Annual Report

2020-21

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

बिज्ञानेन परिपश्यन्ति धीराः

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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Satyendra Nath Bose National Centre for Basic Sciences

Annual Report 2020-2021

Satyendra Nath Bose National Centre for
Basic Sciences

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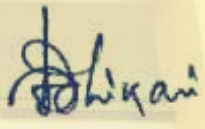
Acknowledgement

Annual Report of the 'Satyendra Nath Bose National Centre for Basic Sciences' is a brief representation of its activities of a financial year. The report reflects research activities, administrative activities, academic progress and achievement of young research scholars, development of infrastructure and facilities, and establishment of network with advanced research groups around the world. It's 11th 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 5th time the Annual Report is translated and typed in Hindi within the Centre. Ajay Kumar Shaw, Office Assistant (Hindi) 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

I am indeed privileged to present the Annual Report of the Satyendra Nath Bose National Centre for Basic Sciences for the year 2020-21. This year coincides will the Golden Jubilee of the establishment of the Department of Science and Technology under which the Centre belongs and reached a land mark of the three and a half decades, since its creation. The Centre continued its commendable efforts to achieve the mandated objectives and played a key role in the country's initiative on cutting edge research and manpower training in basic sciences in the emerging areas of Quantum Science & Technology, Theoretical Physics and Astro-physics, Computational Materials Science, Ultrafast Spectroscopy and Advanced Materials including soft, nano and biomaterials. Amid the global pandemic crisis throughout the year due to COVID-19, staff members and students of the Centre had to face unprecedented challenges for continuing with the normal academic and administrative activities of the Centre. In spite of several bottlenecks, the Centre has achieved some significant landmarks, which are reflected by 240 publications in referred journals, 7 patents (3 - granted, 4 - applied), 42 Ph. D. theses (14 - submitted, 28 - awarded) and 30 ongoing sponsored projects with a total funding of INR 2.21 crores in addition to the TRC project. The quality of publications has been in the top bracket, as evident by the Nature Index ranking of the Centre, which is among the top three DST institutes for the last two consecutive years. I sincerely congratulate all my colleagues, postdoctoral scholars and Ph.D. students for their admirable efforts for the above achievements. In addition to the existing national and international collaborations, this year the Centre has initiated a new joint PhD programme with IISER-Kolkata

Several faculty members have received National / International laurels such as the J. C. Bose Fellowship of SERB, elected fellows of the Indian National Academy of Engineering and Royal Society of Chemistry, London, Platinum Jubilee Award of the National Academy of Sciences India (NASI) - Reliance Industries, SERB Power fellowship and elected editorial board member of prestigious international journals. The Centre has reached a new milestone this year on translational research outputs under the prestigious TRC project supported by DST, which has resulted in transfer of four technologies on i) Non-invasive Hyperbilirubinemia Screening System for Neonatals, ii) A system and kit for non-invasive detection of peptic ulcer diseases, non-ulcerous dyspepsia, and Helicobacter pylori infection, iii) Long-lasting nano-sanitizer with a Dispensing Antimicrobial Layer and iv) Respirator with Attached Exhalation Valve and Suspended Particulate Matter Filter for Comfortable and Hygienic Breathing. It is heartening to note that the last two technologies were developed on a fast track mode to combat the COVID crisis and already commercialized by the companies for practical use.

Along with the teaching activities, the Centre organized several science networking and outreach activities in online mode even in the pandemic situation as a part of the DST Golden Jubilee celebration. Most notable of them are the DST Golden Discourse series on the occasion on 128th birth anniversary of S. N. Bose, 25th S. N. Bose memorial lecture by Prof. Anton Zeillinger, Austria, 15th C. K. Majumdaer memorial lecture by Nobel laureate Prof. Michael Kosterlitz, C. K. Majumdar Memorial Workshop for post-B.Sc. students in collaboration with IAPT, 3rd Annual Conference on Quantum Condensed Matter (QMat-2021), and public Outreach Lectures on the occasion of 6th India International Science Festival (IISF 2020).

Our gratitude to the members of the statutory and advisory and internal administrative committees of the Centre for their advise and support. The reconstituted Governing body of the Centre chaired by Professor B. N. Jagatap took over from October 2020 on completion of the tenure of the previous one chaired by Dr. Srikumar Banerjee. Sincere thanks to all faculty and staff members, administration and support services and students of the Centre for their sincere involvement towards continuous growth of the Centre. Let me also thank the Annual Report Committee for making the report and completing in time in.

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

Samit Kumar Ray
Director
Satyendra Nath Bose National Centre for Basic Sciences

DEAN (FACULTY)

In the year 2020-21, the Covid-19 pandemic disrupted the normal functioning of all institutions. A number of our faculty members and their families unfortunately got affetcted. In spite of the pandemic and lockdown measures, the Centre continued with its academic activities, performing exceptionally in several directions. Our faculty published 240 number of articles in high impact international journals, with several of the above publications resulting from ongoing national and international collaborations. A vibrant technology development programme was pursued at the Technical Research Centre, with the filing of 9 patents and 6 agreements for technology transfers.

A number of online workshops, seminars and distinguished lectures were organized by the Centre. Our faculty delivered several invited lectures in national and international conferences and schools. Though the pandemic prevented physical visits by scientists, our national and international collaborations continued in online mode leading to significant outputs. Our faculty members have been vigorously involved in projects supported by extramural funding, further bolstering the research activities at the Centre. In the current year 12 more extramural projects were sanctioned with 17 ongoing projects. Additionally, our faculty members have actively participated in various science outreach programmes, including the contribution of 16 scientific success stories for the DST media cell.

In this year 3 more regular faculty members have joined, one each in the Departments of AC, CMPMS and TS, respectively. During this period 2 faculty members have left the Centre. Our core faculty strength was supported by 5 Inspire Faculty/Ramanujan Fellows, as well as 3 Emeritus Professors/Senior Scientists, and 4 Visiting (Hon.) Fellows. A substantial contribution to the vibrant academic and research atmosphere of the Centre was provided by our young team of 14 post-doctoral research associates, and 12 other post-doctoral scientists supported by external funding through various schemes/projects of DST and CSIR.

The following awards and recognitions were received by our faculty members:

- Prof. Amitabha Lahiri received an Honorable Mention, Gravity Research Foundation Essay competition.
- Prof. Bhupendra Nath Dev was awarded the DAE Raja Ramanna Fellowship.
- Prof. Gautam De was appointed External Member of CRNN (Calcutta University), Ph.D Committee.
- Dr. Manik Pradhan was nominated Fellow of Royal Society of Chemistry and Fellow of Linnean Society of London. He was also appointed as Early Career Board Member of Analytical Chemistry of American Chemical Society, and Editorial Board Member of Chemical Physics Impact (Elsevier).
- Prof. Priya Mahadevan was appointed SERB Power Fellow. She was also appointed as Editorial Advisory Board Member in ACS Energy Letters and Journal of Magnetism and Magnetic Materials.
- Prof. Rabin Banerjee was awarded NASI senior scientist platinum jubilee fellowship. He also received an Honorable Mention in the Annual Essay contest of the Gravity Research Foundation.
- Prof. Samir K. Pal was nominated Fellow of National Academy of Engineering. He also received NASI-Reliance Industries Platinum Jubilee Award and Abdul Kalam Technology Innovation National Fellowship.
- Prof. Tanusri Saha Dasgupta was appointed J. C. Bose National Professor. She was also appointed Vice-President of Indian Physics Association.

Archan S. Majumdar
Dean (Faculty)

DEAN ACADEMIC PROGRAMME

We take pride in presenting the report of the academic section in the year 2020-21. The mandate of the academic section is to foster and promote academic activities in the Centre in different branches of Physical and Chemical Sciences. The objectives include skill development of research scholars, training of students in discovery, application and communication of knowledge, and exchange of scientific ideas with national and international scientists of eminence. The goal is to prepare young minds to meet the changing and challenging needs of the scientific community.

This year had been an extraordinary year as the activities in significant part of the year got heavily affected by the impact of COVID-19. Most students had to leave the campus at the event lockdown was announced. At the end of lockdown period, it was a challenging task to bring the students back in the campus in a phase-wise manner, opening up of the laboratories in a restricted manner, preparing for the online teaching as well as organizing the online admission tests of the students. I am happy that we were successful in handling this challenges in addition to our usual academic activities.

In the academic year 2020-21, a total of 29 students joined the PhD Programme. Of these, 05 joined Astrophysics & Cosmology, 09 joined Condensed Matter Physics and Material Science, 08 joined Chemical, Biological and Macromolecular Sciences and 07 joined Theoretical Sciences, while 05 students joined I.PhD Programme of the Centre. A total of 14 students submitted their PhD thesis and 28 students were awarded PhD degree. The academic section organized the 25th S.N.Bose memorial lecture by Prof. Zeilinger, 15th C.K.Majumdar memorial lecture by Prof. Kosterlitz, and Bose Colloquiums by Profs. Lorenzo Pavesi, Pratap Raychaudhuri and Sudeshna Sinha. Additionally, Curtain Raising Ceremony of 6th India International Science Festival and National Science day seminar by Prof. Rohini M. Godbole were organized by academic section.

Finally, it is a great privilege for me to get an opportunity to work with incredibly thoughtful, energetic and inspiring faculty colleagues, administrative staff members of the academic section and over all the students. The achievements highlighted in this report – as well as the many other successes not profiled – are the outcome of efforts by countless individuals whose dedication to our academic programmes made it possible.

COURSES TAUGHT IN 2020-21

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

1st Semester:

- PHY 101, *Classical Dynamics*, Biswajit Chakraborty;
- PHY 102, *Mathematical Methods*, Rabin Banerjee & Sunandan Gangopadhyay;
- PHY 103, *Quantum Mechanics I*, M Sanjay Kumar;
- PHY 104, *Computational Methods in Physics I*, Punyabrata Pradhan;
- PHY 203, *Electromagnetic Theory*, Amitabha Lahiri;

2nd Semester:

- PHY 201, *Statistical Mechanics*, Jaydeb Chakrabarti;
- PHY 202, *Quantum Mechanics II*, Manu Mathur;
- PHY 204, *Computational Methods in Physics II*, Punyabrata Pradhan;

- PHY 405, *Biological Physics*, Rajib Kumar Mitra;
- PHY 191, *Basic Laboratory I*, Samir Kumar Pal & Soumen Mondal.

3rd Semester:

- PHY 301, *Atomic & Molecular Physics*, Anjan Barman & Rajib Kumar Mitra;
- PHY 302, *Condensed Matter Physics*, Tanusri Saha Dasgupta & Thirupathaiah Setti;
- PHY 303, *Advanced Quantum Mechanics & Applications*, Archan S Majumdar & Sunandan Gangopadhyay;
- PHY 304, *Project Research II*, Faculty Supervisors;
- PHY 403, *Astrophysics & Cosmology*, Soumen Mondal & Ramkrishna Das.

4th Semester:

- PHY 401, *Project Research III*, Faculty Supervisors;
- PHY 402, *Seminar Course*, Faculty Experts;
- PHY 407, *Advanced Quantum Filed Theory*, Sunandan Gangopadhyay;
- PHY 409, *Advanced Statistical Physics*, Amitabha Lahiri;
- PHY 412, *Physics of Materials*, Ranjan Chaudhury & Kalyan Mandal;
- PHY 413, *Quantum Information Theory*, M Sanjay Kumar;
- PHY 391, *Methods of Experimental Physics*, Thirupathaiah Setti, Rajib Kumar Mitra, Manik Pradhan, Ramkrishna Das & Kalyan Mandal.

Ph.D. Course Work Programme

- PHY 501, *Research Methodology*, Rajib Kumar Mitra & Atindra Nath Pal;
- PHY 502, *Review of the Topical Research*, Faculty Supervisors;
- PHY/CB 591, *Project Research*, Faculty Supervisors;
- CB 521, *Numerical Methods*, Suman Chakrabarty
- CB 523, *Advanced Equilibrium Statistical Mechanics*, Jaydeb Chakrabarti & Gautam Gangopadhyay;
- ●● CB 527, *Molecular Physics & Spectroscopy*, Rajib Mitra & Anjan Barman;
- ●● PHY 503, *Condensed Matter Physics*, Tanusri Saha Dasgupta & Thirupathaiah Setti;
- ●● PHY 506, *Quantum Physics*, Sunandan Gangopadhyay & Archan S Majumdar;
- ●● PHY 510, *Astrophysics*, Soumen Mondal & Ramkrishna Das;
- ●● PHY 616, *Observational Techniques in Astronomy*, Soumen Mondal & Ramkrishna Das;
- ●● CB 540, *Study of Biomacromolecules*, Suman Chakrabarty & Tatini Rakshit;
- ●● PHY 603, *Statistical Physics*, Amitabha Lahiri;
- ●● PHY 601, *Advanced Condensed Matter Physics I*, Ranjan Chaudhury & Kalyan Mandal;
- ●● PHY 602, *Advanced Condensed Matter Physics II*, Tanusri Saha Dasgupta & Manoranjan Kumar;
- ●● PHY 613, *Quantum Information Theory*, M Sanjay Kumar.

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

Ph.D. THESIS SUBMITTED

1. ***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 University of Calcutta, in, 2020
2. ***Experimental Study of Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Multilayers***, Santanu Pan, Supervisor: Anjan Barman, in Jadavpur University, in 2020
3. ***Evanescent wave and cavity enhanced absorption spectroscopy for trace molecule sensing using diode and quantum cascade lasers*** Sanchi Maithani, Supervisor: Manik Pradhan, in University of Calcutta, in August, 2020
4. ***Interactions and Dynamics of Cryoprotectants, Energy Materials and Other Complex Mixtures***, Kajal Kumbhakar, Supervisor: Ranjit Biswas, in Jadavpur University, in October, 2020
5. ***Investigation and Control of Spin Waves in Ferromagnetic Thin Films, Interface and Nanostructures***, Avinash Kumar Chaurasiya, Supervisor: Anjan Barman, in Jadavpur University, in November, 2020

6. ***Spectroscopic And Computational Studies On Functionalized Nanohybrids For Potential Manifold Applications***, Tuhin Kumar Maji, Supervisor: Samir Kumar Pal, in University of Calcutta, in November, 2020

7. ***Magnetic, Dielectric and Microwave Absorption Properties of Transition Metal based Ferrite Nanostructures***, Dipika Mandal, Supervisor: Kalyan Mandal, in Jadavpur University, in December, 2020

8. ***Large Magnetocaloric Effect in Low-Cost Transition Metal Based Alloys for Magnetic Refrigeration***, Subrata Ghosh, Supervisor: Kalyan Mandal, in Jadavpur University, in December, 2020

9. ***Dynamical Aspects of Confined Media, Bulk Binary Mixtures and Other Complex Systems***, Atanu Baksi, Supervisor: Ranjit Biswas, in Jadavpur University, in January, 2021

10. ***Aspects of gauge/gravity duality and it's applications***, Debabrata Ghorai, Supervisor: Sunandan Gangopadhyay & Biswajit Chakraborty, in University of Calcutta, in January, 2021

11. ***Synthesis, Physical Properties And Applications of Metal Oxide Semiconductor Nanostructures And Thin Films***, Chandan Samanta, Supervisor: Barnali Ghosh (Saha), in University of Calcutta, in February, 2021

12. ***Investigations of Multi-component mixtures and complex systems with longer-ranged interactions***, Juriti Rajbangshi, Supervisor: Ranjit Biswas, in Jadavpur University, in February, 2021

13. ***Ultrafast Spin Dynamics in Ferromagnetic Patterned Nanostructures and Multilayers***, Anulekha De, Supervisor: Anjan Barman & Rajib Kumar Mitra, in University of Calcutta, in March, 2021

14. ***Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications***, Soumendra Singh, Supervisor: Samir Kumar Pal, in University of Calcutta, in March, 2021

Ph.D. AWARD RECEIVED

1. ***Electronic Structure of Ni-Mn Based Heusler Alloys***, Soumyadipta Pal, Supervisor: Chhayabrita Maji & Priya Mahadevan, in University of Calcutta, in September, 2020

2. ***Information Theoretic Aspects of Some Non-Gaussian Classical and Quantum Optical Fields***, Soumyakanti Bose, Supervisor: M Sanjay Kumar, in University of Calcutta, in February, 2021

3. ***Synthesis And Study of Physical Property Of Binary Oxide Nanostructures, Thin Film And Devices***, Samik Roy Moulik, Supervisors: Barnali Ghosh (Saha), in University of Calcutta, in January, 2021

4. ***Electronic Structure and Magnetic Properties of Graphene Derivatives and Graphene-based Composite Structures***, Nafday Dhani Milind, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in September, 2020

5. ***Some Studies of Percolation Phenomena in Disordered Systems***, Sumanta Kundu, Supervisor: Subhrangshu S Manna, in University of Calcutta, in December, 2020

6. ***Studies of Cool And Evolved Stars***, Supriyo Ghosh, Supervisor: Soumen Mondal, in University of Calcutta, in October, 2020

7. ***Spectroscopic Studies On Molecules And Nanomaterials For Potential Applications In Medical Diagnosis And Environmental Pollution Monitoring***, Probir Kumar Sarkar, Supervisor: Samir Kumar Pal, in University of Calcutta, in September, 2020

8. ***Dynamics of propagating modes and characterisation of ordering in coupled non-equilibrium systems***, Shauri Chakrabarty, Supervisor: Sakuntala Chatterjee, in University of Calcutta, in March, 2021

9. ***Spectroscopic Studies On Hybrid-Materials Of Medicinally Important Molecules For Enhanced Biological Activity***, Damayanti Bagchi, Supervisors: Samir Kumar Pal, in University of Calcutta, in January, 2021

10. ***Multi-wavelength Studies of Novae***, Anindita Mondal, Supervisors: Ramkrishna Das & Soumen Mondal, in University of Calcutta, in December 2020

11. ***Accreting Black Hole Systems as Classical Analogue Gravity Models***, Pratik Tarafdar, Supervisor Amitabha Lahiri & Tapas Kumar Das, in University of Calcutta, in February, 2021

12. ***Spectroscopic Studies On Structure, Function and Dynamics Of Biological Macromolecules In Physiologically Relevant And Engineered Environments***, Priya Singh, Supervisor: Samir Kumar Pal, in University of Calcutta, in December, 2020

13. ***Magneto-Fluorescent Transition Metal Oxide Nanostructures for Biomedical Application***, Indranil Chakraborty, Supervisors: Kalyan Mandal, in University of Calcutta, in December, 2020

14. ***Investigation and Control of Gigahertz Frequency Spin Wave Dynamics in Magnonic Crystals***, Samiran Choudhury, Supervisor: Anjan Barman, in Jadavpur University, in 2020

15. ***Ultrafast Magnetization Dynamics in Ferromagnetic Thin Films, Heterostructures & Nanostructures***, Sucheta Mondal, Supervisor: Anjan Barman, in Jadavpur University, in 2020

16. ***Single And Double Perovskite Multiferroic Nanostructures With Their Diverse Applications***, Mahebub Alam, Supervisor: Kalyan Mandal, in University of Calcutta, in January, 2021

17. ***Photophysics and dynamics of complex chemical systems***, Ejaj Tarif, Supervisor: Ranjit Biswas, in Jadavpur University, in 2020

18. ***Development of Quantum Cascade Laser (QCL)-Based Spectroscopic Techniques And Their Applications In Trace Gas Analysis***, Mithun Pal, Supervisor: Manik Pradhan, in University of Calcutta, in March, 2021

19. ***Canonical Formulation of Fluid Dynamics***, Arpan Krishna Mitra, Supervisor: Rabin Banerjee, in University of Calcutta, in December, 2020

20. ***Ordering kinetics, steady state and phase transition in active particle systems: Role of noise and boundary***, Sudipta Pattanayak, Supervisor: Manoranjan Kumar & Shardha Mishra, in University of Calcutta, in January, 2021

21. ***Frustrated Magnetic Ladders: A DMRG Study***, Debasmita Maiti, Supervisor: Manoranjan Kumar, in University of Calcutta, in December, 2020

22. ***Spectral And Timing Properties Of Black Holes And Neutron Stars In X-Ray Binaries Using The Two-Component Advective Flow Solution***, Ayan Bhattacharjee, Supervisor: Sandip K Chakrabarti, in University of Calcutta, in January, 2021

23. ***Electronic Structure Of Perovskites And Related Compounds***, Anita Halder, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in March, 2021

24. ***Photophysical Studies On Light Harvesting Nanomaterials For Improved Solar Energy Conversion***, Jayita Patwari, Supervisor: Samir Kumar Pal, in University of Calcutta, in October, 2020

25. ***Investigation Of Metal Insulator Transition In 3D Transition Metal Oxides***, Ravindra Singh Bisht, Supervisor: Arup K Raychaudhuri, in University of Calcutta, in November, 2020

26. ***Sound velocity and internal friction in disordered magnetic alloys***, Md Sarowar Hossain, Supervisor: Pratip Kumar Mukhopadhyay, in University of Calcutta, in March, 2021

27. ***Quantum Correlations: Preservation And Applications***, Suchetana Goswami, Supervisor: Archan S Majumdar, in University of Calcutta, in March 2021

28. ***Characterization Of Periodic Orbits In Open Nonlinear dynamical Systems***, Sandip Saha, Supervisor: Gautam Gangopadhyay, in University of Calcutta, in February, 2021

POST-PhD. PLACEMENT

Suraka Bhattacherjee - Postdoctoral Fellow, Raman Research Institute (RRI), Bangalore

Santanu Pan - Assistant Professor, Netaji Nagar Day College, WB

Atanu Baksi - Visiting Researcher, IISc., Bangalore

Debabrata Ghorai – PDRA, Hanyang University, South Korea

Juriti Rajbangshi - Visiting Researcher, Delhi University

Soumyadipta Pal - Assistant Professor, IEM, Kolkata

Soumyakanti Bose - PDRA, Seoul National University IISER, Mohali

Samik Roy Moulik - Application Scientist, Electron Microscopy Division, SAANS Analytical Equipment Pvt. Ltd. India (Hitachi Hi-tech Corporation)

Nafday Dhani Milind - Postdoctoral Research Fellow, Asia Pacific Centre for Theoretical Physics, South Korea

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

Supriyo Ghosh - Visiting Fellow, TIFR, MumbaiProbir Kumar Sarkar - Assistant Professor, Anandamohan College, WB

Shauri Chakrabarty - Post Doctoral Research Associate, University of Saarland, Saarland, Germany

Damayanti Bagchi - Postdoctoral Scholar, University of California, Santa Barbara

Anindita Mondal - Curator - B, National Council for Science Museums, Kolkata

Pratik Tarafdar - Post Doctoral Fellow, Institute of Mathematical Sciences, Chennai

Priya Singh - Faculty (Guest), Dept. of Chemistry, Delhi Univesity

Indranil Chakraborty - Research Associate, IISc., Bangalore

Samiran Choudhury - Postdoctoral Researcher, Max Plank Institute of Microstructure Physics, Germany

Sucheta Mondal - Post-doctoral Fellow, University of California, Berkleley, USA

Mahebub Alam - Post-doctoral Fellow, Institute for Materials Physics, University of Münster, Germany

Soumendra Singh - Scientist, Bose InstituteShaili Sett - Research Associate, IISc., Bangalore

Putul Malla Chowdhury - Assistant Professor, Physics, Netaji Nagar College for Women, WB

Mithun Pal - Research Assistant, Institute of Physical Chemistry of Christian-Albrechts-University of Kiel, Germany

Arpan Krishna Mitra - Postdoctoral Fellow, HRI, Allahabad

Sudipta Pattanayak - Postdoctoral Fellow, Eberhard Karls University of Tuebingen, Germany

Debasmita Maiti - PDRA, National Tsing Hua University, Taiwan

Ayan Bhattacharjee - Postdoctoral Researcher, Centre for High Energy Astrophysics, UNIST, South Korea

Anita Halder - Research Assistant at Trinity College Dublin

Jayita Patwari - Guest Scientist, University of Duisburg-Essen, Germany

Ravindra Singh Bisht - Postdoctoral Fellow, Tel Aviv University, Israel

Md Sarowar Hossain - Senior Lecturer in Physics, Jaflong Valley boarding School, Sripur, Jaintapur, Sylhet, Bangladesh

Suchetana Goswami – PDRA Centre of New Technologies, University of Warsaw

Sandip Saha - PDRA, KAUST, Abu Dhabi, UAEContinuing at SNBNCBS in Various Research Projects

Ejaj Tarif - Visiting Research Fellow, SNBNCBS

Sanchi Maithani - Visiting Research Fellow, SNBNCBS

Kajal Kumbhakar - Visiting Research Fellow, SNBNCBS

Avinash Kumar Chaurasiya - Visiting Research Fellow, SNBNCBS

Tuhin Kumar Maji - Visiting Research Fellow, SNBNCBS

Dipika Mandal - Visiting Research Fellow, SNBNCBS

Subrata Ghosh - Visiting Research Fellow, SNBNCBS

Chandan Samanta - Visiting Research Fellow, SNBNCBS

Anulekha De - Visiting Researcher, SNBNCBS

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

VISITING RESEARCH FELLOW	SUPERVISOR
2014-2015:	
1. Tuhin Kumar Maji (INSPIRE)	Samir Kumar Pal
2. Suchetana Goswami till 06/11/2020	Archan S. Majumdar
3. Debasmita Maiti (SNB) till 28/07/2020	Manoranjan Kumar
4. Keshab Karmakar (INSPIRE) till 29/07/2020	Kalyan Mandal
5. Mahebub Alam (INSPIRE) till 01/08/2020	Kalyan Mandal
2015-2016:	
6. Dipika Mandal (CSIR)	Kalyan Mandal
7. Subrata Ghosh (CSIR)	Kalyan Mandal
8. Kajal Kumbhakar (CSIR)	Ranjit Biswas

9.	Chandan Samanta (SNB)	Barnali Ghosh (Saha)
10.	Jayita Patwari (CSIR) till 24/09/2020	Samir Kumar Pal

SENIOR RESEARCH FELLOW		SUPERVISOR
2014-2015:		
11.	Anuvab Banerjee (SNB) till 31/07/2020	Ramkrishna Das (Officiating)
12.	Atanu Baksi (CSIR) till 31/12/2020	Ranjit Biswas
13.	Ejaj Tarif (SNB) till 28/07/2020	Ranjit Biswas
14.	Juriti Rajbangshi (SNB) till 14/09/2020	Ranjit Biswas
15.	Sudipta Pattanayak (SNB) till 15/09/2020	M. Sanjay Kumar & Shradha Mishra
16.	Suraka Bhattacharjee (INSPIRE) till 31/07/2020	Manoranjan Kumar (Officiating)
17.	Joydeep Chatterjee (CSIR) till 31/07/2020	Priya Mahadevan
18.	Anulekha De (INSPIRE)	Anjan Barman & Rajib Kumar Mitra
19.	Debabrata Ghorai (INSPIRE) till 31/12/2020	Sunandan Gangopadhyay & Biswajit Chakraborty
20.	Dhrimadri Khata (INSPIRE) till 31/12/2020	Soumen Mondal
21.	Mithun Pal (INSPIRE) till 31/07/2020	Manik Pradhan
22.	Samrat Ghosh (INSPIRE) till 31/12/2020	Soumen Mondal
23.	Sandip Saha (RGNF) till 31/12/2020	Gautam Gangopadhyay
2015-2016:		
24.	Aniruddha Adhikari (SNB)	Samir Kumar Pal
25.	Avisek Maity (SNB)	Barnali Ghosh (Saha)
26.	Rahul Bandyopadhyay (SNB)	Ramkrishna Das
27.	Alik Panja (SNB)	Soumen Mondal
28.	Arnab Sarkar (SNB)	Archan S Majumdar
29.	Shounak Datta (INSPIRE)	Archan S Majumdar
30.	Sudip Kumar Saha (INSPIRE)	Manoranjan Kumar
31.	Shreya Das (INSPIRE)	Tanusri Saha Dasgupta
32.	Suchetana Goswami (SNB) till 06/11/2020	Archan S Majumdar
2016-2017:		
33.	Piklu Santra (UGC)	Ramkrishna Das (Officiating)
34.	Prantik Nandi (CSIR)	Ramkrishna Das (Oficiating)
35.	Sk Imadul Islam (UGC)	Rajib Kumar Mitra
36.	Partha Nandi (SNB)	Biswajit Chakraborty
37.	Subhamita Sengupta (UGC)	Barnali Ghosh(Saha) (Oficiating)
38.	Sumanti Patra (SNB)	Priya Mahadevan
39.	Sayan Kumar Pal (UGC)	Biswajit Chakraborty
40.	Akash Das (UGC)	Manik Pradhan
41.	Saikat Pal (CSIR)	Rajib Kumar Mitra
42.	Sasthi Charan Mandal (CSIR)	aydeb Chakrabarti
43.	Koushik Mandal (UGC)	Manoranjan Kumar & Ranjan Choudhury
44.	Priyanka Saha (INSPIRE)	Kalyan Mandal
45.	Dipanjan Maity (CSIR)	Kalyan Mandal
46.	Bihalan Bhattacharya (INSPIRE)	Archan S Majumdar
47.	Arnab Samanta (Project JRF)	Samir Kumar Pal
2017-2018:		
48.	Arka Chatterjee (INSPIRE)	Samir Kumar Pal
49.	Edwine Tendong (TWAS-BOSE)	Tanusri Saha Dasgupta
50.	Souma Mazumdar (SNB)	Gautam Gangopadhyay (Oficiating)
51.	Anirban Mukherjee (INSPIRE)	Punyabrata Pradhan
52.	Shubhadip Moulik	Atindra Nath Pal
53.	Vishal Kumar Aggarwal (SNB)	Arup Kumar Raychaudhuri & Manik Pradhan
54.	Arundhati Adhikari (SNB)	Anjan Barman
55.	Parushottam Maji (SNB)	Arup Kumar Raychaudhuri & Barnali Ghosh (Saha)
56.	Didhiti Bhattacharya (SNB)	Samit Kumar Ray & Rajib Kumar Mitra

57. Koustav Dutta (INSPIRE) — Anjan Barman
58. Amrit Kumar Mondal (SNB) — Anjan Barman
59. Sk Saniur Rahaman (UGC) — Manoranjan Kumar & M. Sanjay Kumar
60. Rituparna Mandal (INSPIRE) — Sunandan Gangopadhyay
61. Abhik Ghosh Moulik (INSPIRE) — Jaydeb Chakrabarti
62. Arpan Bera (CSIR) — Samir Kumar Pal
63. Biswajit Pabi (INSPIRE) — Atindra Nath Pal
64. Dhrubajyoti Majhi (INSPIRE) — Ranjit Biswas
65. Indrani Kar (SNB) — Thirupathaiah Setti
66. Jayanta Mondal (INSPIRE) — Ranjit Biswas
67. Rafiqul Alam (INSPIRE) — Atindra Nath Pal
68. Rahul Karmakar (INSPIRE) — Jaydeb Chakrabarti
69. Shubhrasish Mukherjee (INSPIRE) — Samit Kumar Ray & Atindra Nath Pal
70. Siddhartha Biswas (INSPIRE) — Soumen Mondal
71. Sudipta Chatterjee (SNB) — Barnali Ghosh (Saha) & Kalyan Mondal

2018-2019:

72. Sumana Pyne (SNB) — Rajib Kumar Mitra
73. Dipanjan Mukherjee (SNB) — Samir Kumar Pal
74. Biswajit Panda (SNB) — Manik Pradhan
75. Narayan Chandra Maity (CSIR) — Ranjit Biswas
76. Shobhan Dev Mandal (CSIR) — Sakuntala Chetterjee
77. Premashis Kumar (SNB) — Gautam Gangopadhyay
78. Anish Das (SNB) — Biswajit Chakraborty
79. Md Nur Hasan (CSIR) — Samir Kumar Pal
80. Tanmoy Chakraborty (CSIR) — Punyabrata Pradhan
81. Susmita Mondal (SNB) — Samir Kumar Pal
82. Deepsikha Das (SNB) — Sakuntala Chetterjee & Punyabrata Pradhan
83. Prasun Boyal (CSIR) — Priya Mahadevan
84. Debayan Mondal (CSIR) — Priya Mahadevan
85. Jyotirmoy Sau (UGC) — Manoranjan Kumar
86. Monalisa Chatterjee (INSPIRE) — Manoranjan Kumar
87. Susmita Changdar (UGC) — Thirupathaiah Setti
88. Pratap Kumar Pal (CSIR) — Anjan Barman
89. Shivam Mishra (INSPIRE) — Priya Mahadevan

JUNIOR RESEARCH FELLOW

2019-2020:

