society, 504, 816-829, 2021
11. Ruchi Pandey, **Ramkrishna Das**, Gargi Shaw and **Soumen Mondal**, *Photoionization Modeling of the Dusty Nova V1280 Scorpii*, The Astrophysical Journal, 925, 187, 2022
12. Supriyo Ghosh, **Soumen Mondal, Ramkrishna Das**, and Somnath Dutta, *Spectroscopic and Photometric Monitoring of a Poorly Known Highly Luminous OH/IR Star: IRAS 18278+0931*, The Astronomical Journal, 161, 198, 2021
13. Dhrimadri Khata, **Soumen Mondal, Ramkrishna Das, Tapas Baug**, *Estimating T_{eff}, radius, and luminosity of M-dwarfs using high-resolution optical and NIR spectral features*, Monthly Notices of the Royal Astronomical Society, 507, 1869-1885, 2021
14. Hong-Li Liu, Tie Liu, Neal J Evans II, Ke Wang, Guido Garay, Sheng-Li Qin, Shanghuo Li, Amelia Stutz, Paul F Goldsmith, Sheng-Yuan Liu, Anandmayee Tej, Qizhou Zhang, Mika Juvela, Di Li, Jun-Zhi Wang, Leonardo Bronfman, Zhiyuan Ren, Yue-Fang Wu, Kee-Tae Kim, Chang Won Lee, Ken'ichi Tatematsu, Maria R Cunningham, Xun-Chuan Liu, Jing-Wen Wu, Tomoya Hirota, Jeong-Eun Lee, Pak-Shing Li,

Sung-Ju Kang, Diego Mardones, Isabelle Ristorcelli, Yong Zhang, Qiu-Yi Luo, L Viktor Toth, Hee-weon Yi, Hyeong-Sik Yun, Ya-Ping Peng, Juan Li, Feng-Yao Zhu, Zhi-Qiang Shen, **Tapas Baug**, L K Dewangan, Eswaraiah Chakali, Rong Liu, Feng-Wei Xu, Yu Wang, Chao Zhang, Jinzeng Li, Chao Zhang, Jianwen Zhou, Mengyao Tang, Qiaowei Xue, Namitha Issac, Archana Soam, Rodrigo H Álvarez-Gutiérrez, ***ATOMS: ALMA three-millimeter observations of massive star-forming regions – III. Catalogues of candidate hot molecular cores and hyper/ultra compact H ii regions***, Monthly Notices of the Royal Astronomical Society, 505, 2801-2818, 2021

15. L K Dewangan, J S Dhanya, N K Bhadari, D K Ojha, **T Baug**, ***Lynds Bright Nebulae: sites of possible twisted filaments and ongoing star formation***, Monthly Notices of the Royal Astronomical Society, 506, 6081-6092, 2021
16. R Arun, Blesson Mathew, G Maheswar, **Tapas Baug**, Sreeja S Kartha, G Selvakumar, P Manoj, B Shridharan, R Anusha, Mayank Narang, ***Clustering of low-mass stars around Herbig Be star IL Cep – evidence of 'Rocket Effect' using Gaia EDR3 ?***, Monthly Notices of the Royal Astronomical Society, 507, 267-281, 2021
17. **T Baug**, Ke Wang, Tie Liu, Yue-Fang Wu, Di Li, Qizhou Zhang, Mengyao Tang, Paul F Goldsmith, Hong-Li Liu, Anandmayee Tej, Leonardo Bronfman, Kee-Tae Kim, Shanghuo Li, Chang Won Lee, Ken'ichi Tatematsu, Tomoya Hirota, L Viktor Toth, ***An ALMA study of outflow parameters of protoclusters: outflow feedback to maintain the turbulence***, Monthly Notices of the Royal Astronomical Society, 507, 4316-4334, 2021
18. Hong-Li Liu, Anandmayee Tej, Tie Liu, Paul F Goldsmith, Amelia Stutz, Mika Juvela, Sheng-Li Qin, Feng-Wei Xu, Leonardo Bronfman, Neal J Evans, Anindya Saha, Namitha Issac, Ken'ichi Tatematsu, Ke Wang, Shanghuo Li, Siju Zhang, **Tapas Baug**, Lokesh Dewangan, Yue-Fang Wu, Yong Zhang, Chang Won Lee, Xun-Chuan Liu, Jianwen Zhou, Archana Soam, ***ATOMS: ALMA Three-millimeter Observations of Massive Star-forming regions – IX. A pilot study towards IRDC G034.43+00.24 on multi-scale structures and gas kinematics***, Monthly Notices of the Royal Astronomical Society, 511, 4480-4489, 2022
19. Rong Liu, Tie Liu, Gang Chen, Hong-Li Liu, Ke Wang, Jin-Zeng Li, Chang Won Lee, Xunchuan Liu, Mika Juvela, Guido Garay, Lokesh Dewangan, Archana Soam, Leonardo Bronfman, Jinhua He, Chakali Eswaraiah, Si-Ju Zhang, Yong Zhang, Feng-Wei Xu, L Viktor Tóth, Zhi-Qiang Shen, Shanghuo Li, Yue-Fang Wu, Sheng-Li Qin, Zhiyuan Ren, Guoyin Zhang, Anandmayee Tej, Paul F Goldsmith, **Tapas Baug**, Qiuyi Luo, Jianwen Zhou, Chang Zhang, ***ATOMS: ALMA three-millimeter observations of massive star-forming regions – VII. A catalogue of SiO clumps from ACA observations***, Monthly Notices of the oyal Astronomical Society, 511, 3618-3635, 2022
20. Sheng-Li Qin, Tie Liu, Xunchuan Liu, Paul F Goldsmith, Di Li, Qizhou Zhang, Hong-Li Liu, Yuefang Wu, Leonardo Bronfman, Mika Juvela, Chang Won Lee, Guido Garay, Yong Zhang, Jinhua He, Shih-Ying Hsu, Zhi-Qiang Shen, Jeong-Eun Lee, Ke Wang, Ningyu Tang, Mengyao Tang, Chao Zhang, Yinghua Yue, Qiaowei Xue, Shanghuo Li, Yaping Peng, Somnath Dutta, Jixing Ge, Fengwei Xu, Long-Fei Chen, **Tapas Baug**, Lokesh Dewangan, Anandmayee Tej, ***ATOMS: ALMA Three-millimeter Observations of Massive Star-forming regions – VIII. A search for hot cores by using C_2H_5CN, CH_3OCHO, and CH_3OH lines***, Monthly Notices of the Royal Astronomical Society, 511, 3463-3476, 2022
21. Hong-Li Liu, Anandmayee Tej, Tie Liu, Namitha Issac, Anindya Saha, Paul F Goldsmith, Jun-Zhi Wang, Qizhou Zhang, Sheng-Li Qin, Ke Wang, Shanghuo Li, Archana Soam, Lokesh Dewangan, Chang Won Lee, Pak-Shing Li, Xun-Chuan Liu, Yong Zhang, Zhiyuan Ren, Mika Juvela, Leonardo Bronfman, Yue-Fang Wu, Ken'ichi Tatematsu, Xi Chen, Di Li, Amelia Stutz, Siju Zhang, L Viktor Toth, Qiu-Yi Luo, Feng-Wei Xu, Jinzeng Li, Rong Liu, Jianwen Zhou, Chao Zhang, Mengyao Tang, Chao Zhang, **Tapas Baug**, E Mannfors, Eswaraiah Chakali, Somnath Dutta, ***ATOMS: ALMA Three-millimeter Observations of Massive Star-forming regions – V. Hierarchical fragmentation and gas dynamics in IRDC G034.43+00.24***, Monthly Notices of the Royal Astronomical Society, 510, 5009-5022, 2022
22. I I Zinchenko, L K Dewangan, **T Baug**, D K Ojha, N K Bhadari, ***ALMA discovery of a dual dense probably rotating outflow from a massive young stellar object G18.88MME***, Monthly Notices of the Royal Astronomical Society: Letters, 506, L45–L49, 2021

23. Arkaprabha Ghosal, Debarshi Das, and Subhashish Banerjee, ***Characterizing qubit channels in the context of quantum teleportation***, Physical Review A, 103, 052422, 2021

24. Arnab Sarkar, Amna Ali & Salah Nasri, ***Perturbative correction terms to electromagnetic self-force due to metric perturbation: astrophysical and cosmological implications***, The European Physical Journal C, 81, 725, 2021

25. D. Chatterjee, D. Debnath, A. Jana, J.-R. Shang, S. K. Chakrabarti, H.-K. Chang, A. Banerjee, A. Bhattacharjee, K. Chatterjee, R. Bhowmick & S. K. Nath, ***AstroSat observation of non-resonant type-C QPOs in MAXI J1535-571***, Astrophysics and Space Science, 366, 82, 2021

26. Anuvab Banerjee, Ayan Bhattacharjee, Debjit Chatterjee, Dipak Debnath, Sandip Kumar Chakrabarti, Tilak Katoch, and H. M. Antia, ***Accretion Flow Properties of GRS 1915+105 During Its θ Class Using AstroSat Data***, The Astrophysical Journal, 916, 68, 2021

27. Prantik Nandi, Arka Chatterjee, Sandip K Chakrabarti, Broja G Dutta, ***Long-term X-ray observations of seyfert 1 galaxy ark 120: on the origin of soft-excess***, Monthly Notices of the Royal Astronomical Society, 506, 3111-3127, 2021

28. Arghajit Jana, Neeraj Kumari, Prantik Nandi, Sachindra Naik, Arka Chatterjee, Gaurava K Jaisawal, Kimitake Hayasaki, Claudio Ricci, ***Broad-band X-ray observations of the 2018 outburst of the changing-look active galactic nucleus NGC 1566***, Monthly Notices of the Royal Astronomical Society, 507, 687-703, 2021

29. Swati Chowdhury, Sudipta Sasmal, James Brundell, Suman Chakraborty, Ayan Bhattacharjee, Sandip K. Chakrabarti, ***Energetic electron precipitation during lightning activities over Indian landmass as observed from WWLLN and NOAA-15 satellite***, Advances in Space Research, 68, 4205-4216, 2021

30. Debarshi Das, Arkaprabha Ghosal, Ananda G. Maity, Som Kanjilal, and Arup Roy, ***Ability of unbounded pairs of observers to achieve quantum advantage in random access codes with a single pair of qubits***, Physical Review A, 104, L060602, 2021

31. Rivu Gupta, Shashank Gupta, Shiladitya Mal, and Aditi Sen(De), ***Constructive feedback of non-Markovianity on resources in random quantum states***, Physical Review A, 105, 012424, 2022

32. Tamal Guha, Mir Alimuddin, Sumit Rout, Amit Mukherjee, Some Sankar Bhattacharya and Manik Banik, ***Quantum Advantage for Shared Randomness Generation***, Quantum, 5, 569, 2021

33. Sumit Rout, Ananda G. Maity, Amit Mukherjee, Saronath Halder, and Manik Banik, ***Multiparty orthogonal product states with minimal genuine nonlocality***, Physical Review A, 104, 052433, 2021

34. Some Sankar Bhattacharya, Ananda G. Maity, Tamal Guha, Giulio Chiribella, and Manik Banik, ***Random-Receiver Quantum Communication***, PRX Quantum, 2, 020350, 2021

Department of Chemical, Biological & Macro-Molecular Sciences

1. Anirban Karmakar and **Gautam Gangopadhyay**, *Electron-Vibration Entanglement of Resonating Dimers in Quantum Transport*, The Journal of Physical Chemistry A, 125, 3122-3134, 2021

2. Biswajit Das, Kinshuk Banerjee, and **Gautam Gangopadhyay**, *On the Role of Magnesium Ions in the DNA-Scissoring Activity of the Restriction Endonuclease ApaI: Stochastic Kinetics from a Single Molecule to Mesoscopic Paradigm*, The Journal of Physical Chemistry B, 125, 4099-4107, 2021

3. Prasanta Kundu, Soma Saha, and **Gautam Gangopadhyay**, *A Revisit to Turnover Kinetics of Individual Escherichia coli β-Galactosidase Molecules*, The Journal of Physical Chemistry B, 125, 8010-8020, 2021

4. Premashis Kumar and **Gautam Gangopadhyay**, *Nonequilibrium thermodynamics of glycolytic traveling wave: Benjamin-Feir instability*, Physical Review E, 104, 014221, 2021

5. Premashis Kumar and **Gautam Gangopadhyay**, *Nonequilibrium thermodynamic characterization of chimeras in a continuum chemical oscillator system*, Physical Review E, 105, 034208, 2022

6. Sandip Saha, **Gautam Gangopadhyay** & Deb Shankar Ray, *Universality in bio-rhythms: A perspective from nonlinear dynamics*, Journal of Biosciences, 47, 16, 2022
7. Souma Mazumdar, **Gautam Gangopadhyay**, *Centre Manifold Analysis of 3-D Nonlinear System and Kinetic Stability of Protein Assembly*, Journal of Applied Nonlinear Dynamics, 11(1), 139-152, 2022
8. Atin Pramanik, Shreyasi Chattopadhyay, Sandipan Maiti, **Goutam De**, Sourindra Mahanty, *Hollow-porous nanospheres of $ZnMn_2O_4$ spinel: A high energy density cathode for rechargeable aqueous battery*, Materials Chemistry and Physics, 263, 124373, 2021
9. Atin Pramanik, Sandipan Maiti, Shreyasi Chattopadhyay, **Goutam De**, Sourindra Mahanty, *'Cotton-ball' shaped porous iron-nickel sulfide: A high-rate cathode for long-life aqueous rechargeable battery*, Materials Research Bulletin, 140, 111307, 2021
10. Sourav Pramanik, Shreyasi Chattopadhyay, Sandip Bysakh, Anindita Mukhopadhyay, **Goutam De**, *Alloy formation and composition partitioning of plasmonic-magnetic Au–Fe nanoparticles embedded in sol-gel SiO_2 films*, Journal of Alloys and Compounds, 873, 159793, 2021
11. Atin Pramanik, Shreyasi Chattopadhyay, **Goutam De** and Sourindra Mahanty, *Efficient energy storage in mustard husk derived porous spherical carbon nanostructures*, Materials Advances, 2, 7463-7472, 2021
12. Rahul Karmakar and **J. Chakrabarti**, *A long-range order in a thermally driven system with temperature-dependent interactions*, Soft Matter, 18, 867-876, 2022
13. Aayatti Mallick Gupta, SasthiCharan Mandal, Sukhendu Mandal, **Jaydeb Chakrabarti**, *Immune escape facilitation by mutations of epitope residues in RdRp of SARS-CoV-2*, Journal of Biomolecular Structure and Dynamics, DOI: 10.1080/07391102.2022.2051746
14. Mausumi Raya, Sasthi Charan Mandal, **Jaydeb Chakrabarti**, *Quantum chemical studies on chelation in nano-bio conjugate between ZnO nanoparticles and cellular energy carrier molecules*, Materials Chemistry and Physics, 279, 125744, 2022
15. Sayoni Bhattacharya, Mithun Pal, Biswajit Panda, **Manik Pradhan**, *Spectroscopic investigation of hydrogen and triple-oxygen isotopes in atmospheric water vapor and precipitation during Indian monsoon season*, Isotopes in Environmental and Health Studies, 57, 368-385, 2021
16. Sanchi Maithani, Abhijit Maity and **Manik Pradhan**, *A perspective on the evolving role of stable isotope analysis and the emergence of cavity enhanced spectroscopy as a potent tool*, Journal of Analytical Atomic Spectrometry, 36, 1813-1825, 2021
17. Saptarshi Pal, Puspendu Barik, **Manik Pradhan**, *Tunable plasmon assisted enhancement of green light emission from ZnO nanoparticles*, Materials Today Communications, 28, 102713, 2021
18. Ardhendu Pal, Biswajit Panda, Sanchi Maithani, **Manik Pradhan**, *Cavity ring-down spectroscopy of l-type doubling in ^{15}N-β-site N_2O isotopomer near 7.8 μm*, Journal of Molecular Spectroscopy, 381, 111523, 2021
19. Akash Das, Soumen Mandal, and **Manik Pradhan**, *Observation of Imbert–Fedorov shift in monolayer MoS_2 via quantum weak measurement*, Optics Letters, 46, 5826-5829, 2021
20. Puspendu Barik, Saptarshi Pal, **Manik Pradhan**, *On-demand nanoparticle-on-mirror (NPoM) structure for cost-effective surface-enhanced Raman scattering substrates*, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 263, 120193, 2021
21. Sanchi Maithani, Abhijit Maity and **Manik Pradhan**, *Probing the H–D isotopic exchange reaction in a liquid droplet via surface plasmon resonance*, Journal of Analytical Atomic Spectrometry, 37, 544-550, 2022
22. Biswajit Panda, Ardhendu Pal and **Manik Pradhan**, *Direct and 2f-wavelength modulation spectroscopy of NO and OCS using an astigmatic multipass cell coupled with a mid-IR 5.2 μm cw-QCL*, Laser Physics, 32, 035702, 2022
23. Ardhendu Pal, Biswajit Panda, Sanchi Maithani, Manik Pradhan, *l-doublet splittings in Δ vibrational state of $^{15}N^{14}N^{16}O$ isotopomer*, Chemical Physics Impact, 3, 100049, 2021
24. Biswajit Panda, Ardhendu Pal, Sanchi Maithani, Abhijit Maity, **Manik Pradhan**, *Ro-vibrational spectral features and pressure broadening dynamics of dideutero-methane*