90. Krishnendu Patra (SNB) — Priya Mahadevan
91. Ria Saha (SNB) — Rajib Kumar Mitra
92. Somashree Ghosal (CSIR) — Manoranjan Kumar
93. Krishnendu Sinha (SNB) — Suman Chakraborty
94. Amrita Mondal (SNB) — Ranjit Biswas
95. Subhajit Singha (SNB) — Rajib Kumar Mitra
96. Soma Dutta (SNB) — Anjan Barman
97. Kanchan Meena (CSIR) — Prosenjit Singha Deo
98. Sreya Pal (CSIR) — Anjan Barman
99. Ramkrishna Patra (CSIR) till 31/07/2020 — Archan S Majumdar & Manik Banik
100. S. Adarsh (SNB) — Archan S. Majumdar
101. Krishanu Mondal (SNB) till 31/08/2020 — Gautam Gangopadhyay
102. Manodip Routh (SNB) — Manoranjan Kumar
103. Abhinandan Das (SNB) — Suman Chakrabarty
104. Subhajit Kar (SNB) — Ramkrishna Das
105. Anirban Paul (SNB) — Jaydeb Chakrabarti
106. Samrat Sen (SNB) till 31/07/2020 — Archan S Majumdar & Manik Banik
107. Ardhendu Pal (SNB) — Manik Pradhan
108. Gesesew Reta Habtie (TWAS-BOSE) — Ramkrishna Das

2020-2021:

109. Rajib Kumbhakar (INSPIRE) — Soumen Mondal
110. Shashank Shekhar Pandey (CSIR) — Archan S. Majumdar
111. Shounak Mukherjee — Suman Chakrabarty
112. Sudip Mandal (CSIR) — Manik Pradhan
113. Sudipta Mitra (SNB) — Ranjit Biswas
114. Aishwaryo Ghosh (INSPIRE) — Tanusri Saha Dasgupta

115. Manoj Gupta (CSIR) — Tanusri Saha Dasgupta
116. Shinjini Paul (INSPIRE) — Priya Mahadevan
117. Koushik Pradhan (SNB) — Tanusri Saha Dasgupta
118. Indrajit Ghose (SNB) — Amitabha Lahiri
119. Riya Barick (SNB) — Amitabha Lahiri
120. Rik Niranjan Mukherjee (INSPIRE) — Ranjit Biswas & Pradip K Ghorai (IISER-K)
121. Suchetana Mukhopadhyay (INSPIRE) — Anjan Barman & Chiranjit Mitra (IISER-K)

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

VISITING RESEARCH FELLOW — **SUPERVISOR**

2014–2015:

122. Avinash Kumar Chaurasiya (INSPIRE) — Anjan Barman
123. Sanchi Maithani (INSPIRE) — Manik Pradhan

SENIOR RESEARCH FELLOW — **SUPERVISOR**

2012–2013:

124. Ayan Bhattacharjee till 10/11/2020 — Sandip Kumar Chakrabarti
125. Monalisa Singh Roy till 31/07/2020 — Manoranjan Kumar

2013–2014:

126. Ankan Pandey — Partha Guha
127. Riddhi Chatterjee — Archan S Majumdar

2014–2015:

128. Ananda Gopal Maity — Archan S Majumdar
129. Ruchi Pandey — Ramkrishna Das
130. Sourav Sahoo — Anjan Barman

2015–2016:

131. Anupam Gorai — Kalyan Mandal
132. Atul Rathod — Manu Mathur
133. Shantonu Mukherjee — Amitabha Lahiri
134. Shashank Gupta — Archan S Majumdar
135. Sudip Majumdar — Anjan Barman & Rajib Kumar Mitra
136. Surya Narayan Panda — Anjan Barman
137. Swarnali Hait — Kalyan Mandal

2016-2017:

138. Achintya Low — Thirupathaiah Setti
139. Ankur Srivastav — Sunandan Gangopadhyay
140. Anwesha Chakraborty — Biswajit Chakraborty
141. Sayan Routh — Thirupathaiah Setti
142. Neeraj Kumar — Sunandan Gangopadhyay

JUNIOR RESEARCH FELLOW

2017-2018:

143. Nivedita Pan — Samir kumar Pal
144. Riju Pal — Atin pal
145. Samir Rom — Tanusri Saha Dasgupta
146. Shubham Purwar — Thirupathaiah Setti
147. Manjari Dutta — Sunanadan Gangopadhyay

2018-2019:

148. Soham Saha — Kalyan Mandal
149. Gaurav I Patel — Soumen Mondal
150. Animesh Hazra — Punyabrata Pradhan
151. Avik Sasmal — Jaydeb Chakrabarti
152. Ishita Jana — Kalyan Mandal
153. Anirban Roychowdury — Sunandan Gangopadhyay
154. Soumen Mandal — Manik Pradhan
155. Rajdeep Biswas — Tanusri Saha Dasgupta
156. Arnab Chakraborty — Amitabha Lahiri
157. Vishwajeet Kumar till 22/01/2021 — Sakuntala Chatterjee

PART TIME RESEARCH SCHOLARS - Ph.D. PROGRAMME

158. **Santanu Pan**, Condensed Matter Physics & Material Sciences, under Anjan Barman
159. **Kartik Adhikari**, Condensed Matter Physics & Material Sciences, under Anjan Barman

160. **J. Wellington**, IIT Delhi, Condensed Matter Physics & Material Sciences, under Samit Kumar Ray
161. **Sourav Karar**, Astrophysics & Cosmology, under Archan S Majumdar & Sunandan Gangopadhyay
162. **Joydeep Chatterjee**, Condensed Matter Physics and Material Sciences, under Priya Mahadevan
163. **Ashis Saha**, Kalyani University, under Sunandan Gangopadhyay
164. **Sukanta Bhattacharyya**, West Bengal State University, under Sunandan Gangopadhyay

PROJECT FELLOWS / ASSISTANTS / TRAINEES

2017-2018:

Anirban Goswami (Project SRF) till 23/03/2021	Barnali Ghosh (Saha)

2018-2019:

Saikat Mitra (Project JRF)	Barnali Ghosh (Saha) & Manik Pradhan
Debashish Paul (Project JRF)	Tatini Rakshit

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
Brateen Dutta (Project Assistant Adhoc)	Tatini Rakshit
Debashis Paul (Project JRF)	Tatini Rakshi

INTEGRATED Ph.D. PPROGRAMME (IPhD) IN PHYSICAL SCIENCES

2018-2019

Varsha Jangir
till 04/01/2021

Ankita Rojario
till 31/07/2020

Shubham Shukla
till 31/07/2020

2019-2020:

Ajay Sharma

Arnab Paul

Banik Rai

Dibyendu Maity

J Sridhar Mohanty

Jayarshi Bhattacharya

Kaliprasanna Majumdar

Ram Surya Sri Shourie

Sagar Kumar Maity

Soham Sen

Soumyabrata Hazra

Saurav Kantha

2020-2021:

Ananya Chakraborty

Pritam Roy

Rajdwip Bhar

Sudip Chakrabarty

Devangshu Roy

Tanusri Saha-Dasgupta

Tanusri Saha-Dasgupta
Dean, Academic Programme

Extended Visitors And Linkage Programme

Visitor and Linkage Programmes

Celebration of "128th Birth Anniversary of Satyendra Nath Bose" & 25th S.N. Bose Memorial Lecture

Prof. Anton Zeilinger

Wolf Prize winner in Physics 2010
Institute for Quantum Optics and Quantum Information, Vienna and President, Austrian Academy of Sciences, Austria

Title of the talk: *From Einstein and Bose to quantum teleportation and beyond*

Date: 01.01.2021
(held through webinar & live streamlined in social media platform)

15th C.K. Majumdar Memorial Lecture

Prof. John Michael Kosterlitz

2016 Nobel Laureate in Physics
Institute for Quantum Optics and Quantum Information, Vienna and President, Austrian Academy of Sciences, Austria

Title of the talk: *Topological Defects and Phase transitions*

Date: 15.02.2021
(held through webinar & live streamlined in social media platform)

Outreach Activity:

6th India International Science Festival (IISF2020)

- The Centre hosted the Curtain Raiser Ceremony of the IISF2020
- The event took place via online on 5th December, 2020
- Public outreach lectures were delivered by

  Prof. Rajib Bandyopadhyay, JU

  Title: *A self powered triboelectric face mask*

  Prof. Goutam De, SNBNCBS

  Title: *The Importance of Nanostructured Coatings: Design and Wet-Chemical Deposition*

  Dr. Bhupati Chakrabarti, IAPT

  Title: *World Class Scientific Contribution of S. N. Bose: A Model of Our Self Reliance in 1920s*

- The Centre also participated virtually in the main event of IISF2020

National Science Day (NSD2021)

- The Centre observed the NSD2021 virtually
- Online seminar was delivered by

  Prof. Rohini M. Godbole, IISc. Bangalore

  Title: *Mega projects: fundamental physics and cutting edge technology meet!*

Advanced Postdoctoral Manpower Programme (APMP)

- Total PDRA (*Centre funded*) on roll – 11
- Total RAs (*Extramural funded*) on roll – 2
- Total NPDF (*Extramural funded*) on roll – 2
- Total SRA (*CSIR funded*) on roll – 2
- New PDRA / NPDF

Name	Designation	Department	Mentor	Date of Joining
Dr. Deblina Majumder	PDRA – I (Centre Funding)	CMP&MS	Prof. Kalyan Mandal	02.07.2020
Dr. Gourhari Jana	RA – I (Adhoc) TUE-CMS	CMP&MS	Prof. Tanusri Saha Dasgupta	28.10.2020
Dr. Soumendu Datta	RA – III (Adhoc) J.C. Bose award	CMP&MS	Prof. Tanusri Saha Dasgupta	01.12.2020
Dr. Soumya Bhattacharya	RA – I (CSIR-HRDG funded)	TS	Prof. Rabin Banerjee	21.12.2020
Dr. Jayeta Banerjee	NPDF (Externally funded)	CBMS	Dr. Manik Pradhan	31.12.2020
Dr. Debarshi Das	NPDF (Externally funded)	A&C	Prof. Archan S Majumdar	15.01.2021
Dr. Soumita Mondal	RA – I (Adhoc) (Externally funded)	CMP&MS	Prof. Priya Mahadevan	15.02.2021

Seminar and Colloquia Programme (SCOLP)

Seminar Type	Date	Speaker & Affiliation	Title
Bose Colloquium	27.11.2020	**Prof. Lorenzo Pavesi** Nanoscience Laboratory Department of Physics, University of Trento - Italy	*Quantum Silicon Photonic*
	11.12.2020	**Prof. Pratap Raychaudhuri** Tata Institute of Fundamental Research - Mumbai	*Observation of Hexatic vortex fluid in a superconducting thin film*
	08.01.2021	**Dr. Sudeshna Sinha,** Indian Institute of Science Education and Research Mohali, India	*Harnessing chaos*

A BRIEF REPORT OF CONFERENCES, WORKSHOPS AND EXTENSION PROGRAMME (CWEP) FROM 01.04.2020 TO 31.03.2021 FOR THE ANNUAL REPORT 2020-2021

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

1) 3rd Annual Conference on Quantum Condensed Matter (QMAT-2020) was held during 07 September to 11 September, 2020 through online mode. Convener: Dr. Manoranjan Kumar, Associate Professor.

2) C.K. Majumdar Memorial Workshop in Physics 2020 organized jointly by Indian Association of Physics Teachers (Regional Council-15) and S.N. Bose National Centre for Basic Sciences during December 28, 2020 to January 04, 2021 through online mode. Convener: Ms. Sukla Chakraborty, Deptt. of Physics, Ananda Mohan College, Kolkata and Co-Convener: Prof. Kalyan Mandal, Sr. Professor, S.N. Bose National Centre for Basic Sciences.

Nibedita Konar **Debashish Bhattacharjee** **Rupam Porel**

Members of Academic and Students' Program Section, SNBNCBS
From left to right: J. Kar, N Konar, C. Chatterjee, R. Porel.

REGISTRAR

Report on Administrative Matters

The Centre has rendered administrative support to its 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 2020-2021 successful. The Centre has a staff strength of 24 in permanent, 11 in temporary and 32 in contractual category as on 31st March 2021, who have performed 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 administrative employees of the Centre have been encouraged to attend various training programmes and workshops on online mode all through the year so that their administrative and technical abilities are enhanced. The Centre has maintained a close communication with the Department of Science and Technology and other ministries and have replied to their various enquiries and requirements on time. The Centre has successfully handled Audit Queries, Parliamentary Questions and various factual informations. The Hindi Cell of the Centre has been functioning effectively since April 2008 and substantial work has been undertaken regarding implementation of the Official Language.

No cases related to vigilance have been reported during the period of 2020-2021. The Centre has also adhered to the norms of the Right to Information Act and so far has received **6 (six)** cases under the said Act in the last financial year all of which has been successfully disposed off.

As part of Vigilance Awareness Week 2020 during 27th October 2020 to 2nd November 2020, the Centre organised Vigilance Pledge and an Essay Competition (Topic: "Vigilant India, Prosperous India"). The essay competition carried a cash award of Rs.5,000/- (1st prize), Rs.3,000/- (2nd prize) and Rs.1,000/- (3rd prize) with winners as:

- 1st Prize – Dr. Joy Prakash Das, Post Doctoral Research Associate-I.
- 2nd Prize – Ms. Mitali Bose, Office Assistant.
- 3rd Prize – Ms. Monalisa Singha Roy, Senior Research Fellow.

The Centre also organised the International Yoga Day on 21st June 2020 through online due to COVID-19 pandemic. The staff and students participated enthusiastically in the session staying at home.

Meetings of the Statutory Committees of the Centre :

(i) The 61st & 62nd Governing Body (GB) meetings of the Centre were held on 13.09.2020 and 04.02.2021 respectively.

(ii) The 39th Finance Committee (FC) meeting of the Centre was held on 13.09.2020.

(iii) The 28th Academic & Research Programme Advisory Committee (ARPAC) meeting of the Centre was held on 23.02.2021.

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, Homeopath and Ayurvedic physicians are available for regular consultation. Facilities like oxygen, wheel chair, stretcher, rest bed etc. are readily available apart from First Aid treatments. The Centre also has tie ups under CGHS with some of the renowned hospitals in Kolkata viz. B.M. Birla Heart Research Centre, Medica Superspeciality Hospital, Peerless Hospitex Hospital and Research Centre Limited, Desun Hospital & Heart Institute, AMRI Hospitals, Charnock Hospitals Pvt. Ltd. etc who provide cash less indoor hospitalisation facility. Outdoor treatments are also available as per CGHS rates. The Centre was successfully able to handle the COVID-19 pandemic by providing initial medical advice and timely hospitalisation to some of the COVID infected scholars through it's medical cell.

The Centre has Crèche facilities (Kishlay) for children of staff and students of the Centre. 'Kishlay' provides a nurtured environment where the child can build a foundation for continued learning. 'Kishlay' provides a family – friendly workplace for its employees.

The Centre houses a modern Guest House by the name of 'Bhagirathi' comprising of 57 air conditioned rooms (including Single Bed, Double Bed & Transit rooms), 5 air conditioned suites and a fully AC Seminar cum Dining Hall and Kitchen with modern facilities and Seminar room. 'Bhagirathi' also has an equipped Doctor's chamber and two Air Conditioned office rooms. The Centre has two hostels by the name 'Radhachura' and 'Krishnachura' and an Essential Staff Quarter (Subarnarekha) which provides hostel accommodation to approximately 32 and 122 students respectively. Subarnarekha also provides accommodation facilities to its essential staff. The students residing in the Centre run their own mess and the hostels have facilities like dining rooms, common rooms etc. The Centre also provides accommodation to Post Doctoral Fellows, on request. The newly constructed Integrated Hostel Building and Transit Quarter (by the name 'Basundhara') is being moderately put into use through its dining hall facilities, housing of summer students and as transit hostel rooms.

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 Q-MAT 2020, 128th Birth Anniversary of Prof. Satyendra Nath Bose, S. N. Bose Memorial Lecture, C. K. Majumdar Memorial Workshop, C. K. Majumdar Memorial Lecture, National Science Day 2021 all through Webinar with minimal physical presence of administrative staff and maintaining all COVID-19 pandemic restrictions. The Centre also arranged COVID-19 awareness pledge and took several measures to control the spread of COVID-19 pandemic among the staff and students of the Centre. The administration efficiently carried out its activities during the pandemic times by maintaining duty roster and restrictive entrance of visitors, vendors etc. The Centre adheres 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, specially during such tough times we are all passing through. I am also grateful to Prof. Samit Kumar Ray, Director for his valuable guidance and advice on administrative matters.

Shohini Majumder
Registrar

Hindi (Rajbhasha) Implementation in the Centre

Activities of the Hindi Cell

The Centre implemented the provisions of the Official Language Act in the year 2020-21. 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 were 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 some 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.

In the month of September 2020, 'Hindi Divas Samaroh' was celebrated by organising 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. Suvodip Mukherjee, Office Assistant.
- 2nd Prize – Ms. Sonali Sen, Office Assistant.
- 3rd Prize – Ms. Mitali Bose, Office Assistant.

On 14th September 2020 "Hindi Diwas Samaroh" was organised through online mode and by maintaining all COVID-19 restrictions; Guest Lecturer, Shri Priyankar Paliwal, Senior Hindi Officer, CGCRI, Kolkata delivered a talk on the said occasion.

The Centre also organised three 'Hindi Workshops' through online mode and by maintaining COVID-19 restrictions during 2020-2021: i) Talk on "Rajbhasha Hindi Aur Uplabhdh Takniki Suvidhao ka Prayog" by Shri Dinesh Kumar Sharma, Hindi Adhikari, Indian Oil, Mumbai, Kolkata on 28.09.2020; ii) Talk on "Karlalayen Hindi Ka Swarup" by Dr. Sanjay Kumar Jaiswal, Assistant Professor, Hindi Bibhag, Vidyasagr University, Midnapore, West Bengal on 10.12.2020; iii) Talk on "Bartaman Paripreksha mey Rajbhasha Karyavayen ki Dasha & Disha" by Shri Nirmal Kumar Dubey, Assistant Director, Rajbhasha Bibhag, Nizam Palace, Kolkata on 26.03.2021.

Shohini Majumder
Registrar

COMMITTEES
(As on 31.03.2021)

Governing Body

Prof. B.N. Jagatap — Chairman
Professor
Department of Physics
IIT Bombay, Mumbai

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

Prof. Prasanta K Panigrahi — Member
Professor
Materials Science Centre,
IIT, Kharagpur

Prof. Pallab Banerjee — Member
Professor
Materials Science Centre,
IIT, Kharagpur

Dr. D.S. Ramesh — Member
Director
IIG, Navi Mumbai

Prof. Manoj Harbola — Member
Professor
Dept. of Physics, IIT, Kanpur

Financial Advisor — Member
Department of Science & Technology
Government of India, New Delhi

Prof. Samit Kumar Ray — Member
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. (Dr.) Uday Bandopadhyay — Member
Director
Bose Institute, Kolkata

Prof. Santanu Bhattacharya — Member
Director
Indian Association for Cultivation of Science
Kolkata

Chief Secretary — Member
Government of West Bengal
Kolkata

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

Finance Committee

Prof. Samit Kumar Ray — Chairman
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

Additional Secretary & Finance Advisor — Member
Department of Science & Technology
New Delhi

Prof. Biswajit Mahanty — Member
Dean (Planning & Coordination) & Professor,
Department of Industrial and System Engineering
IIT, Kharagpur

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

Academic & Research Programme Advisory Committee

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

Prof. Somak Raychaudhury — Member
Director, Inter-University Centre
For Astronomy and Astrophysics, Pune

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

Prof. Amitava Raychaudhuri — Member
Professor Emeritus,
Calcutta University, Kolkata

Prof. Satrajit Adhikari — Member
Professor, IACS, Kolkata

Prof. Gautam Basu — Member
Senior Professor, Bose Institute, Kolkata

Prof. S.M.Yusuf — Member
Scientific Officer (H+), BARC, Mumbai

Prof. Samit Kumar Ray — Member
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Archan S Majumdar — Member
Dean (Faculty)
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Biswajit Chakraborty — Member
Dean (Academic Programme)
S. N. Bose National Centre for Basic Sciences
Kolkata

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

Dr. Saumen Mondal — Permanent Invitee
Head, Department of Astrophysics and Cosmology
S. N. Bose National Centre for Basic Sciences
Kolkata

Dr. M. Sanjay Kumar — Permanent Invitee
Head, Department of
Theoretical Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Kalyan Mandal — Permanent Invitee
Head, Department of Condensed
Matter Physics and Material Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Jaydeb Chakrabarti — Permanent Invitee
Head, Department of Chemical,
Biological and Macromolecular Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

Building Committee

Prof. Samit Kumar Ray — Chairman
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Retd. Engineer of CPWD — Member
(Not below the rank of Superintending Engineer)

Mr. Chirantan Debdas — Member
Superintending Engineer (Electrical)
Indian Institute of Chemical Biology (CSIR)
4, Raja S.C.Mullick Road
Kolkata – 700 032

Prof. Sriman Kumar Bhattacharyya — Member
Deputy Director and Professor Civil Engineering
Indian Institute of Technology Kharagpur
A-193, IIT Campus Kharagpur
721 302 (WB)

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

Consultative Advisory Committee

Prof. Samit Kumar Ray — Chairman
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Archan S Majumdar — Member
Dean (Faculty)
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Biswajit Chakraborty — Member
Dean (Academic Programme)
S. N. Bose National Centre for Basic Sciences
Kolkata

Dr. M. Sanjay Kumar — Member
Head, Department of Theoretical Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

Dr. Saumen Mondal — Member
Head, Department of Astrophysics and Cosmology
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Jaydeb Chakrabarti — Member
Head, Department of Chemical,
Biological and Macromolecular Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

Prof. Kalyan Mandal — Member
Head, Department of Condensed
Matter Physics and Material Sciences
S. N. Bose National Centre for Basic Sciences
Kolkata

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

Mr. Suman Saha — Member
Deputy Registrar (Finance)
S. N. Bose National Centre for Basic Sciences
Kolkata

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

Official Language Implementation Committee

Prof. Samit Kumar Ray — Chairman
Director
S. N. Bose National Centre for Basic Sciences
Kolkata

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

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

Dr. Manoranjan Kumar — Member
Associate Professor
S. N. Bose National Centre for Basic Sciences
Kolkata

Mr. Debashish Bhattacharjee — Member
Deputy Registrar (Administration)
S. N. Bose National Centre for Basic Sciences
Kolkata

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

Mr. Suman Saha — Member
Deputy Registrar (Finance)
S. N. Bose National Centre for Basic Sciences
Kolkata

Mr. Mithilesh Kumar Pande — Member
Campus Engineer cum Estate Officer
S. N. Bose National Centre for Basic Sciences
Kolkata

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

ACADEMIC MEMBERS

(FACULTY MEMBERS) : 2020-2021

Faculty Members		
1	Samit Kumar Ray	Director & Senior Professor : CMPMS
2	Tanusri Saha Dasgupta	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	Senior Professor : TS
13	Partha Guha (Till 30.07.2020)	Senior Professor : TS
14	Manu Mathur	Professor : TS
15	Prosenjit Singha Deo	Professor : CMPMS
16	Soumen Mondal	Professor : A&C
17	Rajib Kumar Mitra	Professor : CBMS
18	Barnali Ghosh (Saha)	Scientist 'F'
19	M.Sanjay Kumar	Associate Professor : TS
20	Manik Pradhan	Associate Professor : CBMS
21	Punyabrata Pradhan	Associate Professor : TS
22	Sakuntala Chatterjee	Associate Professor : TS
23	Manoranjan Kumar	Associate Professor : CMPMS
24	Ramkrishna Das	Associate Professor : A&C
25	Sunandan Gangopadhyay	Associate Professor : TS
26	Suman Chakrabarty	Associate Professor : CBMS
27	Sanjoy Choudhury	Scientist 'D'
28	Atindra Nath Pal	Assistant Professor : CMPMS
29	Thirupathaiah Setti	Assistant Professor : CMPMS
30	Swapan Rana (Till 11.08.2020)	Assistant Professor : TS
31	Urna Basu (From 15.09.2020)	Assistant Professor : TS
32	Tapas Baug (From 15.01.2021)	Assistant Professor : A&C
33	Nitesh Kumar (From 23.02.2021)	Assistant Professor : CMPMS
S. N. Bose Chair Professor		
1	Debashis Mukherjee	CBMS
Emeritus Professors		
1	Gautam De (From 15.07.2020)	CMPMS
2	Milan Kumar Sanyal (Till 30.04.2021)	CMPMS
Visiting (Honorary) Fellow		
1	Bikash K. Chakrabarti	TS
2	Ranjan Chowdhury	CMPMS
3	Bhupendra Nath Dev	CMPMS
4	Subhrangshu Sekhar Manna	TS
DST INSPIRE Faculty		
1	Anup Ghosh	CMPMS
2	Dipanwita Majumdar	CMPMS
3	Tatini Rakshit	CBMS
4	Saumya Mukherjee	CMPMS
Visiting Fellow/Scientist		
1	Madhuri Mandal Goswami (till 30.11.2020)	CMPMS
Ramanujan Fellow		
1	Debanjan Bose (From 04.12.2020)	A&C
NASI Senior Scientist		
1	Rabin Banerjee (From 06.01.2021)	TS
Senior Research Associate		
1	Alo Dutta	CMPMS
2	Sayan Bayan (till 16.04.2021)	CMPMS

ADVANCED POST DOCTORAL MANPOWER PROGRAM (APMP) : 2020-2021

SL. NO.	NAME	STATUS	DEPT.	MENTOR
1	Aayatti Mallick Gupta	PDRA – I (from 16.12.20219 –)	CBMS	Prof. Jaydeb Chakrabarti
2	Amit Mukherjee	PDRA – I (from 06.09.2019 –)	A&C	Prof. Archan S Majumdar
3	Arka Dey	PDRA – I (Till 31.12.2020)	CMPMS	Prof. Samit Kr. Ray
4	Arnab Ghosh	PDRA – II (Till 17.02.2021)	CMPMS	Dr. Barnali Ghosh (Saha)
5	Arun Bera	PDRA – I (Till 02.01.2021)	CBMS	Dr. Manik Pradhan
6	Arpan Bhattacharyya	PDRA – I (from 19.12.2019 –)	CMPMS	Prof. Anjan Barman
7	Ayana Mukhopadhyay	PDRA – I (Till 31.03.2021)	CMPMS	Dr. T.Setti
8	Buddhadeb Pal	PDRA – I (from 20.08.2019 ––)	CMPMS	Dr. Atindra Nath Pal
9	Deblina Majumder	PDRA –I (From 02.07.2020 ––)	CMPMS	Prof. Kalyan Mandal
10	Dharmesh Jain	PDRA –III (from 01.10.2019 ––)	TS	Dr. Sunandan Gangopadhyay
11	Ipsita Basu	PDRA –II (from 03.12.2019 ––)	CBMS	Dr. Suman Chakrabarty
12	Joy Prakash Das	PDRA –I (Till 19.02.2021)	CMPMS	Dr. Manoranjan Kumar
13	Priyanka Garg	PDRA – I (from 05.02.2020 –)	CMPMS	Prof. Priya Mahadevan
14	Yogesh V	PDRA – I (from 06.09.2019 ––)	TS	Dr. M. Sanjay Kumar

NPDF / RESEARCH ASSOCIATE (EXTERNAL FUND) : 2020-2021

1	Anita Halder, RA – I (Ad-hoc)	Till 25.11.2020	CMPMS	Prof. Tanusri Saha Dasgupta
2	Basanta Roondhe, RA – I (Ad-hoc)	Till 02.08.2020	CMPMS	Prof. Tanusri Saha Dasgupta
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	Gourhari Jana, RA – I (Ad-hoc)	Till 31.01.2021	CMPMS	Prof. Tanusri Saha Dasgupta
6	Jayeta Banerjee, NPDF	From 31.12.2020	CBMS	Dr. Manik Pradhan
7	Sayan Bayan, SRA – CSIR Fund	Till 13.04.2021	CMPMS	Prof. Samit Kr. Ray
8	Soumita Mondal, RA – I (Ad-hoc)	From 15.02.2021	CMPMS	Prof. Priya Mahadevan
9	Soumya Bhattacharyya, RA – I (CSIR Fund)	Till 05.01.2021	TS	Prof. Rabin Banerjee
10	Soumendu Datta, RA – III (Ad-hoc)	From 01.12.2020	CMPMS	Prof. Tanusri Saha Dasgupta
11	Sumit Halder, RA – I (Ad-hoc)	From 01.03.2021	CMPMS	Dr. Manoranjan Kumar

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

ADMINISTRATIVE AND TECHNICAL STAFF MEMBERS

Shohini Majumder	Registrar
Jaydeb Chakrabarti	Vigilance Officer
Debashish Bhattacharjee	Public Information Officer

Other Members

Saumen Adhikari	Librarian cum Information Officer
Nibedita Konar	Deputy Registrar (Academic)
Debashish Bhattacharjee	Deputy Registrar (Administration)
Shiladitya Chatterjee	Deputy Registrar (Finance) *[till 27.07.2020]*
Suman Saha	Deputy Registrar (Finance) *[joined on 12.02.2021]*
Mithilesh Kumar Pande	Campus Engineer cum Estate Officer *[joined on 01.09.2020]*
Santosh Kumar Singh	Assistant Registrar (Purchase)
Sirsendu Ghosh	Programme Coordinating Officer
Achyut Saha	Personal Assistant to Director
Swapnamoy Datta	Stenographer
Sanchari Dasgupta	Assistant (General) *[joined on 23.06.2020]*
Jaydeep Kar	Programme Assistant
Prosenjit Talukdar	Programme Assistant
Shiba Prasad Nayak	Pump Operator
Bijoy Kumar Pramanik	Junior Assistant (Guest House)
Bhupati Naskar	Library Stack Assistant
Siddhartha Chatterjee	Upper Division Clerk
Swarup Dutta	Project Assistant
Sushanta Kumar Biswas	Driver
Partha Mitra	Attendant
Ratan Acharya	Attendant
Swapan Ghosh	Attendant
Rajarshi Barman	Attendant
Sabyasachi Mondal	Attendant

PERSONNEL WITH TEMPORARY STATUS

Biman Roy	Attendant (Administration)
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

Sunish Kumar Deb	Advisor (Liaison) *[till 16.02.2021]*
A.K.Sarkar	Advisor (Finance)
B.S.Panda	Consultant (Legal)
Amitabha Haldar	Executive Engineer
Ayan Deb	Assistant Engineer (Electrical)
Sutapa Basu	PS to Registrar
Abhijit Ghosh	Junior Computer Engineer
Sagar Samrat De	Junior Computer Engineer

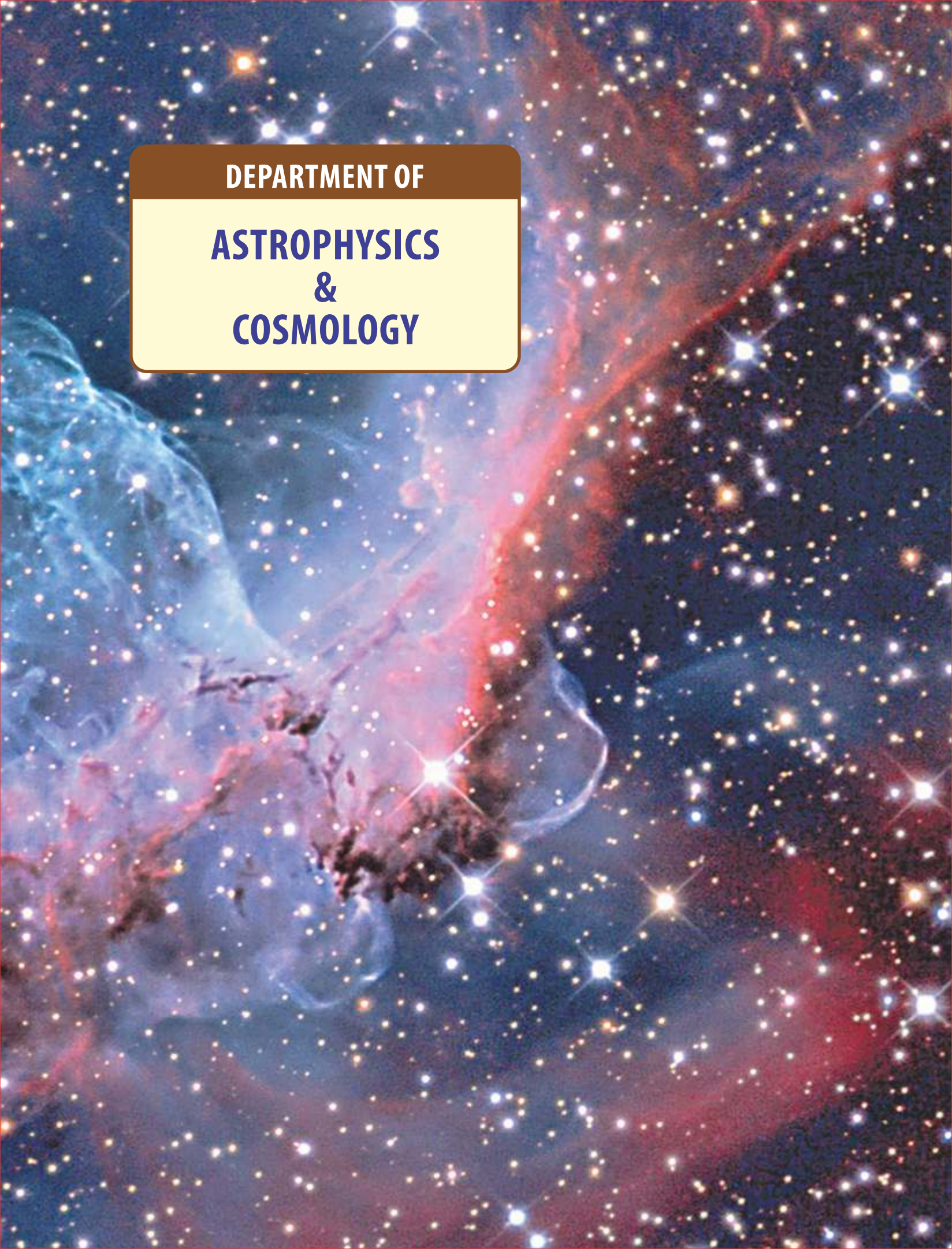
Deblina Mukherjee	Junior Computer Engineer
Amit Roy	Technical Assistant (Library)
Gurudas Ghosh	Technical Assistant (Library)
Ananya Sarkar	Technical Assistant (Library)
Shakti Nath Das	Technical Assistant
Urmi Chakraborty	Technical Assistant
Amit Kumar Chanda	Technical Assistant
Joy Bandopadhyay	Technical 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
Amit Kumar Ghosh	Mechanic
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
Dr. Gopal Chandra Sengupta	Doctor of Ayurvedic

Administrative Section

Purchase Section


DEPARTMENT OF
ASTROPHYSICS
&
COSMOLOGY

DEPARTMENT OF
Astrophysics and Cosmology

SOUMEN MONDAL

Department profile indicators

Table A : Manpower and resources

Number of faculty members	05
Number of Post –doctoral research associate (centre + project)	04
Number of Ph.D students	26
Number of other project staff	02
Number of summer students	02
Projects (ongoing)	04

Table B: Research Activities indicators

Number of research papers in Journals	16
Number of Book-chapters/books	–
Number of other publications	02
Number of Ph.D students graduated (submitted + degree awarded)	04
Number of M.Tech/M.Sc projects	04

Table C: Academic activities and likeage

Number of courses taught by faculty members		07
Number of Visitors (non –associates)		–
Number of associates		01
Number of Seminars organized		01
Number of Conference/Symposia/Advanced Schools organized		–
Number of talks delivered by members of department in conferences/Symposia	National	02
	International	01

Most important research highlights

- Multi-wavelength studies on Galactic star-forming regions.
- Spectroscopic studies of Low-mass Galactic M-dwarfs, M giants and AGB stars.
- Photometric variability properties in very low mass stars and brown dwarfs in star-formating regions.
- A construction of novae grid model using photoionization code CLOUDY is successfully implemented to estimate physical parameters of novae.
- Optical/Near-IR spectra of several planetary nebulae are analyszed to estimate their physical parameters.
- Circumstellar dust shell of post-main sequence stars.
- Astronomical Instrumentation.
- Evidence of Outflow-induced Soft Lags of Galactic Black Holes.

- Detection of genuine tripartite entanglement by multiple sequential observers.
- Thermodynamic utility of non-Markovianity from the perspective of resource interconversion.
- Convex resource theory of non-Markovianity.
- Protecting quantum correlations in presence of generalised amplitude damping channel: the two-qubit case,
- Genuine Einstein-Podolsky-Rosen steering of three-qubit states by multiple sequential observers.

Summary of research activities

- The optical I-band photometric variability down to 19 mag of a young (~2–3 Myr) star-forming region IC 348 in the Perseus molecular cloud is studied here. We aim to explore the fast rotation (in the time-scales of hours) in very low-mass stars including brown dwarfs (BDs). From a sample of 177 light curves using our new I-band observations, we detect new photometric variability in 22 young M dwarfs including 6 BDs, which are bonafide members in IC 348 and well characterized in the spectral type of M dwarfs. Interestingly, an optical flare is detected in a young M2.75 dwarf in one night data on 2016 December 20. From the flare light curve, we estimate the emitted flared energy of 1.48×10^{35} erg., which is rarely observed in active M dwarfs (Samrat Ghosh et al., MNRAS, 2021).
- A comprehensive characterization of the Galactic open cluster M 36 is presented here. Some 200 member candidates have been identified on the basis of proper motion and parallax measured by the Gaia DR2. With an estimated age of ~15 Myr, M 36 is free of nebulosity. To the southwest of the cluster, we discover a highly obscured (A_V up to ~23 mag), compact dense cloud, within which three young stellar objects in their infancy (ages less than 0.2 Myr) are identified. If the physical association between M 36 and the young stellar population can be unambiguously established, this manifests a convincing example of prolonged star formation activity spanning up to tens of Myr in molecular clouds (Alik Panja et al., APJ, 2021).
- Two compact planetary nebulae (PNe), PB1 and PC 19 using the optical spectra observed at 2 m Himalayan Chandra Telescope (HCT) and archival/literature data are studied here. The morpho-kinematic code to construct 3D morphologies of the PNe and the photoionization code to model the observed spectra are used here. The 3D model of PB 1 consists of an elongated shell surrounded by a bipolar halo and that of PC 19 consists of an open lobed bipolar structure and a spiral filamentary pair. The elemental abundances of He, C, N, O, Ne, S, Ar, and Cl are obtained from the modeling of the observed spectra, and it was found that He, C, and N abundances to be significantly higher in case of PB 1. From photo-ionization modeling, the different physical parameters of the central stars, namely effective temperature, luminosity, gravity, hydrogen density profiles, radii, distances to the PNe, and masses are estimated (Rahul Bandyopadhyay et al. MNRAS, 2020).
- More than 70 percent of all stars in our Galaxy are M dwarfs, dominating the stellar populations by numbers having a very low mass range (0.075–0.50 solar mass) and effective temperature (Teff) less than 4000 K. Observational evidence confirms that the chances of the occurrence of planetary systems, especially Earth-like planets orbiting in 'habitable zones', increases with decreasing stellar mass and radius. Medium resolution (R ~ 1200) spectra of 53 M-type dwarfs covering the wavelength ranges 1.50–1.80 m and 1.95–2.45 m from new observations using the TIFR Near-Infrared Spectrometer and Imager instrument on the 2-m Himalayan Chandra Telescope are presented here. Using interferometrically measured effective temperature (Teff), radius, and luminosity of nearby bright calibrator stars, the new empirical relationships among those fundamental parameters and spectral indices are established (Dhrimadri Khata, et al., MNRAS, 2020).
- The optical and near-Infrared spectra of the dust forming nova V1280 Scorpii to understand how the physical and chemical parameters change from the pre-dust phase to the post-dust phase are studied here. From the best-fit model, the values of

different parameters, e.g. temperature, luminosity, density, elemental abundances etc. are estimated. Dust condensation conditions are achieved with high enough density and low enough temperature, and a mixture of small amorphous carbon dust and large astrophysical silicate dust are fitted best in the observed spectra. The model yields a very high abundances of a few elements, e.g. carbon, nitrogen, oxygen etc. relative to solar in the ejecta, during the pre-dust phase, which decrease in the post-dust phase. (Ruchi Pandey et al. ApJ, 2021 (under review)).

- The physical process that governs the formation of a massive star (> 8 solar mass) is an unsolved problem in astrophysics. In recent years, two other large-scale (pc-scale) theories have gained considerable observational evidence. One of them is the collision between two nearby molecular clouds, followed by strong shock compression of gas, that is capable to give the sufficient accretion rate to form massive stars. Evidence of such cloud-cloud collision is also found observationally. In a recent study on eleven Galactic massive star-forming regions using Atacama Large millimeter/submillimeter Array (ALMA) data we found no correlation of outflow axis with the orientation of filaments or even with the large-scale magnetic field direction (Baug et al., 2020).
- We explore the possibility of multiple usage of a single genuine entangled state by considering a scenario consisting of three spin-1/2 particles shared between Alice, Bob and multiple Charlies. Alice performs measurements on the first particle, Bob performs measurements on the second particle and multiple Charlies perform measurements on the third particle sequentially. Here the choice of measurement settings of each Charlie is independent and uncorrelated with the choices of measurement settings and outcomes of the previous Charlies. In this scenario, we investigate whether more than one Charlie can detect genuine tripartite entanglement, and we answer this question affirmatively (Ananda G. Maity et al., Physical Review A, 2020).
- We investigate the possibility of multiple use of a single copy of three-qubit states for genuine tripartite Einstein-Podolsky-Rosen (EPR) steering. A pure three-qubit state of either the Greenberger-Horne-Zeilinger (GHZ)-type or W-type is shared between two fixed observers in two wings and a sequence of multiple observers in the third wing who perform unsharp or non-projective measurements acting independently of each other. The choice of measurement settings for each sequence is independent and uncorrelated with the measurement settings and outcomes of the previous observers. We investigate all possible types of genuine tripartite steering in the above set-up (Shashank Gupta, et al. Physical Review A, 2021).
- We present a formalism for detection of non-Markovianity through uncertainty relations. We show that when there is an information back-flow to the system from its environment through CP-divisibility breaking, the Choi-states corresponding to the reduced system evolution contain at least one negative eigenvalue. The consequent break down of uncertainty relations for such states can be used to witness non-Markovian dynamics (Samyadeb Bhattacharya, et al. Journal of Physics A: Mathematical and Theoretical, 2020).

Soumen Mondal

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. Suchetana Goswami; Quantum Information; Awarded
2. Shounak Datta; Quantum Information; Under progress
3. Riddhi Chatterjee; Relativistic Quantum Mechanics; Under progress
4. Arnab Sarkar; Gravitation & Cosmology; Under progress; K. R. Nayak (IISER Kolkata) (Co-supervisor)
5. Ananda Gopal Maity; Quantum Information; Under progress
6. Shashank Gupta; Quantum Information; Under progress
7. Bihalan Bhattacharya; Quantum Information; Under progress
8. Arun Kumar Das; Quantum Information; Under progress
9. Subhankar Bera; Quantum Information; Under progress
10. Shashank Sekhar Pandey; Gravitation and Cosmology; Under progress

b) Post-Docs

1. Arup Roy; Quantum Information
2. Amit Mukherjee; Quantum Information
3. Debarshi Das; Quantum Information

Teaching

1. Autumn semester; Advanced Quantum Mechanics; Integrated PhD; 12 students; with 1 (Sunandan Gangopadhyay) co-teacher
2. Autumn semester; Quantum Physics; PhD; 3 students; with 1 (Sunandan Gangopadhyay) co-teacher

Publications

a) In journals

1. Ananda G. Maity, Debarshi Das, Arkaprabha Ghosal, Arup Roy, and **A. S. Majumdar**, *Detection of genuine tripartite entanglement by multiple sequential observers*, Physical Review A, 101, 042340, 2020
2. Ananda G Maity, Samyadeb Bhattacharya and **A S Majumdar**, *Detecting non-Markovianity via uncertainty relations*, Journal of Physics A: Mathematical and Theoretical, 53, 175301, 2020
3. Samyadeb Bhattacharya, Bihalan Bhattacharya and **A S Majumdar**, *Thermodynamic utility of non-Markovianity from the perspective of resource interconversion*, Journal of Physics A: Mathematical and Theoretical, 53, 335301, 2020
4. Samyadeb Bhattacharya, Bihalan Bhattacharya and **A S Majumdar**, *Convex resource theory of non-Markovianity*, Journal of Physics A: Mathematical and Theoretical, 54, 035302, 2021
5. Suchetana Goswami, Sibasish Ghosh and **A S Majumdar**, *Protecting quantum correlations in presence of generalised amplitude damping*

channel: the two-qubit case, Journal of Physics A: Mathematical and Theoretical, 54, 045302, 2021

6. Shashank Gupta, Ananda G. Maity, Debarshi Das, Arup Roy, and **A. S. Majumdar**, *Genuine Einstein-Podolsky-Rosen steering of three-qubit states by multiple sequential observers*, Physical Review A, 103, 022421, 2021

Independent publication of student/post-doc

7. Biswajit Paul, Kaushiki Mukherjee, Ajoy Sen, Debasis Sarkar, Amit Mukherjee, Arup Roy, and Some Sankar Bhattacharya, *Persistency of genuine correlations under particle loss*, Physical Review A, 102, 022401, 2020
8. Biswajit Paul, Kaushiki Mukherjee, Sumana Karmakar, Debasis Sarkar, Amit Mukherjee, Arup Roy & Some Sankar Bhattacharya, *Detection of genuine tripartite entanglement in quantum network scenario*, Quantum Information Processing, 19, 246, 2020
9. Sagnik Dutta, Amit Mukherjee, and Manik Banik, *Operational characterization of multipartite nonlocal correlations*, Physical Review A, 102, 052218, 2020
10. Pratapaditya Bej, Arkaprabha Ghosal, Debarshi Das, Arup Roy, and Somshubhro Bandyopadhyay, *Information-disturbance trade-off in generalized entanglement swapping*, Physical Review A, 102, 052416, 2020
11. Rivu Gupta, Shashank Gupta, Shiladitya Mal, and Aditi Sen (De), *Performance of dense coding and teleportation for random states: Augmentation via preprocessing*, Physical Review A, 103, 032608, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Online Symposium on Quantum Information & Computation; Jun 29, 2020; IIIT Hyderabad; 1 hr
2. International Physics Webinar; Sep 30, 2020; Pabna University; 1 hr

Administrative duties

1. Dean (Faculty)

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

1. Applications of Quantum Information; DST; 3 years; PI
2. Free space quantum communication: road to satellite quantum communication; DST; 3 years; Co-PI
3. Quantum heat engines; DST; 3 years; Co-PI

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

1. Bose Institute, Kolkata; Sl. No. 1, 10; National
2. IMSc, Chennai; Sl. No. 5; National
3. Calcutta University; Sl. No. 7; National
4. IISER Kolkata, IISER Thiruvanathapuram; Sl. No. 9; National
5. HRI, Allahabad; Sl. No. 11; National
6. University of Hong Kong; Sl. No. 7, 8; International

Outreach program organized / participated

1. Online seminars (2) TEQUIP-III, NIT Sikkim, 3-17 October, 2020

Areas of Research

Quantum Information Science; Cosmology

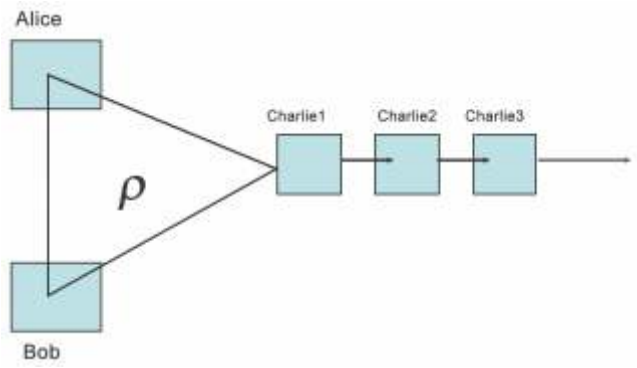


Fig. 1. Sequential detection of genuine tripartite entanglement.

We explore the possibility of multiple usage of a single genuine entangled state by considering a scenario

consisting of three spin-1/2 particles shared between Alice, Bob and multiple Charlies. Alice performs measurements on the first particle, Bob performs measurements on the second particle and multiple Charlies perform measurements on the third particle sequentially. Here the choice of measurement settings of each Charlie is independent and uncorrelated with the choices of measurement settings and outcomes of the previous Charlies. In this scenario, we investigate whether more than one Charlie can detect genuine tripartite entanglement, and we answer this question affirmatively. In order to probe genuine entanglement, we use correlation inequalities whose violations certify genuine tripartite entanglement in a device-independent way. We extend our investigation by using appropriate genuine tripartite entanglement witness operators. Using each of these different tools for detecting genuine tripartite entanglement, we find out the maximum number of Charlies who can detect genuine entanglement in the above scenario.

We investigate the possibility of multiple use of a single copy of three-qubit states for genuine tripartite Einstein-Podolsky-Rosen (EPR) steering. A pure three-qubit state of either the Greenberger-Horne-Zeilinger (GHZ)-type or W-type is shared between two fixed observers in two wings and a sequence of multiple observers in the third wing who perform unsharp or non-projective measurements acting independently of each other. The choice of measurement settings for each sequence is independent and uncorrelated with the measurement settings and outcomes of the previous observers. We investigate all possible types of genuine tripartite steering in the above set-up. For each case we obtain an upper limit on the number of observers on the third wing who can demonstrate genuine EPR steering through violation of a tripartite steering inequality. We show that the GHZ allows for a higher number of observers compared to that for W states.

We present a formalism for detection of non-Markovianity through uncertainty relations. We show that when there is an information back-flow to the system from its environment through CP-divisibility breaking, the Choi-states corresponding to the reduced system evolution contain at least one negative eigenvalue. The consequent break down of uncertainty relations for such states can be used to witness non-Markovian dynamics.

We present some relevant examples of the phenomenon for qubit channels. We further prove that square of the variance of a suitable hermitian operator can act as a non-linear witness of non-Markovianity. We finally show that non-Markovianity is necessary in order to decrease the uncertainty of the states undergoing unital dynamics for qubits. This provides another method of certifying non-Markovianity.

We establish a convex resource theory of non-Markovianity inducing information backflow under the constraint of small time intervals within the temporal evolution. We identify the free operations and a generalized bona-fide measure of non-Markovian information backflow. The framework satisfies the basic properties of a consistent resource theory. The proposed resource quantifier is lower bounded by the optimization free Rivas-Huelga-Plenio (RHP) measure of non-Markovianity. We next define the robustness of non-Markovianity and show that it can directly linked with the RHP measure of non-Markovianity through a lower bound. This enables a physical interpretation of the RHP measure. We further relate robustness of non-Markovianity with the quantum capacity of dephasing channels.

Any kind of quantum resource useful in different information processing tasks is vulnerable to several types of environmental noise. Here we study the behaviour of quantum correlations such as entanglement and steering in two-qubit systems under the application of the generalised amplitude damping channel and propose two protocols towards preserving them under this type of noise. First, we employ the technique of weak measurement and reversal for the purpose of preservation of correlations. We then show how the evolution under the channel action can be seen as an unitary process. We use the technique of weak measurement and most general form of selective positive operator valued measure (POVM) to achieve preservation of correlations for a significantly large range of parameter values.

Plan of Future Work Including Project

1. 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. The scenario based on temporal correlations does not require entanglement, a costly and fragile resource. Moreover, unlike previously proposed self-testing protocols in the prepare and measure scenario, our approach requires neither dimensional restrictions, nor other stringent assumptions on the type of measurements. We further analyse the robustness of this hitherto unexplored domain of self-testing of measurements.

2. 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. Incorporating the Heisenberg picture with symmetric operator ordering, the vacuum fluctuation and the self-reaction contributions are distinguished. We evaluate the resonance energy shift and the relaxation rate of energy of the two atom system from the self-reaction contribution in the Heisenberg equation of motion. We investigate the variation of these two quantities with relevant parameters such as atomic entanglement, acceleration, interatomic distance and position with respect to the boundaries. We show that both the energy level shift and the relaxation rate can be controlled by tuning the above parameters. It is observed that the relaxation rate can be enhanced or diminished by a more significant amount compared to the energy level shift.

3. 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). 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 is demonstrated. We further obtain an upper bound on the GUP parameter using standard values of the system parameters.

4. 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. A corresponding witness operator is constructed and shown to be weakly optimal and locally implementable. 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.

Debanjan Bose

Ramanujan Fellow
Astrophysics & Cosmology
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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Tanima Mondal; Neutrino Oscillation Measurements with HyperK; Ongoing; Sanjoy Majumdar (Co-supervisor)

Talks / Seminars Delivered in reputed conference / institutions during the Period

1. **Invited talk** in a workshop named "Science with CTA" during the 39th meeting of the Astronomical Society of India held online, Title : "Atmospheric Cherenkov technique"; 19th February, 2021; Online; 30 minutes

Areas of Research

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

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.

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 wavelength 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 are developing a model to explain VHE emission from GRBs.

I am co-ordinating to submit a joint expression of interests (EOI) on behalf of Indian community to Hyper-Kamiokande collaboration. We intend to contribute in hardware, software and in physics analysis. Earlier this 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

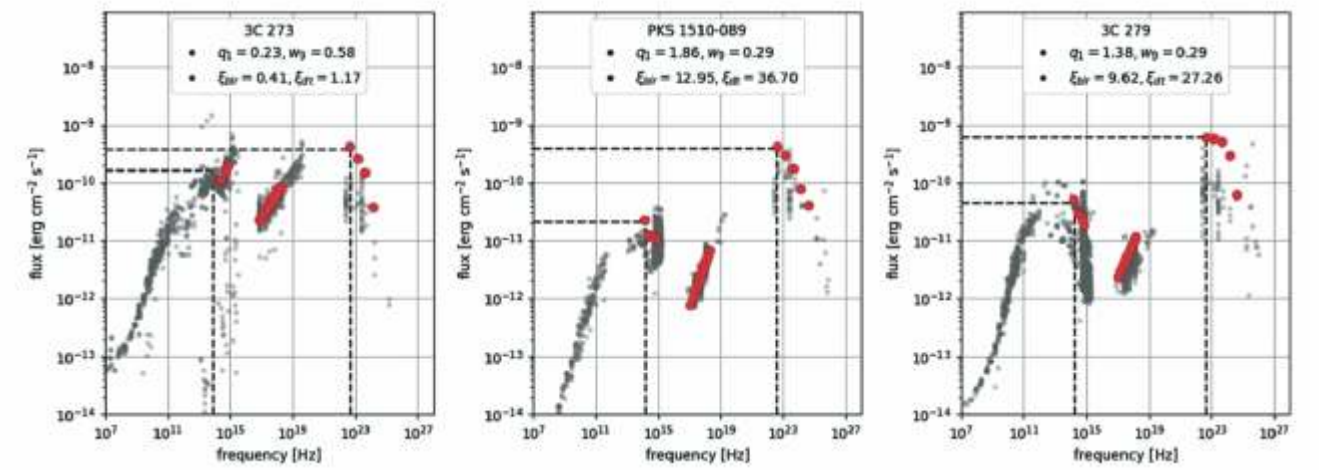

Figure 1. Spectral Energy Distrbutions for blazars 3C 273, PKS 1510-089 & 3C 279. Orphan flares are detected for them in gamma-rays. They are modelled with leptonic emissions.

working with oscillation working group to develop software for HyperK to study neutrino oscillation properties.

We are preparing a mega-science proposal to CTA. In that we propose to build few medium size telescopes (10-12m diameter). At present one of my master student is doing a 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.

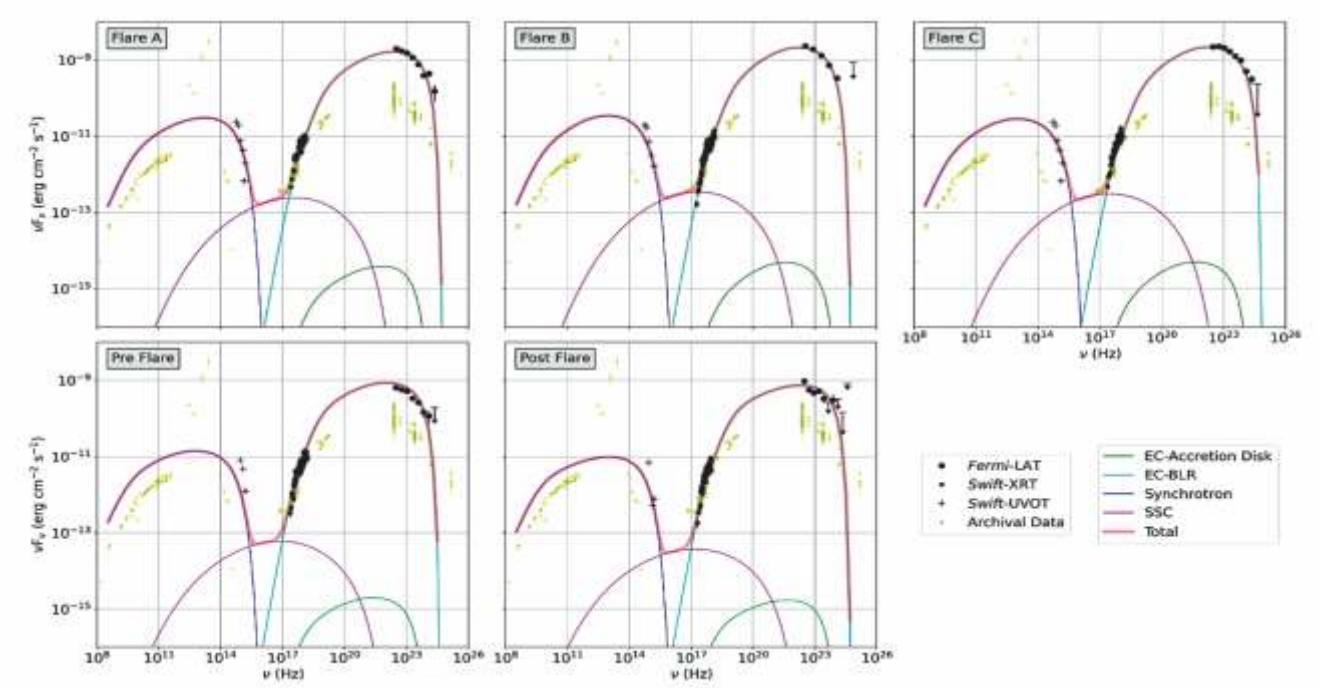

Figure 2. The multi frequency SED data fit with a leptonic External-Compton model for PKS 1830-211

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 planning to submit a pilot proposal. We are interested in contributing in for DAQ, and tank structure for IWCD (Intermediate Water Cherenkov Detector). 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.

Muon Tomography of Volcanoes and Cosmic-ray Tomography of the Moon. Using muons we will study volcanoes located in Andaman Island. We are also doing some GEANT4 based simulations to measure the density structure of the shallow surface of the Moon using cosmic-rays. Our aim is to build a satellite based detector for this.

Ramkrishna Das

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Anindita Mondal; Multi-wavelength Study of Novae; Awarded; Dr Soumen Mondal, SNBNCBS (Co-supervisor)
2. Ayan Bhattacharjee; Accretion flow around Black Hole and Neutron star; Thesis submitted; Prof Sandip K Chakrabarti (Supervisor)
3. Anubhab Banerjee; Nature of transient, variable and persistent X-Ray emissions from accretion around Black Holes in compact X-Ray Binaries; Thesis submitted; Prof Sandip K Chakrabarti (Supervisor)
4. Dhrimadri Khata; Understanding Physical Properties of M-dwarfs: Optical and Near-IR Spectroscopic Studies; Under progress; Dr Soumen Mondal (Supervisor)
5. Prantik Nandi; Active Galactic Nucleus; Under progress; Prof Sandip K Chakrabarti (Supervisor)
6. Rahul Bandyopadhyay; Study of Planetary Nebuale; Under progress
7. Ruchi Pandey; Properties of Novae; Under progress
8. Gesesew Reta Habti; Study of Novae; Under progress
9. Subhajit Kar; Massive stars; Under progress

Teaching

1. Autumn semester; PHY 403; Integrated PhD; 14 students; with 1 (Dr Soumen Mondal) co-teacher
2. Autumn semester; PHY 510; PhD; 4 students; with 1 (Dr Soumen Mondal) co-teacher
3. Spring semester; PHY 391; Integrated PhD; 8 students; with 3 (Dr Manik Pradhan, Dr Tirupathaia Setti, and Dr Rajib Mitra) co-teachers

Publications

a) In journals

1. Rahul Bandyopadhyay, **Ramkrishna Das**, Soumen Mondal, Samrat Ghosh, *Morphology and ionization characteristics of planetary nebulae PB 1 and PC 19*, Monthly Notices of the Royal Astronomical Society, 496, 814-831, 2020
2. Dhrimadri Khata, Soumen Mondal, **Ramkrishna Das**, Supriyo Ghosh, Samrat Ghosh, *Understanding the physical properties of young M dwarfs: NIR spectroscopic studies*, Monthly Notices of the Royal Astronomical Society, 493, 4533-4550, 2020
3. Samrat Ghosh, Soumen Mondal, Somnath Dutta, **Ramkrishna Das**, Santosh Joshi, Sneh Lata, Dhrimadri Khata, Alik Panja, *Fast photometric variability of very low mass stars in IC 348: detection of superflare in an M dwarf*, Monthly Notices of the Royal Astronomical Society, 500, 5106 – 5116, 2021

b) Conference proceedings / Reports / Monographs / Books

1. Ramkrishna Das, "Elemental abundances in novae", Journal of Astrophysics and Astronomy, Volume 42, Issue 2, article id. 13, 2021

Administrative duties

1. Liason Office & Chairman, Reservation Cell of the Centre
2. Member of Seminar and Colloquium Programme (SCOLP)
3. Member of Newsletter Committee
4. Member, Conference, Workshop and Extension Programme (CWEP)
5. 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
6. Member, Committee for Selection of Integrated PhD students
7. Member, Committee for Selection of Junior Research Fellow, Department of Astrophysics & Cosmology

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

1. Butterfly Galaxies: Study and Search of the Winged Radio Galaxies to Solve the Mystery of Wing Formation and the Nature of Jets; Submitted to SERB; Co-PI

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

1. Dr Santosh Joshi, ARIES, Nainital; Sl. No. 3; National
2. Dr Sneh Lata, ARIES, Nainital; Sl. No. 3; National

Areas of Research

Novae, Planetary Nebulae, Massive Stars, Modeling of spectra

1. We have studied two compact planetary nebulae (PNe), PB1 and PC 19 using the optical spectra observed at 2 m Himalayan Chandra Telescope (HCT) and archival/literature data. We have used the morpho-kinematic code to construct 3D morphologies of the PNe (Figure 1) and the photoionization code to model the observed spectra (Figure 2). The 3D model of PB 1 consists of an elongated shell surrounded by a bipolar halo and that of PC 19 consists of an open lobed bipolar structure and a spiral filamentary pair. We analyze the ionization structure of the PNe by deriving several plasma parameters and by photoionization modelling. We estimate the elemental abundances of the elements, He, C, N, O, Ne, S, Ar, and Cl, from our analysis. We find He, C, and N abundances to be significantly higher in case of PB 1. From photoionization modeling we estimate different physical parameters of the central stars and the central star, namely effective temperature, luminosity, gravity, hydrogen density profiles, radii, etc., and distances to the PNe as ~4.3 kpc for PB 1 and as ~5.6 kpc for PC 19. Progenitor masses are estimated from theoretical evolutionary

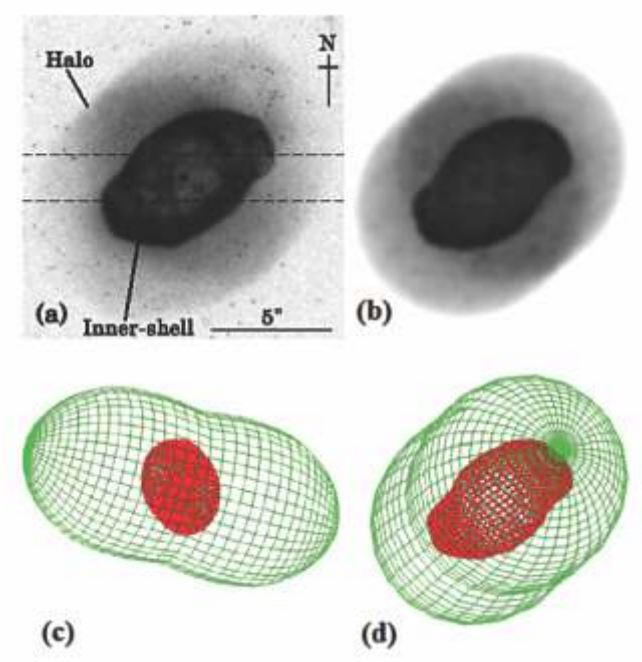

Figure 1: (a) HST HA image of PB 1, used for the 3D reconstruction. The position and width of the slit used for HCT spectroscopic observation is marked with dotted line on the image. (b) The rendered grey-scale 2D model image for comparison with the observed image. (c) The side view and (d) the sky view from the Earth of the constructed 3D model of PB 1.