($^{12}CH_2D_2$) in the $\nu_9(B_2)$ fundamental band, Journal of Molecular Spectroscopy, 384, 111572, 2022

25. Arun Bera, Arpan Maiti, Abhijit Maity & **Manik Pradhan**, *Exploring C, H and O isotope-specific adsorption of CO_2 and H_2O vapour in nanostructured polyaniline*, MRS Communications, 11, 843-849, 2021
26. Chiranjit Ghosh, Debashis Patra, Niranjan Bala, Indira Majumder, Nayim Sepay, Prabuddha Mukhopadhyay, Sukhen Das, Rita Kundu, Michael G. B. Drew, Armando Rafael León, Tapas Ghosh, **Manik Pradhan**, *A family of amphiphilic dioxidovanadium(V) hydrazone complexes as potent carbonic anhydrase inhibitors along with anti-diabetic and cytotoxic activities*, BioMetals, 2022, https://doi.org/10.1007/s10534-022-00384-7
27. Puspendu Barik and **Manik Pradhan**, *Selectivity in trace gas sensing: recent developments, challenges, and future perspectives*, Analyst, 147, 1024-1054, 2022
28. **Manoj Mandal**, Keisuke Saito, Hiroshi Ishikita, *Requirement of Chloride for the Downhill Electron Transfer Pathway from the Water-Splitting Center in Natural Photosynthesis*, The Journal of Physical Chemistry B, 126, 123-131, 2022
29. Sonali Mondal, Partha Pyne, Animesh Patra, **Rajib Kumar Mitra**, and Soumen Ghosh, *Effect of Surfactant Tail Length on the Hydroxypropyl Cellulose-Mediated Premicellar Aggregation of Sodium n-Alkyl Sulfate Surfactants*, Langmuir, 37, 6168-6177, 2021
30. Partha Pyne and **Rajib Kumar Mitra**, *Excipients Do Regulate Phase Separation in Lysozyme and Thus Also Its Hydration*, The Journal of Physical Chemistry Letters, 13, 931-938, 2022
31. Atanu Baksi, Juriti Rajbangshi and **Ranjit Biswas**, *Water in biodegradable glucose-water-urea deep eutectic solvent: modifications of structure and dynamics in a crowded environment*, Physical Chemistry Chemical Physics, 23, 12191-12203, 2021
32. Juriti Rajbangshi, Kallol Mukherjee, and **Ranjit Biswas**, *Heterogeneous Orientational Relaxations and Translation–Rotation Decoupling in (Choline Chloride + Urea) Deep Eutectic Solvents: Investigation through Molecular Dynamics Simulations and Dielectric Relaxation Measurements*, The Journal of Physical Chemistry B, 125, 5920-5936, 2021
33. Kajal Kumbhakar, Asmita Dey, Amrita Mondal, Priyadarsi De, and **Ranjit Biswas**, *Interactions and Dynamics in Aqueous Solutions of pH-Responsive Polymers: A Combined Fluorescence and Dielectric Relaxation Study*, The Journal of Physical Chemistry B, 125, 6023-6035, 2021
34. Juriti Rajbangshi, **Ranjit Biswas**, *Heterogeneous dynamics in [BMIM][PF_6] + Cosolvent binary Mixtures: Does It depend upon cosolvent Polarity?*, Journal of Molecular Liquids, 341, 117342, 2021
35. Dhrubajyoti Maji, Sandipa Indra & **Ranjit Biswas**, *Dielectric relaxations of molten acetamide: dependence on the model interaction potentials and the effects of system size*, Journal of Chemical Sciences, 133, 104, 2021
36. Sirshendu Dinda, Arnab Sil, Anuradha Das, Ejaj Tarif, **Ranjit Biswas**, *Does urea modify microheterogeneous nature of ionic amide deep eutectics? Clues from non-reactive and reactive solute-centered dynamics*, Journal of Molecular Liquids, 349, 118126, 2022
37. Atanu Baksi and **Ranjit Biswas**, *Dynamical Anomaly of Aqueous Amphiphilic Solutions: Connection to Solution H-Bond Fluctuation Dynamics?*, ACS Omega, 7, 10970-10984, 2022
38. Arka Chatterjee, Nivedita Pan, Tuhin Kumar Maji, Sheik Saleem Pasha, Soumendra Singh, Saleh A. Ahmed, Jalal T. Al-Thakafy, and **Samir Kumar Pal**, *Highly Sensitive Optical Sensor for Selective Detection of Fluoride Level in Drinking Water: Methodology to Fabrication of Prototype Device*, ACS Sustainable Chemistry & Engineering, 9, 7160-7170, 2021
39. Aniruddha Adhikari, Susmita Mondal, Monojit Das, Ria Ghosh, Pritam Biswas, Soumendra Darbar, Soumendra Singh, Anjan Kumar Das, Siddhartha Sankar Bhattacharya, Debasish Pal, Asim Kumar Mallick, and **Samir Kumar Pal**, *Redox Buffering Capacity of Nanomaterials as an Index of ROS-Based Therapeutics and Toxicity: A Preclinical Animal Study*, ACS Biomaterials Science & Engineering, 7, 2475-2484, 2021
40. Mamta Kumari, Manisha Sharma, Swati Rani, Damayanti Bagchi, Arpan Bera, Dipanjan Mukherjee, **Samir Kumar Pal**, Subho Mozumdar, *Solvent dependent photophysical study of stable and medicinally active diketone modified*

pyrazole derivatives of curcumin: A spectroscopic study, Journal of Photochemistry and Photobiology A: Chemistry, 416, 113337, 2021

41. Nivedita Pan, Tuhin Kumar Maji, Sayantika Bandyopadhyay, Pritam Biswas, Arka Chatterjee, Mala Mitra, Arpita Chatterjee and **Samir Kumar Pal**, *A Combined Spectroscopic and Theoretical Analysis of Plasmonic Silver Nanoparticle Sensor Towards Detailed Microscopic Understanding of Heavy Metal Detection*, Plasmonics, 17, 223-236, 2022

42. Aniruddha Adhikari, Susmita Mondal, Tanima Chatterjee, Monojit Das, Pritam Biswas, Ria Ghosh, Soumendra Darbar, Hussain Alessa, Jalal T. Althakafy, Ali Sayqal, Saleh A. Ahmed, Anjan Kumar Das, Maitree Bhattacharyya & **Samir Kumar Pal**, *Redox nanomedicine ameliorates chronic kidney disease (CKD) by mitochondrial reconditioning in mice*, Communications Biology, 4, 1013, 2021

43. Saleh A. Ahmed, Nivedita Pan, Hatem M. Altass, Jayita Patwari, Rami J.Obaid, Hussain Alessa, Rabab S. Jassas, **Samir Kumar Pal**, *Broad light harvesting under restricted environment: Photophysical understanding leading to enhanced reactive oxygen species generation*, Journal of Photochemistry and Photobiology A: Chemistry, 418, 113422, 2021

44. Essam M.Hussein, Nizar ElGuesmi, Tuhin K. Maji, Rabab S. Jassas, Abdulrahman A. Alsimaree, Hatem M. Altass, Ziad Moussa, **Samir K.Pal**, Saleh A. Ahmed, *Synthesis and photophysical properties of benzimidazoles grafted pyrazole-containing pyrene or fluorene moiety: A combined spectroscopic and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 419, 113465, 2021

45. Arnab Samanta, **Samir Kumar Pal**, and **Subhra Jana**, *Synthesis of Template-Free Iron Oxyhydroxide Nanorods for Sunlight-Driven Photo-Fenton Catalysis*, ACS Omega, 6, 27905-27912, 2021

46. Neha Bhattacharyya, Soumendra Singh, Dipanjan Mukherjee, Nairit Das, Arka Chatterjee, Aniruddha Adhikari, Susmita Mondal, Pulak Mondal, Asim Kumar Mallicke and **Samir Kumar Pal**, *Picosecond-resolved fluorescence resonance energy transfer (FRET) in diffuse reflectance spectroscopy explores biologically relevant hidden molecular contacts in a non-invasive way*, Physical Chemistry Chemical Physics, 24, 6176-6184, 2022

47. Susmita Mondal, Nivedita Pan, Ria Ghosh, Arpan Bera, Dipanjan Mukherjee, Tuhin Kumar Maji, Anirudddha Adhikari, Sangeeta Ghosh, Prof. Chinmoy Bhattacharya, **Prof. Samir Kumar Pal**, *Interaction of a Jaundice Marker Molecule with a Redox-Modulatory Nano-Hybrid: A Combined Electrochemical and Spectroscopic Study toward the Development of a Theranostic Tool*, ChemMedChem, e202100660, 2022

48. Dipanjan Mukherjee, Md. Nur Hasan, Ria Ghosh, Gourab Ghosh, Arpan Bera, Sujanthi Easwara Prasad, Ankita Hiwale, Praveen K. Vemula, Ranjan Das, and **Samir Kumar Pal**, *Decoding the Kinetic Pathways toward a Lipid/DNA Complex of Alkyl Alcohol Cationic Lipids Formed in a Microfluidic Channel*, The Journal of Physical Chemistry B, 126, 588-600, 2022

49. Arnab Samanta, **Samir Kumar Pal** and **Subhra Jana**, *Exploring flowery MnO_2/Ag nanocomposite as an efficient solar-light-driven photocatalyst*, New Journal of Chemistry, 46, 4189-4197, 2022

50. Dipanjan Mukherjee, Md. Nur Hasan, Ria Ghosh, Gourab Ghosh, Arpan Bera, Sujanthi Easwara Prasad, Ankita Hiwale, Praveen K. Vemula, Ranjan Das, and **Samir Kumar Pal**, *Decoding the Kinetic Pathways toward a Lipid/DNA Complex of Alkyl Alcohol Cationic Lipids Formed in a Microfluidic Channel*, The Journal of Physical ChemistryB, 126, 588-600, 2022

51. Nivedita Pan, Neha Bhattacharyya, Amrita Banerjee, Pritam Biswas, Lopamudra Roy, Arka Chatterjee, Rama Bhattacharjee, Soumendra Singh, Saleh A. Ahmed, Arpita Chattopadhyay, Mala Mitra and **Samir Kumar Pal**, *Paper-based plasmonic nanosensor monitors environmental lead pollution in real field*, New Journal of Chemistry, 46, 8177-8184, 2022

52. Saleh A. Ahmed, Md. Nur Hasan, Hatem M. Altass, Arpan Bera, Reem I. Alsantali, Nivedita Pan, Abdullah Y. A. Alzahrani, Damayanti Bagchi, Jabir H. Al-Fahemi, Abdelrahman S. Khder, and **Samir Kumar Pal**, *Tetracycline Encapsulated in Au Nanoparticle-Decorated ZnO Nanohybrids for Enhanced Antibacterial Activity*, ACS Applied Nano Materials, 5, 4484-4492, 2022

53. Md. Nur Hasan, Arpan Bera, Tuhin Kumar Maji, Dipanjan Mukherjee, Nivedita Pan, Debjani Karmakar, **Samir Kumar Pal**, *Functionalized nano-MOF for NIR induced bacterial remediation: A combined spectroscopic and computational study*, Inorganica Chimica Acta, 532, 120733, 2022

54. Neha Bhattacharyya, Soumendra Singh, Animesh Halder, Aniruddha Adhikari, Ria Ghosh, Deep Shikha, Santanu Kumar Tripathi, Asim Kumar Mallick, Pulak Mondal, **Samir Kumar Pal**, *An Energy-Resolved Optical Non-invasive Device Detects Essential Electrolyte Balance in Humans at Point-of-Care*, Transactions of the Indian National Academy of Engineering, 6, 355-364, 2021

55. Dipanjan Mukherjee, Debashish Paul, Sushmita Sarker, Md. Nur Hasan, Ria Ghosh, Sujanthi Easwara Prasad, Praveen K. Vemula, Ranjan Das, Arghya Adhikary, **Samir Kumar Pal** and **Tatini Rakshit**, *Polyethylene Glycol-Mediated Fusion of Extracellular Vesicles with Cationic Liposomes for the Design of Hybrid Delivery Systems*, ACS Applied Bio Materials, 4, 8259-8266, 2021

56. Susmita Mondal, Anirudddha Adhikari, Ria Ghosh, Manali Singh, Monojit Das, Soumendra Darbar, Siddhartha Sankar Bhattacharya, Debasish Pal & Samir **Kumar Pal**, *Synthesis and spectroscopic characterization of a target-specific nanohybrid for redox buffering in cellular milieu*, MRS Advances, 6, 427-433, 2021

57. Md. Nur Hasan, Arpan Bera, Tuhin Kumar Maji, **Samir Kumar Pal**, *Sensitization of nontoxic MOF for their potential drug delivery application against microbial infection*, Inorganica Chimica Acta, 523, 120381, 2021

58. Anastasiia V. Kornilova, Sergey M. Novikov, Galiya A. Kuralbayeva, **Subhra Jana**, Ivan V. Lysenko, Anastasia I. Shpichka, Anna V. Stavitskaya, Maxim V. Gorbachevskii, Andrei A. Novikov, Saltanat B. Ikramova, Peter S. Timashev, Aleksey V. Arsenin, Valentyn S. Volkov, Alexander N. Vasiliev and Victor Yu. Timoshenko, *Halloysite Nanotubes with Immobilized Plasmonic Nanoparticles for Biophotonic Applications*, Applied Sciences, 11, 4565, 2021

59. Arnab Samanta and **Subhra Jana**, *Ni-, Co-, and Mn-Doped Fe_2O_3 Nano-Parallelepipeds for Oxygen Evolution*, ACS Applied Nano Materials, 4, 5131-5140, 2021

60. Mantu Santra, Aniruddha Seal, Kankana Bhattacharjee, and **Suman Chakrabarty**, *Structural and dynamical heterogeneity of water trapped inside Na^+-pumping KR2 rhodopsin in the dark state*, The Journal of Chemical Physics, 154, 215101, 2021

61. J.B.Deshpande, **S.Chakrabarty**, A. A. Kulkarni, *Heterogeneous nucleation in citrate synthesis of AgNPs: Effect of mixing and solvation dynamics*, Chemical Engineering Journal, 421, 127753, 2021