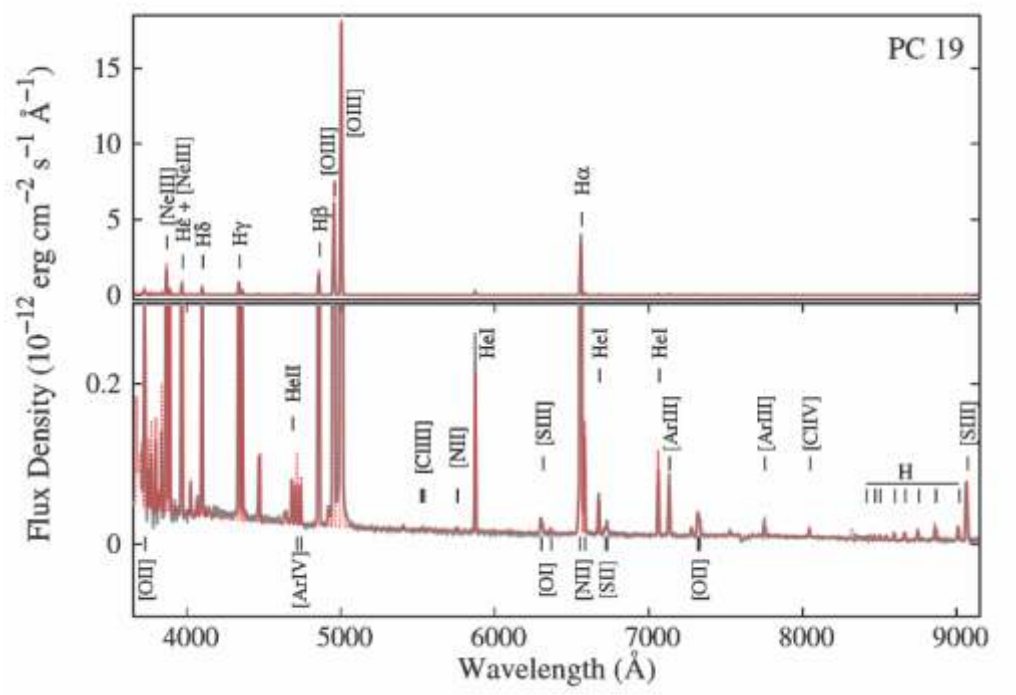

Figure 2: The observed optical spectrum (grey solid line) and the modelled spectrum (red dashed line) are shown for PC 19. Prominent emission lines are marked. Fluxes are in absolute scale. The vertically zoomed spectrum (lower panel) shows the fit of the weaker lines and the continuum.

trajectories and are found to be ~1.67 and ~2.38 M for PB 1 and PC 19, respectively.

2. We have observed medium resolution (~ 1200) near-infrared H- and K-band spectra (1.50-1.80 m and 1.95-2.45 m, respectively) of 53 M-type dwarf stars (M0V-M7V) using the TIFR Near-Infrared Spectrometer and Imager instrument on the 2-m Himalayan Chandra Telescope. Using interferometrically measured effective temperature (T_{eff}), radius and luminosity of nearby bright calibrator stars, we have created new empirical relationships among those fundamental parameters and spectral indices. The equivalent widths of H-band spectral features like Mg (1.57 m), Al (1.67 m) and Mg (1.71 m), and the H_2O-H index are found to be good indicators of T_{eff}, radius and luminosity and we establish linear functions using these features relating to those stellar parameters. The root-mean-squared error of our best fits are 102 K, 0.027 Rsun and 0.12 dex respectively. Using spectral-type standards along with known parallaxes, we calibrate both H- and K-band H_2O indices as a tracer of spectral type and absolute K_s magnitude, and estimate metallicities, mass etc. of M-dwarfs using the K-band calibration relationships.

3. We have modeled the optical and near-Infrared spectra of the dust forming nova V1280 Scorpii to understand how the physical and chemical parameters change from the pre-dust phase to the post-dust phase. From the best-fit model, we estimate the values of different parameters, e.g. temperature, luminosity, density, elemental abundances etc. Dust condensation conditions are achieved with high enough density and low enough temperature. We find a mixture of small amorphous carbon dust and large astrophysical silicate dust. Our model yields a very high

abundances of a few elements, e.g. carbon, nitrogen, oxygen etc. relative to solar in the ejecta, during the pre-dust phase, which decrease in the post-dust phase. (submitted to ApJ, paper under review).

Plan of Future Work Including Project

1. We are reducing and analyzing the observed data. We are planning to observe more object using the available facilities.
2. We are modeling the observed spectra to understand the physics inside the objects.
3. We are in a process to establish S N Bose Centre's Astronomical Observatory at Purulia. We are preparing the the proposal and planning to submit it at the earliest.

Any other Relevant Information including social impact of research

1. i. Progress in the basic sciences is required to solve the problems and understand the world around us. ii. Solving the basic scientific questions improves and enriches the basic knowledge. iii. Development of human resource, through teaching and supervising PhD students, helps to build the Nation. iv. Generates manpower for worldwide astronomical projects.

Soumen Mondal

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Astrophysics & Cosmology
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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Supriyo Ghosh; Studies on Cool and Evolved stars; Awarded
2. Anindita Mondal; Multi-wavelength studies of Novae; Awarded; Soumen Mondal (Co-supervisor), Ramkrishna Das (Supervisor)
3. Samrat Ghosh; Understanding the Atmosphere of Brown Dwarfs and Low Mass Stars; Under progress
4. Dhrimadri Khata; Understanding of Physical Properties of M-dwarfs : Optical and Near-IR Spectroscopic Studies; Under progress; Soumen Mondal (Supervisor), Ramkrishna Das (Co-supervisor)
5. Alik Panja; A Multiwavelength Study of Galactic Star-forming Regions; Under progress
6. Siddhartha Biswas; Studies of Pre-main Sequence stars in the Galactic Star-forrmation processes; Under progress
7. Diya Ram; Understanding of Active M dwarfs; Under progress
8. Rajib Kumbhakar; Studies of Galactic Very Low-mass Stars
9. Gaurav Patel; Studies of Galactic HII regions; Under progress

b) Post-Docs

1. Arka Chatterjee; Research on Compact Objects and AGNs

c) External Project Students / Summer Training

1. Lopamudra Roy; Spectroscopy techniques for understanding of Milk Adulteration; Technical Reserach Center, SNBNCBS
2. Supratim Sen; Spectroscopy techniques for understanding of Milk Adulteration in NIR wavelengths; Technical Reserach Center, SNBNCBS
3. Pallabi Saha; Understanding Galactic Low Mass Stars: M-Dwarfs; Department of Physics, Diamond Harbour Women's University
4. Swagata Mukhopadhyay; Multi Wavelength Study Of Star Forming Region; Department of Physics, Diamond Harbour Women's University
5. Sipra Sinha; Mira Variable - A Pulsating M-Giants; Department of Physics, Diamond Harbour Women's University
6. Simantini Maiti; Estimation of Fundamental Parameter of Stellar Sources; Department of Physics, Diamond Harbour Women's University

Teaching

1. Autumn semester; Basic Laboratory -I (PHY 191); Integrated PhD; 05 students; with 1 (Prof. Samir K. Pal) co-teacher
2. Spring semester; Astrophysics and Astronomy (PHY 403); Integrated PhD; 13 students; with 1 (Dr. Ramkrishna Das) co-teachers
3. Spring semester; Astrophysics and Astronomy (PHY 510); PhD; 04 students; with 1 (Dr. Ramkrishna Das) co-teachers

4. Autumn semester; Observational Techniques in Astronomy; PhD; 05 students; with 1 (Dr. Ramkrishna Das) co-teachers

Publications

a) In journals

1. Alik Panja, Wen Ping Chen, Somnath Dutta, Yan Sun, Yu Gao, and **Soumen Mondal**, *Sustaining Star Formation in the Galactic Star Cluster M 36?*, The Astrophysical Journal, 910, 80, 2021
2. Samrat Ghosh, **Soumen Mondal**, Somnath Dutta, Ramkrishna Das, Santosh Joshi, Sneh Lata, Dhrimadri Khata, Alik Panja, *Fast photometric variability of very low mass stars in IC 348: detection of superflare in an M dwarf*, Monthly Notices of the Royal Astronomical Society, 500, 5106 – 5116, 2021
3. upriyo 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. Rahul Bandyopadhyay, Ramkrishna Das, **Soumen Mondal**, Samrat Ghosh, *Morphology and ionization characteristics of planetary nebulae PB 1 and PC 19*, Monthly Notices of the Royal Astronomical Society, 496, 814-831, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Invited talk on "Understanding of Pre-main Sequence Stars in Galactic Star-Forming Regions" in the HCT20 Science Meeting; Sep 29, 2020; Indian Institute of Astrophysics, Bangalore (online); 20 mins

Administrative duties

1. (i). Head of the Department of Astrophysics and Cosmology, S. N. Bose National Centre of Basic Sciences (ii). Nodal Officer of Technical Research Centre (TRC), S. N. Bose National Centre of Basic Sciences (iii). Internal committee member in Board of Studies (BoS); Students' Curriculum & Research Evaluation Committee (SCREC); Project and Patent cell; Member in Library Committee; Land-acquisition committee for the Astronomical Observatory, Advisory committee member of Computer cell, etc.

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

1. Technical Research Centre (TRC), SNBNCBS; DST; January 2016 - June 2021; PI

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

1. Prof. Wen-Ping Chen, National Central University, Taiwan; Sl. No. 1; International
2. Prof. Yu Gao, Purple Mountain Observatory and Department of Astronomy, Xiamen University, Republic of China; Sl. No. 1; International
3. Dr. Somanth Dutta, Institute of Astronomy and Astrophysics, Academia Sinica, Taipei, Taiwan; Sl. No. 1,2,3; International
4. Dr. Yan Sun, Purple Mountain Observatory, Nanjing 210033, People's Republic of China; Sl. No. 1; International
5. Dr. Santosh Joshi, Aryabhatta Research Institute of Observational Sciences(ARIES), Nainital-263 002, India; Sl. No. 3; National
6. Dr. Sneh Lata, Aryabhatta Research Institute of Observational Sciences(ARIES), Nainital-263 002, India; Sl. No. 3; National

Areas of Research

(IMulti-wavelength studies on Galactic star-forming regions; (ii) Spectroscopic studies of Low-mass M-dwarfs, M giants and AGB stars; (iii) Photometric variability studies of Brown dwarfs and Very Low Mass stars; (iv) Extra-solar Planets; (v) Astronomical Instrumentation

1. **Fast photometric variability of very low mass stars in star-forming region IC 348: detection of superflare in an M dwarf**

The optical *I*-band photometric variability down to ≅19 mag of a young (~2–3 Myr) star-forming region IC 348 in the Perseus molecular cloud is studied here. We aim to explore the fast rotation (in the time-scales of hours) in

very low-mass stars including brown dwarfs (BDs). From a sample of 177 light curves using our new *I*-band observations, we detect new photometric variability in 22 young M dwarfs including 6 BDs, which are bonafide members in IC 348 and well characterized in the spectral type of M dwarfs. Out of 22 variables, 11 M dwarfs including one BD show hour-scale periodic variability in the period range 3.5–11 h , and rest are aperiodic in nature. Interestingly, an optical flare is detected in a young M2.75 dwarf in one night data on 2016 December 20. From the flare light curve, we estimate the emitted flared energy of 1.48 × 10^{35} erg. The observed flared energy with an uncertainty of tens of percent is close to the superflare range (~10^{34} erg), which is rarely observed in active M dwarfs **(Samrat Ghosh et al., MNRAS, 2021).**

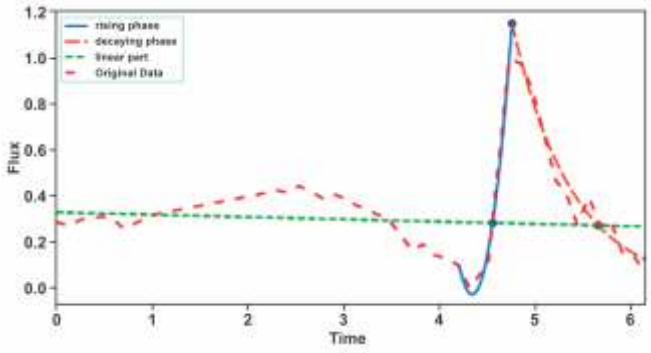

Figure 1. *A flare event in M2.75 dwarf (ID233) is observed in 2016 December 20. The light curve is fitted in three parts for three different regions: constant phase (before flare), rising phase, and decaying phase. Three blue triangles are indicating flare start, peak, and ending time in our calculation.*

2. Sustaining Star Formation in the Galactic Star Cluster M 36?

A comprehensive characterization of the Galactic open cluster M 36 is presented here. Some 200 member candidates have been identified on the basis of proper motion and parallax measured by the Gaia DR2. With an estimated age of ~15 Myr, M 36 is free of nebulosity. To the southwest of the cluster, we discover a highly obscured (A_V up to ~23 mag), compact dense cloud, within which three young stellar objects in their infancy (ages less than 0.2 Myr) are identified. If the physical association between M 36 and the young stellar population can be unambiguously established, this manifests a convincing example of prolonged star

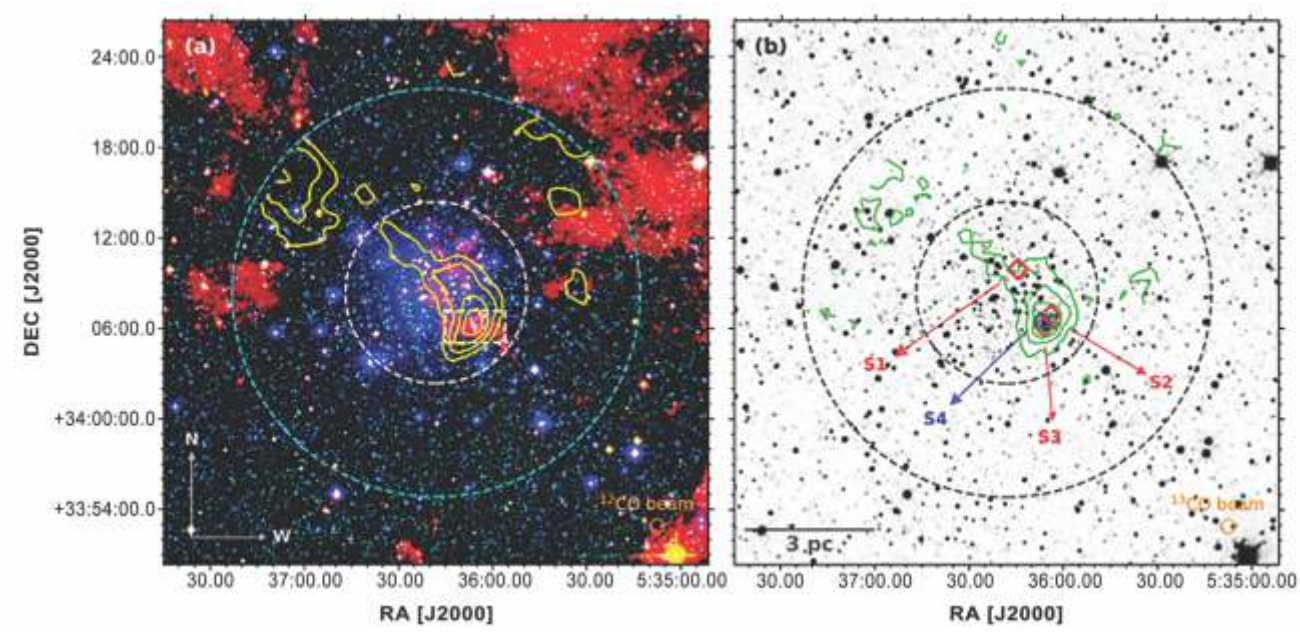

Figure 2. *(a) Color composite image of M 36 using optical and infrared data, taken from DSS2 B 0.44 Mm (blue), 2MASS K 2.2 Mm (green), and WISE W3 12 Mm (red) for a region of M 36 . The ^{12}CO (J = 1–0) distribution is traced by the yellow contours. The high-extinction complex is depicted by the white rectangle. (b) The corresponding WISE 4.6 Mm image is presented, with the green contours representing the ^{13}CO (J = 1–0) integrated intensity. The four YSOs (S1-4) are indicated*

formation activity spanning up to tens of Myr in molecular clouds **(Alik Panja et al., APJ, 2021).**

Plan of Future Work Including Project

1. A. Scientific programs in the observational Astronomy : (i) Spectrophotometric studies of late M-type stars (dwarfs and giants) and Miras: Spectrophotometric studies of low-to-intermediate mass stars represent a vital test of theoretical models of stellar evolution, structure, and atmospheres. Optical/Near-IR spectrophotometric studies of these objects are undertaken to understand their atmospheres and pulsation. Furthermore, studies of M dwarfs have been recognized as promising targets in the search for small extra-solar planets. (ii) Multi-wavelength studies of Galactic star-forming regions: Multi-wavelength studies of such regions provide a census of Young Stellar Objects, their fundamental parameters. To provide comprehensive observations and in-depth study of the physical properties of Very Low Mass (VLM) objects and brown dwarfs, we are studying these objects using the National telescope facilities. (iii). Astronomical Instrumentation: With our expertise in the Optical/IR instrument design and development, we are working to establish an Astronomical Instrumentation Laboratory at the Centre for building the state-of-art backend instruments for the telescopes. B. Establishment of S. N. Bose Centre Telescope project at Panchet Hill, Purulia: A new Astronomical 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. We got recently the approval for 2 hectares of land at Panchet hill-top, Purulia for this Observatory site from the Forest department of Govt. Of India and state Govt. Of West Bengal. Scientific motivations for our telescope program encompass forefront problems in Astronomy and Astrophysics ranging from Extra-solar planets to Black-hole astrophysics.

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 needs in educational sectors as well as a need for National/ International mega projects (like TMT, LIGO, 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 trial run. Such a project is intended for societal benefit and valuable Knowledge resource for the food sector and security.

Tapas Baug

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Astrophysics & Cosmology
tapasbaug@bose.res.in

Guidance of Students/Post-Docs/Scientists

a) Post-Docs

1. Piyali Saha; Observational study of Galactic star formation

b) External Project Students / Summer Training

1. Aashique Unikrishnan; Characterization of a few Star-forming Filaments National Institute of Technology, Calicut
2. Swagata Bera; Distances of a sample of Mira variables using two methods and their comparison; Visva Bharati University, Shantiniketan

Areas of Research

Galactic massive star formation, Circumstellar dust shell of post-main sequence stars, Astronomical Instrumentation

The physical process that governs the formation of a massive star (> 8 solar mass) is an unsolved problem in astrophysics. It is still doubted whether the formation mechanism of a massive star is a scaled-up version that produces low-mass stars or if it is a fundamentally different process. The observational study of pre-main sequence phases of massive star formation are elusive because massive stars are relatively rare, have a quick pre-main sequence evolution and nucleosynthesis in their core begins before they come out of the optically thick parent molecular envelope. Two basic sets of theories are available in the literature describing the core-scale (<0.01 pc) formation mechanisms of massive stars. One class of theories propose that massive stars form within the massive prestellar cores in a similar manner that forms their low-mass counterpart (i.e., `core accretion' model). Other theories tend to believe that massive stars form in completely different mechanisms such as competitive clump-scale accretion (i.e., `competitive accretion' model).

In recent years, two other large-scale (pc-scale) theories have gained considerable observational evidence. One of them is the collision between two nearby molecular clouds, followed by strong shock compression of gas, that is capable to give the sufficient accretion rate to form massive stars. Evidence of such cloud-cloud collision is also found observationally (see Baug et al., 2016). Another potential theory for the formation of a massive star is accretion through filaments. Filamentary structures identified in Galactic molecular clouds have the ability to form both low-mass and massive stars. Observationally, the formation of massive stars at the junction of multiple filaments is found in several Galactic star-forming regions (see e.g., Baug et al., 2015; Baug et al., 2018).

After the advent of Herschel observations, filaments are found to be ubiquitous in Galactic star-forming clouds. These filaments are believed to aid star-formation by channeling gas along their long-axes. However, a direct implication of accretion through filaments would be identifying a direct correlation between the protostellar accretion and gas flow along the filaments. But direct detection of accreting gas at the core scale is difficult because of complicated gas dynamics at that scale. A solution to this problem could be finding a correlation of the protostellar jets or bipolar outflows associated with the filamentary structures. A general understanding is that these bipolar outflows are launched by the rotating

accretion disk of the protostar, and can be used to infer the orientation of the accretion disk. One would, thus, ideally expect a preferred position angle of bipolar outflows with respect to the orientation of the long axis of the filaments. Also, these outflows are much easier to detect compared to accretion disks. Theories predict different orientations of accretion disks (hence, the angular momentum axes) of protostars with respect to filament long-axis (parallel or perpendicular) depending on the physical conditions of the surrounding environment and the strength of magnetic fields.

Previous studies towards the low-mass regions found conflicting results. Some of the studies found an orthogonal outflow-filament orientation, while other studies found a random distribution of outflow-filament orientation in the Perseus molecular cloud. A previous study on a young massive star-forming region found orthogonal orientation of outflows with respect to the host filaments. On the contrary, in a recent study on eleven Galactic massive star-forming regions using Atacama Large millimeter/submillimeter Array (ALMA) data we found no correlation of outflow axis with the orientation of filaments or even with the large-scale magnetic field direction (Baug et al., 2020). Figure 1 shows the cumulative distribution of the plane of sky position angles (gamma_Fil) between the outflow axes and the orientations of the host filaments. The cumulative distribution resembles more to the random distribution generated using Monte-Carlo simulations (see Baug et al. 2020 for more details).

Plan of Future Work Including Project

1. S. N. Bose National Centre for Basic Sciences took the initiative to build the first astronomical observation facility in the Eastern part of India. The plan is to set up a 1.5-m telescope at Panchet hill (23.6286 N, 86.7668 E), Purulia district of West Bengal. The primary aims of this telescope project are – (1) for cutting-edge scientific observations, (2) to train younger researchers and students in observational astronomy, and (3) to fill the longitudinal gap for uninterrupted monitoring of any astronomical event in the optical/Infrared wavelength regime. I am involved in this project as an Executive team member. We have already submitted a proposal for funding of this project to Department of Science and Technology, Govt. of India.

2. I am involved in several projects on massive star formation using the data from Atacama Large Millimeter/submillimeter Array (ALMA). The unprecedented sensitivity and resolution of ALMA data help us to resolve the finer details of the Galactic star-forming regions, and thus, the detailed physical mechanisms. I am involved in ALMA projects along with several national and international collaborators. In future, I would like to pursue research on Galactic massive star formation using the observations from ALMA and several other national telescopes (e.g., Giant Metrewave Radio Telescope; 3.6-m Devasthal Optical Telescope; 2-m Himalayan Chandra Telescope, etc).

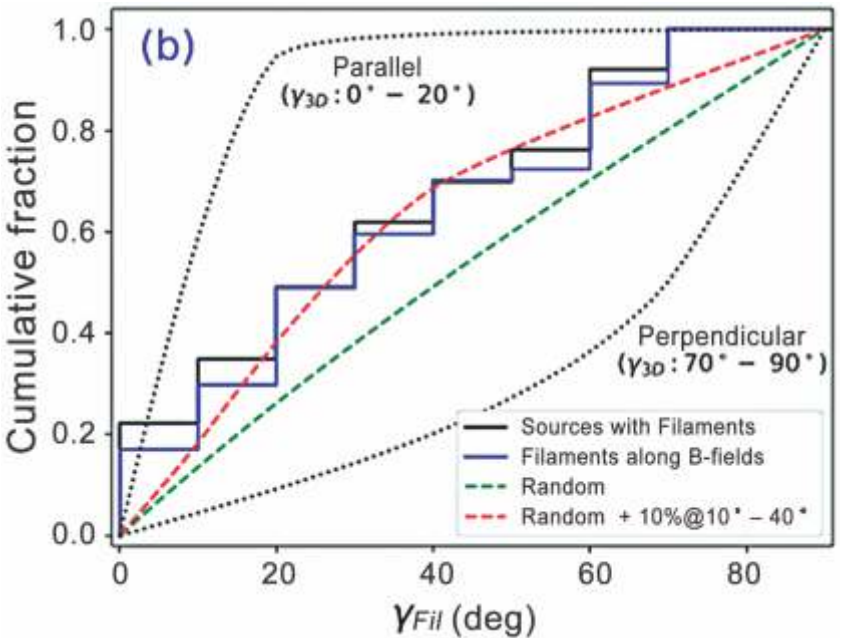
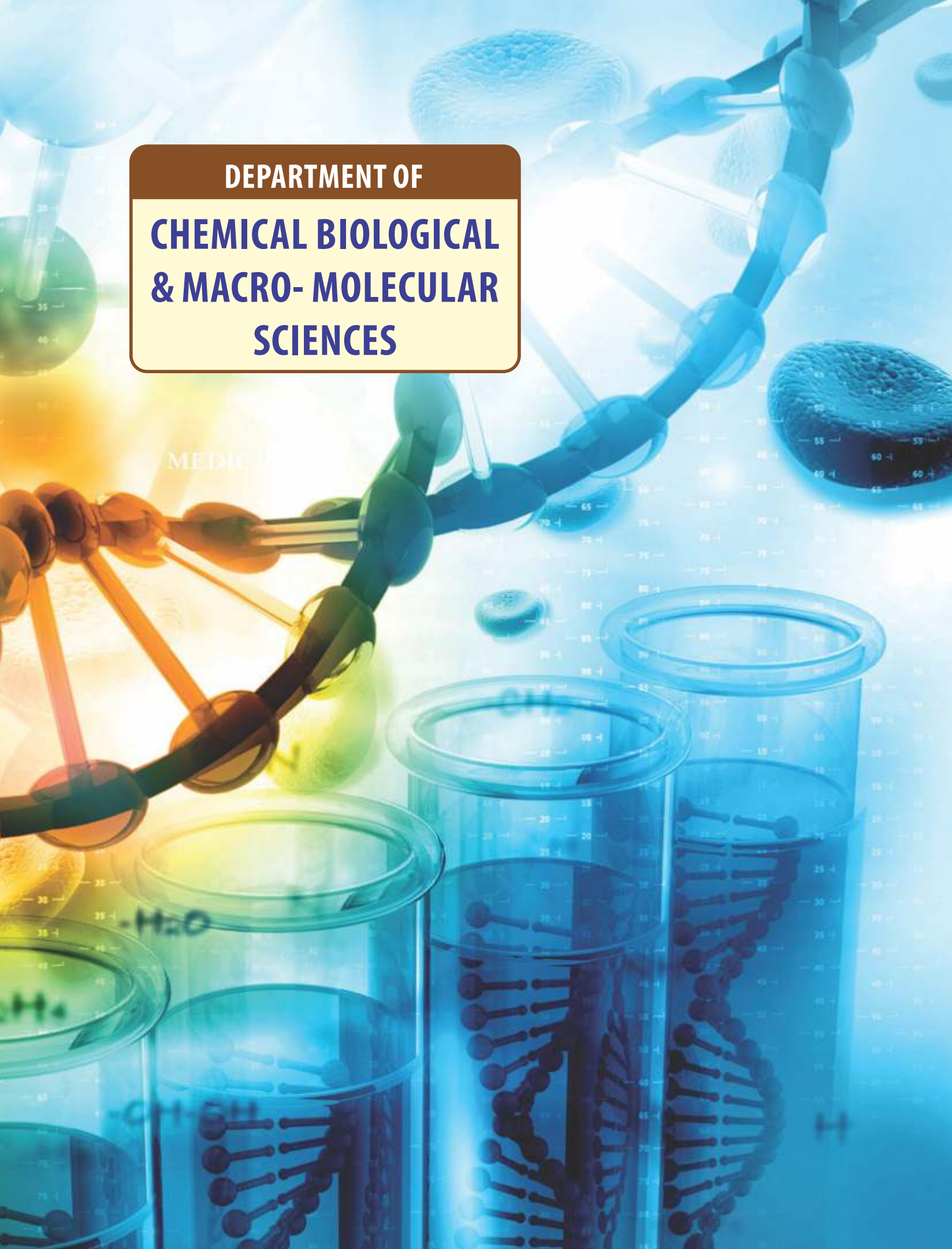


Figure 1. Cumulative histogram function of the projected plane of sky position angles between the directions of outflows and position angles of filaments (gamma_Fil). The Green dashed line marks a theoretical cumulative distribution function if the outflow directions are purely random.


DNA
DNA
molecule



DEPARTMENT OF

CHEMICAL BIOLOGICAL & MACRO- MOLECULAR SCIENCES

DEPARTMENT OF
Chemical Biological & Macro Molecular Sciences

JAYDEB CHAKRABARTI

Department profile indicators

Table A : Manpower and resources

Number of faculty members	10 (including Emeritus, Inspire etc.)
Number of Post –doctoral research associate (centre + project)	3 + 1
Number of Ph.D students	44
Number of other project staff	03
Number of summer students	NIL
Projects (ongoing)	07

Table B: Research Activities indicators

Number of research papers in Journals	66
Number of Book-chapters/books	–
Number of other publications	1
Number of Ph.D students graduated (submitted + degree awarded)	(Submitted = 6 + Degree = 7) Total = 13
Number of M.Tech/M.Sc projects	

Table C: Academic activities and likeage

Number of courses taught by faculty members		07
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	1 + 1 + 3 + 2 = 7
	International	0

Most important research highlights

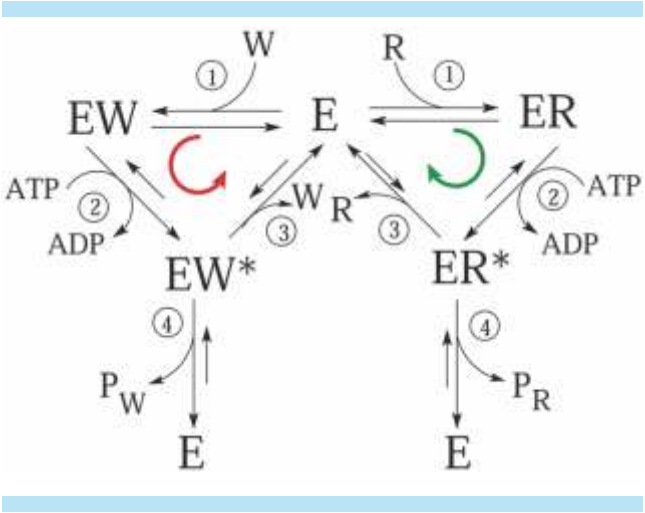
- Exploration of heterogeneity length and timescales for ionic deep eutectics
- Polarity Impact on spatio-temporal heterogeneity
- Confinement effects on preferential solvation
- Experimentally determined the ortho-to-para ratio (OPR) for D_2O nuclear spin-isomers in the isolated gaseous phase to be (1.950.16):1 by using high-resolution cavity ring-down spectroscopy coupled with quantum cascade laser.
- Investigation of the role of entropy production in kinetic proof reading in chemical network
- Exploration of the energetic and entropic cost due to Turing and Hopf instabilities in nonlinear open system

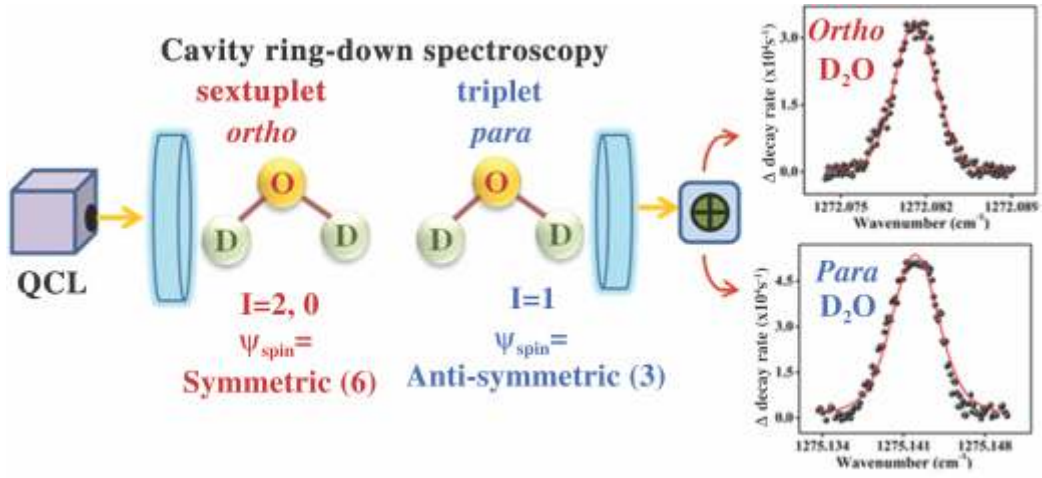
- Devising a unified approach to deal with the dynamic disorder in various chemical and biological processes
- The molecular mechanism of protonation induced dynamic allostery in a PDZ domain protein elucidated using molecular dynamics simulation.
- Microscopic insight to specificity of metal ion cofactor in DNA cleavage by restriction endonuclease EcoRV

Summary of research activities

Here are some highlights of different research activities in the department:

1. Micro-heterogeneous solution structure and dynamics have been explored for ionic deep eutectics, confined binary mixtures and binary mixtures of ionic liquids with common organic solvents. Important results regarding confined induced impact on preferential solvation, cosolvent polarity dependence of heterogeneous dynamics in ionic liquid + cosolvent binary mixtures, and anion identity dependence of heterogeneity in ionic deep eutectics have been observed.
2. We probe directly the spin behaviour of D_2O molecules in the gas phase and thus fostering exploration of spin-dependent chemistry in a wide range of chemical and biological systems. We have also developed a quantum weak measurement (QWM) technique for amplifying and detecting tiny optical beam shift effects and may provide important applications in precision metrology.
3. Using terahertz spectroscopy, we established the alteration of the collective hydration of water during the fibrillation process (native - intermediate - fibril) of a model protein bovine serum albumin. This is one of the very first reports on the dynamics of water during fibril formulation. The label-free THz study concludes that water dynamics change systematically with protein conformational changes as it experiences a hydrophobic environment during the initial protein unfolding process, followed by the release of bound water during oligomerization and finally the hydrophobic interior of the fibril. Our study unambiguously concluded a strong correlation between the change in hydration (as obtained from THz spectroscopy) and the structural perturbation (as evidenced from the CD signal) as two clear transitions were observed in the fibrillation pathways. Such in vitro study is a primary step



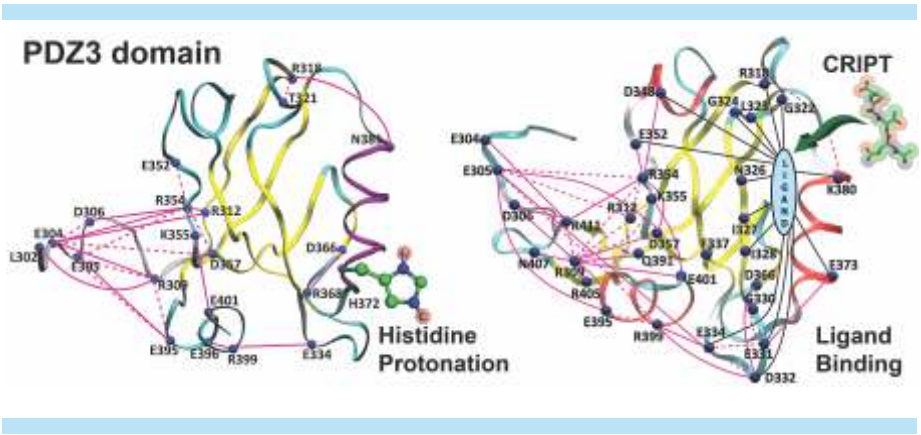


towards experimentally detecting the onset of the fibrillation process via THz spectroscopy of the water network structure

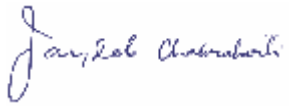
4. Major biological polymerization processes achieve remarkable accuracy while operating out of thermodynamic equilibrium by utilizing the mechanism known as kinetic proofreading. Here, we study the interplay of the thermodynamic and kinetic aspects of proofreading by exploring the dissipation and catalytic rate, respectively, under the realistic constraint of fixed chemical potential difference. Theoretical analyses reveal non-monotonic variations of the catalytic rate and total entropy production rate (EPR), the latter quantifying the dissipation, at steady state. Applying this finding to a tRNA selection network in protein synthesis, we observe that the network tends to maximize both the EPR and catalytic rate, but not the accuracy. Simultaneously, the system tries to minimize the ratio of the EPRs due to the proofreading steps and the catalytic steps. Therefore, dissipation plays a guiding role in the optimization of the catalytic rate in the tRNA selection network of protein synthesis.[J. Chem. Phys. 152, 111102 (2020)]

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

   - Universal mechanism of dynamic allostery in PDZ domain in terms of protonation state change and ligand binding (Publication: *J. Phys. Chem. Lett.* **11**, 9026 (2020))
   - Effect of various additives on the growth kinetics of methane hydrates and the molecular mechanism (Publications: *J. Mol. Liq.* **319**, 114296 (2020), *Ind. Eng. Chem. Res.* **59**, 20591 (2020))
   - Inhibition of Acetylcholinesterase (AChE) activity towards therapeutic strategy to control Alzheimer's disease (Publications: *ACS Pharmacol. Transl. Sci.* **4**, 193 (2021), *J. Phys. Chem. B* **125**, 1531 (2021))



6. We study by Brownian Dynamics simulations a system of oppositely charged colloid subject to a constant electric field. We consider sufficiently strong electric field where the like charges in the system form macroscopic lanes. We examine spatial correlation lengths characterizing structural order and that between particles of different mobility. We find that the correlation lengths show dependence on the observation time. Moreover, slow particles are responsible for formation of lanes and offer independent length-scale in the steady states. [Ref: Physcial Chemistry Chemical Physics, 22, 17731-17737, 2020.



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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Premashis Kumar; Nonequilibrium thermodynamics of open nonlinear dynamical systems; Under progress

b) Post-Docs

1. Prasanta Kundu; Dynamic disorder and conformational fluctuation in reaction kinetics

Teaching

1. Autumn semester; Advanced Equilibrium Statistical Mechanics; PhD; 4 students; with 1 (Jaydeb Chakrabarty) co-teacher

Publications

a) In journals

1. Premashis Kumar and **Gautam Gangopadhyay**, *Energetic and entropic cost due to overlapping of Turing-Hopf instabilities in the presence of cross diffusion*, Physical Review E, 101, 042204, 2020
2. Prasanta Kundu, Soma Saha, and **Gautam Gangopadhyay**, *Mechanical Unfolding of Single Polyubiquitin Molecules Reveals Evidence of Dynamic Disorder*, ACS Omega, 5, 9104-9113, 2020
3. Prasanta Kundu, Soma Saha and **Gautam Gangopadhyay**, *Kinetics of escape of ssDNA molecules from -hemolysin nanopores: a dynamic disorder study*, Journal of Statistical Mechanics: Theory and Experiment, 2020, 053501, 2020
4. Sandip Saha, **Gautam Gangopadhyay** and Deb Shankar Ray, *Systematic designing of bi-rhythmic and tri-rhythmic models in families of Van der Pol and Rayleigh oscillators*, Communications in Nonlinear Science and Numerical Simulation, 85, 105234, 2020
5. Prasanta Kundu, Soma Saha and **Gautam Gangopadhyay**, *Stochastic Kinetic Approach to the Escape of DNA Hairpins from an -Hemolysin Channel*, The Journal of Physical Chemistry B, 124, 6575-6584, 2020
6. Sandip Saha, Sagar Chakraborty and **Gautam Gangopadhyay**, *Suppressing birhythmicity by parametrically modulating nonlinearity in limit cycle oscillators*, Physica D: Nonlinear Phenomena, 416, 132793, 2021
7. Prasanta Kundu, Soma Saha and **Gautam Gangopadhyay**, *An Exactly Solvable Stochastic Kinetic Theory of Single-Molecule Force Experiments*, The Journal of Physical Chemistry B, 124, 7735-7744, 2020
8. Sandip Saha, **Gautam Gangopadhyay**, Sangeeta Kumari & Ranjit Kumar Upadhyay, *Parametric Excitation and Hopf Bifurcation Analysis of a Time Delayed Nonlinear Feedback Oscillator*, International Journal of Applied and Computational Mathematics, 6, Article Number 123, 2020
9. Prasanta Kundu, Soma Saha, and **Gautam Gangopadhyay**, *Kinetics of Allosteric Inhibition of*

Single Enzyme by Product Molecules, The Journal of Physical Chemistry B, 124, 11793 – 11801, 2020

10. Krishnendu Pal, Dibakar Ghosh and **Gautam Gangopadhyay**, *Synchronization and metabolic energy consumption in stochastic Hodgkin-Huxley neurons: Patch size and drug blockers*, Neurocomputing, 422, 222 – 234, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Talk delivered on Ultrasensitivity as a Stochastic Activation Event; Mar 31, 2021; (Online); Chemistry Department, Stat Mech Gr Visva-Bharati University, Santiniketan; 4-5PM

Administrative duties

1. Member of Project and Patent Cell, SNBNCBS
2. Transparency Officer, SNBNCBS

Membership of Learned Societies

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

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

1. Dr. Soma Saha, Assistant Professor, Chemistry Department, Presidency University, Kolkata; Sl. No. 2,3,5,7; National
2. Prof. Sagar Chakraborty, Physics Department, IIT Kanpur; Sl. No. 6; National
3. Prof. D S Ray, School of Chemical Sciences, IACS, Kolkata; Sl. No. 4; National
4. Prof. Ranjit Kumar Upadhyay, Applied Mathematics, Indian School of Mines; Sl. No. 8; National
5. Prof. Dibakar Ghosh, Indian Statistical Institute, Kolkata; Sl. No. 10; National

Areas of Research

Theoretical Chemical Physics

1. Exploration of the energetic and entropic cost in nonlinear open system:

   A systematic introduction to nonequilibrium thermodynamics of dynamical instabilities are considered for an open nonlinear system beyond conventional Turing pattern in presence of cross diffusion. An altered condition of Turing instability in presence of cross diffusion is best reflected through a critical control parameter and wave number containing both the self- and cross-diffusion coefficients. Our main focus is on entropic and energetic cost of Turing-Hopf interplay in stationary pattern formation. Depending on the relative dispositions of Turing-Hopf codimensional instabilities from the reaction-diffusion equation it clarifies two aspects: energy cost of pattern formation, especially how Hopf instability can be utilized to dictate a stationary concentration profile, and the possibility of revealing nonequilibrium phase transition. In the Brusselator model, to understand these phenomena, we have analyzed through the relevant complex Ginzberg-Landau equation using multiscale Krylov-Bogolyubov averaging method. Due to Hopf instability it is observed that the cross-diffusion parameters can be a source of huge change in free-energy and concentration profiles.

2. Multiscale dynamics in open Chemical and Biological Systems:

   The self-sustained chemical oscillations are also regularly observed in biological world to maintain a cyclic steady state e.g., cell division[, circadian oscillation, calcium oscillations and other bio-systems. Our aim in this project is to look into the physical and mathematical properties of weakly nonlinear systems containing periodic orbits by adopting various methods of multiscale perturbation analysis to cover single to multi-limit cycles which can arise in various practical situations. We have presented an unified scheme to express a class of system of equations in two variables intoa Liénard - Levinson - Smith(LLS) oscillator form. We have derived the condition for

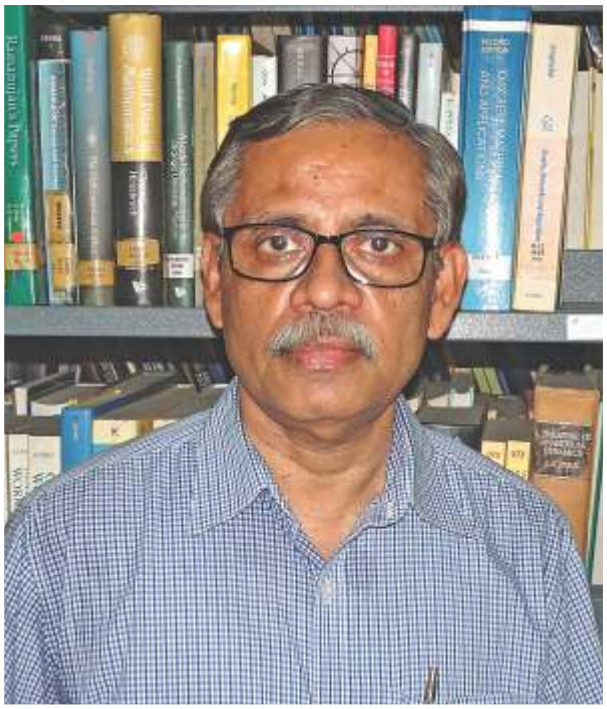
limit cycle for arbitrary polynomial functions of damping and restoring force. A method is devised to determine the maximum number of limit cycles admissible for a LLS oscillator. Based on this approach we proposed a scheme for systematic designing of generalised Rayleigh andVan der Pol families of oscillators with a desired number of multiple limit cycles.

3. A single molecule approach to deal with the dynamic disorder in various chemical and biological processes:

   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 a microscopic model in which the dynamics of protein is described in terms of the anomalous diffusion of a Brownian particle in a harmonic potential well under the action of fractional Gaussian noise. Starting from a non-Markovian diffusion equation supplemented with an exponential sink term accounts for the electron transfer reaction between the donor and acceptor groups, we calculate the survival probability from the solution of the corresponding diffusion–reaction equation to quantify the average activation energy for the conformational dynamics suggesting an alternative interpretation for the observed non-exponential ET kinetics associated with dynamic disorder rather than a static heterogeneity.

Plan of Future Work Including Project

1. Energetic and entropic cost in nonequilibrium steady state A systematic introduction to nonequilibrium thermodynamics of dynamical instabilities can be considered for an open nonlinear system beyond conventional Turing pattern. Our main focus is on entropic and energetic cost of stationary pattern formation which can clarify: energy cost of pattern formation, and the possibility of revealing nonequilibrium phase transition. In this context, complex Ginzberg- Landau equation can be utilized to see how the different nonlinear phenomena play their roles in stationary pattern, for example, Hopf instability and the cross-diffusion parameters etc in controlling the free-energy and concentration profiles. In similar spirit, the role of energetic discrimination is of utmost importance for the reaction network of high specificity when the rate is arbitrarily low, which can be implemented for improving ac- curacy through a proofreading network for error-dissipation trade-off regime and beyond. The nonequilibrium steady state theory can be incorporated with a recently developed thermody- namic framework to obtain the error basin, dissipation, and energetics of kinetic proofreading with energetic discrimination in binding and unbinding processes. It can be advantageous in maintaining and enhancing the specificity with externally controllable concentration parameters.



Goutam De

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Publications

a) In journals

1. Anuja Das, Arka Bikash Dey, Shreyasi Chattopadhyay, **Goutam De**, Milan K. Sanyal, and Rabibrata Mukherjee, *Nanoparticle Induced Morphology Modulation in Spin Coated PS/PMMA Blend Thin Films*, Langmuir, 36, 15270 – 15282, 2020
2. Prasun Choudhury, Shreyasi Chattopadhyay, **Goutam De** and Basudeb Basu, *Ni–rGO–zeolite nanocomposite: an efficient heterogeneous catalyst for one-pot synthesis of triazoles in water*, Materials Advances, 2, 3042-3050, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. A lecture entitled "The importance of nanostructured coatings: Design and wet-chemical deposition" was delivered at the Curtain Raiser Ceremony of 6th India International Science Festival 2020; 05/12/2020; SNBNCBS; 05:15-05:45 pm

Awards, Recognitions

1. External Member of CRNN (Calcutta University) PhD committee, External member of "Faculty assessment committee of JNCASR"

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

1. Design and Fabrication of washable all-cotton 3 or 4-layer mask with controlled superhydrophilic/ hydrophobic surface modifications; In house (TRC); 10/09/2020- Continuing; PI /in collaboration with Prof S. K. Pal and CSIR CGCRI

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

1. Indian Institute of Technology, Kharagpur; Sl. No. 1; National

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

Aiming to develop a 3 or 4-layer washable cotton mask we have fabricated several coatings. Following points are noteworthy:

1. Prepared several zirconia/silica-based hydrophobic/hydrophilic sols and deposited coatings by dipping method on Govt. permitted woven cotton fabrics with good breathing performance.
2. The hydrophobicity and hydrophilicity of the sols were controlled to obtain coatings with different water contact angles. For this purpose, 2 sets of coatings were prepared by controlling the

covalently bonded hydrophobic components (a) fluorine-based and (b) alkyl-based.

3. Silica-based superhydrophobic (alkyl-based) coatings doped with ZnO were also prepared on the cotton fabrics in order to obtain antimicrobial activity along with hydrophobicity.

4. Following Table summarizes the water contact angle (WCA/degree) data of the coated fabrics measured using 6 L water droplets:

Sr. no.	ZrO2-based fluorine series (ZF)	Sr. no.	ZrO2-based alkyl series (ZA)	Sr. no.	SiO2-ZnO (SZ)
ZF1	~0-<5	ZA1	~0-<5	–	–
ZF2	55±2	ZA2	47±2	–	–
ZF3	98±2	ZA3	92±2	–	–
ZF4	118±2	ZA4	120±2	–	–
ZF5	145±2	ZA5	135±2	–	–
ZF6	156±3	ZA6	144±3	SZ1	152±3

As shown in the above table that the surface wettability (WCA) of the cotton fabrics can be controlled from close to 0 to as high as 156° by controlling the sol compositions.

5. All the above coatings are very stable and durable. They have tested by dipping in different pH solutions (acidic to alkaline) for about 7 days, and found to be almost unaffected.

6. Interestingly the SiO2-ZnO coating sols can be lyophilized to dryness and the solids can be redispersed to obtain the similar coatings on fabrics.

7. Coatings were characterized by FTIR, SEM, XRD, PL, antimicrobial (SiO2-ZnO) and WCA measurements.

Based on the above data further work is in progress.

Other activities:

Analysis of our previously acquired data and discussion with collaborators for paper publication.

Plan of Future Work Including Project

(i) The ongoing activity on the development of superhydrophilic/hydrophobic coatings on cotton fabrics will be completed.

(ii) New work to be undertaken: Main problems of rooftop solar installations are biofouling, dust accumulation, reflection loss. These are causing severe loss of transmission, and the performance of solar modules deteriorate quickly. To solve the above problems antireflection cum self-cleaning hydrophobic coatings on solar cover glass could be very useful. Though the related dip-coating process is known (De et al, Ind. Patent Appl. No. 201811023896, June 27, 2018), further development of suitable sols using cheap chemicals and industrially more viable processes (brush coating, drum coating, roller coating etc.) are need to be developed. Therefore, future work will be done in this line keeping in view technology development.

(iii) Some ongoing collaborative basic research activities (Plasmon mediated hot electron transfer in metal nanoparticles, abrasion resistant refractive index controlled coatings) and technological work for TRC will be continued.

Any other Relevant Information including social impact of research

(i) Attended the Scientific Advisory Council (SAC) meeting of Institute of Advanced Study in Science

and Technology (IASST, DST), Guwahati during July 17-18, 2020 as a committee member.

(ii) Acted as a member of the board of examiners (External examiner) of a PhD thesis "Engineering Fragility of Hybrid Organic-Inorganic Perovskite for Diverse Applications" of IIT Kanpur (October 2020).

(iii) Attended as external expert for the 2 assessment committees (AC-I: Scientist F to G and ACII: Scientist E to F & D to E) of International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI, Hyderabad) held on 04/01/2021 (AC-I) and 05/01/2021 (AC-II)

(iv) Attended the CRNN (Calcutta University) PhD committee meeting as an external member on 02/02/2021 and 26/02/2021.

(v) Attended as an external member of the "Faculty assessment committee of JNCASR" held on March 25, 2021.

(vi) Manuscript handling of the Royal Society of Chemistry (RSC) journals, Journal of Materials Chemistry A and Materials Advances as Associate Editor. Also attended virtual meetings as Editorial Board member of those journals.

(vii) Nominated several names of Indian researchers (including SNBNCBS) to the RSC as 'Emerging Investigators', 'Lectureship award', 'Invited authors', 'Fellowship (FRSC)' etc.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Sashthi Charan Mandal; Biophysics; Under progress
2. Edwine Tendong; Soft matter physics; Under progress; Tanusri Saha-Dasgupta (Supervisor)
3. Abhik Ghosh Moulik; Biophysics; Under progress
4. Rahul Karmakar; Soft matter physics; Under progress
5. Anirban Pal; Biophysics; Under progress
6. Suravi Pal; Soft matter physics; Under progress
7. Avik Sasmal; Not decided; Under progress
8. Konika Kole; Not decided; Under progress

b) Post-Docs

1. Ayatti Mallik; Biophysics

Teaching

1. Autumn semester; CB523; PhD; 5 students; with 1 (Gautam Gangopadhyay) co-teacher
2. Spring semester; PHY201; Integrated PhD

Publications

a) In journals

1. Satyabrata Maiti, Debasish Mukherjee, Parthajit Roy, **Jaydeb Chakrabarti** and Dhananjay Bhattacharyya, *Stacking geometry between two sheared Watson-Crick basepairs: Computational chemistry and bioinformatics based prediction*, Biochimica et Biophysica Acta (BBA) - General Subjects, 1864, 129600, 2020
2. Takashi Yoshimoto, Hisako Hashimoto, Mausumi Ray, Naoki Hayakawa, Tsukasa Matsuo, **Jaydeb Chakrabarti** and Hiromi Tobita, *Products of [2 + 2] Cycloaddition between a W≡Si Triple-bonded Complex and Alkynes: Isolation, Structure, and Non-classical Bonding Interaction*, Chemistry Letters, 49, 311-314, 2020
3. E Tendong, T Saha Dasgupta and **J Chakrabarti**, *Dynamics of water trapped in transition metal oxide-graphene nano-confinement*, Journal of Physics: Condensed Matter, 32, 325101, 2020
4. Piya Patra, Raja Banerjee and **Jaydeb Chakrabarti**, *Control of solvent exposure of cationic polypeptides in anionic environment*, Chemical Physics Letters, 750, 137503, 2020
5. Suman Dutta and **J. Chakrabarti**, *Length-scales of dynamic heterogeneity in a driven binary colloid*, Physical Chemistry Chemical Physics, 22, 17731-17737, 2020
6. Sasthi Charan Mandal, Lakshmi Maganti, Manas Mondal, **Jaydeb Chakrabarti**, *Microscopic insight to specificity of metal ion cofactor in DNA cleavage by restriction endonuclease EcoRV*, Biopolymers, 111, e23396, 2020
7. Aayatti Mallick Gupta, **Jaydeb Chakrabarti** and Sukhendu Mandal, *Non-synonymous mutations of*

SARS-CoV-2 leads epitope loss and segregates its variants, Microbes and Infection, 22, 598 – 607, 2020

Administrative duties

1. Head of the Department, CBMS
2. Convenor, SCOLP

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

1. D. Bhattacharya's group, SINP; Sl. No. 1; International

Areas of Research

Statistical mechanics of soft matter and biological systems

Length scale of dynamic heterogeneity:

Here we study by Brownian Dynamics simulations a system of oppositely charged colloid subject to a constant electric field. We consider sufficiently strong electric field where the like charges in the system form macroscopic lanes. We examine spatial correlation lengths characterizing structural order and that between particles of different mobility. We find that the correlation lengths show dependence on the observation time. Moreover, slow particles are responsible for formation of lanes and offer independent length-scale in the steady states.[Ref: Physcial Chemistry Chemical Physics, 22, 17731-17737, 2020.

Microscopic insight to specificity of metal ion cofactor in DNA cleavage by restriction endonuclease EcoRV

Restriction endonucleases protect bacterial cells against bacteriophage infection by cleaving the incoming foreign DNA into fragments. In presence of Mg^{2+} ions, EcoRV is able to cleave the DNA but not in presence of Ca^{2+}. We make an attempt to understand this difference using conformational thermodynamics. We calculate the changes in conformational free energy and entropy of conformational degrees of freedom, like DNA base pair steps and dihedral angles of protein residues in Mg^{2+}-EcoRV-DNA complex compared to Ca2+-EcoRV-DNA complex using all-atom Molecular Dynamics (MD) trajectories. We find that the base pairs in cleavage region are highly disordered compared to Mg2+-EcoRV-DNA. One of the acidic residues ASP90, co-ordinating to the metal ion, is conformationally destabilized and disordered, while basic residue LYS92 gets conformational stability and order. The changes in conformational stability and order of the base pair steps and the residues lead to cofactor sensitivity of the enzyme. [Ref: Biopolymers, 2020; e23396.]

Plan of Future Work Including Project

1. Modification membrane properties in presence of short biomolecules, like polypetide, Hyaluronic acid and so forth.
2. Phase behaviour of ligand capped nanoparticles
3. Manipulation of reverse osmosis membranes
4. Time dependent perturbation of colloidal structures

Manik Pradhan

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Sanchi Maithani; Cavity Ring-down Spectroscopy and Evanescent Wave; Thesis submitted
2. Mithun Pal; Quantum Cascade Laser Spectroscopy; Awarded
3. Akash Das; Quantum weak measurements in 2D materials; Under progress
4. Biswajit Panda; High-resolution molecular spectroscopy; Under progress
5. Ardhendu Pal; Cavity ring-down spectroscopy; Under progress
6. Vishal Agarwal; Nanomaterials and Spectroscopy; Under progress; Manik Pradhan (Co-supervisor)
7. Soumen Mandal; Optical beam shifts; Under progress
8. Sudip Mandal; Surface Plasmon Resonance; Under progress

b) Post-Docs

1. Arpan Maiti; Nano Materials and surface plasmon resonance
2. Arun Bera; Gas sensing and nano materials
3. Jayeta Banerjee; Nano materials and surface plasmon resonance

c) External Project Students / Summer Training

1. Sayani Bhattacharya; Breath Analysis and medical diagnosis; TRC Project Student (SNBNCBS)
2. Saikat Ghosh; Nano Materials and isotope analysis; SERB Project Student
3. Debatri Ghosh; Breath analysis and medical diagnosis; TRC Project Assistant (SNBNCBS)

Teaching

1. Spring semester; Project Research III (PHY 401); Title: Quantum weak measurements and applications to material science; Integrated PhD; 1 student
2. Spring semester; Project Research III (PHY 401); Title: Surface plasmon resonance and its applications to condensed matter physics; Integrated PhD; 1 student
3. Spring semester; Methods in Experimental Physics (PHY 391) Shared; Integrated PhD; 13 students
4. Spring semester; Summer Project Research I (PHY 292); Title: Laser Spectroscopy: techniques and applications in environmental and biomedical sciences; Integrated PhD; 1 student
5. Autumn semester; Project Research II (PHY 304); Title: Laser Spectroscopy: techniques and applications in environmental and biomedical sciences; Integrated PhD; 1 student

Publications

a) In journals

1. Abhijit Maity, Sanchi Maithani, Ardhendu Pal and **Manik Pradhan**, *High-resolution spectroscopic probing of ortho and para nuclear-spin isomers of*

heavy water in the gas phase, Chemical Physics, 541, 111041, 2021

2. Abhijit Maity, Sanchi Maithani, and **Manik Pradhan**, *Cavity Ring-Down Spectroscopy: Recent Technological Advancements, Techniques, and Applications*, Analytical Chemistry, 93, 388-416, 2021
3. Akash Das and **Manik Pradhan**, *Wavelength and chemical potential dependence of optical beam shifts in graphene*, Journal of Modern Optics, 68, 146 – 152, 2021
4. Akash Das and **Manik Pradhan**, *Quantum weak measurement of Goos-Hänchen shift in monolayer MoS_2*, Journal of the Optical Society of America B, 38, 387 – 391, 2021
5. Puspendu Barik and **Manik Pradhan**, *Plasmonic luminescent solar concentrator*, Solar Energy, 216, 61 – 74, 2021
6. Akash Das and **Manik Pradhan**, *Investigation of the optical beam shifts for monolayer MoS_2 using polarimetric technique*, Journal of Optics, 22, 105004, 2020
7. Sanchi Maithani and **Manik Pradhan**, *Cavity ring-down spectroscopy and its applications to environmental, chemical and biomedical systems*, Journal of Chemical Sciences, 132, 114, 2020
8. Akash Das and **Manik Pradhan**, *Quantum weak measurement of Goos–Hänchen effect of light in total internal reflection using a Gaussian-mode laser beam*, Laser Physics Letters, 17, 066001, 2020

b) Conference proceedings / Reports / Monographs / Books

1. Dheeraj Singh, Manik Pradhan and Arnulf Materny, "Modern Techniques of Spectroscopy: Basics, Instrumentation and Applications": Springer Nature (ISSN: 2363-5096), 2021
2. Abhijit Maity, Mithun Pal and Manik Pradhan, "Cavity Ring-Down Spectroscopy": "Modern Techniques of Spectroscopy: Progress in Optical Science and Photonics, vol 13": Springer Nature (ISBN: 978-981-33-6083-9), 2021
3. Mithun Pal and Manik Pradhan, "Quantum Cascade Laser Spectroscopy": "Modern Techniques of Spectroscopy: Progress in Optical Science and Photonics, vol 13": Springer Nature (ISBN: 978-981-33-6083-9), 2021
4. Mithun Pal and Manik Pradhan, "Exhaled Breath CH_4 and H_2S Sensing using Mid-IR Quantum Cascade Laser (QCL)": Progress in Optomechatronics: Springer Nature (ISBN: 978-981-15-6467-3), 2020
5. Abhijit Maity, Sanchi Maithani and Manik Pradhan, "Cavity Ring-Down Spectroscopy: Recent Technological Advances and Applications": "Molecular and Laser Spectroscopy: Advances and Applications Volume 2, Elsevier, (ISBN: 978-0-12-818870-5), 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Structure and Dynamics in Biology, Chemistry and Material Science; Nov 16, 2020; IIT Roorkee; 16-20 November, 2020

Administrative duties

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

Patents Taken and Process Developed with Details

1. "A system and kit for non-invasive detection of peptic ulcer disease, non-ulcerous dyspepsia and Helicobacter pylori infection", FER submitted on 25/02/2021; E-91/872/2021/KOL; Applied
2. "A Gas-sensing system for selective detection of NO gas and a method for fabricating the same", FER submitted on 19/03/2021; E-91/1284/2021/KOL; Applied
3. "Dioxo vanadium (V) complex as carbonic anhydrase inhibitor", Date of Granting: 16/06/2020; 338829; Granted

Awards, Recognitions

1. Fellow of Royal Society of Chemistry (FRSC)
2. Fellow of Linnean Society of London (FLS)
3. Early Career Board Member of Analytical Chemistry of American Chemical Society (ACS)
4. Editorial Board Member of Chemical Physics Impact (Elsevier)

Membership of Learned Societies

1. Americal Chemical Society (ACS)
2. Royal Society of Chemistry (RSC)
3. Chemical Research Society of India (CRSI)
4. Indian Physics Association (IPA)
5. Indian Laser Association (ILA)
6. Indian Society of Chemists and Biologists (ISCB)
7. Research Society for the Study of Diabetes in India (RSSDI)

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; DST; 2017-2021; Co-PI

Areas of Research

Laser Spectroscopy, High-resolution Molecular Spectroscopy, Applications of Laser Spectroscopy in Environmental, Biomedical and Material Sciences

1. Cavity Ring-Down Spectroscopic Detection of Nuclear Spin Isomers of Heavy Water in the Gas Phase:

Doubly deuterated water (D_2O) exhibits two distinct nuclear spin-isomers, ortho and para, which have not much been studied and there is hardly any information about the spin-exchange processes of D_2O. Here, we investigated the nuclear-spin quantum states of D_2O in gas phase by evaluating the ortho-to-para ratio (OPR) using high-resolution cavity ring-down spectroscopy coupled with quantum cascade laser in the mid-IR spectral region at 7.8m. We experimentally achieved an OPR of (1.950.16):1 for D_2O spin-isomers in the isolated gaseous phase. We further analyzed the OPR of the residual D_2O in a 1:1 mixture of D_2O and H_2O, and observed indications of potential alteration of thermodynamic probability of ortho and para nuclear-spin states of D_2O associated with the D-H exchange reaction in the system. Our findings pave the way to probe directly the spin behaviour of D_2O molecules in the gas phase and thus fostering exploration of spin-dependent chemistry in a wide range of chemical and biological systems.