62. Vrushali R. Hande and **Suman Chakrabarty**, *How Far Is "Bulk Water" from Interfaces? Depends on the Nature of the Surface and What We Measure*, The Journal of Physical Chemistry B, 126, 1125-1135, 2022

63. Vrushali Hande and **Suman Chakrabarty**, *Size-Dependent Order–Disorder Crossover in Hydrophobic Hydration: Comparison between Spherical Solutes and Linear Alcohols*, ACS Omega, 7, 2671-2678, 2022

64. Sk Imadul Islam, Partha Pyne, Dipak Kumar Das, Shounak Mukherjee, **Suman Chakrabarty**, and **Rajib Kumar Mitra**, *Molecular Insight into Dye–Surfactant Interaction at Premicellar Concentrations: A Combined Two-Photon Absorption and Molecular Dynamics Simulation Study*, Langmuir, 38, 3105-3112, 2022

65. Akbar Ali, Sai P. Nagumantri, **Tatini Rakshit**, Suchetan Pal, *Control of Glucose-Induced Degradation and Cargo Release in Multi-Responsive Polymer Hydrogels*, Macromolecular Chemistray and Physics, 222, 2170033, 2021

66. Suchetan Pal and **Tatini Rakshit**, *Folate-Functionalized DNA Origami for Targeted Delivery of Doxorubicin to Triple-Negative Breast Cancer*, Frontiers in Chemistry, 9, 721105, 2021

67. Michael Traxler, Sebastian Gisbertz, **Dr. Pradip Pachfule**, Dr. Johannes Schmidt, Dr. Jérôme Roeser, Susanne Reischauer, Jabor Rabeah, Dr. Bartholomäus Pieber, Prof. Arne Thomas, *Acridine-Functionalized Covalent Organic Frameworks (COFs) as Photocatalysts for Metallaphotocatalytic C–N Cross-Coupling*, Angewandte Chemie, e202117738, 2022

68. Pravrati Taank, Riyanka Karmakar, Rituraj Sharma, Rajesh Kumar Yadav, Megha Shrivastava, Naresh Chandra Maurya, Tuhin Kumar Maji, Debjani Karmakar,

and K. V. Adarsh, *An Insightful Picture of Multi-Particle Recombination in Few-Layer MoS_2 Nanosheets*, The Journal of Physical Chemistry C, 126, 416-422, 2022

Department of Condensed Matter Physics and Material Sciences

1. Ritwik Maity, **Alo Dutta**, Saswata Halder, Santiranjan Shannigrahi, **Kalyan Mandal** and T. P. Sinhaa, *Enhanced photocatalytic activity, transport properties and electronic structure of Mn doped $GdFeO_3$ synthesized using the sol–gel process*, Physical Chemistry Chemical Physics, 23, 16060-16076, 2021
2. Sadhan Chanda, Ritwik Maity, Sujoy Saha, **Alo Dutta** and T. P. Sinha, *Double perovskite nanostructured Dy_2CoMnO_6 an efficient visible-light photocatalysts: synthesis and characterization*, Journal of Sol-Gel Science and Technology, 99, 600-613, 2021
3. **Alo Dutta**, Anupam Gorai, Dipika Mandal & **Kalyan Mandal**, *Dielectric and microwave absorption properties of $Na_{0.5}Bi_{0.5}TiO_3$–$SrTiO_3$ system*, Ferroelectrics, 583, 252-263, 2021
4. Himadri Sekhar Tripathi, Moumin Rudra, Rajesh Mukherjee, **Alo Dutta**, T. P. Sinha, *Investigation of doping effect on electrical conduction mechanism and Li+ ion insertion/extraction in ZnO-XV_2O_5 {X=5% and 10%} electrode for superior energy storage application*, Solid State Communications, 339, 114490, 2021
5. Surya Narayan Panda, Sudip Majumder, Arpan Bhattacharyya, Soma Dutta, Samiran Choudhury, and **Anjan Barman**, *Structural Phase-Dependent Giant Interfacial Spin Transparency in W/CoFeB Thin-Film Heterostructures*, ACS Applied Materials & Interfaces, 13, 20875-20884, 2021
6. Anulekha De, Justine Lynn Drobitch, Sudip Majumder, Saswati Barman, Supriyo Bandyopadhyay and **Anjan Barman**, *Resonant amplification of intrinsic magnon modes and generation of new extrinsic modes in a two-dimensional array of interacting multiferroic nanomagnets by surface acoustic waves*, Nanoscale, 13, 10016-10023, 2021
7. Md Rejaul Karim, Arundhati Adhikari, Surya Narayan Panda, Purbasha Sharangi, Soubhik Kayal, Gouranga Manna, P. S. Anil Kumar, Subhankar Bedanta, **Anjan Barman**, and Indranil Sarkar, *Ultrafast Spin Dynamics of Electrochemically Grown Heusler Alloy Films*, The Journal of Physical Chemistry C, 125, 10483-10492, 2021
8. Sourav Sahoo, Andrew May, Arjen van Den Berg, Amrit Kumar Mondal, Sam Ladak, and **Anjan Barman**, *Observation of Coherent Spin Waves in a Three-Dimensional Artificial Spin Ice Structure*, Nano Letters, 21, 4629-4635, 2021
9. Surya Narayan Panda, Sudip Majumder, Samiran Choudhury, Arpan Bhattacharya, Sumona Sinha and **Anjan Barman**, *Femtosecond laser-induced spin dynamics in single-layer graphene/CoFeB thin films*, Nanoscale, 13, 13709-13718, 2021
10. Avinash Kumar Chaurasiya, Amrit Kumar Mondal, Jack C. Gartside, Kilian D. Stenning, Alex Vanstone, Saswati Barman, Will R. Branford, and **Anjan Barman**, *Comparison of Spin-Wave Modes in Connected and Disconnected Artificial Spin Ice Nanostructures Using Brillouin Light Scattering Spectroscopy*, ACS Nano, 15, 11734-11742, 2021
11. Kartik Adhikari, Samiran Choudhury, Saswati Barman, Yoshichika Otani and **Anjan Barman**, *Observation of magnon–magnon coupling with high cooperativity in $Ni_{80}Fe_{20}$ cross-shaped nanoring array*, Nanotechnology, 32, 395706, 2021
12. Bipul Kumar Mahato and **Anjan Barman**, *Magnetization reversal mechanism of chemically synthesized linear chains of α-Fe nanospheres*, Journal of Materials Science, 56, 19476-19483, 2021
13. Sudip Majumder, Samiran Choudhury, Saswati Barman, Yoshichika Otani, **Anjan Barman**, *Reconfigurable spin-wave dynamics in two-dimensional quasiperiodic magnonic crystals*, Physica E: Low-dimensional Systems and Nanostructures, 134, 114901, 2021
14. Arundhati Adhikari, Chandrima Banerjee, Amrit Kumar Mondal, Avinash Kumar Chaurasiya, Samiran Choudhury, Jaivardhan Sinha, Saswati Barman, **Anjan Barman**, *Anisotropic spin-wave propagation in asymmetric width modulated $Ni_{80}Fe_{20}$ nanostripes*, Materials Science and Engineering: B, 272, 115385, 2021
15. Avinash Kumar Chaurasiya, Jaivardhan Sinha, Samiran Choudhury & **Anjan Barman**, *Influence of variation of tungsten layer thickness on interfacial Dzyaloshinskii–*

Moriya interaction in W/CoFeB/SiO_2 heterostructures, Bulletin of Materials Science, 44, 277, 2021

16. Koustuv Dutta, Anulekha De, Sucheta Mondal, Saswati Barman, Yoshichika Otani, **Anjan Barman**, *Dynamic configurational anisotropy in $Ni_{80}Fe_{20}$ antidot lattice with complex geometry*, Journal of Alloys and Compounds, 884, 161105, 2021

17. Jayshankar Nath, Alexandru Vladimir Trifu, Mihai Sebastian Gabor, Ali Hallal, Stephane Auffret, Sebastien Labau, Aymen Mahjoub, Edmond Chan, Avinash Kumar Chaurasiya, Amrit Kumar Mondal, Haozhe Yang, Eva Schmoranzerova, Mohamed Ali Nsibi, Isabelle Joumard, **Anjan Barman**, Bernard Pelissier, Mairbek Chshiev, Gilles Gaudin, Ioan Mihai Miron, *Mechanism of Spin-Orbit Torques in Platinum Oxide Systems*, Advanced Electronic Materials, 2101335, 2022

18. Santanu Pan, Fabian Ganss, Suryanarayan Panda, Gabriel Sellge, Chandrima Banerjee, Jaivardhan Sinha, Olav Hellwig & **Anjan Barman**, *Mechanism of femtosecond laser induced ultrafast demagnetization in ultrathin film magnetic multilayers*, Journal of Materials Science, 57, 6212-6222, 2022

19. Sajid Husain, Sreya Pal, Xin Chen, Prabhat Kumar, Ankit Kumar, Amrit Kumar Mondal, Nilamani Behera, Nanhe Kumar Gupta, Soumyarup Hait, Rahul Gupta, Rimantas Brucas, Biplab Sanyal, **Anjan Barman**, Sujeet Chaudhary, and Peter Svedlindh, *Large Dzyaloshinskii-Moriya interaction and atomic layer thickness dependence in a ferromagnet-WS_2 heterostructure*, Physical Review B, 105, 064422, 2022

20. Payal Bhattacharjee, **Anjan Barman**, Saswati Barman, *Operation of Magnetic Vortex Transistor by Spin-Polarized Current: A Micromagnetic Approach*, Physica Status Solidi (a): applications and materials science, 219, 2100564, 2022

21. Raisa Fabiha, Jonathan Lundquist, Sudip Majumder, Erdem Topsakal, **Anjan Barman**, Supriyo Bandyopadhyay, *Spin Wave Electromagnetic Nano-Antenna Enabled by Tripartite Phonon-Magnon-Photon Coupling*, Advanced Science, 9, 2104644, 2022

22. Amrit Kumar Mondal, Sudip Majumder, Sourav Sahoo, Surya Narayan Panda, Sumona Sinha, and **Anjan Barman**, *Defect-Density- and Rashba-Shift-Induced Interfacial Dzyaloshinskii–Moriya Interaction and Spin Pumping in Single-Layer Graphene/$Co_{20}Fe_{60}B_{20}$ Heterostructures: Implications for New-Generation Spintronics*, ACS Applied Nano Materials, 5, 5056-5063, 2022

23. Anulekha De, Sri Sai Phani Kanth Arekapudi, Leopold Koch, Fabian Samad, Surya Narayan Panda, Benny Böhm, Olav Hellwig, and **Anjan Barman**, *Magnetic Configuration Driven Femtosecond Spin Dynamics in Synthetic Antiferromagnets*, ACS Applied Materials & Interfaces, 14, 13970-13979, 2022

24. Md Rejaul Karim, Surya Naryan Panda, **Anjan Barman** and Indranil Sarkar, *Strain and crystallite size controlled ordering of Heusler nanoparticles having high heating rate for magneto-thermal application*, Nanotechnology, 33, 235701, 2022

25. Supriyo Bandyopadhyay, Jayasimha Atulasimha, and **Anjan Barman**, *Magnetic straintronics: Manipulating the magnetization of magnetostrictive nanomagnets with strain for energy-efficient applications*, Applied Physics Reviews, 8, 041323, 2021

26. Bivas Rana, Amrit Kumar Mondal, Supriyo Bandyopadhyay and **Anjan Barman**, *Applications of nanomagnets as dynamical systems: I*, Nanotechnology, 33, 062007, 2022

27. Bivas Rana, Amrit Kumar Mondal, Supriyo Bandyopadhyay and **Anjan Barman**, *Applications of nanomagnets as dynamical systems: II*, Nanotechnology, 33, 082002, 2022

28. **Anjan Barman**, Gianluca Gubbiotti, S Ladak, A O Adeyeye, M Krawczyk, J Gräfe, C Adelmann, S Cotofana, A Naeemi, V I Vasyuchka, B Hillebrands, S A Nikitov, H Yu, D Grundler, A V Sadovnikov, A A Grachev, S E Sheshukova, J-Y Duquesne, M Marangolo, G Csaba, W Porod, V E Demidov, S Urazhdin, S O Demokritov, E Albisetti, D Petti, R Bertacco, H Schultheiss, V V Kruglyak, V D Poimanov, S Sahoo, J Sinha, H Yang, M Münzenberg, T Moriyama, S Mizukami, P Landeros, R A Gallardo, G Carlotti, J-V Kim, R L Stamps, R E Camley, B Rana, Y Otani, W Yu, T Yu, G E W Bauer, C Back, G S Uhrig, O V Dobrovolskiy, B Budinska, H Qin, S van Dijken, A V Chumak, A Khitun, D E Nikonov, I A Young, B W Zingsem and M Winklhofer, *The 2021 Magnonics Roadmap*, Journal of Physics: Condensed Matter, 33, 413001, 2021

29. Suma Das and **Avijit Chowdhury**, *Recent advancements of g-C_3N_4-based magnetic photocatalysts towards the degradation of organic pollutants: a review*, Nanotechnology, 33, 072004, 2021

30. Avisek Maity, Saikat Mitra, Chandni Das, Sohel Siraj, A.K.Raychaudhuri and **Barnali Ghosh**, *Universal sensing of ammonia gas by family of lead halide perovskites based on paper sensors: Experiment and molecular dynamics*, Materials Research Bulletin, 136, 111142, 2021

31. Arnab Ghosh, Milon Miah, Arun Bera, Shyamal Kumar Saha, **Barnali Ghosh**, *Synthesis of freestanding 2D CuO nanosheets at room temperature through a simple surfactant free co-precipitation process and its application as electrode material in supercapacitors*, Journal of Alloys and Compounds, 862, 158549, 2021

32. Avisek Maity, A. K. Raychaudhuri, and **Barnali Ghosh**, *Paper-Based Stable Broad Band Optical Detector Made from Mixed Cation Organic Perovskite Halides*, The Journal of Physical Chemistry C, 125, 10646-10652, 2021

33. Parushottam Majhi, Sudipta Chatterjee, Ravindra Singh Bisht, V. Raghavendra Reddy, **Barnali Ghosh** and A. K. Raychaudhuri, *Diffused metal-insulator transition in $NdNiO_3$ film grown on $BaTiO_3$: Likely evidence of electronic Griffiths phase*, Physical Review Materials, 5, 085005, 2021

34. Subarna Datta, Ankita Ghatak, **Barnali Ghosh**, *Effect of structural deformations on the transport properties of half-doped manganite nanowires: An insight through high resolution image simulation*, Materials Science and Engineering: B, 272, 115300, 2021

35. Avisek Maity, Chandni Das, A K Raychaudhuri, Abhijit Saha and **Barnali Ghosh**, *Highly radiation resistant room temperature organic perovskite halide ($FAPbI_3$) crystal for direct detection of gamma-ray photons down to nano curie activity*, Journal of Physics D: Applied Physics, 54, 455104, 2021

36. Snehamoyee Hazra, Subhamita Sengupta, Soumyaranjan Ratha, Ankita Ghatak, A K Raychaudhuri and **Barnali Ghosh**, *Piezoelectric Nanogenerators based on Lead Zirconate Titanate nanostructures: an insight into the effect of potential barrier and morphology on the output power generation*, Nanotechnology, 33, 155403, 2022

37. Arka Chaudhuri, Rupali Rakshit, Kazunori Serita, Masayoshi Tonouchi, and **Kalyan Mandal**, *Electromagnetic Response of SiO_2@Fe_3O_4 Core–Shell Nanostructures in the THz Regime*, IEEE Transactions on Magnetics, 57, 2300206, 2021

38. Indranil Chakraborty, Deblina Majumder, Rupali Rakshit, Mahebub Alam, Suprabhat Mukherjee, Anupam Gorai, and **Kalyan Mandal**, *Magnetic Field-Dependent Photoluminescence of Tartrate-Functionalized Gadolinium-Doped Manganese Ferrite Nanoparticles: A Potential Therapeutic Agent for Hyperbilirubinemia Treatment*, ACS Applied Nano Materials, 4, 4379-4387, 2021

39. Mahebub Alam and **Kalyan Mandal**, *Origin of ferroelectricity in multiferroic $ErFeO_3$*, Physica B: Condensed Matter, 612, 412935, 2021

40. Anupam Gorai, Dipika Mandal and **Kalyan Mandal**, *Multi-layered nano-hollow spheres for efficient electromagnetic wave absorption*, Nanotechnology, 32, 345707, 2021

41. Dipanjan Maity, Keshab Karmakar, Debashish Pal, Soham Saha, Gobinda Gopal Khan, and **Kalyan Mandal**, *One-Dimensional p-$ZnCo_2O_4$/n-ZnO Nanoheterojunction Photoanode Enabling Photoelectrochemical Water Splitting*, ACS Applied Energy Materials, 4, 11599-11608, 2021

42. Dipika Mandal, **Kalyan Mandal**, *Electromagnetic wave attenuation properties of MFe_2O_4 (M = Mn, Fe, Co, Ni, Cu, Zn) nano-hollow spheres in search of an efficient microwave absorber*, Journal of Magnetism and Magnetic Materials, 536, 168127, 2021

43. Subrata Ghosh, Saheli Samanta, Jayee Sinha, and **Kalyan Mandal**, *Measurement protocols dependent giant magnetocaloric effect in MnNiSi-based system*, Applied Physics Letters, 119, 183901, 2021

44. Saheli Samanta, Subrata Ghosh and **Kalyan Mandal**, *Observation of giant exchange bias effect in Ni–Mn–Ti all-d-metal Heusler alloy*, Journal of Physics: Condensed Matter, 34, 105801, 2022

45. Priyanka Saha, Rupali Rakshit, Anupam Gorai, Dipika Mandal & **Kalyan Mandal**, *Unusual dielectric properties of hollow magnesium ferrite nanospheres: a potential*

lightweight microwave absorber, Journal of Materials Science, 57, 4569-4582, 2022

46. Sambunath Das, Dayasindhu Dey, S. Ramasesha and **Manoranjan Kumar**, *Quantum phases of spin-1 system on 3/4 and 3/5 skewed ladders*, Journal of Applied Physics, 129, 223902, 2021

47. Sudip Kumar Saha, Manodip Routh, **Manoranjan Kumar**, and Zoltán G. Soos, *Low-temperature thermodynamics of the antiferromagnetic J_1–J_2 model: Entropy, critical points, and spin gap*, Physical Review B, 103, 245139, 2021

48. Sk Saniur Rahaman, Shaon Sahoo, **Manoranjan Kumar**, *Quantum phases and thermodynamics of a frustrated spin-1/2 ladder with alternate Ising-Heisenberg rung interactions*, Journal of Physics: Condensed Matter, 33, 265801, 2021

49. Sambunath Das, Dayasindhu Dey, **Manoranjan Kumar**, and S. Ramasesha, *Quantum phases of a frustrated spin-1 system: The 5/7 skewed ladder*, Physical Review B, 104, 125138, 2021

50. Gaurav K. Shukla, Jyotirmoy Sau, Nisha Shahi, Anupam K. Singh, **Manoranjan Kumar**, and Sanjay Singh, *Anomalous Hall effect from gapped nodal line in the Co_2FeGe Heusler compound*, Physical Review B, 104, 195108, 2021

51. Subhajit Roychowdhury, Sukriti Singh, Satya N. Guin, **Nitesh Kumar**, Tirthankar Chakraborty, Walter Schnelle, Horst Borrmann, Chandra Shekhar, and Claudia Felser, *Giant Topological Hall Effect in the Noncollinear Phase of Two-Dimensional Antiferromagnetic Topological Insulator $MnBi_4Te_7$*, Chemistry of Materials, 33, 8343-8350, 2021

52. Sukriti Singh, Jonathan Noky, Shaileyee Bhattacharya, Praveen Vir, Yan Sun, **Nitesh Kumar**, Claudia Felser, Chandra Shekhar, *Anisotropic Nodal-Line-Derived Large Anomalous Hall Conductivity in ZrMnP and HfMnP*, Advanced Materials, 33, 2104126, 2021

53. Feng Liu, Tongjin Zhang, Debayan Mondal, Shiyong Teng, Ying Zhang, Keke Huang, Dayang Wang, Wensheng Yang, **Priya Mahadevan**, Yong Sheng Zhao, Renguo Xie, Narayan Pradhan, *Light-Emitting Metal-Organic Halide 1D and 2D Structures: Near-Unity Quantum Efficiency, Low-Loss Optical Waveguide and Highly Polarized Emission*, Angewandte Chemie, 60, 13548-13553, 2021

54. Rohit Kumar Rohj, Akmal Hossain, **Priya Mahadevan** and D. D. Sarma, *Band Gap Reduction in Ferroelectric $BaTiO_3$ Through Heterovalent Cu-Te Co-Doping for Visible-Light Photocatalysis*, Frontiers in Chemistry, 9, 682979, 2021

55. Debayan Mondal and **Priya Mahadevan**, *Shape Control of Emissive Properties of Mn-Doped $CsPbBr_3$ Nanocrystals*, The Journal of Physical Chemistry C, 125, 11462-11467, 2021

56. Shishir Kumar Pandey, Abhinav Kumar, Sagar Sarkar, and **Priya Mahadevan**, *Understanding the ferromagnetic insulating state in Cr-doped VO_2: Density functional and tight binding calculations*, Physical Review B, 104, 125110, 2021

57. Biswajit Pabi, Debayan Mondal, **Priya Mahadevan**, and **Atindra Nath Pal**, *Probing metal-molecule contact at the atomic scale via conductance jumps*, Physical Review B, 104, L121407, 2021

58. Feng Liu, Debayan Mondal, Kai Zhang, Ying Zhang, Keke Huang, Dayang Wang, Wensheng Yang, **Priya Mahadevan** and Renguo Xie, *Zero-dimensional plate-shaped copper halide crystals with green-yellow emissions*, Materials Advances, 2, 3744-3751, 2021

59. Yutaka Nikaido, Tom Ichibha, Kenta Hongo, Fernando A. Reboredo, K. C. Hari Kumar, **Priya Mahadevan**, Ryo Maezono, and Kousuke Nakano, *Diffusion Monte Carlo Study on Relative Stabilities of Boron Nitride Polymorphs*, The Journal of Physical Chemistry C, 126, 6000-6007, 2022

60. Suman Bera, Biswajit Hudait, Debayan Mondal, Sanjib Shyamal, **Priya Mahadevan**, and Narayan Pradhan, *Transformation of Metal Halides to Facet-Modulated Lead Halide Perovskite Platelet Nanostructures on A-Site Cs-Sublattice Platform*, Nano Letters, 22, 1633-1640, 2022

61. Janardhan Rao Gadde, Anasuya Karmakar, Tuhin Kumar Maji, Subhrajit Mukherjee, Rajath Alexander, Anjanashree M. R. Sharma, Sarthak Das, Anirban Mandal, Kinshuk Dasgupta, Akshay Naik, Kausik Majumdar, Ranjit Hawaldar, K. V. Adarsh, **Samit Kumar Ray**, and Debjani Karmakar, *Two-dimensional ReS_2: Solution to the unresolved queries on its structure and inter-layer coupling leading to potential optical applications*, Physical Review Materials, 5, 054006, 2021

62. Subhendu Sinha Sarkar, Susnata Bera, Md. Samim Hassan, Sameer Sapra, Ravinder K. Khatri, and **Samit K. Ray**, *$MoSe_2$–$Cu_{2-x}S$/GaAs Heterostructure-Based Self-Biased Two Color-Band Photodetectors with High Detectivity*, The Journal of Physical Chemistry C, 125, 10768-10776, 2021

63. Hasmat Mondal, **Samit K. Ray**, Poulomi Chakrabarty, Soumili Pal, Gaurab Gangopadhyay, Sourav Das, Shreyasi Das, and Rabaya Basori, *High-Performance Chlorophyll-b/Si Nanowire Heterostructure for Self-Biasing Bioinorganic Hybrid Photodetectors*, ACS Applied Nano Materials, 4, 5726-5736, 2021

64. John Wellington John, Veerendra Dhyani, Sudarshan Singh, Alka Jakhar, Arijit Sarkar, Samaresh Das, **Samit K Ray**, *Low-noise, high-detectivity, polarization-sensitive, room-temperature infrared photodetectors based on Ge quantum dot-decorated Si-on-insulator nanowire field-effect transistors*, Nanotechnology, 32, 315205, 2021

65. Sourabh Pal, Sayan Bayan, Dipak K. Goswami, and **Samit K. Ray**, *Boron Carbonitride Nanosheet/ZnO Nanorod Heterojunctions for White-Light Emission*, ACS Applied Nano Materials, 4, 8572-8585, 2021

66. Sourabh Pal, Arup Ghorai, Dipak K.Goswami, **Samit K. Ray**, *Strain mediated light emission using heterojunctions of all-inorganic mixed-halide perovskite nanocrystals via piezo-phototronic effect*, Nano Energy, 87, 106200, 2021

67. Samir Rom, Aishwaryo Ghosh, Anita Halder, and **Tanusri Saha Dasgupta**, *Machine learning classification of binary semiconductor heterostructures*, Physical Review Materials, 5, 043801, 2021

68. A. Bhattacharyya, T. K. Bhowmik, D. T. Adroja, B. Rahaman, S. Kar, S. Das, **T. Saha-Dasgupta**, P. K. Biswas, T. P. Sinha, R. A. Ewings, D. D. Khalyavin, and A. M. Strydom, *Dynamic spin fluctuations in the frustrated spin chain compound $Li_3Cu_2SbO_6$*, Physical Review B, 103, 174423, 2021

69. Soumendu Datta, Uttam Pal, and **Tanusri Saha-Dasgupta**, *Effect of Mg Doping on Structural, Alloying, Electronic, Optical, and Bactericidal Properties of Cu_nAg_{25-n} Nanoclusters: A Computational Study*, The Journal of Physical Chemistry C, 125, 11066-11074, 2021

70. Anita Halder, Shreya Das, Prabuddha Sanyal & **Tanusri Saha-Dasgupta**, *Understanding complex multiple sublattice magnetism in double double perovskites*, Scientific Reports, 11, 21764, 2021

71. **Tanusri Saha-Dasgupta**, *Understanding and prediction of quantum materials via modelling and computation*, Bulletin of Materials Science, 44, 270, 2021

72. Shiladitya Karmakar and **Tanusri Saha-Dasgupta**, *High-performance thermoelectric properties of strained two-dimensional tellurium*, Physical Review Materials, 5, 124006, 2021

73. Hena Das, Alejandro F. Rébola, and **Tanusri Saha-Dasgupta**, *Exploring the possible origin of the spin reorientation transition in $NdCrO_3$*, Physical Review Materials, 5, 124416, 2021

74. Uttam Pal, Kartikey K.Yadav, D.K.Singh, **Tanusri Saha-Dasgupta**, *Extraction behavior of yttrium with Aliquat336 from nitrate and thiocyanate media: A microscopic view from computational analysis*, Materials Today Communications, 28, 102603, 2021

75. Shreya Das, Sreekar Voleti, **Tanusri Saha-Dasgupta**, and Arun Paramekanti, *XY magnetism, Kitaev exchange, and long-range frustration in the J_{eff} = 1/2 honeycomb cobaltates*, Physical Review B, 104, 134425, 2021

76. Dipayan Sen and **Tanusri Saha-Dasgupta**, *Rational Design of Magnetic Hybrid Transition Metal Double Perovskites in Polyatomic Anionic Systems*, Chemistry of Materials, 34, 1821-1828, 2022

77. K.Denisova, P.Lemmens, D.Wulferding, P.Berdonosov, V.Dolgikh, A.Murtazoev, E.Kozlyakova, O.Maximova, A.Vasiliev, I.Shchetinin, F.Dolgushin, A.Iqbal, B.Rahaman, **T.Saha-Dasgupta**, *$Cu_9O_2(SeO_3)_4Cl_6$ revisited: Crystal structure, Raman scattering and first-principles calculations*, Journal of Alloys and Compounds, 894, 162291, 2022

78. Abhisek Bandyopadhyay, A. Chakraborty, S. Bhowal, Vinod Kumar, M. M. Sala, A. Efimenko, F. Bert, P. K. Biswas, C. Meneghini, N. Büttgen, I. Dasgupta, **T. Saha Dasgupta**, A. V. Mahajan, and Sugata Ray, *Breakdown of atomic spin-orbit coupling picture in an apparently isolated pseudo-one-dimensional iridate: Sr_3NaIrO_6*, Physical Review B, 105, 104431, 2022

79. Susmita Changdar, Grigory Shipunov, Nesta B. Joseph, Nicholas C. Plumb, Ming Shi, Bernd Büchner, Awadhesh Narayan, Saicharan Aswartham, and **Setti Thirupathaiah**, *Anomalous band renormalization due to a high-energy kink in $K_{0.65}RhO_2$ with colossal thermoelectric power factor*, Physical Review Materials, 5, 055402, 2021

80. Sayan Routh and **Setti Thirupathaiah**, *Observation of Exchange Bias in Antiferromagnetic $Cr_{0.79}Se$ Due to the Coexistence of Itinerant Weak Ferromagnetism at Low Temperatures*, ACS Omega, 6, 28012-28018, 2021

81. S. Kanthal, P.Manna, Md. A. Ahmed, A. Banerjee, S. Adhikary, S. Kanungo, A. K. Yadav, S. N. Jha, D. Bhattacharyya and S. Bandyopadhyay, *Unique magnetic properties of Nd based cuprate francisite: Major enhancement upon Co doping*, Applied Surface Science, 544, 148951, 2021

82. M D Hossain, A T M K Jamil, M R Hasan, M A Ali, I N Esha, Md Sarowar Hossain, M A Hakim and M N I Khan, *Impact of V substitution on the physical properties of Ni–Zn–Co ferrites: structural, magnetic, dielectric and electrical properties*, Materials Research Express, 8, 046102, 2021

83. Putul Malla Chowdhury and A.K.Raychaudhuri, *Electromigration of oxygen and resistive state transitions in sub-micron width long strip of $La_{0.85}Sr_{0.15}MnO_3$ connected to an engineered oxygen source*, Materials Research Bulletin, 137, 111160, 2021

84. Sudipta Pattanayak, Shradha Mishra and Sanjay Puri, *Domain Growth in the Active Model B: Critical and Off-critical Composition*, Soft Materials, 19, 286-296, 2021

85. Debashish Pal, Ayan Sarkar, Nani Gopal Ghosh, Devendra Mayurdhwaj Sanke, Dipanjan Maity, Keshab Karmakar, Debasish Sarkar, Sanjio S. Zade, and Gobinda Gopal Khan, *Integration of $LaCo(OH)_x$ Photo-Electrocatalyst and Plasmonic Gold Nanoparticles with Sb-Doped TiO_2 Nanorods for Photoelectrochemical Water Oxidation*, ACS Applied Nano Materials, 4, 6111-6123, 2021

86. Kaushik Naskar, Arka Dey, Suvendu Maity, Partha Pratim Ray, and Chittaranjan Sinha, *Charge Transportation in Zn(II)/Cd(II)-Based 2D MOFs of 5-Nitro-isophthalate with Isonicotinic Hydrazide*, Crystal Growth & Design, 21, 4847-4856, 2021

87. Sudipta Chatterjee, Ravindra Singh Bisht, V. Raghavendra Reddy, and A. K. Raychaudhuri, *Emergence of large thermal noise close to a temperature-driven metal-insulator transition*, Physical Review B, 104, 155101, 2021