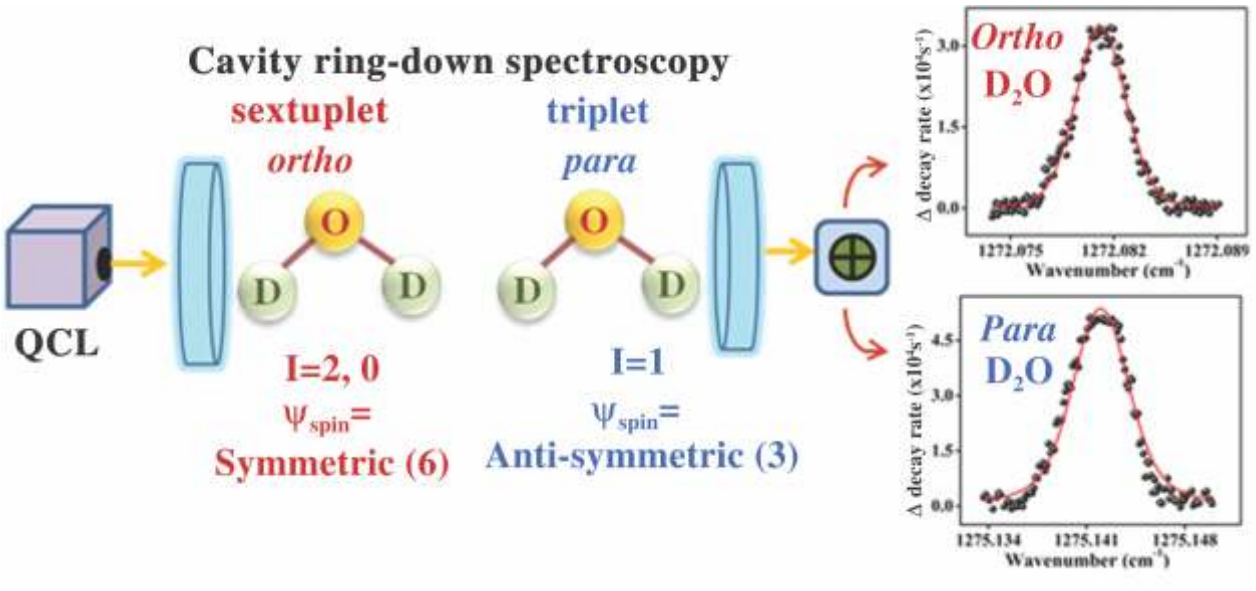

Figure 1: Optical detection of nuclear-spin isomers of D_2O

2. Development of Quantum Weak Measurement Technique for Optical Beam Shifts Measurements:

We have developed the quantum weak measurement (QWM) technique for the demonstration of the Goos-Hänchen (GH) shift of light in total internal reflection (TIR) condition for a Gaussian mode laser beam of 633nm passing through an air-glass interface. The QWM technique has been exploited as a weak value amplification scheme to observe the amplified optical GH shift. The amplification of the GH shift depends on the angular deviation from the exact orthogonal position required for weak measurement. We subsequently investigated in detail the profiles of the beam pattern and their horizontal and vertical shifts. We have also presented that the beam shift values obtained experimentally agree well with the theoretical results for a specific choice of angle of deviation from the orthogonal condition of weak measurement. Our results clearly demonstrate the advantages of the QWM technique for amplifying and detecting tiny optical beam shift effects and may provide important applications in precision metrology.

Plan of Future Work Including Project

1. Development of Broadband Cavity Enhanced Absorption Spectroscopy (BBCEAS) technique for trace molecule detection.
2. Exploration of Spin-chemistry in gas phase molecules
3. Investigation of optical beam shifts in various 2D materials using quantum weak measurement.

Any other Relevant Information including social impact of research

1. "Pyro-Breath" technology has transferred to a startup company for commercialization. The device diagnoses H. pylori bacterial infection in stomach and various gastric disorders by human exhaled breath analysis without going for painful endoscopic based biopsy tests.

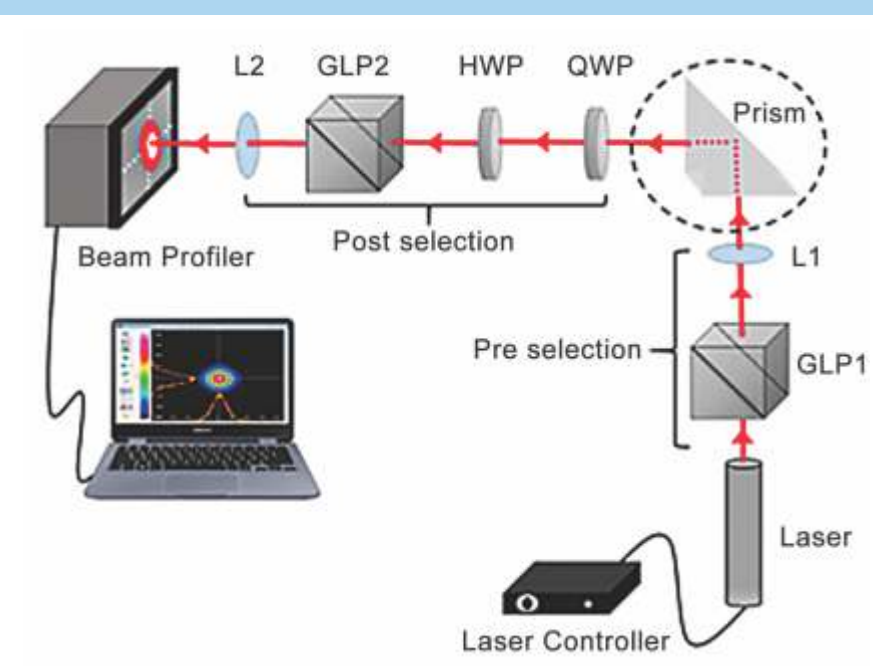

Figure 2. Experimental setup for Quantum Weak Measurement

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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; Under progress
2. Saikat Pal; Studies on the Effects of Different Crowding agents on Protein FoldingUnfolding Process and its Kinetics as well as Activity; Under progress
3. Partha Pyne; Studies of Some Biophysical Processes Using Ultrafast Spectroscopic Techniques; Under progress
4. Anulekha De; Nanomagnetism; Thesis submitted; Prof. Anjan Barman (Co-supervisor)
5. Didhiti Bhattacharya; Opto-electronic, Electrical and Spectroscopic studies of two dimensional materials; Under progress; Prof. Samit K. Ray (Co-supervisor)
6. Sumana Pyne; Application of Ultrafast Spectroscopy in Biological Systems; Under progress
7. Sudip Majumder; Nanomagnetism; Under progress; Prof. Anjan Barman (Co-supervisor)
8. ia Saha; Studies on the Effects of Different Crowding agents on Protein Folding Unfolding Process and its Kinetics as well as Activity; Under progress
9. Subhajit Singha; Application of Ultrafast Spectroscopy in Chemical/Biological Systems; Under progress

b) Post-Docs

1. Bibhab Bandhu Majumdar; Protein folding under stressed environments

Teaching

1. Autumn semester; PHY 301 (Atomic and Molecular Physics); Integrated PhD; 12 students; with 1 (Prof. Anjan Barman) co-teacher
2. Autumn semester; CB 527 (Molecular Physics & Spectroscopy); PhD; 1 student; with 1 (Prof. Anjan Barman) co-teacher
3. Autumn semester; PHY 501 (Research Methodology); PhD; 20 students; with 1 (Prof. Atindra Nath Pal) co-teacher
4. Spring semester; PHY 405 (Biological Physics); Integrated PhD; 5 students

Publications

a) In journals

1. Debasish Das Mahanta and **Rajib Kumar Mitra**, *Connection of large amplitude angular jump motions with temporal heterogeneity in aqueous solutions*, Physical Chemistry Chemical Physics, 22, 9339-9348, 2020
2. S Bayan, D Bhattacharya, **R K Mitra** and **S K Ray**, *Self-powered flexible photodetectors based on Ag nanoparticle-loaded g-C_3N_4 nanosheets and*

PVDF hybrids: role of plasmonic and piezoelectric effects, Nanotechnology, 31(36):365401, 2020

3. Didhiti Bhattacharya, Sayan Bayan, **Rajib K. Mitra**, and **Samit K. Ray**, *Flexible Biomechanical Energy Harvesters with Colossal Piezoelectric Output (2.07 V/kPa) Based on Transition Metal Dichalcogenides-Poly(vinylidene fluoride) Nanocomposites*, ACS Applied Electronic Materials, 2, 3327 – 3335, 2020
4. S. Bayan, D. Bhattacharya, **R. K. Mitra** and **S. K. Ray**, *Two-dimensional graphitic carbon nitride nanosheets: a novel platform for flexible, robust and optically active triboelectric nanogenerators*, Nanoscale, 12, 21334 – 21343, 2020
5. Sk Imadul Islam, Arindam Das and **Rajib Kumar Mitra**, *Excited state proton transfer in reverse micelles: Effect of temperature and a possible interplay with salvation*, Journal of Photochemistry and Photobiology A: Chemistry, 404, 112928, 2021
6. Partha Pyne, Nirnay Samanta, Himanshu Gohil, S. S. Prabhu and **Rajib Kumar Mitra**, *Alteration of water absorption in the THz region traces the onset of fibrillation in proteins*, Chemical Communications, 57, 998 – 1001, 2021

Administrative duties

1. Faculty in-charge, students affairs
2. Member, Admission committee
3. Chairman, Internal Standing Technical Committee; Convener, External Technical Committee
4. Member, Students' Curriculum & Research Evaluation (SCREC) Committee
5. Warden, Students hostel

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. S S Prabhu at TIFR, Mumbai; Sl. No. 6; National

Areas of Research

Experimental biophysical chemistry, spectroscopy

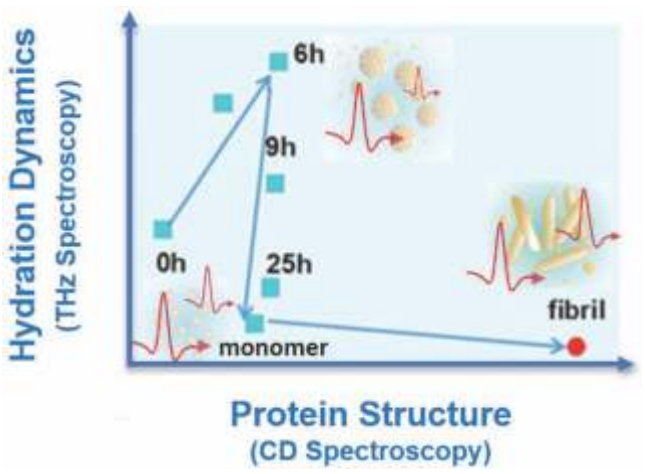
Considering the heterogeneity existing in real biological environments we investigate the excited state proton transfer (ESPT) process in a bio-mimicking reverse micellar (RM) systems. We have made a detailed study on the ESPT process of a photo-acid-luciferin at different temperatures in RMs composed of: anionic AOT, cationic DDAB, and neutral Igepal-520 using steady state and time resolved fluorescence measurements. We found that with increasing temperature both solvation as well as the ESPT rate accelerate, however, the extent of the increase is RM specifc, and they even not complement each other. Our study has established the pivotal role of solvation to be considered to explain ESPT process, specially in constrained environments like in RMs.

We have made a simulation investigation on the large angular jumps that take place when a rotating water molecule exchanges its hydrogen bond (H-bond) identity. This motion differs from the small angular diffusional steps occurring within short time intervals which define the 'Debye diffusion model' of water dynamics. Our investigation was intended to whether these two processes do eventually complement each other. Orientational dynamics of water in its mixture with a small hydrophobic molecule 1,2-dimethoxy ethane (DME) was studied microscopically using the all-atom classical molecular dynamics (MD) simulation technique. We found that the reorientational motions of water molecules are governed by continuous making and breaking of intermolecular H-bonds with their partners. We characterise these H-bond reorientation motions with the description of the ''large amplitude angular jump model'' and explore the coupling between the rotational

and translational motions. By following the trajectories of each molecule in the solutions we describe the orientational dynamics of liquid water with a 'continuous time random walk' (CTRW) approach. Finally, we explored the diffusivity distribution through the jump properties of the water molecules, which successfully leads to the inherent transient heterogeneity of the solutions. We observed that the heterogeneity increases with increasing DME content in the mixtures. Our study correlates the coupling between rotational and translational motions of water molecules in the mixtures.

A scalable, flexible, cost-effective self-poled piezoelectric nanogenerator was fabricated by using chemically exfoliated layered MoS_2 nanosheets embedded in poly (vinylidene fluoride) PVDF polymers. This nanogenerator was able to produce 22V under 10.6kPa mechanical impact leading to an unprecedented piezoelectric output (2.07 V/kPa) using a two-dimensional materials, as well as was able to generate piezoelectric output voltage by mechanical bending via strain, with a piezoelectric energy conversion efficiency of ~ 17.8%, which was capable to drive multiple commercial light emitting devices. It also appeared as an excellent bio-mechanical energy harvesting device which offers an excellent power density of ~88.5 $\mu W/cm^2$ upon finger tapping (~3.1 kPa).

Using terahertz spectroscopy, we established the alteration of the collective hydration of water during the fibrillation process (native - intermediate - fibril) of a model protein bovine serum albumin. This is one of the very first reports on the dynamics of water during fibril formulation. The label-free THz study concludes that water dynamics change systematically with protein conformational changes as it experiences a hydrophobic environment during the initial protein unfolding process, followed by the release of bound water during oligomerization and finally the hydrophobic interior of the fibril. Our study unambiguously concluded a strong correlation between the change in hydration (as obtained from THz spectroscopy) and the structural perturbation (as evidenced from the CD signal) as two clear transitions were observed in the fibrillation pathways. Such in vitro study is a primary step towards experimentally detecting the onset of the fibrillation process via THz spectroscopy of the water network structure.



Plan of Future Work Including Project

1. We plan to underline the inherent role of solvation dynamics on the excited state proton transfer (ESPT) process of some photo-acids. We would use various solvents of different polarities and their mixtures (both in bulk and encapsulated in reverse micelles) and would apply two different time-resolved techniques (fluorescence and transient absorption) to accomplish this.
2. Fabrication of efficient flexible photosensitive piezoelectric nanogenerators (PENG) using composites of polyvinylidene fluoride (PVDF) and chemically exfoliated tungsten disulfide (WS2) nanosheets. Such device is expected to produce an enormously high output voltage compared to the conventional ones. We will also explore photo-response of such materials.
3. 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.

4. 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.

5. 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.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Juriti Rajbangshi; Computer Simulations of Complex Chemical Systems; Thesis submitted
2. Ejaj Tarif; Experimental studies of deep eutectics; Awarded
3. Kajal Kumbhakar; Experimental Studies of Energy Materials; Awarded
4. Atanu Baksi; Computer Simulations of Aqueous & Other Systems; Thesis submitted
5. Narayan Maity; Experimental Studies of Metastable and Self-Organised Systems; Under progress
6. Jayanta Mondal; Experimental Studies of Ionic and Neutral Deep Eutectics; Under progress
7. Dhrubajyoti Maji; Computer Simulations of Deep Eutectics; Under progress
8. Amrita Mondal; Experimental Studies of Complex Chemical Systems; Under progress
9. Sudipta Mitra; Computer Simulations of Relaxation Dynamics in Condensed Phases; Under progress
10. Rik N Mukherjee; Computer Simulations of Ionic Deep Eutectic and Other Systems; Under progress

Publications

a) In journals

1. Swarup Banerjee, Pradip Kr. Ghorai, Suman Das, Juriti Rajbangshi, and **Ranjit Biswas**, *Heterogeneous dynamics, correlated time and length scales in ionic deep eutectics: Anion and temperature dependence*, The Journal of Chemical Physics, 153, 234502, 2020
2. Atanu Baksi and **Ranjit Biswas**, *Does Confinement Modify Preferential Solvation and H-Bond Fluctuation Dynamics? A Molecular Level Investigation through Simulations of a Bulk and Confined Three-Component Mixture*, The Journal of Physical Chemistry B, 124, 11718 – 11729, 2020
3. Juriti Rajbangshi, Swarup Banerjee, Pradip Kr. Ghorai and **Ranjit Biswas**, *Cosolvent polarity dependence of solution structure in [BMIM] [PF_6] + acetonitrile/1, 4-dioxane/hexane binary mixtures: Insights from composition dependent Voronoi polyhedra analyses, iso-surfaces and radial distribution functions*, Journal of Molecular Liquids, 317, 113746, 2020
4. Atanu Baksi, Pradip Kr. Ghorai, and **Ranjit Biswas**, *Dynamic Susceptibility and Structural Heterogeneity of Large Reverse Micellar Water: An Examination of the Core–Shell Model via Probing the Layer-wise Features*, The Journal of Physical Chemistry B, 124, 2848-2863, 2020

Areas of Research

Physical Chemistry Chemical Physics, Experiments (Spectroscopy), Theory & Simulations

Exploring the local environment around a dissolved solute in a bulk aqueous solution of alcohol and assessing the impact of confinement on the solvation structure is an important topic yet much less studied. Such a study is important because it can provide critical information regarding the miscibility of an amphiphilic drug after delivery at a designated nanoscopic site and the subsequent release. The present molecular dynamics simulation study reports an in-depth investigation of the composition-dependent solvation structure around a dissolved hydrophobic solute, coumarin 153 (C153), in ambient binary mixtures of methanol and water in both bulk and under confinement. The confinement is a spherical sodium bis(2-ethylhexyl) sulfosuccinate (AOT) reverse micelle with a diameter of 55 Å. Inter- and intraspecies H-bond fluctuation dynamics have been monitored and compared with those from the corresponding bulk binary mixtures. It has been observed that confinement accentuates the preferential solvation phenomenon and facilitates the di-mixing of mixture components. The present study reveals that the tetrahedral H-bond network of neat liquid water becomes severely affected upon the addition of methanol, which becomes further distorted under confinement. Interestingly, structural hydrogen bond relaxation timescales become longer in confined binary mixtures than in bulk binary mixtures.

Heterogeneous relaxation dynamics often characterizes deep eutectic solvents. Extensive and molecular dynamics simulations have been carried out in the temperature range, $303 \leq T/K \leq 370$, for studying the anion and temperature dependencies of heterogeneous dynamics of three different ionic acetamide deep eutectics: acetamide + LiX, X being bromide (Br^-), nitrate (NO_3^-), and perchlorate (ClO_4^-). These systems are chosen because the fractional viscosity dependence of average relaxation rates reported by various measurements has been attributed to the heterogeneous dynamics of these systems. Simulations performed here attempt to characterize the heterogeneous relaxation dynamics in terms of correlated time and length scales and understand the solution inhomogeneity in microscopic terms. Additionally, simulation studies for pure molten acetamide have been performed to understand the impact of ions on motional features of acetamide in these ionic deep eutectic systems. The computed radial distribution functions suggest microheterogeneous solution structure and dependence upon anion identity and temperature. A significant plateau in the simulated time dependent mean squared displacements indicates pronounced cage-rattling and inhomogeneity in relaxation dynamics. Simulated diffusion coefficients for acetamide and ions show decoupling from the simulated viscosities of these deep eutectics. Calculated two- and four-point correlation functions reveal the presence of dynamic heterogeneity even at 180 K above the measured thermodynamic glass transition temperature (Tg). Further analyses reveal the existence of multiple timescales that respond strongly to the rise in solution temperature. The simulated dynamic structure factor and overlap function relaxations show strong stretched exponential relaxations. The simulation results support the experimental observation that the bromide system is the most dynamically heterogeneous among these three systems. Correlated length scales show much weaker anion and temperature dependencies with an estimated length of 1 nm, suggesting formation of clusters at the local level as the origin for the micro-heterogeneous nature of these ionic deep eutectics.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Damayanti Bagchi; Spectroscopic and Microscopic Studies on Nanohybrids of Inorganic Metal-oxides with Medicinally Important Organic Ligands; Awarded
2. Probir Sarkar; Spectroscopic Studies on Molecules and Nanomaterials for Potential Applications in Medical Diagnosis and Environmental Pollution Monitoring; Awarded
3. Priya Singh; Spectroscopic Studies on Structure, Function and Dynamics of Biological Macromolecules in Physiologically Relevant and Engineered Environments; Awarded
4. Jayita Patwari; Photophysical Studies on Light Harvesting Nanomaterials for Improved Solar Energy Conversion; Awarded
5. Tuhin Maji; Combined experimental and computational investigation on optical and catalytic properties of functionalized metal oxides; Thesis submitted; Dr. Debjani Karmakar, HBNI, BARC (Co-supervisor)
6. Aniruddha Adhikari; Studies on Therapeutic Potential of Various Nanomaterials and Ethnobotanical Ingredients in Preclinical Disease Model; Thesis submitted
7. Soumendra Singh; Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications; Thesis submitted
8. Animesh Halder; Development and Validation of Optical Methodologies for Potential Biomedical and Environmental Applications; Thesis submitted
9. Arka Chatterjee; Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis; Under progress
10. Arpan Bera; Spectroscopic Studies on Functional Nanohybrids and their Potential Biological Application; Under progress
11. Dipanjan Mukherjee; Microfluidic-Assisted Optical Spectroscopic Studies on Biomolecular Recognition in Physiologically Relevant Engineered Environments; Under progress; Professor R. Das, West Bengal State University (Co-supervisor)
12. Md. Nur Hasan; Optical spectroscopy and Ab-initio study on biocompatible nanohybrids for their potential biomedical and environmental applications; Under progress; Dr. Debjani Karmakar, HBNI, BARC (Co-supervisor)
13. Susmita Mondal; Studies on Biochemical and Molecular aspects of Redox Modulatory Theranostic Nanomaterials in Preclinical Disease Model; Under progress
14. Arnab Samanta; Synthesis and Characterization of Nanoscale Alloys and Metal Oxides for Potential Application in Catalysis; Under progress; Dr. Subhra Jana, SNBNCBS (Co-supervisor)
15. Amrita Banerjee; Multi-parameter detection using optical spectroscopy for monitoring and control of bio-medical anomalies, food adulteration and

environmental pollution; Under progress; Dr. Subhadipta Mukhopadhyay, Jadavpur University (Co-supervisor)

16. Loapamudra Roy; Exploration of Optical Methodologies for the Development of Prototypes in the Real-world Application; Under progress; Professor Kallol Bhattacharya, Calcutta University, Kolkata (Co-supervisor)

17. Ria Ghosh; In-vitro and In-vivo investigation on self-organised assemblies for their potential drug delivery activities; Under progress; Professor Maitree Bhattacharyya, Calcutta university (Co-supervisor)

18. Nivedita Pan; Photophysical Studies on Hybrid Nanomaterials for manifold application; Under progress

b) External Project Students / Summer Training

1. Nairit Das; Development of Device for Food Safety; IIT KGP
2. Deepsikha; Development of Biomedical Instrument; Jamia Milia University
3. Neha Bhattacharya; Spectroscopic Studies on Biomaterials and Development of Small Spectroscopy-based Devices for Potential Application in Biomedical Diagnosis and Therapeutic Strategy; C.U
4. Mahasweta Goswami; Development of Biomedical Instrument for real world application; VIT

Teaching

1. Spring semester; PHY191; Integrated PhD; 13 students; with 1 (Dr. Soumen Mondal) co-teacher

Publications

a) In journals

1. Pritam Biswas, Aniruddha Adhikari, Susmita Mondal, Monojit Das, Siddhartha Sankar Bhattacharya, Debasish Pal, Sudeshna Shyam Choudhury and **Samir Kumar Pal**, *Synthesis and spectroscopic characterization of a zinc oxide-polyphenol nanohybrid from natural resources for enhanced antioxidant activity with less cytotoxicity*, Materials Today: Proceedings, 43, 3481-3486, 2021
2. Susmita Mondal, Aniruddha Adhikari, Manali Singh, Ria Ghosh, Mahasweta Goswami, Pritam Biswas and **Samir Kumar Pal**, *Spectroscopic study on the interaction of Co^{2+} with citrate-Mn_3O_4: Towards the development of nanotherapy against cobalt toxicity*, Materials Today: Proceedings, 43, 3692-3697, 2021
3. 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 and **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
4. Md. Nur Hasan, Tuhin Kumar Maji, Uttam Pal, Arpan Bera, Damayanti Bagchi, Animesh Halder, Saleh A. Ahmed, Jabir H. Al-Fahemi, Tahani M. Bawazeer, Tanusri Saha-Dasgupta and **Samir Kumar Pal**, *Wide bandgap semiconductor-based novel nanohybrid for potential antibacterial activity: ultrafast spectroscopy and computational studies*, RSC Advances, 10, 38890 - 38899, 2020
5. Soumendra Singh, Animesh Halder, Oindrila Sinha, Nilasha Chakrabarty, Tanima Chatterjee, Aniruddha Adhikari, Priya Singh, Deep Shikha, Ria Ghosh, Amrita Banerjee, Partha Pratim Das Mahapatra, Amit Mandhar, Maitree Bhattacharyya, Surajit Bose, Saleh A. Ahmed, Ahmed Alharbi, Ahmed M. Hameed and **Samir Kumar Pal**, *Spectroscopic Studies on the Biomolecular Recognition of Toluidine Blue: Key Information Towards Development of a Non-Contact, Non-Invasive Device for Oral Cancer Detection*, Frontiers in Oncology, 10, 529132, 2020
6. Saleh A. Ahmed, Md. Nur Hasan, Damayanti Bagchi, Hatem M. Altass, Moataz Morad, Ismail I. Althagafi, Ahmed M. Hameed, Ali Sayqal, Abd El Rahman S. Khder, Basim H. Asghar, Hanadi A. Katouah and **Samir Kumar Pal**, *Nano-MOFs as targeted drug delivery agents to combat antibiotic-*

resistant bacterial infections, Royal Society Open Science, 7, 200959, 2020

7. Swati Rani, Damayanti Bagchi, Uttam Pal, Mamta Kumari, Manisha Sharma, Arpan Bera, Javaid Shabir, **Samir Kumar Pal**, Tanusri Saha-Dasgupta, and Subho Mozumdar, *The Role of Imidazolium-Based Surface-Active Ionic Liquid to Restrain the Excited-State Intramolecular H-Atom Transfer Dynamics of Medicinal Pigment Curcumin: A Theoretical and Experimental Approach*, ACS Omega, 5, 25582 – 25592, 2020

8. ipanjan Mukherjee, Tatini Rakshit, Priya Singh, Suman Mondal, Debashish Paul, Manisha Ahir, Arghya Adhikari, Theja P. Puthiyapurayil, Praveen Kumar Vemula, Dulal Senapati, Ranjan Das and **Samir Kumar Pal**, *Differential flexibility leading to crucial microelastic properties of asymmetric lipid vesicles for cellular transfection: A combined spectroscopic and atomic force microscopy studies*, Colloids and Surfaces B: Biointerfaces, 196, 111363, 2020

9. Essam M. Hussein, Nizar El Guesmi, Ziad Moussa, Uttam Pal, **Samir K. Pal,** Tanusri Saha Dasgupta, and Saleh A. Ahmed, *Unprecedented Regio- and Stereoselective Synthesis of Pyrene-Grafted Dispiro[indoline-3,2 -pyrrolidine-3 ,3 -indolines]: Expedient Experimental and Theoretical Insights into Polar [3 + 2] Cycloaddition*, ACS Omega, 5, 24081-24094, 2020

10. Tuhin Kumar Maji, Aswin J. R, Subhrajit Mukherjee, Rajath Alexander, Anirban Mondal, Sarthak Das, Rajendra Kumar Sharma, Naba Kumar Chakraborty, Kinshuk Dasgupta, Anjanashree M. R. Sharma, Ranjit Hawaldar, Manjiri Pandey, Akshay Naik, Kausik Majumdar, **Samir Kumar Pal**, K. V. Adarsh, Samit Kumar Ray, and Debjani Karmakar, *Combinatorial Large-Area MoS_2/Anatase–TiO_2 Interface: A Pathway to Emergent Optical and Optoelectronic Functionalities*, ACS Applied Materials & Interfaces, 12, 44345 – 44359, 2020

11. Nairit Das, Neha Bhattacharyya, Soumendra Singh, Animesh Halder, Deep Shikha and **Samir Kumar Pal**, *Simultaneous measurement of atmospheric moisture and temperature in the presence of suspended particulates using ultrasonic technique*, Japanese Journal of Applied Physics, 59, 096503, 2020

12. Tuhin Kumar Maji, Kumar Vaibhav, **Samir Kumar Pal** & Debjani Karmakar, *Broken symmetries and the related interface-induced effects at Weyl-system TaAs in proximity of noble metals*, Scientific Reports, 10, 14438, 2020

13. Soumendra Singh, Animesh Halder, SK. Abdul Mohid, Damayanti Bagchi, Oindrila Sinha, Amrita Banerjee, Probir Kumar Sarkar, Anirban Bhunia, Sanjay K. Ghosh, Amitabha Mitra and **Samir Kumar Pal**, *Nonthermal Atmospheric Plasma-Induced Cellular Envelope Damage of Staphylococcus aureus and Candida albicans Biofilms: Spectroscopic and Biochemical Investigations*, IEEE Transactions on Plasma Science, 48, 2768-2776, 2020

14. Debashish Paul, Anuradha Roy, Arpita Nandy, Brateen Datta, Prateeka Borar, **Samir Kumar Pal**, Dulal Senapati, and Tatini Rakshit, *Identification of Biomarker Hyaluronan on Colon Cancer Extracellular Vesicles Using Correlative AFM and Spectroscopy*, The Journal of Physical Chemistry Letters, 11, 5569-5576, 2020

15. Tuhin Kumar Maji, Kumar Vaibhav, Ranjit Hawaldar, K. V. Adarsh, **Samir Kumar Pal** and Debjani Karmakar, *Intriguing electronic and optical prospects of FCC bimetallic two-dimensional heterostructures: epsilon near-zero behavior in UV-Vis range*, Physical Chemistry Chemical Physics, 22, 16314-16324, 2020

16. Animesh Halder, Aniruddha Adhikari, Ria Ghosh, Soumendra Singh, Amrita Banerjee, Nilanjana Ghosh, Arnab Madhab Bhattacharya, Shrabani Mandal, Prantar Chakrabarti, Debasis Bhattacharyya, Hatem M. Altass, Moataz Morad, Saleh A. Ahmed, Asim Kumar Mallick and **Samir Kumar Pal**, *Large scale validation of a new non-invasive and non-contact bilirubinometer in neonates with risk factors*, Scientific Reports, 10 11149, 2020

17. Saleh A. Ahmed, Md. Nur Hasan, Damayanti Bagchi, Hatem M. Altass, Moataz Morad, Rabab S. Jassas, Ahmed M. Hameed, Jayita Patwari, Hussain Alessa, Ahmed Alharbi, and **Samir Kumar Pal**,

Combating Essential Metal Toxicity: Key Information from Optical Spectroscopy, ACS Omega, 5, 15666–15672, 2020

18. Kanika Kole, Animesh Halder, Soumendra Singh, Arnab Samanta, Sankar Das, Asim Kumar Kundu, Debasis Bhattacharyya, **Samir Kumar Pal**, and Subhra Jana, *Chromogenic-Functionalized Silica Nanoflower Composites for the Detection of Carbon Dioxide*, ACS Applied Nano Materials, 3, 4321-4328, 2020

19. Tuhin Kumar Maji, Md. Nur Hasan, Sangeeta Ghosh, Dirk Wulferding, Chinmoy Bhattacharya, Peter Lemmens, Debjani Karmakar and **Samir Kumar Pal**, *Development of a magnetic nanohybrid for multifunctional application: From immobile photocatalysis to efficient photoelectrochemical water splitting: A combined experimental and computational study*, Journal of Photochemistry and Photobiology A: Chemistry, 397, 112575, 2020

20. Ravinder Kumar, Debiprasad Panda, Debabrata Das, Arka Chatterjee, Binita Tongbram, Jhuma Saha, Sourabh Upadhyay, Raman Kumar, **Samir Kumar Pal** and Subhananda Chakrabarti, *Realization of high-quality InGaAs/GaAs quantum dot growth on Ge substrate and improvement of optical property through ex-situ ion implantation*, Journal of Luminescence, 223, 117208, 2020