88. Debarati De, Priyanka Upadhyay, Arpita Das, Ajay Ghosh, Arghya Adhikary, Madhuri Mandal Goswami, *Studies on cancer cell death through delivery of dopamine as anti-cancer drug by a newly functionalized cobalt ferrite nano-carrier*, Colloids and Surfaces A: Physicochemical and Engineering Aspects, 627, 127202, 2021

89. Mithun Bhowmick, Akhilesh Kumar Singh, Puspendu Barik, Haowen Xi, and Bruno Ullrich, *All-optical switch based on PbS quantum dots*, Applied Physics Letters, 119, 192103, 2021

90. Subhamita Sengupta, Ankita Ghatak, Arup Kumar Raychaudhuri, *Effect of low temperature structural phase transitions in $BaTiO_3$ on electrical transport through a metal-ferroelectric-metal multilayer of AuCr/$BaTiO_3$/Nb:$SrTiO_3$*, Journal of Physics: Condensed Matter, 33, 465702, 2021

91. M. D. Hossain, A. T. M. K. Jamil, Md. Sarowar Hossain, S. J. Ahmed, H. N. Das, R. Rashid, M. A. Hakim and M. N. I. Khan, *Investigation on structure, thermodynamic and multifunctional properties of Ni–Zn–Co ferrite for Gd^{3+} substitution*, RSC Advances, 12, 4656-4671, 2022

Department of Theoretical Sciences

1. Shantonu Mukherjee & **Amitabha Lahiri**, *Spin gauge theory, duality and fermion pairing*, Journal of High Energy Physics, 2022, 68, 2022

2. Sudip Mukherjee, Soumyajyoti Biswas, Arnab Chatterjee and **Bikas K.Chakrabarti**, *The Ising universality class of kinetic exchange models of opinion dynamics*, Physica A: Statistical Mechanics and its Applications, 567, 125692, 2021

3. Asim Ghosh, **Bikas K.Chakrabarti**, *Limiting value of the Kolkata index for social inequality and a possible social constant*, Physica A: Statistical Mechanics and its Applications, 573, 125944, 2021

4. Soumyajyoti Biswas and **Bikas K. Chakrabarti**, *Social inequality analysis of fiber bundle model statistics and prediction of materials failure*, Physical Review E, 104, 044308, 2021

5. Sayan Kumar Pal, Partha Nandi, Sibasish Ghosh, Frederik G.Scholtz, **Biswajit Chakraborty**, *Emergent entropy of exotic oscillators and squeezing in three-wave mixing process*, Physics Letters A, 403, 127397, 2021
6. Anwesha Chakraborty, Partha Nandi, and **Biswajit Chakraborty**, *Spectral triple with real structure on fuzzy sphere*, Journal of Mathematical Physics, 63, 023504, 2022
7. Anwesha Chakraborty, Partha Nandi, **Biswajit Chakraborty**, *Fingerprints of the quantum space-time in time-dependent quantum mechanics: An emergent geometric phase*, Nuclear Physics B, 975, 115691, 2022
8. Subhadip Chakraborti, Tanmoy Chakraborty, Arghya Das, Rahul Dandekar, and **Punyabrata Pradhan**, *Transport and fluctuations in mass aggregation processes: Mobility-driven clustering*, Physical Review E, 103, 042133, 2021
9. **Punyabrata Pradhan**, *Time-Dependent Properties of Sandpiles*, Frontiers in Physics, 9, 641233, 2021
10. **Rabin Banerjee**, *Covariant formulation of the Newton-Hooke particle and its canonical analysis*, Physical Review D, 103, 125009, 2021
11. **Rabin Banerjee**, *Hamiltonian formulation of higher rank symmetric gauge theories*, The European Physical Journal C, 82, 22, 2022
12. Shobhan Dev Mandal and **Sakuntala Chatterjee**, *Effect of receptor cooperativity on methylation dynamics in bacterial chemotaxis with weak and strong gradient*, Physical Review E, 105, 014411, 2022
13. Shobhan Dev Mandal & **Sakuntala Chatterjee**, *Effect of switching time scale of receptor activity on chemotactic performance of Escherichia coli*, Indian Journal of Physics, 96, 2022
14. Ashis Saha and **Sunandan Gangopadhyay**, *Holographic study of entanglement and complexity for mixed states*, Physical Review D, 103, 086002, 2021
15. Sukanta Bhattacharyya and **Sunandan Gangopadhyay**, *Path-integral action in the generalized uncertainty principle framework*, Physical Review D, 104, 026003, 2021
16. Debabrata Ghorai, **Sunandan Gangopadhyay**, *Analytical study of holographic superconductor with backreaction in 4d Gauss-Bonnet gravity*, Physics Letters B, 822, 136699, 2021
17. Manjari Dutta, Shreemoyee Ganguly and **Sunandan Gangopadhyay**, *Investigation of a harmonic oscillator in a magnetic field with damping and time dependent noncommutativity*, Physica Scripta, 96, 125224, 2021
18. Ankur Srivastav and **Sunandan Gangopadhyay**, *Novel vortices and the role of a complex chemical potential in a rotating holographic superfluid*, Physical Review D, 104, 126004, 2021
19. Anirban Roy Chowdhury, Ashis Saha & **Sunandan Gangopadhyay**, *Entanglement wedge cross-section for noncommutative Yang-Mills theory*, Journal of High Energy Physics, 2022, 192, 2022
20. Saumya Ghosh, **Sunandan Gangopadhyay** and Prasanta K. Panigrahi, *Noncommutative quantum cosmology with perfect fluid*, Modern Physics Letters A, 37, 2250009, 2022
21. Diganta Parai, Debabrata Ghorai and **Sunandan Gangopadhyay**, *Holographic insulator/superconductor phase transition via matching method and thermodynamic geometry approach*, International Journal of Modern Physics A, 37, 2150249, 2022
22. Anirban Roy Chowdhury, Ashis Saha and **Sunandan Gangopadhyay**, *Entropy function from the Einstein boundary term*, Europhysics Letters, 134, 60003, 2021
23. Anish Das, Ashis Saha and **Sunandan Gangopadhyay**, *Study of circular geodesics and shadow of rotating charged black hole surrounded by perfect fluid dark matter immersed in plasma*, Classical and Quantum Gravity, 39, 075005, 2022
24. Soham Sen, Sukanta Bhattacharyya and **Sunandan Gangopadhyay**, *Probing the generalized uncertainty principle through quantum noises in optomechanical systems*, Classical and Quantum Gravity, 39, 075020, 2022
25. Suchetana Pal, Diganta Parai, and **Sunandan Gangopadhyay**, *Analytical approach to compute conductivity of p-wave holographic superconductors*, Physical Review D, 105, 065015, 2022
26. Ion Santra, **Urna Basu**, and Sanjib Sabhapandit, *Active Brownian motion with directional reversals*, Physical Review E, 104, L012601, 2021

27. Ion Santra, **Urna Basu** and Sanjib Sabhapandit, *Direction reversing active Brownian particle in a harmonic potential*, Soft Matter, 17, 10108-10119, 2021
28. V. Yogesh and Prosenjit Maity, *Squeezing in the quantum Rabi model with parametric nonlinearity*, The European Physical Journal Plus, 136, 5721, 2021
29. M. Balamurugan, R. Chakrabarti, B. Virgin Jenisha, and V. Yogesh, *Generalized spin kitten states in a strongly coupled spin-oscillator system*, Physical Review A, 103, 063703, 2021
30. Indrajit Ghose and Parongama Sen, *The variational method applied to the harmonic oscillator in the presence of a delta function potential*, European Journal of Physics, 42, 045406, 2021
31. Sudipta Pattanayak, Shradha Mishra, and Sanjay Puri, *Ordering kinetics in the active model B*, Physical Review E, 104, 014606, 2021
32. Bihalan Bhattacharya & Samyadeb Bhattacharya, *Convex geometry of Markovian Lindblad dynamics and witnessing non-Markovianity*, Quantum Information Processing, 20, 253, 2021
33. Dharmesh Jain & Arkajyoti Manna, *Stokes phenomena in ${}_3d\mathcal{N}=2$ SQED$_2$ and $\mathbb{CP}^1$ models*, Journal of High Energy Physics, 2021, 112, 2021
34. Partha Nandi, Sankarshan Sahu, Sayan Kumar Pal, *A note on broken dilatation symmetry in planar noncommutative theory*, Nuclear Physics B, 971, 115511, 2021
35. Sreetama Das, Sudipto Singha Roy, Samyadeb Bhattacharya and Ujjwal Sen, *Nearly Markovian maps and entanglement-based bound on corresponding non-Markovianity*, Journal of Physics A: Mathematical and Theoretical, 54, 395301, 2021

Inter-Departmental Publications

1. Manisha Sharma, Uttam Pal, Mamta Kumari, Damayanti Bagchi, Swati Rani, Dipanjan Mukherjee, Arpan Bera, **Samir Kumar Pal**, **Tanusree Saha Dasgupta** and Subho Mozumdar, *Effect of solvent on the photophysical properties of isoxazole derivative of curcumin: A combined spectroscopic and theoretical study*, Journal of Photochemistry and Photobiology A: Chemistry, 410, 113164, 2021
2. Dipanjan Mukherjee, Priya Singh, Soumendra Singh, Debanjona Singh Roy, Subhankar Singha, Uttam Pal, Jhimli Sengupta, Rami J. Obaid, Saleh A. Ahmed, **Tanusri Saha Dasgupta**, Ranjan Das, **Samir Kumar Pal**, *Host assisted molecular recognition by human serum albumin: Study of molecular recognition controlled protein/drug mimic binding in a microfluidic channel*, International Journal of Biological Macromolecules, 176, 137-144, 2021
3. Riddhi Chatterjee, **Sunandan Gangopadhyay** & **A. S. Majumdar**, *Resonance interaction of two entangled atoms accelerating between two mirrors*, The European Physical Journal D, 75, 179, 2021
4. Didhiti Bhattacharya, Sayan Bayan, **Rajib Kumar Mitra** and **Samit K. Ray**, *2D WS_2 embedded PVDF nanocomposites for photosensitive piezoelectric nanogenerators with a colossal energy conversion efficiency of ~25.6%*, Nanoscale, 13, 15819-15829, 2021
5. Susmita Mondal, Ria Ghosh, Aniruddha Adhikari, Dr. Uttam Pal, Dipanjan Mukherjee, Pritam Biswas, Dr. Soumendra Darbar, Soumendra Singh, Dr. Surajit Bose, **Prof. Tanusri Saha-Dasgupta**, **Prof. Samir Kumar Pal**, *In vitro and Microbiological Assay of Functionalized Hybrid Nanomaterials To Validate Their Efficacy in Nanotheranostics: A Combined Spectroscopic and Computational Study*, ChemMedChem, 16, 3739-3749, 2021
6. Kallol Mukherjee, Suman Das, Juriti Rajbangshi, Ejaj Tarif, **Anjan Barman**, and **Ranjit Biswas**, *Temperature-Dependent Dielectric Relaxation in Ionic Acetamide Deep Eutectics: Partial Viscosity Decoupling and Explanations from the Simulated Single-Particle Reorientation Dynamics and Hydrogen-Bond Fluctuations*, The Journal of Physical Chemistry B, 125, 12552-12567, 2021
7. Riddhi Chatterjee, **Sunandan Gangopadhyay** and **A. S. Majumdar**, *Violation of equivalence in an accelerating atom-mirror system in the generalized uncertainty principle framework*, Physical Review D, 104, 124001, 2021
8. Ria Ghosh, Soumendra Singh, Dipanjan Mukherjee, Susmita Mondal, Monojit Das, Uttam Pal, Aniruddha Adhikari, Aman Bhushan, Surajit Bose, Siddharth Sankar

Bhattacharyya, Debasish Pal, **Tanusri Saha-Dasgupta**, Maitree Bhattacharyya, Debasis Bhattacharyya, Asim Kumar Mallick, Ranjan Das, **Samir Kumar Pal**, *Host-Assisted Delivery of a Model Drug to Genomic DNA: Key Information from Ultrafast Spectroscopy and in silico Study*, ChemBioChem, e202200109, 2022

9. Shubhrasish Mukherjee, Didhiti Bhattacharya, Sumanti Patra, Sanjukta Paul, **Rajib Kumar Mitra, Priya Mahadevan, Atindra Nath Pal,** and **Samit Kumar Ray**, *High-Responsivity Gate-Tunable Ultraviolet–Visible Broadband Phototransistor Based on Graphene–WS_2 Mixed-Dimensional (2D-0D) Heterostructure*, ACS Applied Materials & Interfaces, 14, 5775-5784, 2022

10. Pritam Biswas, Dr. Uttam Pal, Aniruddha Adhikari, Susmita Mondal, Ria Ghosh, Dipanjan Mukherjee, **Prof. Dr. Tanusri Saha-Dasgupta**, Dr. Sudeshna Shyam Choudhury, Prof. Dr. Ranjan Das, **Prof. Dr. Samir Kumar Pal**, *Essential Loop Dynamics Modulates Catalytic Activity in a-Chymotrypsin*, ChemistrySelect, 7, e202104262, 2022

11. Aniruddha Adhikari, Susmita Mondal, Monojit Das, Pritam Biswas, Uttam Pal, Soumendra Darbar, Siddhartha Sankar Bhattacharya, Debasish Pal, **Tanusri Saha-Dasgupta**, Anjan Kumar Das, Asim Kumar Mallick, **Samir Kumar Pal**, *Incorporation of a Biocompatible Nanozyme in Cellular Antioxidant Enzyme Cascade Reverses Huntington's Like Disorder in Preclinical Model*, Advanced Healthcare Materials, 10, 2001736, 2021

12. Aniruddha Adhikari, Uttam Pal, Sayan Bayan, Susmita Mondal, Ria Ghosh, Soumendra Darbar, **Tanusri Saha-Dasgupta, Samit Kumar Ray**, and **Samir Kumar Pal**, *Nanoceutical Fabric Prevents COVID-19 Spread through Expelled Respiratory Droplets: A Combined Computational, Spectroscopic, and Antimicrobial Study*, ACS Applied Bio Materials, 4, 5471-5484, 2021

13. Sayan Bayan, Aniruddha Adhikari, Uttam Pal, Ria Ghosh, Susmita Mondal, Soumendra Darbar, **Tanusri Saha-Dasgupta, Samit Kumar Ray**, and **Samir Kumar Pal**, *Development of Triboelectroceutical Fabrics for Potential Applications in Self-Sanitizing Personal Protective Equipment*, ACS Applied Bio Materials, 4, 5485-5493, 2021

14. Arpan Bera, Md. Nur Hasan, Uttam Pal, Damayanti Bagchi, Tuhin Kumar Maji, **Tanusri Saha-Dasgupta**, Ranjan Das, **Samir KumarPal**, *Fabrication of nanohybrids toward improving therapeutic potential of a NIR photo-sensitizer: An optical spectroscopic and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 424, 113610, 2022

15. E Tendong, **T Saha-Dasgupta**, **J Chakrabarti**, *Viscoelastic response of fluid trapped between two dissimilar van der Waals surfaces*, Journal of Physics: Condensed Matter, 34, 195101, 2022

Technical Research Centre

1. S. Pal, S. Bhowmick, S. A. Khan, A. Claverie, D. Kanjilal, A. K. Bakshi & A. Kanjilal, *Annealing temperature-driven near-surface crystallization with improved luminescence in self - patterned alumina films*, Journal of Materials Science: Materials in Electronics, 32, 11709–11718, 2021

2. Sourav Ghosh, Rajkumar Jana, Sagar Ganguli, Harish Reddy Inta, Gouri Tudu, Heramba V. S. R. M. Koppisetti, Ayan Datta and Venkataramanan Mahalingam, *Nickel-cobalt oxalate as an efficient non-precious electrocatalyst for an improved alkaline oxygen evolution reaction*, Nanoscale Advances, 3, 3770-3779, 2021

3. Sourav Ghosh, Sukanya Kundu and Milan Kanti Naskar, *Mesoporous CuO nanostructures for low-temperature CO oxidation*, Bulletin of Materials Science, 44, 189, 2021

4. Bhaswati Kashyap, Sagar Ramrao Barge, Simanta Bharadwaj, Barsha Deka, Seydur Rahman, Aparajita Ghosh, Prasenjit Manna, Partha Pratim Dutta, Yunus Sheikh, Raghuram Kandimalla, Suman Kumar Samanta, Joshodeep Boruwa, Shilpi Saikia, Deepsikha Swargiary, Parul Kamboj, Deepika Tuli, Uttam Pal, Jagat C.Borah, Sanjay Kumar Banerjee, Narayan Chandra Talukdar, *Evaluation of therapeutic effect of Premna herbacea in diabetic rat and isoverbascoside against insulin resistance in L6 muscle cells through bioenergetics and stimulation of JNK and AKT/mTOR signaling cascade*, Phytomedicine, 93, 153761, 2021

Total number of Journal Publications: 247

Other Publications

Department of Astrophysics & Cosmology

1. High Energy Astrophysical Neutrinos; Debanjan Bose & Subhendu Rakshit; Springer Briefs in Astronomy (2021)
2. Ramkrishna Das, "Elemental abundances in Novae", Journal of Astrophysics and Astronomy (JAA), Volume 42, p. 13, 2021
3. VizieR Online Data Catalog: NGC 2282 photometry of variable stars (Dutta+, 2018) - VizieR On-line Data Catalog: J/MNRAS/476/2813, April 2021

Department of Chemical, Biological & Macro-Molecular Sciences

1. RK Mitra, DK Palit "Probing Biological Water Using Terahertz Absorption Spectroscopy" Terahertz Technology, Ed. Dr. Borwen You and Dr. Ja-Yu Lu, IntechOpen, 2021
2. N. Bhattacharyya, A. Halder, S. Singh, A. Adhikari, R. Ghosh, P. Mondal and S. K.Pal "Detection of Lithium in Real World using Optical Emission Spectroscopy: Caution to E-Waste Management", 6th International Conference for Convergence in Technology (I2CT) 2021 pp. 1-5

Department of Condensed Matter Physics and Material Sciences

1. In the Coffee table book: A journey Towards Excellence (June 1986 to May 2021): Published on the occasion of Golden Jubilee Celebration of Department of Science & Technology , GOI, May 2021. Published by S. N. Bose National Centre For Basic Sciences, Year 2021. topic title: "On Application potential in environment protection and medical diagnosis using Different Gas sensors, Piezoelectric nanowires for Sensitive motion and Energy harvesting nanogenerators. Also on Optical detectors"
2. D. Maity, K. Mandal, "One-Dimensional p-ZnCo2O4/ n-ZnO Nanoheterojunction Photoanode Enabling Photoelectrochemical Water Splitting", Proceedings of Recent Advances in Catalysis Science and Engineering (RACSE) , 26-28 October 2021
3. Saheli Samanta, Subrata Ghosh, and Kalyan Mandal, "Large plateau-like Magnetic entropy change in Sn doped Ni-Co-Mn-Ti all d metal Heusler alloy", Proceedings of Joint MMM - Intermag Conference, 10-14 January 2022
4. Anupam Gorai, Rohan Mandal, Dipika Mandal, "Anupam Gorai, Rohan Mandal, Dipika Mandal, "Enhanced Electromagnetic Wave Absorption by Bi-layered Nano-hollow Spheres", Proceedings of Joint MMM - Intermag Conference, 10-14 January 2022
5. K. Mandal, S. Ghose, M. Mandal, D. Majumder, S. Talukdar, I. Chakraborty, S. K Panda, "Chapter 2-Notes on useful materials and synthesis through various chemical solution techniques" in the book "Chemical Solution Synthesis for Materials Design and Thin Film Device Applications" Ed: S. Das and S. Dhara, (Elsevier, 2021) Pages: 29-78
6. Author - Prosenjit Singha Deo, title of book - Mesoscopic route to time travel, publisher - Springer, October 2021
7. Book : Ranjan Chaudhury, "Gateway to Condensed Matter Physics and Molecular Bio-physics --- Concepts and Theoretical Perspectives" ; Palm Bay, Florida (USA) and Burlington, Ontario (Canada) : Apple Academic Press, 2021 (23.12.2021)

Department of Theoretical Sciences

1. Ambalika Biswas, Amitabha Lahiri, "Naturalness and Two Higgs Doublet Models," (with A. Biswas) Proceedings of the 23rd DAE-BRNS High Energy Physics Symposium (hepbrns2018), Chennai, India 10-14 Dec, 2018, Published in Springer Proc. Phys. 261, 187 (2021)
2. Manna, S. S., Stella, A. L., Grassberger, P., Dickman, R., eds. Self-Organized Criticality, Three Decades Later. Lausanne: Frontiers Media SA. (2022) doi: 10.3389/978-2-88974-219-6

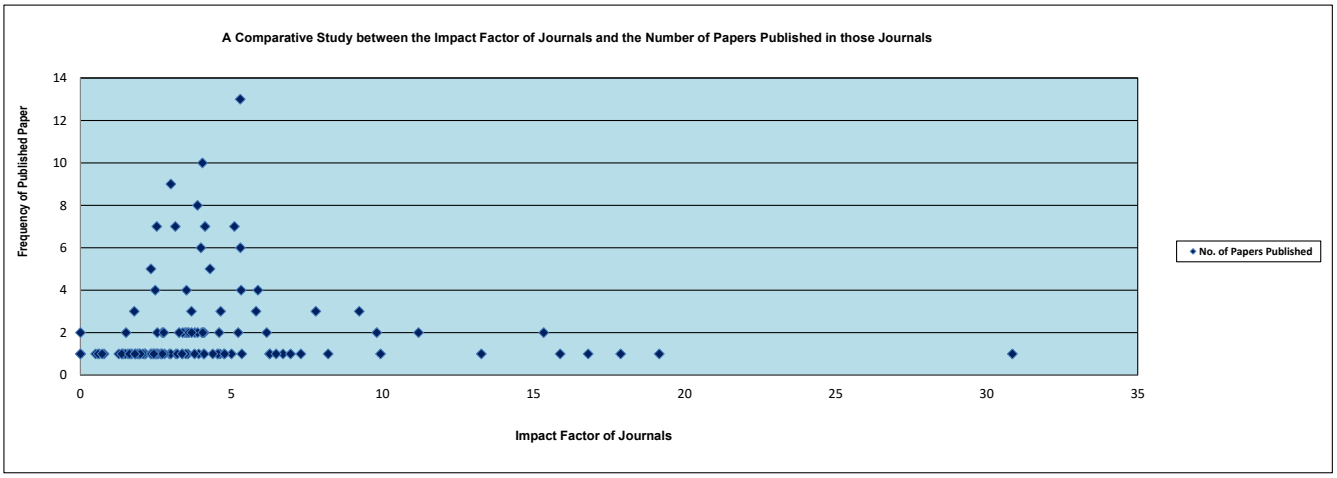
Total number of Other Publications : 14

Impact Factor for Publications in the Financial Year 2021-22

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
1	ACS Applied Bio Materials	2.5	3	7.5
2	ACS Applied Energy Materials	6.024	1	6.024
3	ACS Applied Materials & Interfaces	9.229	3	27.687
4	ACS Applied Nano Materials	5.097	7	35.679
5	ACS Biomaterials Science & Engineering	4.749	1	4.749
6	ACS Nano	15.881	1	15.881
7	ACS Omega	3.512	4	14.048
8	ACS Sustainable Chemistry & Engineering	8.198	1	8.198
9	Advanced Electronic Materials	7.295	1	7.295
10	Advanced Healthcare Materials	9.933	1	9.933
11	Advanced Materials	30.849	1	30.849
12	Advanced Science	16.806	1	16.806
13	Advances in Space Research	2.152	1	2.152
14	Analyst	4.616	1	4.616
15	Angewandte Chemie	15.336	2	30.672
16	Applied Physics Letters	3.791	2	7.582
17	Applied Physics Reviews	19.162	1	19.162
18	Applied Sciences	2.679	1	2.679
19	Applied Surface Science	6.707	1	6.707
20	Astronomical Journal	6.263	1	6.263
21	Astrophysical Journal	5.874	4	23.496
22	Astrophysics and Space Science	1.83	1	1.83
23	BioMetals	2.949	1	2.949
24	Bulletin of Materials Science	1.783	3	5.349
25	Chemical Engineering Journal	13.273	1	13.273
26	Chemical Physics Impact	0.5	1	0.5
27	Chemistry of Materials	9.811	2	19.622
28	ChemistrySelect	2.109	1	2.109
29	ChemBioChem	3.164	1	3.164
30	ChemMedChem	3.466	2	6.932
31	Classical and Quantum Gravity	3.528	2	7.056
32	Colloids and Surfaces A: Physicochemical and Engineering Aspects	4.539	1	4.539
33	Communications Biology	6.268	1	6.268
34	Crystal Growth & Design	4.076	1	4.076
35	European Journal of Physics	0.781	1	0.781
36	European Physical Journal C	4.59	2	9.18
37	The European Physical Journal D	1.425	1	1.425
38	The European Physical Journal Plus	3.911	1	3.911
39	The European Physical Journal Special Topics	2.707	2	5.414
40	Europhysics Letters	1.947	1	1.947
41	Ferroelectrics	0.62	1	0.62
42	Frontiers in Chemistry	5.221	2	10.442

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
43	Frontiers in Physics	3.56	1	3.56
44	Indian Journal of Physics	1.947	1	1.947
45	IEEE Transactions on Magnetics	1.7	1	1.7
46	Inorganica Chimica Acta	2.545	2	5.09
47	International Journal of Biological Macromolecules	6.953	1	6.953
48	International Journal of Modern Physics A	1.381	1	1.381
49	Isotopes in Environmental and Health Studies	1.675	1	1.675
50	Journal of Alloys and Compounds	5.316	4	21.264
51	Journal of Analytical Atomic Spectrometry	4.023	2	8.046
52	Journal of Applied Physics	2.546	1	2.546
53	Journal of Applied Nonlinear Dynamics	0.588	1	0.588
54	Journal of Astrophysics and Astronomy	1.27	1	1.27
55	Journal of Biomolecular Structure and Dynamics	5	1	5
56	Journal of Biosciences	1.826	1	1.826
57	Journal of Chemical Physics	3.488	1	3.488
58	Journal of Chemical Sciences	1.573	1	1.573
59	Journal of High Energy Physics	5.81	3	17.43
60	Journal of Magnetism and Magnetic Materials	2.993	1	2.993
61	Journal of Materials Science: Materials in Electronics	2.478	4	9.912
62	Journal of Mathematical Physics	1.488	1	1.488
63	Journal of Molecular Liquids	6.165	2	12.33
64	Journal of Molecular Spectroscopy	1.507	2	3.014
65	Journal of Photochemistry and Photobiology A: Chemistry	4.291	5	21.455
66	Journal of Physical Chemistry A	2.781	1	2.781
67	Journal of Physical Chemistry B	2.991	9	26.919
68	Journal of Physical Chemistry C	4.126	7	28.882
69	The Journal of Physical Chemistry Letters	6.475	1	6.475
70	Journal of Physics A: Mathematical and Theoretical	2.132	1	2.132
71	Journal of Physics Communications	1.9	1	1.9
72	Journal of Physics D: Applied Physics	3.207	1	3.207
73	Journal of Physics: Condensed Matter	2.333	5	11.665
74	Journal of Sol-Gel Science and Technology	2.326	1	2.326
75	Langmuir	3.882	2	7.764
76	Laser Physics	1.366	1	1.366
77	Macromolecular Chemistray and Physics	2.527	1	2.527
78	Materials Advances	NA	2	NA
79	Materials Chemistry and Physics	4.094	2	8.188
80	Materials Research Bulletin	4.641	3	13.923
81	Materials Research Express	1.62	1	1.62
82	Materials Science and Engineering: B	4.051	2	8.102
83	Materials Today Communications	3.383	2	6.766
84	Modern Physics Letters A	2.066	1	2.066
85	Monthly Notices of the Royal Astronomical Society	5.287	13	68.731
86	MRS Advances	0.72	1	0.72
87	MRS Communications	2.566	1	2.566
88	Nano Energy	17.881	1	17.881
89	Nano Letters	11.189	2	22.378
90	Nanoscale	7.79	3	23.37
91	Nanoscale Advances	4.553	1	4.553

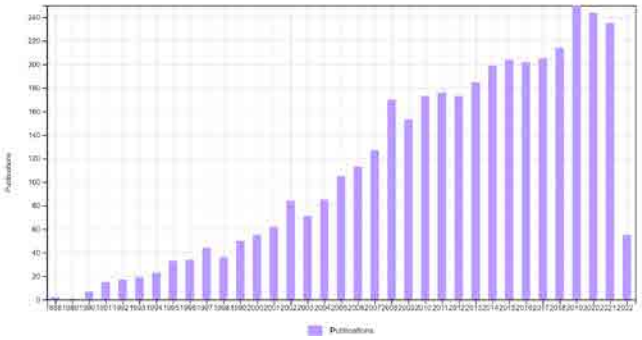
Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
92	Nanotechnology	3.874	8	30.992
93	New Journal of Chemistry	3.591	2	7.182
94	Nuclear Physics B	2.759	2	5.518
95	Optics Letters	3.776	1	3.776
96	Physica A: Statistical Mechanics and its Applications	3.263	2	6.526
97	Physica B: Condensed Matter	2.436	1	2.436
98	Physica E	3.382	1	3.382
99	Physica Scripta	2.487	1	2.487
100	Physica Status Solidi (a): applications and materials science	1.981	1	1.981
101	Physical Chemistry Chemical Physics	3.676	3	11.028
102	Physical Review A	3.14	7	21.98
103	Physical Review B	4.036	10	40.36
104	Physical Review D	5.296	6	31.776
105	Physical Review E	2.529	7	17.703
106	Physical Review Materials	3.989	6	23.934
107	Physics Letters A	2.654	1	2.654
108	Physics Letters B	4.771	1	4.771
109	Phytomedicine	5.34	1	5.34
110	Plasmonics	2.404	1	2.404
111	PRX Quantum	NA	1	NA
112	Quantum	2.713	1	2.713
113	Quantum Information Processing	2.349	1	2.349
114	Quantum Studies: Mathematics and Foundations	NA	1	NA
115	RSC Advances	3.361	1	3.361
116	Scientific Reports (Nature Publishing Group)	4.38	1	4.38
117	Soft Materials	2.429	1	2.429
118	Soft Matter	3.679	2	7.358
119	Solid State Communications	1.804	1	1.804
120	Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy	4.098	1	4.098
121	Transactions of the Indian National Academy of Engineering	NA	1	NA
	TOTAL	**531.358**	**247**	**1069.424**

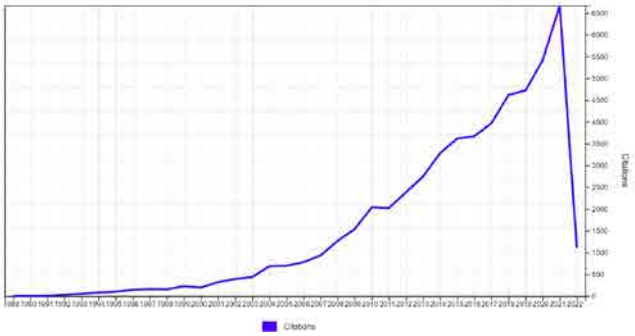


Research Publication Status

Citation Report (On 31st March, 2022)

Time Span = All years. Database =SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.