21. Sudip Nag, Damayanti Bagchi, Dhrubajyoti Chattopadhyay, Maitree Bhattacharyya, **Samir Kumar Pal**, *Protein assembled nano-vehicle entrapping photosensitizer molecules for efficient lung carcinoma therapy*, International Journal of Pharmaceutics, 580, 119192, 2020

22. Mahitosh Biswas, Ravinder Kumar, Arka Chatterjee, Yuanpeng Wu Zetain Mi, Pallab Bhattacharya, **Samir Kumar Pal** and Subhananda Chakrabarti, *Effects of rapid thermal annealing in InGaN/GaN quantum disk-in-GaN nanowire arrays*, Journal of Luminescence, 222, 117123, 2020

23. Pritam Biswas, Aniruddha Adhikari, Uttam Pal, Priya Singh, Monojit Das, Tanusri Saha-Dasgupta, Sudeshna Shyam Choudhury, Ranjan Das and **Samir Kumar Pal**, *Flexibility modulates the catalytic activity of a thermostable enzyme: key information from optical spectroscopy and molecular dynamics simulation*, Soft Matter, 16, 3050-3062, 2020

24. Tuhin Kumar Maji, Damayanti Bagchi, Nivedita Pan, Ali Sayqal, Moataz Morad, Saleh A. Ahmed, Debjani Karmakar and **Samir Kumar Pal**, *A combined spectroscopic and ab initio study of the transmetalation of a polyphenol as a potential purification strategy for food additives*, RSC Advances, 10, 5636-5647, 2020

25. Aniruddha Adhikari, Pritam Biswas, Susmita Mondal, Monojit Das, Dr. Soumendra Darbar, Dr. Ahmed M. Hameed, Dr. Ahmed Alharbi, Prof. Saleh A. Ahmed, Dr. Siddhartha Sankar Bhattacharya, Dr. Debasish Pal, **Prof. Samir Kumar Pal**, *A Smart Nanotherapeutic Agent for in vitro and in vivo Reversal of Heavy-Metal-Induced Causality: Key Information from Optical Spectroscopy*, ChemMedChem, 15, 420-429, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Application-driven Basic Research for the Development of Indigenous Scientific Devices and Nanomedicines for Our Country: National Technology Day-2020; May 11, 2020; Kolkata; 60 Min
2. All Nanomedicines are Nanoparticles but all Nanoparticles are not Nanomedicines: Online FDP on "Advaced Materials & Engineering"; Jan 22, 2021; Kolkata; 60 Min
3. Proposal on Nanotechnology based Healthcare Solutions: Workshop on Grant Writing (Dec 08, 2020); Dec 8, 2020; IISc Bangalore; 60 Min

Administrative duties

1. Chairman, Pest Control
2. Convener, Project and Patent cell
3. Member, Internal Purchase Committee
4. Chairman, Technical Cell

Patents Taken and Process Developed with Details

1. A Compound Used in a Device for the Detection of Arsenic level in Drinking Water and its Method for Preparation thereof; PCT (International Patent) Appl. (2020); Applied
2. An Active Respirator with Attached Exhalation Valve and Suspended Particulate Matter Filter for Comfortable and Hygienic Breathing; Indian Pat. Appl. (2020), TEMP/E-1/29497/2020-KOL dated 23rd June 2020; Applied
3. A Long-lasting Nano-Sanitizer with a Dispensing Antimicrobial Layer; Indian Pat. Appl. (2020), TEMP/E-1/29493/2020-KOL dated 23rd June 2020; Applied
4. Development of Tribo-electroceutical Fabric for Potential Application inSelfSanitizing Personal Protective Equipment (PPE); Indian Pat. Appl. (2020), TEMP/E-1/42583/2020-KOL dated 4th September 2020; Applied
5. A Nanoceutical Fabric for Source-control to Prevent COVID-19 Spread Including Through Expelled Respiratory Droplets; Indian Pat. Appl. (2020), TEMP/E-1/42574/2020-KOL dated 4th September 2020; Applied

Awards, Recognitions

1. Fellow of National Academy of Engineering (FNAE) 2020
2. NASI-Reliance Industries Platinum Jubilee Award 2020
3. Abdul Kalam Technology Innovation National Fellowship 2020

Membership of Learned Societies

1. American Chemical Society
2. Indian Association for the Cultivation of Science, Life Member
3. Indian Physical Society
4. 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 Peter Lemmens Institute for Condensed Matter Physics Institut für Physik der Kondensierten Materie TU Braunschweig, Germany; Sl. No. 19; International
2. Professor Saleh Ahmed Umm Al-Qura University · Department of Chemistry, Saudi Arabia; Sl. No. 4, 5, 6, 9, 16, 17, 23, 25; International
3. Professor Asim Kumar Mallick NRS Medical College; Sl. No. 3, 16; National
4. Professor Ranjan Das, Department of Chemistry, West Bengal State University; Sl. No. 8; National
5. Professor Sudeshna Shyam Choudhury (bhattacharya) Department: Microbiology & Envs St.Xavier's College, 30 Park Street, Kolkata 700 016; Sl. No. 1, 23; National

Outreach program organized / participated

1. Speaker for lecture at "An International Webinar on Physics organized by Dept. of Physics, Pabna University of Science and Technology on 19thy May 2021
2. Speaker for the lecture at "Indian Physics Association Colloquium, Innovative Technology & Applications" on 8th May 2021

3. Speaker for the lecture at AWARENESS SESSION ON TECHNOLOGY COMMERCIALIZATION on 6th February 2021

Areas of Research

Ultrafast Spectroscopy

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

Plan of Future Work Including Project

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

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 potent inhibitors for Acetylcholinesterase enzyme; Under progress
2. Krishnendu Sinha; Phosphorylation code in RhoGDI regulation; Under progress
3. Shounak Mukherjee; Molecular mechanism of ion pumping by KR2 Rhodopsin; Under progress

b) Post-Docs

1. Ipsita Basu; Understanding the role of protein-membrane interactions towards function of GPCR class of proteins

Teaching

1. Autumn semester; Numerical Methods (CB 521); PhD; 20 students
2. Spring semester; Study of BioMacromolecules (CB 540); PhD; 3 students; with 1 (Dr. Tatini Rakshit) co-teacher

Publications

a) In journals

1. Amit Kumawat and **Suman Chakrabarty**, *Protonation-Induced Dynamic Allostery in PDZ Domain: Evidence of Perturbation-Independent Universal Response Network*, The Journal of Physical Chemistry Letters, 11, 9026 – 9031, 2020
2. Sinjan Das, Shounak Mukherjee, **Suman Chakrabarty**, and Nitin Chattopadhyay, *Hydroxyl Group-Directed Solvation of Excited-State Intramolecular Proton Transfer Probes in Water: A Demonstration from the Fluorescence Anisotropy of Hydroxyflavones*, The Journal of Physical Chemistry A, 125, 57 – 64, 2021
3. Amit Kumawat, Shabnam Raheem, Fasil Ali, Tanveer Ali Dar, **Suman Chakrabarty**, Masood Ahmad Rizvi, *Organoselenium Compounds as Acetylcholinesterase Inhibitors: Evidence and Mechanism of Mixed Inhibition*, The Journal of Physical Chemistry B, 125, 1531 – 1541, 2021
4. Prayasee Baruah, Abhinandan Das, Debojit Paul, **Suman Chakrabarty**, Kripamoy Aguan, and Sivaprasad Mitra, *Sulfonylurea Class of Antidiabetic Drugs Inhibit Acetylcholinesterase Activity: Unexplored Auxiliary Pharmacological Benefit toward Alzheimer's Disease*, ACS Pharmacology & Translational Science, 4, 193-205, 2021
5. Nilesh Choudhary, Omkar Singh Kushwaha, Gaurav Bhattacharjee, **Suman Chakrabarty**, and Rajnish Kumar, *Macro and Molecular Level Insights on Gas Hydrate Growth in the Presence of Hofmeister Salts*, Industrial & Engineering Chemistry Research, 59, 20591 – 20600, 2020
6. Vrushali Hande, Nilesh Choudhary, **Suman Chakrabarty** and Rajnish Kumar, *Morphology and dynamics of self-assembled structures in mixed surfactant systems (SDS + CAPB) in the context of methane hydrate growth*, Journal of Molecular Liquids, 319, 114296, 2020

b) Conference proceedings / Reports / Monographs / Books

1. Suman Chakrabarty, "Role of Buried Water in the Mechanism of Photoactivation of KR2 Rhodopsin" Biophysical Journal 120, 131a (2021)

Talks / Seminars Delivered in reputed conference / institutions

1. Statistical Mechanics in Chemistry and Biology (SMCB-2021); Jan 23, 2021; Online 4 days
2. Departmental seminar at Chemistry Department, IIT Gandhinagar; Mar 19, 2021; Online; 1 day

Administrative duties

1. Served in several purchase related committees and student evaluation committees

Membership of Learned Societies

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

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, DST, India; 3 years; PI

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

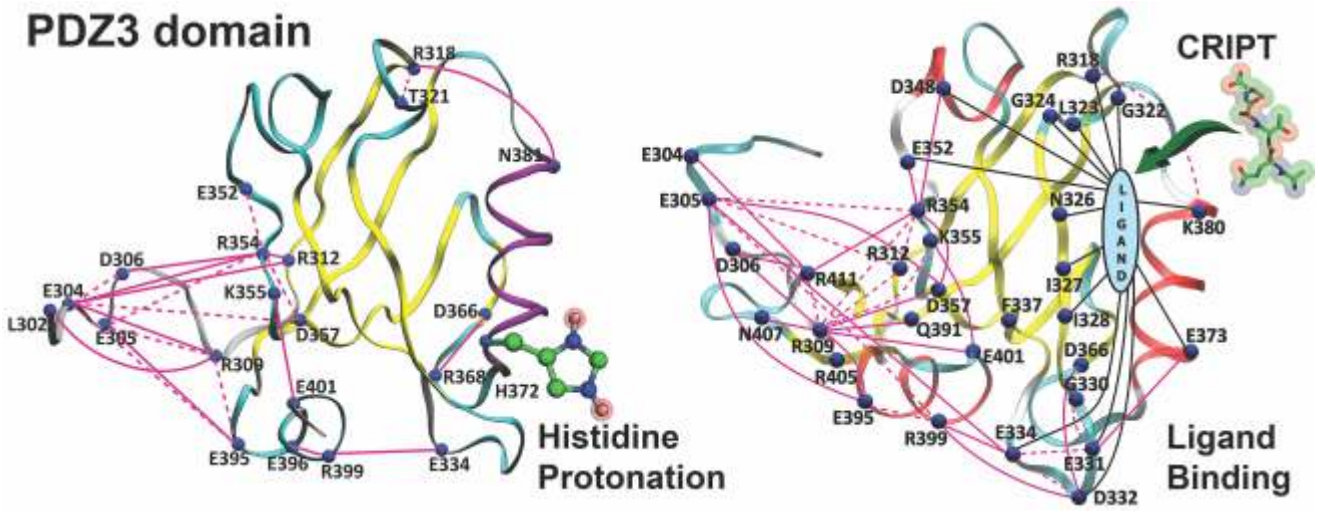
1. Collaboration with Prof. Nitin Chattopadhyay from Jadavpur University on the microscopic origin of high fluorescence anisotropy for Hydroxyflavones; Molecular mechanism of ion pumping by KR2 Rhodopsin; National
2. Collaboration with Prof. M. A. Rizvi from University of Kashmir on the mechanism and role of organoselenium compounds as Acetylcholinesterase inhibitors; Sl. No. 3; National
3. Collaboration with Prof. Sivaprasad Mitra from North-Eastern Hill University (NEHU) on the mechanism and role of sulfonylurea class of antidiabetic drugs as Acetylcholinesterase inhibitors; Study of BioMacromolecules (CB 540); National
4. Collaboration with Prof. Rajnish Kumar from IIT Madras on the effect of additives like salts and surfactants on methane hydrate growth kinetics; Sl. No. 5, 6; National

Areas of Research

Theoretical and computational physical chemistry, computational molecular biophysics

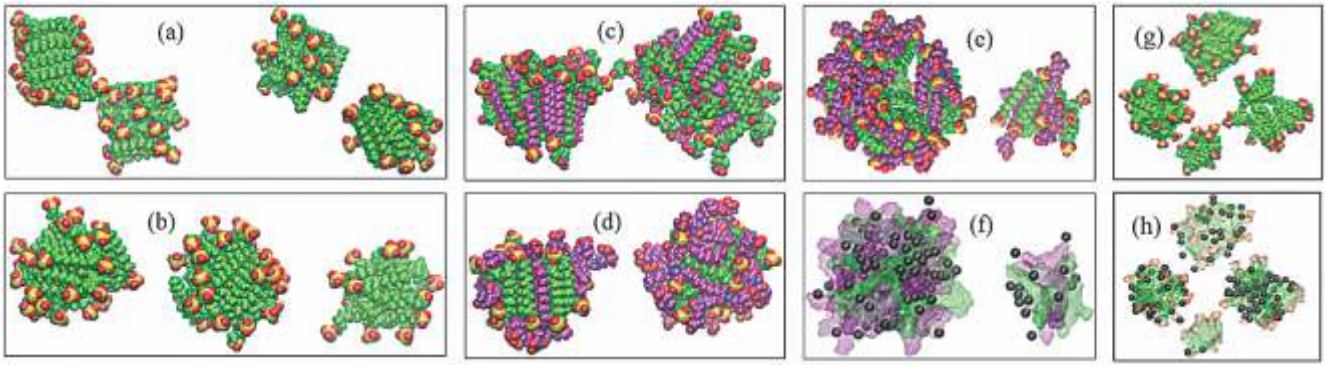
We use a combination of large scale atomistic molecular dynamics simulation and enhanced sampling methods to understand the connection between structure, interaction, dynamics and function of complex biomolecular systems. A few representative examples where we have made significant progress recently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

1. **Universal mechanism of dynamic allostery in PDZ domain:** PDZ domain protein demonstrates a classic example of dynamic allostery, where distal dynamics of side-chains gets modulated on ligand binding without discernible structural changes. Traditionally dynamic allostery has been attributed to purely entropic origin. We have demonstrated earlier (PNAS 2017) that dynamic allostery in PDZ domain can be attributed to long range re-arrangement and re-wiring of hydrogen bonded network and redistribution of electrostatic energies. Recently, we have demonstrated that a different energetic perturbation, namely protonation of a key histidine residue (His372) can also lead to similar dynamic response as ligand binding. Interestingly, the same set of residues seem to be involved. This observation suggests that such proteins may have evolved a unifying universal response system involving hydrogen bonded network that can respond to different types of external perturbations. (Publication: J. Phys. Chem. Lett. 11, 9026 (2020)).



2. **Effect of various additives on the growth kinetics of methane hydrates and the molecular mechanism:** Marine gas hydrates are promising source of alternative energy. It is crucial to design novel thermodynamic and kinetic promoters of hydrate decomposition for more energy efficient extraction of methane from marine hydrates. Moreover, hydrate formation can have disastrous consequence in fuel pipelines due to blockage. In such scenario, hydrate inhibitors are indispensable. In collaboration with the group of Prof. Rajnish Kumar in IIT Madras, we have investigated the effect of various novel additives on hydrate growth kinetics and developed molecular level understanding of the physico-chemical processes by which such additives function. (Publications: J. Mol. Liq. 319, 114296 (2020), Ind. Eng. Chem. Res. 59, 20591 (2020))

3. **Inhibition of Acetylcholinesterase (AChE) activity towards therapeutic strategy to control Alzheimer's disease:** Inhibition of the enzyme Acetylcholinesterase has emerged as a potential strategy to reduce the symptoms of Alzheimer's disease. In collaboration with synthetic chemists we have investigated the molecular mechanism of binding and inhibitory effect of several anti-diabetic drugs and organoselenium compounds on AChE. We have elucidated the origin of experimentally observed mixed inhibition for several of these potential drug molecules. (Publications: ACS Pharmacol. Transl. Sci. 4, 193 (2021), J. Phys. Chem. B 125, 1531 (2021))



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) towards elucidating the thermodynamics and kinetics of biomolecular recognition and signalling processes.

Any other Relevant Information including social impact of research

1. The collaborative work with Prof. Rajnish Kumar on the effect of surfactant mixtures on methane uptake during hydrate formation has been widely discussed and appreciated in the popular media. Some of these are mentioned here:

1. DST media cell: https://dst.gov.in/newly-designed-additive-molecules-may-obviate-need-long-pipelines-transporting-natural-gas
2. Tweet by Dr. Harsh Vardhan: https://twitter.com/drharshvardhan/status/1314792894327267329?lang=en
3. The Hindu Business Line: https://www.thehindubusinessline.com/news/science/indian-scientists-discover-chemicals-to-help-make-gas-hydrates-faster/article32918521.ece

Tatini Rakshit

DST Inspire Faculty
CBMS
tatini.rakshit@bose.res.in

Guidance of Students/Post-Docs/Scientists

a) External Project Students / Summer Training

1. Debashish Paul (SERB project JRF); Mechano-elastic properties of biomacromolecules; S. N. Bose National Centre for Basic Sciences, Kolkata
2. Brateen Datta (DST Inspire project assistant); Biophysical Characteristics of Extracellular Vesicles towards biomarker discovery; S. N. Bose National Centre for Basic Sciences, Kolkata

Teaching

1. Spring semester; Study of Biomacromolecules (CB540); Ph.D. course work in Chemical Sciences; 3 students; Shared with Dr. Suman Chakrabarty

Publications

a) In journals

1. Brateen Datta, Debashish Paul, Uttam Pal, and **Tatini Rakshit**, *Intriguing Biomedical Applications of Synthetic and Natural Cell-Derived Vesicles: A Comparative Overview*, ACS Applied Bio Materials, 4, 2863-2885, 2021
2. Debashish Paul, Anuradha Roy, Arpita Nandy, Brateen Datta, Prateeka Borar, Samir Kumar Pal, Dulal Senapati, and **Tatini Rakshit**, *Identification of Biomarker Hyaluronan on Colon Cancer Extracellular Vesicles Using Correlative AFM and Spectroscopy*, The Journal of Physical Chemistry Letters, 11, 5569-5576, 2020
3. **Tatini Rakshit**, Daniël P. Melters, Emilios K. Dimitriadis and Yamini Dalal, *Mechanical properties of nucleoprotein complexes determined by nanoindentation spectroscopy*, Nucleus, 11, 264-282, 2020
4. Dipanjan Mukherjee, **Tatini Rakshit**, Priya Singh, Suman Mondal, Debashish Paul, Manisha Ahir, Arghya Adhikari, Theja P. Puthiyapurayil, Praveen Kumar Vemula, Dulal Senapati, Ranjan Das and **Samir Kumar Pal**, *Differential flexibility leading to crucial microelastic properties of asymmetric lipid vesicles for cellular transfection: A combined spectroscopic and atomic force microscopy studies*, Colloids and Surfaces B: Biointerfaces, 196, 111363, 2020
5. **Tatini Rakshit**, Sudipta Bera, Jayeeta Kolay and Rupa Mukhopadhyay, *Nanoscale solid-state electron transport via ferritin: Implications in molecular bioelectronics*, Nano-Structures & Nano-Objects, 24, 100582, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Gangeya Student Chapter, organized by IISER kolkata , Biophysics week celebration; March 27, 2021; online; 30 mins

Areas of Research

Extracellular vesicles (EV) are naturally occurring nanoparticles with unique structure, surface

biochemistry, and mechanical characteristics. These distinct nanometer-sized bio-particles are secreted from the surfaces of normal and cancer cells and are of potential interest as cancer biomarkers. We use high-resolution Atomic force Microscopy (AFM) to show single-vesicle quantitative differences between EVs derived from colon cancer cell HCT 116 and normal colon epithelial cell CCD-Co18. At the single-vesicle level, HCT 116 derived EVs exhibit significantly ($P < 0.05$) increased Hyaluronan surface densities compare to CCD-Co18. Spectroscopic experiments including Fourier Transform Infrared Spectroscopy (FT-IR), Circular Dichroism (CD) and RAMAN spectroscopy univocally support our observation. Taken together, this strategy could be realized as a non-invasive colon cancer diagnostic in future. We have also recently contributed a review article on comparative aspects of synthetic and natural vesicles in biomedical field in general.

Plan of Future Work Including Project

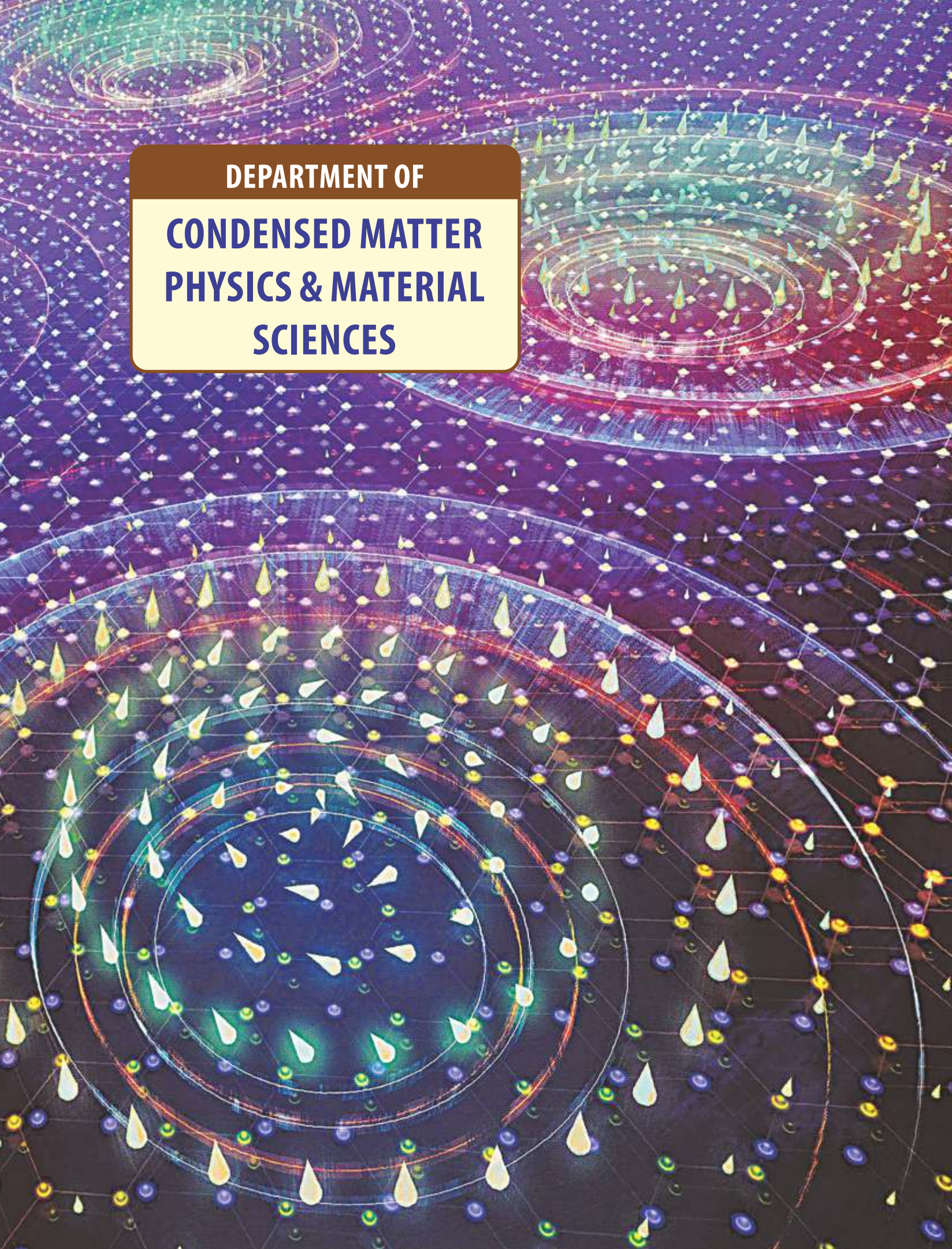
We are working on quantifying mechanical properties of Biomarker Hyaluronan on extracellular vesicle surface by single molecule force spectroscopy. In another project we have developed a drug delivery system by fusion of synthetic and natural vesicles, we will use these hybrids for drug/gene delivery.

Any other Relevant Information including social impact of research

The work published in JPCL 2020 has been highlighted by DST media cell https://pib.gov.in/PressReleseDetailm.aspx?PRID=1639974

and featured at IndiaBioscience (TIFR publication)

https://indiabioscience.org/news/2020/a-nanosized-tool-to-non-invasively-detect-cancer-cells



DEPARTMENT OF

CONDENSED MATTER PHYSICS & MATERIAL SCIENCES

DEPARTMENT OF
Condensed Matter Physics & Material Sciences

PRIYA MAHADEVAN

Department profile indicators

Table A : Manpower and resources		
Number of faculty members		18 (including Ex-Director)
Number of Post –doctoral research associate (centre + project)		8 + 8
Number of Ph.D students		66
Number of other project staff		03
Number of summer students		–
Projects (ongoing)		16

Table B: Research Activities indicators		
Number of research papers in Journals		108
Number of Book-chapters/books		–
Number of other publications		06
Number of Ph.D students graduated (submitted + degree awarded)		Submitted = 7, Awarded = 12 Total = 19
Number of M.Tech/M.Sc projects		

Table C: Academic activities and likeage		
Number of courses taught by faculty members		07
Number of Visitors (non –associates)		01
Number of associates		0
Number of Seminars organized		Nil
Number of Conference / Symposia /Advanced Schools organized		2
Number of talks delivered by members of department in conferences / Symposia	National	21
	International	10

Most important research highlights

- Group of Anjan Barman has developed a magnonic nanochannel array by periodically tailoring perpendicular magnetic anisotropy using electric field, a step which can potentially revolutionize on-chip data transfer and processing.
- Group of Atin Pal has found an unusual high conductance regime in junctions of ferrocene and gold electrodes.
- Group of Barnali Ghosh has developed a high-response optical detector based on n-ZnO/p-Si nanowires core – shell arrays decorated with plasmonic Au nanoparticles that works in the from 300 nm to 1100 nm.

- Group of Kalyan Mandal has demonstrated that nano-hollow spheres of $MnFe_2O_4/CoFe_2O_4$ function as electromagnetic wave absorbers and are suitable for high-frequency applications.
- Group of Manoranjan Kumar has examined the temperature dependence of structural dimerization and electronic dimerization in bond-order-wave phase in strongly correlated spin models.
- Group of Priya Mahadevan has identified the origin of flat band formation in twisted bilayers of transition metal dichalcogenides.
- Group of S.K. Ray has synthesised highly stable inorganic -$CsPbI_3$ nanorods.
- Group of Tanusri Saha-Dasgupta has shown that the reduced dimensionality and the kagome structure leads to a ferromagnetic Chern metal in Fe_3Sn_2.
- Group of T. Setti has explained the anomalous temperature dependent resistivity in FeSi through the electron-phonon interactions.

Summary of research activities

The focus of the research activities of the department has been on examining various phenomena in condensed matter systems, both theoretically and experimentally, as well as exploring possible applications which range from finding the optimal materials for water splitting, using a combination of materials to harness a larger frequency range of the solar spectrum, searching for optimal materials that can absorb electromagnetic radiation as well as using magnonic devices for data communication and processing.

In the direction of exploring new avenues to on-chip data communication and processing, the group of Anjan Barman has been exploring arrays of magnonic nanochannels. This is generated by considering a CoFeB/MgO layer through a one-dimensional stripe-like array of indium tin oxide electrodes placed on top of $Ta/CoFeB/MgO/Al_2O_3$ heterostructures. The perpendicular magnetic anisotropy has been tailored periodically by using an electric field at the CoFeB/MgO interface. Probing the spin wave dispersions, they find that under the application of a moderate gate voltage, magnonic bands appear in the bandgap, which can be switched off by removing the voltage.

The group of Manoranjan Kumar has been working on using density matrix renormalization group to examine the low energy excitations of low dimensional systems in order to calculate the thermodynamics at low temperature accurately. They have recently applied this method to examine the temperature dependence of structural dimerization and electronic dimerization in the bond-order-wave phase in strongly correlated spin models.

The group of Priya Mahadevan has re-examined the electronic structure of twisted bilayers of $MoSe_2$. As these are van der Waal's homobilayers, one expects only weak interaction between the layers and so the recent experimental observations suggesting the possibility of strong correlation physics playing a role is surprising. Quantitatively determining the perturbation at various twist angles, they were able to identify both the limit and the origin of the flat band formation in this class of materials. The mechanism they find is different from what is found for graphene.

The group of Tanusri Saha-Dasgupta has examined the effect of enhanced correlations in a single kagome bilayer of Fe_3Sn_2 . They find that the dimensional confinement naturally leads to a ferromagnetic Chern metal solution. Setting up a model for the band structure near the fermi energy, they are able to capture the physics of the Chern metal with a nonzero anomalous Hall response over a relevant parameter regime along with a possible superconducting instability resulting in a topological superconductor.

The group of T. Setti has studied the electronic structure of FeSi. While no fermi arcs are found in CoSi and RhSi are found here, they find a Debye energy of 80 meV from their angle resolved photoemission experiments. This indicated that the anomalous temperature dependent resistivity that they find is due to electron-phonon interactions.

The group of S.K. Ray has used a novel colloidal synthesis route to grow air stable, inorganic -$CsPbI_3$ nanorods. The

synthesised rods are found to be highly stable under 45-55% humid conditions, and are therefore of potential use in optoelectronic devices.

In order to increase the frequency range of an optical detector, the group of Barnali Ghosh has been considering one based on core shell arrays of nZnO/-Si nanowires which have been decorated with plasmonic Au nanoparticles. This is found to work over a broad frequency range varying from 300 nm which is in the ultraviolet to 1100 nm which is in the near infra-red. Its broadband character is achieved by using photogating as well as favorable band alignments so that carriers generated at longer wavelengths in visible and NIR in Au NPs and Si NWs arrays were introduced into the conduction band of ZnO, which by itself is sensitive in the UV region.

The group of Kalyan Mandal has been working on overcoming the challenges encountered in using ZnO nanostructures for photoelectrochemical water splitting. Depositing $ZnCo_2O_4$ (ZCO) over ZnO nanorods, they find improved visible light-harvesting performance due to the narrow band gap of ZCO. The type-II band alignment between $ZnCo_2O_4$ and ZnO Nanorods (NRs) accelerates the charge transfer process and reduces electron-hole recombination.