No. of Publications	**:**	**3821**
Sum of the Times Cited	**:**	**54478**
Sum of Times Cited without self-citations	**:**	**44103**
Citing Articles	**:**	**35653**
Citing Articles without self-citations	**:**	**32965**

Total no. of Papers published	Total no. of Citation received	Citations per paper	Citation per year*	h-index
3821	54478	54478 / 3821= 14.26	54478 / 35 =1556.51	83

* Year of establishment of the Centre is 1986. Citations received after 1987 to 2022 = 35 years

Source	**:**	**Web of Science**
Prepared by	**:**	**Dr. Saumen Adhikari, Librarian – cum – Information Officer**

Accounts

Satyendra Nath Bose National Centre for Basic Sciences

BUDGET SUMMARY 2021-2022

The Funds come from the Department of Science and Technology, New Delhi. The following is the Summary of the Budget estimates for the year 2021-2022.

(Figure in Lakhs)

	Actuals 2020-2021	Budget Estimate 2021-2022	Revised Estimate 2021-2022
Plan	3815.23	4558.38	4296.87*
TOTAL	**3815.23**	**4558.38**	**4296.87***

* Sanctioned by DST Plan Rs. 4708.00 lakh released as under:

Plan

(Rs. in lakh)

Sl. No.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/SAL/003/2021/1	19.05.2021	400.00
2	AI/SNB/SAL/003/2021/2	18.08.2021	425.00
3	AI/SNB/SAL/003/2021/3	30.09.2021	325.00
4	AI/SNB/SAL/003/2021/4	30.12.2021	140.00
5	AI/SNB/SAL/003/2021/5	28.03.2022	100.00
6	AI/SNB/GEN//003/2021/1	19.05.2021	450.00
7	AI/SNB/GEN//003/2021/2	18.08.2021	450.00
8	AI/SNB/GEN//003/2021/3	30.09.2021	475.00
9	AI/SNB/GEN//003/2021/4	30.12.2021	425.00
10	AI/SNB/GEN//003/2021/5	28.03.2022	33.00
11	AI/SNB/CAP/003/2021/1	19.05.2021	200.00
12	AI/SNB/CAP/003/2021/2	18.05.2021	350.00
13	AI/SNB/CAP/003/2021/3	30.09.2021	200.00
14	AI/SNB/CAP/003/2021/4	30.12.2021	250.00
15	AI/SNB/CAP/003/2021/5	28.03.2022	485.00
	TOTAL (PLAN)		**Rs. 4708.00**

INDEPENDENT AUDITOR'S REPORT

To the Governing Body of Satyendra Nath Bose National Centre for Basic Sciences

Qualified Opinion

We have audited the accompanying financial statements of Satyendra Bose National Centre for Basic Sciences ("the Centre"), which comprise the balance sheet as at March 31, 2022, and the Income and Expenditure Account , Receipts and Payments Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements of the entity are prepared, in all material respects, in accordance with the rules of the Centre and the Society.

Basis for Qualified Opinion

1. Last physical verification of fixed assets was conducted in the year 2013 . Since then , no physical verification of fixed assets has been carried out . As a result ,identification of obsolete/ unserviceable items could not be made by the Centre.
2. Liability for T.D.S default as per 26AS statement for Financial Year 2021-22 of Rs. 25869.00 has not been provided in the accounts. Further outstanding demand of Rs. 2,82,780.00 for other previous years have not been provided for in the accounts.

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 entity 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

We draw attention to the matters stated in the following note numbers to the financial statements. Our opinion is not modified in respect of these matters.

a) As per 26AS statement for the AY (2022-23), Rs. 35,89,325.00 and Rs.101.50 are refundable against Tax Deducted at Source and Tax Collected at Source respectively , for which the Centre is yet to submit the required income tax return.

b) Bank interest on Savings Bank Accounts & Fixed Deposit accounts refundable to DST is Rs.2,95,51,006.76 Refer to schedule-7 and the note on accounts - 2.2.4 of schedule-25.

Responsibilities of Management and those charged with Governance for the Financial Statements

The management of the Centre is responsible for the preparation of the financial statements in accordance with the rules of the Centre and for such internal control as the management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the entity'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.

As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by GB.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the entity's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the entity to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

Materiality is the magnitude of misstatements in the financial statements that, individually or in aggregate, makes it probable that the economic decisions of a reasonably knowledgeable user of the financial statements may be influenced. We consider quantitative materiality and qualitative factors in (i) planning the scope of our audit work and in evaluating the results of our work; and (ii) to evaluate the effect of any identified misstatements in the financial statements

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards

For Roy & Bagchi,
Chartered Accountants
FRN: 301053E

(Amit Mitra)
Partner
M. No. -060694
UDIN: 22060694APSQDS4351

Place: Kolkata
Date: 24.08.2022

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

Balance Sheet AS AT 31ST MARCH 2022

Amount (Rs.)

	Schedule	Current Year	Previous Year
FUNDS AND LIABILITIES			
Capital / Corpus Fund	1	1339278916.58	1198723826.32
Reserves And Surplus	2	-	
Earmarked / Endowment Funds	3	294625792.61	335681997.22
Secured Loans And Borrowings	4		
Unsecured Loans And Borrowings	5		
Deferred Credit Liabilities	6		
Current Liabilities and Provisions	7	81416704.58	77819370.41
TOTAL		**1715321413.77**	**1612225193.95**
ASSETS			
Fixed Assets	8	706776267.04	674291535.95
Investments - From Earmarked / Endowment Funds	9	194150237.00	265927124.00
Investments - Others	10	578938579.00	435570805.00
Current Assets, Loans, Advances Etc.	11	235456330.73	236435729.00
Miscellaneous Expenditure (to the extent not written off or adjusted)			
TOTAL		**1715321413.77**	**1612225193.95**
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN: 301053E

Date: 24/08/2022
Place: Kolkata

UDIN-22060694APSQDS4351

(Amit Mitra)
Partner
Membership no: 060694

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

Income and Expenditure Account FOR THE YEAR ENDED 31ST MARCH 2022

Amount (Rs.)

FUNDS AND LIABILITIES	Schedule	Current Year	Previous Year
INCOME			
Income from Services	12	8199279.95	8678679.00
Grants / Subsidies	13	322300000.00	341400000.00
Fees / Subscriptions (Student Admission & Semester Fees)	14	982504.00	1059750.00
Income from Investments (Income on Investment) from earmarked / endowment Funds transferred to Funds)	15		
Income from Technology Transfer & Contract Project	16	560000.00	2625000.00
Interest on Loan (HBA etc.) to employees	17	301532.00	188428.00
Other Income	18	1760626.28	516141.12
Increase / (decrease) in stock of finished goods and works-in-progress	19		
TOTAL (A)		**334103942.23**	**354467998.12**
EXPENDITURE			
Establishment Expenses	20	140762100.00	165668263.00
Other Administrative Expenses etc.	21	170651397.68	115539713.59
Expenditure on Grants, Subsidies etc.	22		
Bank interest adjustable (refunded to DST shown separately in Schedule 7)			
TOTAL (B)		**311413497.68**	**281207976.59**
Balance being excess of Income over Expenditure (A-B)		22690444.55	73260021.53
Prior period adjustments (Credit)		772341.12	592819.00
Transfer to / from Capital Fund			
BALANCE BEING SURPLUS / (DEFICIT) CARRIED TO			
CORPUS / CAPITAL FUND		**23462785.67**	**73852840.53**
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN: 301053E

Date: 24/08/2022
Place: Kolkata

UDIN-22060694APSQDS4351

(Amit Mitra)
Partner
Membership no: 060694

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

Receipts and Payments Accounts for the year ended 31st March 2022

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Expenses :**		
a) Cash in hand	9083.00	40650.00	a) Establishment Expenses	157510669.00	192086966.00
b) Bank Balances :			b) Administrative Expenses	122699361.60	92726026.20
i. In current accounts(Schd 11A)	82541353.63	50204316.87	c) Maintenance	36190357.00	36743186.00
ii. In deposit accounts			**II. Payments made against funds for various Projects**		
Schedule - 10	519520689.00	476771951.00			
Schedule - 11A	22042464.00	163055800.94			
iii. Savings accounts (Schd 11A)	58387229.80	61441229.47	**III. Investments and deposits made**		
iv. Remittance-in-Transit			a) Out of Earmarked/ Endowment	10000000.00	28854396.00
II. Grants Received			b) CPWD Deposit and NBCC Deposit		
a) From Government of India			c) Bank Gurantee & LC A/C	20849655.00	6167669.00
- For the year	515973268.00	536751918.00	d) Out of Own Fund	125000000.00	270424738.94
- For the previous year					
b) From State Government			**IV. Expenditure on Fixed Assets & Capital Work-in-Progress**		
c) From Other sources (details)					
(Grants for capital & revenue exp.			a) Purchase of Fixed Assets	121013634.24	205575670.00
To be shown separately)			b) Expenditure on Capital Work-in-Progress		0.00
			V. Refund of Interest		

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

Receipts and Payments Accounts for the year ended 31st March 2022

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
III. Interest Received			a) To the Government of India	15206049.00	0.00
a) On Bank deposits	7184045.76	17152146.00	b) To the State Government		
			c) To other providers of funds		
IV. Other Income	11502606.28	8619579.12	**VI. Finance Charges (Interest)**		
V. Amount Borrowed			**VII. Other Payments**	45011470.93	92869194.94
VI. Any other receipts	6274281.46	9361790.17	**VIII. Closing Balances**		
			a) Cash in hand	17877.00	9083.00
VII. Amount transferred from Current Account / Savings Account to Deposit Account.	77212035.00	320222267.94	b) Bank Balances :		
			I. In current accounts(Schd 11A)	114243200.96	72750444.15
			ii. In deposit accounts		
VIII. Amount transferred from Deposit Account to Savings Account & Currect Account.	114955812.00	0.00	Schedule - 10	596732724.00	519520689.00
			Schedule - 11A	1192809.00	57715447.00
			iii. Savings accounts(Schd.11A)	49935060.20	68178139.28
			iv. Remittance-in-Transit		
	1415602867.93	**1643621649.51**		**1415602867.93**	**1643621649.51**

As Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN: 301053E

(Amit Mitra)
Partner
Membership no: 060694

Date: 24/08/2022
Place: Kolkata

UDIN-22060694APSQDS4351

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 1 - Capital Fund

Amount (Rs.)

	Current Year		Previous Year	
Balance as at the beginning of the year	1198723826.32		1053452329.61	
Add : Contributions towards Corpus / Capital Fund	148500000.00		105500000.00	
Less: Depreciation for the year	31407695.41		34081343.82	
Add : Surplus during the year	23462785.67		73852840.53	
		1339278916.58		1198723826.32
BALANCE AS AT THE YEAR - END		1339278916.58		1198723826.32

Schedule 2 - Reserves and Surplus:

Amount (Rs.)

	Current Year		Previous Year	
	₹	₹	₹	₹
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

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3 - Earmarked / Endowment Funds

Amount (Rs.)

	FUND-WISE BREAK UP					TOTAL	
	Technical Research Centre	Project Fund	Retirement Benefits Fund	Staff Medical Fund	Corpus Fund	Current Year	Prev. Year
a) Opening balance of the funds	77067736.48	123820642.74	107081849.00	8787719.00	18924050.00	335681997.22	511608573.70
b) Additions to the Funds							
i) Donations / Grants / Contributions		45173268.00	10108074.00	1265663.00	3620771.00	60167776.00	92576142.00
ii) Income from investments made on account of funds	3323165.00	4010504.00	5654597.00	332339.00	748028.00	14068633.00	22848762.00
iii) Other additions -Provision during the year							
TOTAL (a + b)	**80390901.48**	**173004414.74**	**122844520.00**	**10385721.00**	**23292849.00**	**409918406.22**	**627033477.70**
c) Utilisation/Expenditure towards objectives of Funds							
i) Capital Expenditure							
Fixed Assets	34609327.01	8018537.00				42627864.01	202217043.00
Others							
Total							
ii) Revenue Expenditure							
Salaries, Stipend and allowances etc.	3855431.00	29235981.00				33091412.00	45708383.00
Rent							
Other Administrative expenses							
Other Payments	2938592.84	10840078.76	15541096.00	332339.00		29652106.60	29897095.48
iii) Adjustment (Interest)							
Interest Refunded to DST	9921231.00					9921231.00	13528959.00
TOTAL (c)	**51324581.85**	**48094596.76**	**15541096.00**	**332339.00**	**0.00**	**115292613.61**	**291351480.48**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**29066319.63**	**124909817.98**	**107303424.00**	**10053382.00**	**23292849.00**	**294625792.61**	**335681997.22**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 4 - Secured Loans and Borrowings

Amount (Rs.)

	Current Year		Previous Year	
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**

SCHEDULE 5 - Unsecured Loans and Borrowings

Amount (Rs.)

	Current Year		Previous Year	
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**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 6 - Deferred Credit Liabilities

Amount (Rs.)

	Current Year		Previous Year	
a) Acceptances secured by hypothecation of capital equipment and other assets				
b) Others				
TOTAL	**Nil**	**Nil**	**Nil**	**Nil**

SCHEDULE 7 - Current Liabilities and Provisions

Amount (Rs.)

	Current Year		Previous Year	
A. CURRENT LIABILITIES				
1. Acceptances				
2. Sundry Creditors:				
a) For Capital expenditure	8158201.00			25193310.00
b) Others - Revenue expenditure (including TRC & Project)	14574669.00			8335058.00
3. Othert Liabilities	2704860.88			4812041.88
4. Deposit from Contractors (including Project & TRC)	12301556.00			12050812.00
5. Deposit from Students	2249500.00			1979500.00
6. Deposit from Contractual Employees	1598434.00			1636746.00
7. Provident Fund Account (Payable)	0.00			53.10
8. Project Overhead Fund	7319228.43			6963221.43
9. Interest earned on fixed deposit and savings bank (Refundable to DST)	29551006.76			15206049.00
10. Employees Welfare Fund	100000.00			100000.00
11. EVLP Overhead Fund	2859248.51			1542579.00
TOTAL (A)	**81416704.58**			**77819370.41**
B. PROVISIONS				
1. For Taxation				
2. Gratuity				
3. Superannuation / Pension				
4. Accumulated Leave Encashment				
5. Trade Warranties / Claims				
6. Others - Adhoc Bonus	**0.00**			**0.00**
TOTAL (B)	**0.00**	**-**		**0.00**
TOTAL (A + B)	**81416704.58**			**77819370.41**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 8 - Fixed Assets

Amount (Rs.)

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	0.00	10950654.60	10950654.60
2. BUILDINGS:										
a) On Leasehold Land	449056735.86	299490.00		449356225.86	73690216.42	7110409.93		80800626.35	368555599.51	375366519.44
b) On Freehold Land										
c) Ownership Flats/ Premises										
d) Superstructures on Land not belonging to the entity										
3. PLANT MACHIENRY & EQUIPMENT	510085099.22	42946908.23		553032007.45	443945118.36	16820014.15		460765132.51	92266874.94	66139980.86
4. VEHICLES	1042199.00			1042199.00	545554.24	85640.84		631195.08	411003.92	496644.76
5. FURNITURE, FIXTURES	41987893.22	1232441.00		43220334.22	35696430.29	1778797.08		37475227.37	5745106.85	6291462.93
6. OFFICE EQUIPMENT	6155904.29	49992.00		6205896.29	5433122.12	268146.00		5701268.12	504628.17	722782.17
7. COMPUTER & LAN INSTALLATION	93574093.44	3292247.00	178165.00	96688175.44	72780721.78	4403562.51	102598.27	77081686.02	19606489.42	20793371.66
8. ELECTRIC INSTALLATIONS	11699040.00			11699040.00	8533860.81	941124.90		9474985.71	2224054.29	3165179.19
9. LIBRARY BOOKS	256893807.11	16146915.00		273040722.11	69586478.05			69586478.05	203454244.06	187307329.06
10. TUBEWELLS & W.SUPPLY	-	-		0.00	-	-		0.00	0.00	-
11. OTHER FIXED ASSETS	84225.55			84225.55	80014.27			80014.27	4211.28	4211.28
TOTAL OF CURRENT YEAR	**1381529652.29**	**63967993.23**	**178165.00**	**1445319480.52**	**710291516.34**	**31407695.41**	**102598.27**	**741596613.48**	**703722867.04**	**671238135.95**
PREVIOUS YEAR	**1353035550.29**	**33466240.00**	**19,18,738.00**	**1384583052.29**	**676210172.52**	**34081343.82**	**-**	**710291516.34**	**671238135.95**	**671853239.77**
B. CAPITAL WORK IN PROGRESS	**3053400.00**			**3053400.00**					**3053400.00**	**3053400.00**
TOTAL (A + B)	**1384583052.29**	**63967993.23**	**178165.00**	**1448372880.52**	**710291516.34**	**31407695.41**	**102598.27**	**741596613.48**	**706776267.04**	**674291535.95**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 9 - Investments from Earmarked / Endowment Funds

Amount (Rs.)

	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Project Fund Investment	63540324.00	51193466.00
7. Retirement Benefit Fund Investment	93577032.00	111545038.00
8. Staff Medical Fund Investment	6789112.00	6789112.00
9. Corpus Fund Investment (Project Overhead)	12449624.00	12449624.00
10. TRC Fund Investment	17794145.00	83949884.00
TOTAL	**194150237.00**	**265927124.00**

SCHEDULE 10 - Investments - Others

Amount (Rs.)

	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Others - Fixed Deposit with Indian Overseas Bank (including Project Overhead Investment)	487261365.00	346589084.00
Fixed Deposit with Union Bank of India	91677214.00	88981721.00
TOTAL	**578938579.00**	**435570805.00**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 11 - Current Assets, Loans, Advances Etc.

Amount (Rs.)

	Current Year		Previous Year	
A. CURRENT ASSETS:				
1. Inventories:				
a) Stores and Spares		32969.57		36425.57
2) Cash Balances in hand		17877.00		9083.00
3) Bank Balances:				
a) With Scheduled Banks:				
On Current Accoutns:				
Indian Overseas Bank (CA-089302000000220)	82169274.16		54509553.85	
Indian Overseas Bank (CA-089302000000273)	12580128.75		16140086.91	
Union Bank of India (CA-460901010034252)	3327974.42		579798.39	
HDFC Bank (GEM) (373218248)	45340.00	98122717.33	1521005.00	72750444.15
On Deposit Accounts for LC&BG:				
Indian Overseas Bank (CA-089302000000220)	27328923.00		35672983.00	
Indian Overseas Bank (SB-089301000018598 TRC)			15874795.00	
Indian Overseas Bank (CA-089302000000273 PROJECT)	1192809.00	28521732.00	6167669.00	57715447.00
On Savings Accounts:				
Indian Overseas Bank (SB-089301000010662 UNAST)	3668215.00		3558873.20	
Indian Overseas Bank (SB-089301000012029 SYNC.)	817571.36		793282.76	
Indian Overseas Bank (SB-089301000011479 NANO TECH)	579676.06		562482.46	
Union Bank of India (SB-460901110050013)	8046945.77		8047075.57	
Axis Bank (SB-775010100024408)	223174.00		5838931.00	
Axis Bank (SB-775010100017860)	1850.00		1795.00	
Union Bank of India (SB-460902010097273 TRC)	66356.80		13753.80	
Indian Overseas Bank (SB- 089301000018598 TRC)	16054126.83		9777155.68	
HDFC Bank (SB-6771192)	615794.01		602083.01	
Indian Overseas Bank (SB-089302000019902)	35981834.00	66055543.83	38982706.80	68178139.28
5. Remittance - in - Transit				
6. Post Office-Savings Accounts				
TOTAL (A)		**192750839.73**		**198689539.00**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Balance Sheet as at 31.03.2022

SCHEDULE 11 - Current Assets, Loans, Advances Etc.

Amount (Rs.)

	Current Year		Previous Year	
B. LOANS, ADVACNES AND OTHER ASSETS				
1. Loans:				
a) Staff including HBA ,Vehicle &PC Advance (includes Project A/c)		146825.00		571225.00
Project Account		0.00		
Advance to Project		0.00		
Technical Research Centre				
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account - CPWD Deposit Account	438840.00		438840.00	
b) GST payment	0.00		0.00	
c) Others	305430.00		305430.00	
d) Contractors & Suppliers	5375275.00	6119545.00	5375275.00	6119545.00
3. Income Accrued:				
a) On Investments from Earmarked / Endowment Funds(Including Project & TRC)	24993222.00		24608684.00	
b) On investmetns - Others	8699768.00		3408118.00	
c) Income Tax (TDS) Refundable		33692990.00	0.00	28016802.00
4. Sundry Debtors - National Research Development Corporation		2657513.00		2940000.00
5. Security Deposit (including Project)		88618.00		98618.00
TOTAL (B)		**42705491.00**		**37746190.00**
TOTAL (A + B)		**235456330.73**		**236435729.00**

Schedules Forming Part of Income & Expenditure for the Year Ended 31.03.2022

SCHEDULE 12 - Income from Sales / Services

Amount (Rs.)

	Current Year	Previous Year
1) Income from Sales		
a) Sale of Finished Goods		
b) Sale of Raw Material		
c) Sale of Scraps		
2) Income from Services		
a) Guest House Rent	364299.95	397033.00
b) Hostel Charges (Recovery of HRA)	5717635.00	5973018.00
c) Equipment Utilisation Fees	474700.00	120800.00
d) Hostel Maintenance Fees	1161723.00	1741641.00
e) Project Overhead	389449.00	297230.00
f) Income from BSNL	54973.00	142932.00
g) Seminer Hall Rent	0.00	0.00
h) Dining Hall Rent	0.00	0.00
i) Recovery of Water Charges	0.00	6025.00
j) Conference Registration Fee	36500.00	0.00
TOTAL	**8199279.95**	**8678679.00**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Income & Expenditure for the Year Ended 31.03.2022

SCHEDULE 13 - Grants / Subsidies (Irrevocable Grants & Subsidies Received)

Amount (Rs.)

	Current Year	Previous Year
1) Central Government	322300000.00	341400000.00
2) State Government(s)		
3) Government Agencies		
4) Institutions / Welfare Bodies		
5) International Organsations		
6) Others		
TOTAL	**322300000.00**	**341400000.00**

SCHEDULE 14 - Fees / Subscriptions

Amount (Rs.)

	Current Year	Previous Year
1) Student Admission Fee	126504.00	100500.00
2) Annual Fees / Subscriptions		
3) Student Semester Fee	856000.00	959250.00
4) Consultancy Fees		
5) Others		
TOTAL	**982504.00**	**1059750.00**

SCHEDULE 15 - Income From Investments (Income on Invest. from Earmarked / Endowment Funds transferred to Funds)

Amount (Rs.)

	Investment from Earmarked Fund		Investment - Others	
	Current Year	Previous Year	Currnet Year	Previous Year
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

Schedules Forming Part of Income & Expenditure for the Year Ended 31.03.2022

SCHEDULE 16 - Income from Technology Transfer & Contract Project

Amount (Rs.)

	Current Year	Previous Year
1. Income from Technology Transfer	560000.00	2625000.00
2. Income from Contract Project		
3. Others		
TOTAL	**560000.00**	**2625000.00**

SCHEDULE 17 - Interest Earned

Amount (Rs.)

	Current Year	Previous Year
1) On Term Deposits:		
a) With Scheduled Banks		
b) With Institutions		
c) Others		
2) On Savings Accounts:		
a) With Scheduled Banks		
b) Post Office Savings Accounts		
c) Others		
3) On Loans:		
a) Employees / Staff (Interest on HBA etc.)	301532.00	188428.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	**301532.00**	**188428.00**

SCHEDULE 18 - Other Income

Amount (Rs.)

	Current Year	Previous Year
1) Profit on Sale / disposal of Assets:		
a) Owned Assets		
b) Assets acquired out of grants, or received free of cost		
2) Export Incentives realized		
3) Fees for Miscellaneous Services		
4) Miscellaneous Income	1760626.28	516141.12
TOTAL	**1760626.28**	**516141.12**

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Income & Expenditure for the Year Ended 31.03.2022

SCHEDULE 19 - Increase/(Decrease) in Stock of Finished Goods & Work in Progress

Amount (Rs.)

		Current Year	Previous Year
a)	Closing stock		
	Finished Goods		
	Work-in-Progress		
b)	Less: Opening Stock		
	Finished Goods		
	Work-in-Progress		
NET INCREASE/(DECREASE) [a-b]		**Nil**	**Nil**

SCHEDULE 20 - Establishment Expenses

Amount (Rs.)

		Current Year	Previous Year
a)	Salaries and Wages	117502728.00	106995987.00
b)	Other Allowances and Bonus	0.00	0.00
c)	Employer's Contribution to Provident Fund	3534961.00	3867187.00
d)	Contribution to Retirement Benefits Fund	10108074.00	417438.00
e)	Staff Welfare Expenses (Medical)	3003569.00	2480006.00
f)	Employer's Contribution to NPS	5390774.00	3578652.00
g)	Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	1221994.00	3326660.00
TOTAL		**140762100.00**	**120665930.00**

SCHEDULE 21 - Other Administrative Expenses Etc.

Amount (Rs.)

		Current Year	Previous Year
a)	Extended Visitors Programme (Including Seminars & Workshops)	11466656.00	14137761.72
b)	Meeting Expenses	720682.00	517229.00
c)	Library General Expenses	120108.00	75330.00
d)	Electricity and Power	35709722.00	31313071.00
e)	Laboratory Expenses	9780903.00	6372273.00
f)	Insurance	30383.00	16859.00
g)	Repairs and Maintenance	50000956.00	51345473.00
h)	Vehicles Hire Charges	1930574.00	2140247.00
i)	Postage, Telephone and Communication Charges	871883.00	763219.00
j)	Printing and Stationary	1169333.00	511039.00
k)	Travelling and Conveyance Expenses	134250.00	598990.00

(Continued on next page)

Satyendra Nath Bose National Centre for Basic Sciences

Schedules Forming Part of Income & Expenditure for the Year Ended 31.03.2022

SCHEDULE 21 - Other Administrative Expenses Etc. *(Contd...)*

Amount (Rs.)

	Current Year	Previous Year
l) Contingency to Faculty	20000.00	10000.00
m) Auditors' Remuneration	59000.00	59000.00
n) Bank Charges	193899.83	154863.60
o) Professional Charges (Legal Charges)	18896.00	251461.00
p) Staff Training & Welfare	89718.00	46295.00
q) Patent & Trademark	106714.00	86208.00
r) Integrated Ph.D.	1129831.00	1519805.00
s) Hindi Programme	764320.00	25870.00
t) Advertisement and Publicity	199484.00	1085879.00
u) Others	1104977.85	616146.27
v) Municipal Tax	141388.00	141388.00
w) Contract Services	18161958.00	17629467.00
x) Stipend (Post B.Sc. & Post M.Sc.)	36725761.00	31124172.00
TOTAL	**170651397.68**	**160542046.59**

SCHEDULE 22 - Expenditure on Grants, Subsidies Etc.

Amount (Rs.)

	Current Year	Previous Year
a) Grants given to Institutions / Organisations		
b) Subsidies given to Institutions / Organisations		
TOTAL	**Nil**	**Nil**

SCHEDULE 23 - Interest

Amount (Rs.)

	Current Year	Previous Year
a) On Fixed Loans		
b) On Other Loans (including Bank Charges)		
c) Others		
TOTAL	**Nil**	**Nil**

Satyendra Nath Bose National Centre for Basic Sciences

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.

4.4 Expenditure incurred for purchasing Computer etc. out of Spares & Repair Expenses of Equipment allocation are charged to revenue.

5. DEPRECIATION

5.1 Depreciation on capitalization has been charged on the value determined / estimated at the time of take over and as and when on further items were added subsequently to Assets.

5.2 Depreciation is provided on straight-line method as per rates specified in the Companies Act, 2013.

5.3 In respect of additions to / deletion from fixed assets during the year, depreciation is considered on pro-rata basis. Depreciation is provided from the date of acquisition of the assets.

Satyendra Nath Bose National Centre for Basic Sciences

SCHEDULE 24 - Significant Accounting Policies

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.

5.6 Depreciation on part of Office Building funded by TRC Fund is not provided but depreciation on part of the building funded by Centre Fund is provided

6. FOREIGN CURRENCY TRANSACTIONS

6.1 Transactions denominated in foreign currency are accounted at the exchange rate prevailing at the date of transaction.

7. RETIREMENT BENEFITS

7.1 Liability towards gratuity payable on death/retirement of employees is computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.2 Provision for accumulated leave encashment benefit to the employees is accrued and computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.3 Liabilities under above accounts are invested separately in fixed deposit accounts with nationalized bank.

Satyendra Nath Bose National Centre for Basic Sciences

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.1,05,00,000.00). Interest earned on such deposit is accounted on cash basis.
- Letters of Credit opened by Bank on behalf of the Centre and Project Rs. 1,31,88,209/- (Previous year Rs.3,13,40,652.00) 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)
GST	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 and not provided for Rs. Nil (Previous year Rs. Nil).

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, 2021 was Rs.30,53,400.00 addition during the year is Rs.Nil -,totaling to Rs.30,53,400.00 an amount of Rs.0.00 has been capitalized, leaving balance of Rs.30,53,400.00 which has been carried forward.

2.2.3 Current Assets, Loans and Advances

In the opinion of the Management, the current assets, loans and advances have a value on realization in the ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

Unadjusted Travelling Advances:-

Name	Amount	Remarks
Amrtya Sarkar	Rs. 63000.00	Unadjusted since 2012-13

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SCHEDULE 25 - Contingent Liabilities and Notes on Accounts

2.2.4. Amount payable to DST Rs. 2,95,51,006.76 relates to Interest Earned on SB & Fixed. Deposits during the Financial Year 2021-22.

2.2.5 Taxation

In view of there being no taxable income under Income-tax Act 1961, no provision for Income tax has been considered necessary.

2.2.6 Foreign Currency Transactions

i) Value of Imports Calculated on C.I.F basis :

	Current Year	Previous Year
- Capital Goods	Rs.3,66,83,739/-	Rs.4,33,50,822/-
- Consumables	Rs.8,61,978/-	Rs.15,14,277/-

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

2.2.7 Corresponding figures for the previous year have been re-grouped / re-arranged, wherever necessary.

Kolkata
Dated: 24.08.2022

PARA-WISE REPLIES TO THE AUDIT OBSERVATIONS

Sl.	Audit Observations	Para-wise replies
1	Last physical verification of fixed assets was conducted in the year 2013. Since then, no physical verification of fixed assets has been carried out. As a result, identification of obsolete / unserviceable items could not be made by the Centre.	Work order for physical verification of fixed will be awarded very soon in order to identify obsolete / unserviceable items. On completion of said physical verification of fixed assets necessary adjustment will be given in the accounts accordingly.
2	Liability for T.D.S default as per 26AS statement for Financial Year 2021-22 of Rs. 25,869.00 has not been provided in the accounts. Further outstanding demand of Rs. 2,82,780.00 for other previous years have not been provided for in the accounts.	The Centre has already engaged M/s Roy & Bagchi, the statutory auditor of the Centre to examine the T.D.S default as mentioned in 26AS statement for the financial year 2021-22. Necessary action in this respect will be initiated as per the advice of M/s Roy & Bagchi.

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Block - JD, Sector - III, Salt Lake, Kolkata - 700106

Phone: + 91 33 2335 5706/07/08, Fax: +91 33 2335 3477

http://www.bose.res.in