Priya Mahadevan

Head, Department of Condensed Matter Physics and Material Sciences

Anjan Barman

Senior Professor
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abarman@bose.res.in

Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Avinash Kumar Chaurasiya; Brillouin Light Scattering Studies of Spin Waves in Ferromagnetic Thin Films and Nanostructures; Thesis submitted
2. Anulekha De; Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Nanostructures; Thesis submitted; Prof. Rajib Kumar Mitra (Co-supervisor)
3. Sourav Sahoo; Ultrafast Spin Dynamics of 2D and 3D Magnonic Crystals; Under progress
4. Surya Narayan Panda; All-Optical Investigation of Spin-Orbit Effects in Ferromagnet/Nonmagnet Heterostructures; Under progress
5. Koustuv Dutta; Femto and Picosecond Spin Dynamics of Low Dimensional Magnetic Structures; Under progress
6. Amrit Kumar Mondal; Spin Wave Propagation and Localization in Continuous and Confined Magnetic Thin Film; Under progress
7. Arundhati Adhikari; Quasistatic and Ultrafast Magnetization Dynamics in Ferromagnetic Nanostructures; Under progress
8. Sudip Majumder; Ferromagnetic Resonance of Magnetic Thin films and Nanostructures; Under progress; Prof. Rajib Kumar Mitra (Co-supervisor)
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; Static and Dynamics Magnetic Properties of Topological Insulator/Ferromagnet Heterostructures; Under progress; Prof. Chiranjib Mitra, IISER Kolkata (Co-supervisor)
13. Santanu Pan; Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Heterostructures; Awarded
14. Kartik Adhikari; Ferromagnetic Resonance of Patterned Magnetic Nanostructures; Under progress

b) Post-Docs

1. Arpan Bhattacharya; Spin-Orbit Effects in Magnonics

c) External Project Students / Summer Training

1. Shreya Mehta; Investigation of Magnetization Reversal Mechanism of Ferromagnetic Nanostructures using Micromagnetic Simulation; Pt. Ravishankar Shukla University, Raipur

Teaching

1. Autumn semester; PHY301: Atomic and Molecular Physics; Integrated PhD; 12 students; with 1 (Prof. Rajib Kumar Mitra) co-teachers

2. Autumn semester; CB 527: Molecular Physics and Spectroscopy; PhD; 3 students; with 1 (Prof. Rajib Kumar Mitra) co-teacher
3. Spring semester; PHY401: Project Research III; Integrated PhD; 2 students

Publications

a) In journals

1. Anulekha De, Koustuv Dutta, Sucheta Mondal, Saswati Barman, Yoshichika Otani, and **Anjan Barman**, *Magnonic crystals with complex geometry*, Physical Review B, 103, 064402, 2021
2. Sourav Sahoo, Surya Narayan Panda, Saswati Barman, Yoshichika Otani and **Anjan Barman**, *Nanochannels for spin-wave manipulation in $Ni_{80}Fe_{20}$ nanodot arrays*, Journal of Magnetism and Magnetic Materials, 522, 167550, 2021
3. **Anjan Barman**, Sucheta Mondal, Sourav Sahoo, and Anulekha De, *Magnetization dynamics of nanoscale magnetic materials: A perspective*, Journal of Applied Physics 128, 170901, 2020
4. M.R.Karim, D.Panda, A.Adhikari, P.Sharangi, P.Mandal, S.Ghosh, S.Bedanta, **A.Barman** and I.Sarkar, *Electrodeposited Heusler alloy films with enhanced magneto-optical property*, Materials Today Communications, 25, 101678, 2020
5. Samiran Choudhury, Avinash Kumar Chaurasiya, Amrit Kumar Mondal, Bivas Rana, Katsuya Miura, Hiromasa Takahashi, YoshiChika Otani and **Anjan Barman**, *Voltage controlled on-demand magnonic nanochannels*, Science Advances, 6, eaba5457, 2020
6. Justine Lynn Drobitch, Anulekha De, K. Dutta, Pratap Kumar Pal, Arundhati Adhikari, **Anjan Barman** and Supriyo Bandyopadhyay, *Extreme Subwavelength Magnetoelastic Electromagnetic Antenna Implemented with Multiferroic Nanomagnets*, Advanced Materials Technologies, 5, 2000316, 2020
7. Amrit Kumar Mondal, Chandrima Banerjee, Arundhati Adhikari, Avinash Kumar Chaurasiya, Samiran Choudhury, Jaivardhan Sinha, Saswati Barman, and **Anjan Barman**, *Spin-texture driven reconfigurable magnonics in chains of connected $Ni_{80}Fe_{20}$ submicron dots*, Physical Review B, 101, 224426, 2020
8. Akash Kumar, Avinash Kumar Chaurasiya, Niru Chowdhury, Amrit Kumar Mondal, Rajni Bansal, Arun Barvat, Suraj P. Khanna, Prabir Pal, Sujeet Chaudhary, **Anjan Barman** and P. K. Muduli, *Direct measurement of interfacial Dzyaloshinskii–Moriya interaction at the $MoS_2/Ni_{80}Fe_{20}$ interface*, Applied Physics Letters, 116, 232405, 2020
9. Santanu Pan, Takeshi Seki, Koki Takanashi, and **Anjan Barman**, *Ultrafast demagnetization mechanism in half-metallic Heusler alloy thin films controlled by the Fermi level*, Physical Review B, 101, 224412, 2020
10. Sujit Deshmukh, Debosmita Banerjee, Gourav Bhattacharya, Sam J. Fishlock, **Anjan Barman**, James McLaughlin, and Susanta Sinha Roy, *Red Mud-Reduced Graphene Oxide Nanocomposites for the Electrochemical Sensing of Arsenic*, ACS Applied Nano Materials, 3, 4084-4090, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Spin-Orbit Effects in Spintronics, W2S Webinar on Spintronics; Jun 11, 2020; NISER Bhubneswar (Online Mode); 60 min
2. Spin-Orbit Effects in Spin Dynamics, The 2020 Around-the-Clock Around-the-Globe Magnetics Conference; Aug 27, 2021; IEEE Magnetics Society (Online Mode); 45 min
3. Interface Driven Ultrafast Spin Dynamics in Ferromagnet/Nonmagnet and Ferromagnet/2D Material Heterostructures, 3rd International Conference on Quantum Condensed Matter (QMAT 2020); Sep 7, 2020; S. N. Bose National Centre for Basic Sciences (Online Mode); 30 min
4. Emergent Magnonic Phenomena in Magnetic Thin Films and Nanostructures, International Conference on Emerging Electronics (ICEE 2020); Nov 26, 2020; IIT Delhi (Online Mode); 30 min
5. Squeezing the Time and Length Scale for New Generation Spintronics, Emerging Trends in

Research Methodology in Condensed Matter, Materials Science and Nanoscience (ETRMCMMSN) 2020; Dec 1, 2021; Neotia University, KOlkata (Online Mode); 45 min

6. Ultrafast spin dynamics in graphene/ferromagnet thin film heterostructures, The 4th International Symposium for CRC Spintronics; Feb 24, 2021; Tohoku University, Japan (Online Mode); 30 min
7. Application of Spin-Orbit Effects in Spintronic and Magnonic Devices, Current Trends in Materials Science and Engineering (CTMSE-2021); Mar 13, 2021; IEM Kolkata (Online Mode); 45 min

Administrative duties

1. Associate Dean (Faculty)
2. Member of the Technical Cell Advisory Committee
3. Member of the Faculty Search Committee
4. Convenor of APMP

Membership of Learned Societies

1. Member of American Physical Society
2. Member of IEEE
3. 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 - 2021; PI

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

1. Prof. Yoshichika Otani, RIKEN-CEMS, Wako and Univ. of Tokyo, Japan; Sl. No. 1, 2, 5; International
2. Prof. Supriyo Bandyopadhyay, Virginia Commonwealth University, USA; Sl. No. 6; International
3. Prof. K. Takanshi and Dr. T. Seki, Tohoku University, Japan; Sl. No. 9; International
4. Prof. P. K. Muduli, IIT Delhi; Sl. No. 8; National
5. Dr. Indranil Sarkar, INST, Mohali; Sl. No. 4; National
6. Prof. S. S. Roy, Shiv Nadar University; Sl. No. 10; National

Outreach program organized / participated

1. A New Spin on Next generation Computing, A. Barman, Vigyan-Jyoti Programme of DST, Oct. 6, 2021 (lecture and virtual lab visit).

Areas of Research

Experimental Condensed Matter Physics, Nanomagnetism, Spintronics, Magnonics, Ultrafast Dynamics, Spectroscopy

A. Development of on-demand and reconfigurable magnonic nanochannels: Development of energy-efficient magnonic nanochannels (MNCs) can revolutionize on-chip data communication and processing. We have developed a dynamic MNC array by periodically tailoring perpendicular magnetic anisotropy using electric field. We used Brillouin light scattering spectroscopy to probe the spin-wave (SW) dispersion of MNCs formed by applying a static electric field at the CoFeB/MgO interface through a one-dimensional stripe-like array of indium tin oxide electrodes placed on top of Ta/CoFeB/MgO/Al_2O_3 heterostructures. Magnonic bands, consisting of two SW frequency modes, appear with a bandgap under the application of moderate gate voltage, which can be switched off by withdrawing the voltage. Simulated SW mode profiles show propagating SWs through nanochannels with different magnetic properties. The anticrossing between these two modes gives rise to the observed magnonic bandgap.

B. Development of extreme subwavelength magnetoelastic electromagnetic antenna using two-phase multiferroic nanomagnets: Emission/radiation efficiency of antenna is limited by emission area and wavelength making it challenging to miniaturize antennas to extreme subwavelength dimensions without severely compromising their efficiencies. We have

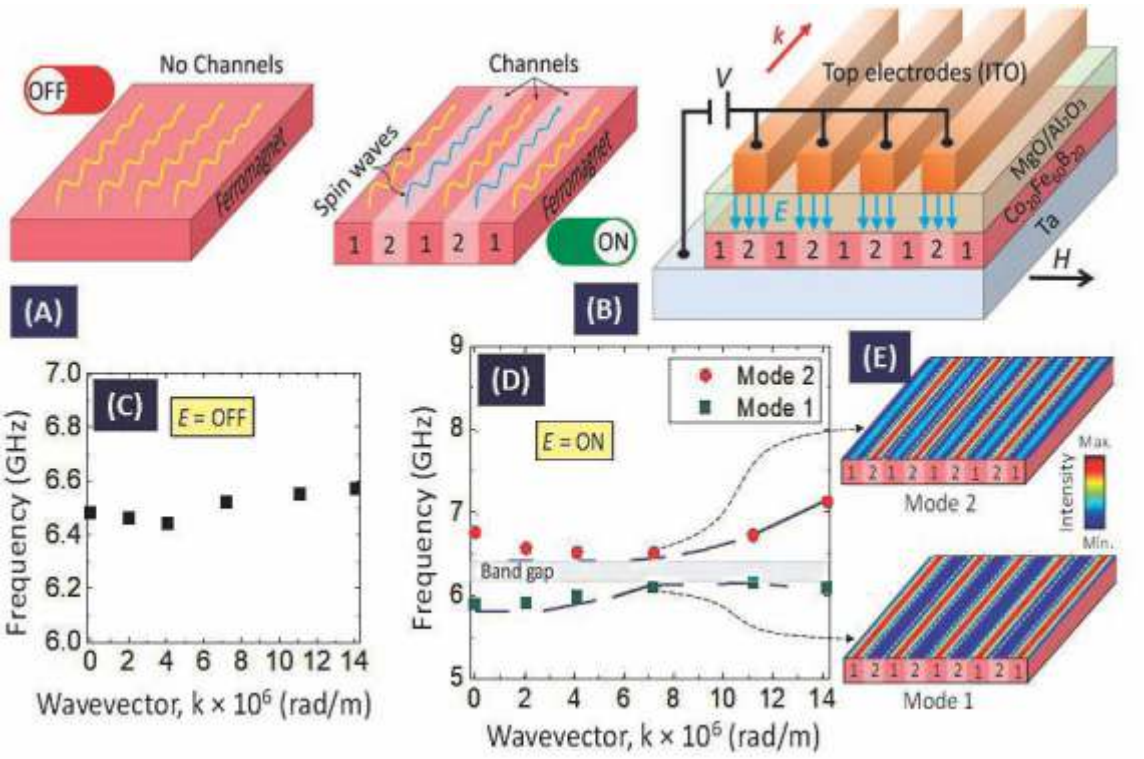

Fig. 1: A. Schematic illustration shows the concept of spin wave nanochannels. B. Schematic illustration shows the device structure and formation of nanochannels. Spin-wave frequencies versus wavevector when electric field, E is OFF (C) and ON (D). E. Heatmap plots show the spatial distribution of spin-wave intensity for spin-wave mode 2 and mode 1 at wavevector k = 7.1 × 10^6 rad/m.

overcome this challenge by actuating an electromagnetic (EM) antenna made of magnetostrictive nanomagnets deposited on a piezoelectric substrate by surface acoustic wave (SAW) whose wavelength is about five orders of magnitude smaller than the EM wavelength at the same frequency. These extreme subwavelength antennas allow drastic miniaturization of communication systems.

C. Fermi level controlled ultrafast spin dynamics in Heusler alloy thin films: We have demonstrated electronic band-structure controlled ultrafast demagnetization mechanism in $Co_2Fe_xMn_{1-x}Si$ Heusler alloy thin films by systematic variation of composition. The spin-flip scattering rate controlled by spin-density of states at the Fermi level is found to be responsible for a nonmonotonic variation of demagnetization time with composition with a maximum at $x = 0.4$. An inverse relation of demagnetization time with Gilbert damping indicates the dominance of interband scattering mechanism. This establishes a correlation between ultrafast demagnetization and magnetic damping based on Fermi-level position in this Heusler alloy system.

D. Spin-texture driven reconfigurable magnonics in ferromagnetic nanodot array: We have demonstrated reconfigurable magnonic band structure and band gap by a bias-field controlled spin texture in chains of connected Ni80Fe20 nanodots. For an identical field value, we could achieve both "*S*" and shifted-core vortex states based on magnetic history leading to a drastic change in magnonic band structure. A first-order phase transition from magnetic saturated to vortex state drives this change, as opposed to a continuous change from the saturation to *S* state.

E. Observation of interfacial Dzyaloshinskii–Moriya interaction at the $MoS_2/Ni_{80}Fe_{20}$ interface: We have directly measured interfacial Dzyaloshinskii–Moriya interaction (iDMI) at the interface of MoS_2 and $Ni_{80}Fe_{20}$ (Py), using Brillouin light scattering spectroscopy. A clear asymmetry in spin-wave dispersion is observed in

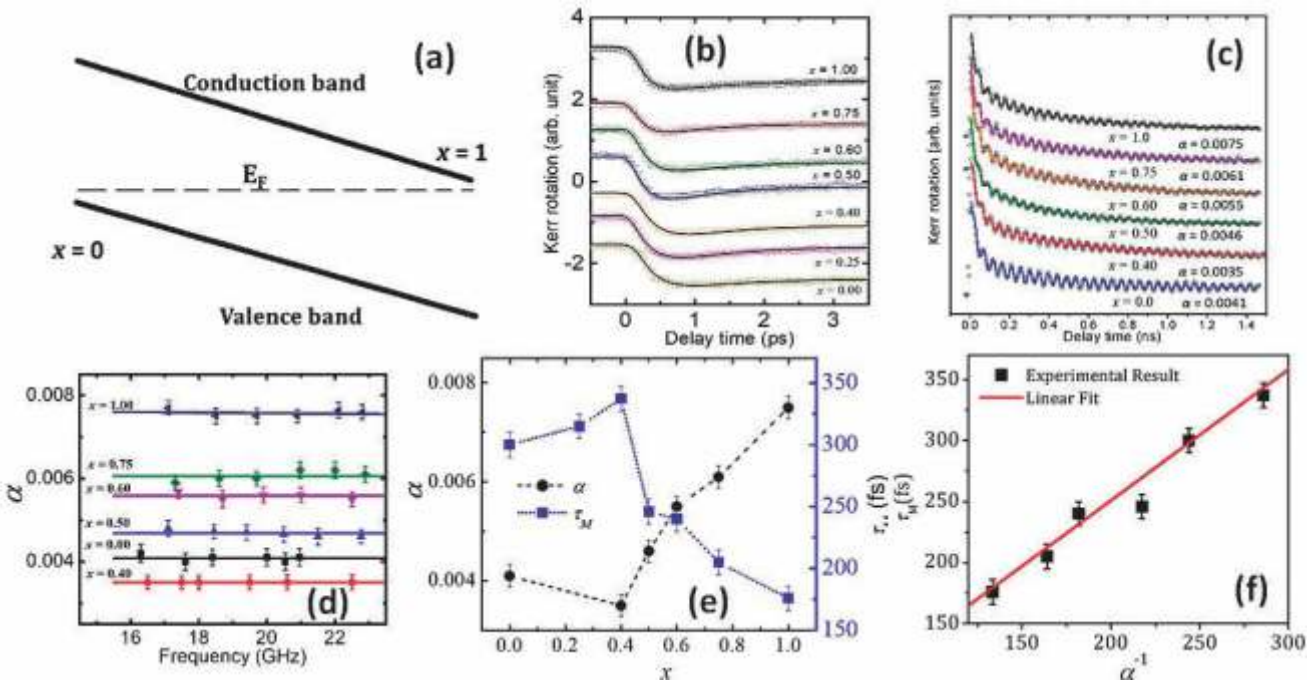

Fig. 2: A. Schematic of composition-dependent band structure of CFMS Heusler alloy. Time-resolved B. ultrafast demagnetization and C. precessional dynamics. D. Damping as a function of frequency. E. Variation of damping and demagnetization time with composition. F. Correlation between demagnetization time and damping.

MoS_2/Py/Ta due to the iDMI. Linear scaling of the iDMI constant with the inverse of Py thickness indicates the interfacial origin of the iDMI. We further observe an enhancement of iDMI constant in 3-4 layer MoS_2/Py system as compared to that in two layer MoS_2/Py, caused by a higher density of MoO_3 defect species.

Plan of Future Work Including Project

1. We plan to study interfacial spin transparency and spin-mixing conductance in W (t)/$Co_{20}Fe_{60}B_{20}$ (d)/SiO_2 (2 nm) thin-film heterostructures and study its dependence on the crystalline phase of W as a function of its thickness. Effects such as spin memory loss and two-magnon scattering will be investigated.
2. We will study coherent spin waves within a three-dimensional artificial spin ice (ASI) structure made of connected nanowires in a diamond bond lattice using Brillouin light scattering. The 3DASI was fabricated by using a combination of two-photon lithography and thermal evaporation.
3. We will study spin-wave response of two different two-dimensional kagome ASI nanostructures via Brillouin light scattering, a continuously connected system and a disconnected system with vertex gaps. This motivated by the comparison of how the dipolar coupling and dipole-exchange coupling mediated magnetic microstates affect the spin-wave dynamics?
4. We will study the effects of surface acoustic waves on the spin-wave dynamics in a densely packed array of two-phase multiferroic nanomagnets made of Co nanodots patterned on $LiNbO_3$ substrate. Such strongly magnetostatically coupled nanomagnets will show natural resonant spin-wave modes in absence of a bias magnetic field. We will study the possibility of resonant amplification of intrinsic magnetic modes and generation of new extrinsic (driven) modes in this system. The amplification factor and nature of resonant and non-resonant modes will be extensively studied.

5. We will study 'magnon-magnon coupling' in an array of cross-shaped $Ni_{80}Fe_{20}$ nanorings, each of which will act as a resonant nano-cavity for the magon eigenmodes. The tailored inter- and intra-element dipolar couplings may lead to the strongly coupled modes with high cooperativity and opening large anticrossing gaps. We will study the coherent propagation of the hybrid modes as opposed to the uncoupled eigenmodes.

Any other Relevant Information including social impact of research

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

Anup Ghosh

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Darshana Yazhini; Peptides on Plasmonic nanoparticles; Under progress

b) External Project Students / Summer Training

1. Suranjana Chakrabarty (Project Student); Peptides on Plasmonic nanoparticles
2. Swagata Maity (Visiting Student); Peptides on Plasmonic nanoparticles

Publications

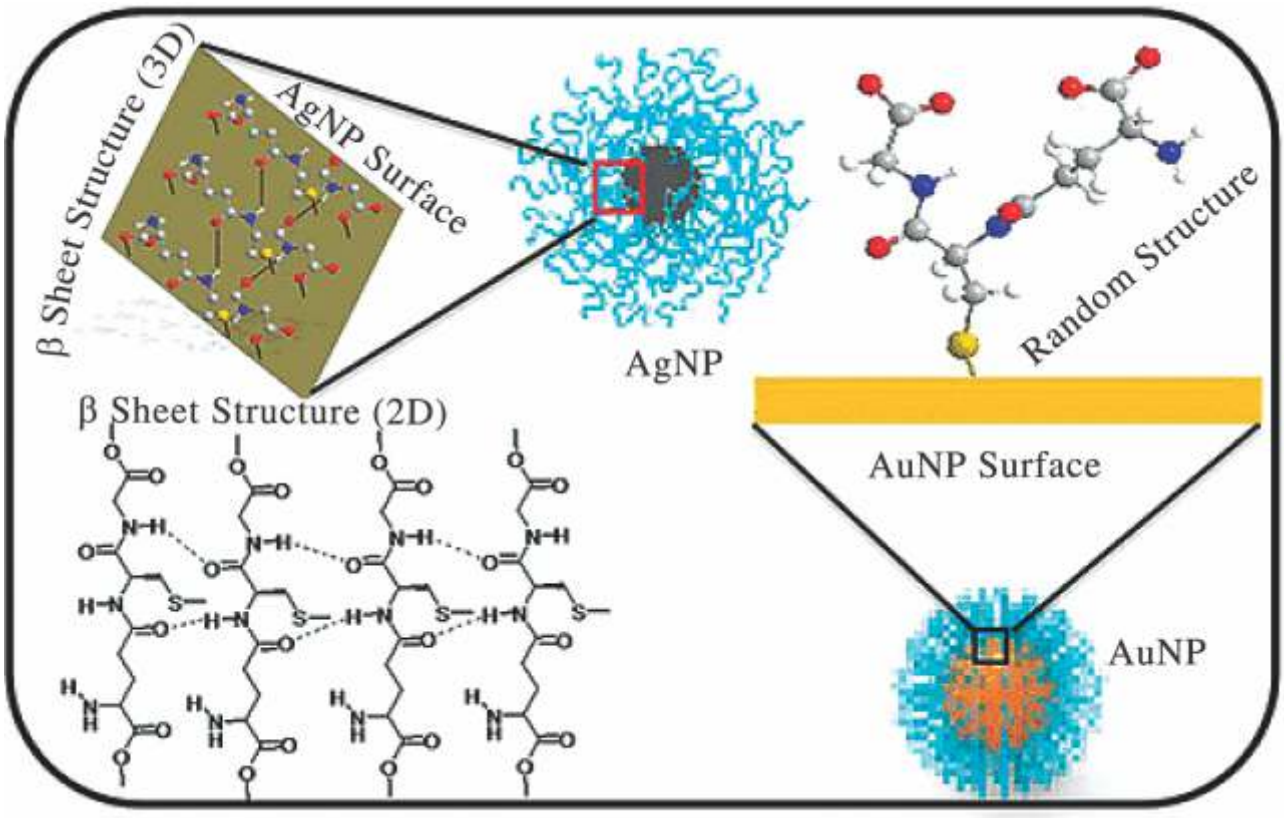
a) In journals

1. Suranjana Chakrabarty, Swagata Maity, Darshana Yazhini, and **Anup Ghosh**, *Surface-Directed Disparity in Self-Assembled Structures of Small-Peptide l-Glutathione on Gold and Silver Nanoparticles*, Langmuir, 36, 11255 – 11261, 2020

Areas of Research

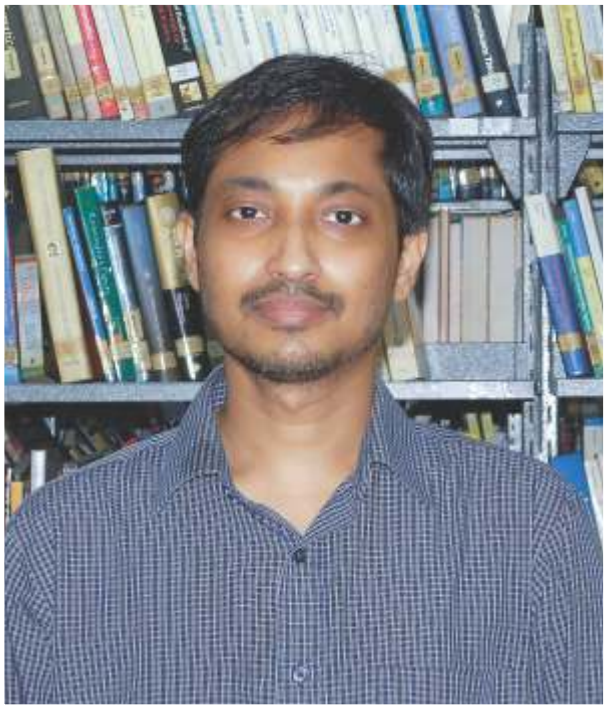
Surface Enhanced Infrared Spectroscopy, Linear Infrared Spectroscopy, Ultrafast Two Dimensional Infrared (2D IR), Surface Ligands Conformation, Glutathione

Despite the key roles of L-glutathiones (GSHs) inbiology and nano-biotechnology, understanding their labile structures and hydrogen bond interactions with nanoparticles has posed a critical challenge to the scientific community. The structural conformation of GSH as a capping layer on gold nanoparticle (AuNP) and silver nanoparticle (AgNP) surfaces is investigated. In this report, we attempt to explore the material-dependent interaction of GSH with different spherical nanoparticle surfaces by employing Fourier transform infrared (FTIR) spectroscopy. The infrared signal of amide I of GSH is studied as a function of different materials' spherical nanoparticles with comparable size. We revealed the -sheet secondary structure of GSH on AgNPs and the random structure on AuNPs even though both the nanoparticles have comparable shapes and sizes and belong to the same group of the periodic table. The GSH is firmly anchored on the gold and silver surface via the thiol of the cys part. However, our experimental data designate a further interaction with the AgNP surface via the carboxylic acid group of the gly- and glu- end of the molecule. It is observed that enhancement of IR absorption of amide I of GSH is pronounced by a factor of 10 on AuNP but, in contrast, on the same-sized AgNP, the suppression is perceived by a factor of 2, even though both are plasmonic materials with respect to free GSH. This study can be used as a point of reference for understanding the structural conformation of the capping layer on nanoparticle surfaces as well as surface enhancement of the IR absorption of amide I. We would like to emphasize that molecular self-assembly on the nanoparticle surfaces is definitely of very broad interest for chemists working in nearly any subdiscipline, spanning from the nanoparticle-based medicine to surfaceenhanced spectroscopy to heterogeneous catalysis, etc.



Plan of Future Work Including Project

1. Infrared spectroscopy is the finger print spectroscopy for a specific molecule. But the sensitivity of this spectroscopy is less compare to UV-vis/fluorescence spectroscopy. To use IR spectroscopy significantly, we need to enhance the signal of infrared probes, so that lower concentrations of molecules can be measured easily. To enhance the absorption coefficient of vibrational transition for a particular molecule, SEIRAS has been introduced. SEIRAS is nothing but the surface enhanced infrared absorption spectroscopy where the absorption coefficient of a vibrational mode enhances in the environment of plasmon polariton of nano particles. We will compare the enhancement of different infrared probes for a particular size and shape of NP and also for a particular probe on different size and shape of NP from different materials. Furthermore, we will attach amide/peptides on NP where highest enhancement obtained from the above experiment. Using polarization-selective 2DIR spectroscopy, we will reveal the molecular conformations of amide/peptide on the surface of NPs with different size and shapes from different materials. The fibril-like structure of amide and peptides will be studied by using ultrafast 2D IR spectroscopy. The stability of the fibril structures in different pH and presence of different salt ion. Parallely we will compare the enhancement of amide and peptide signal in the presence and absence of different salt ion in different pH. We will compare the enhancement for different secondary structures on NP. The response of secondary structure with change in the environment is important not only for the chemical and nano-technological applications of the NPs, but also for NP-based medicine. For amide we may use glutathione, since it is abundant in the cytosol and can potentially exchange with various NP ligands. Internalized NPs with GSH SAM eventually reach the acidic lysosome, where the fibril-like structure on their surface may initiate various processes.



Atindra Nath Pal

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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), Atindra Nath Pal (Co-supervisor)
4. Rafiqul Alam; An investigation of transport phenomena in topological materials; Under progress
5. Riju Pal; Charge and spin transport in hybrid two dimensional nanodevices; Under progress

b) Post-Docs

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

c) External Project Students / Summer Training

1. Tausif; On chip gas sensor based on 2d materials; TRC, SNBNCBS
2. Taniya Basu; Technical Assistant of the clean room; TRC, SNBNCBS
3. Soumili Dutta; Research Assistant for clean room device fabrication; TRC, SNBNCBS

Teaching

1. Autumn semester; PHY 501- Research Methodology; PhD; 38 students; with 1 (Prof. Rajib Kumar Mitra) co-teacher

Talks / Seminars Delivered in reputed conference / institutions

1. Invited talk at QMAT 2020 (September 7-11, 2020); Sep 8, 2020; SNBNCBS (online mode); 30 min

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; PI

Conference / Symposia / Schools organized

1. Q-MAT : 2020: 3RD ANNUAL CONFERENCE OF QUANTUM CONDENSED MATTER; Sep 7, 2020; SNBNCBS (online mode); 4 days

Areas of Research

Experimental condensed matter physics

Ferrocene based highly conducting single molecular molecular junction at ambient temperature:

We have investigated the conductance property of ferrocene and ferrocene based single molecular junction. For all the studied molecule (ferrocene, 1,1' bis(aminomethyl)ferrocene and 1,1' dicyanoferrocene), a high conductance region is observed (0.2-0.5 G_0). Apart from that, we observed a low conductance region in the molecules with anchoring group, which may be related to the junction forming due to the connection with the anchoring groups like CN or NH_2. The high conductance is rather surprising and promising in this metallocene based molecular junction. Initial speculation could be that the gold is directly binding with the Fe atom and high conductance may originate due to spin dependent quantum interference effect similar to our former work on vanadocene molecular junction at low temperature. We are collaborating with Dr. Richard Korytar, Charles University, for transport calculations.

Gate tunable Broadband photodetector with graphene-WS_2 hybrid:

One of our major research directions is hybrid optoelectronic devices from TMDC and other 2D materials. In this work, we demonstrate a lithography free cost-effective hybrid phototransistor based on CVD graphene and chemically exfoliated WS2 quantum dots (QDs). In this 2D-0D configuration, WS2 QDs act as light absorber, while the CVD grown single layered graphene is the conductive channel for photocurrent flow. This experimental results demonstrate a highly stable low cost graphene based UV-visible (365-633 nm) broadband phototransistor. Adding with the simple solution process for the preparation of WS2 QDs, these results are very promising for scaling up to make photodetector devices for future optoelectronic applications.

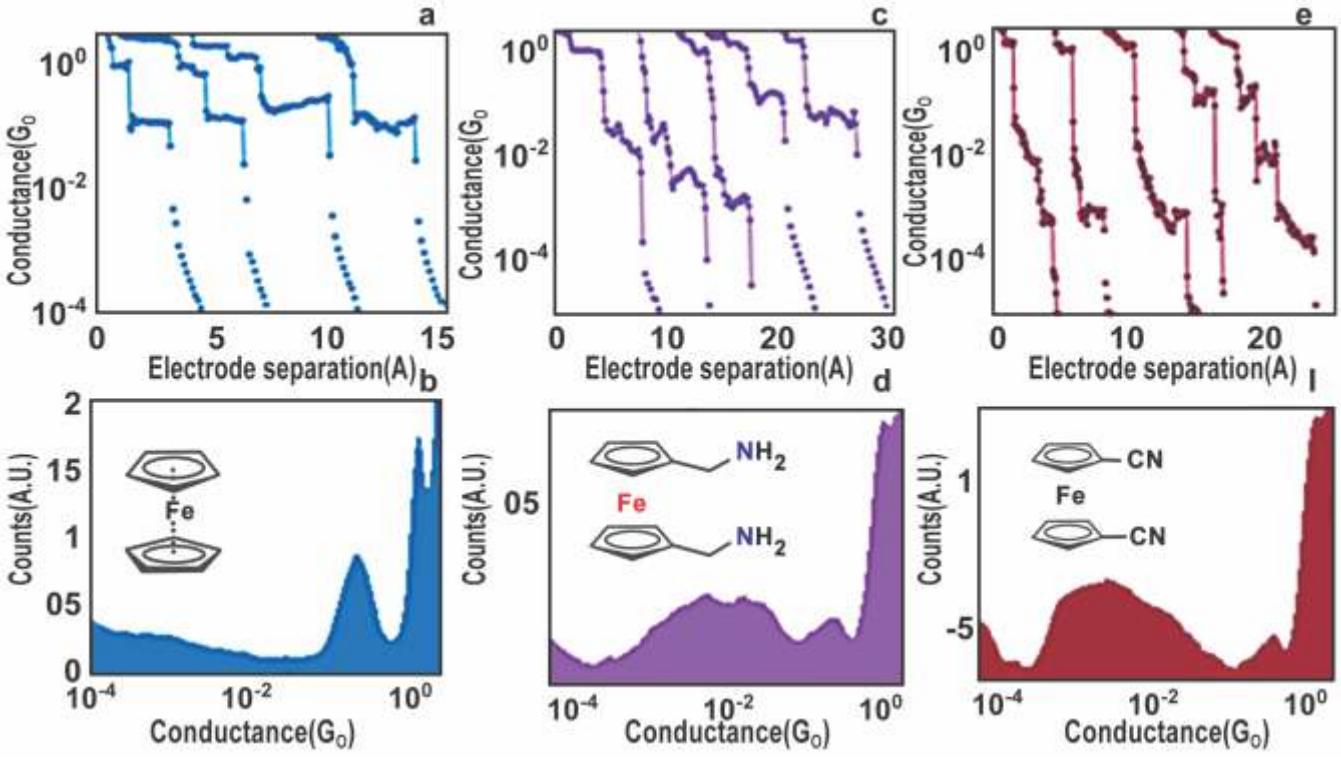

Figure 1 : Typical conductance traces for Mol A (Ferrocene), (a), Mol B (1.1 'bis(aminomethyl)ferrocene)(c) & Mol C (1.1' dicyanoferrocene) (e) respectively, (b), (d) & (f) conductance histogram for Mol A, B & C and histogram is constructed from 1500, 5000 & 5000 traces with 40 bins per decode.

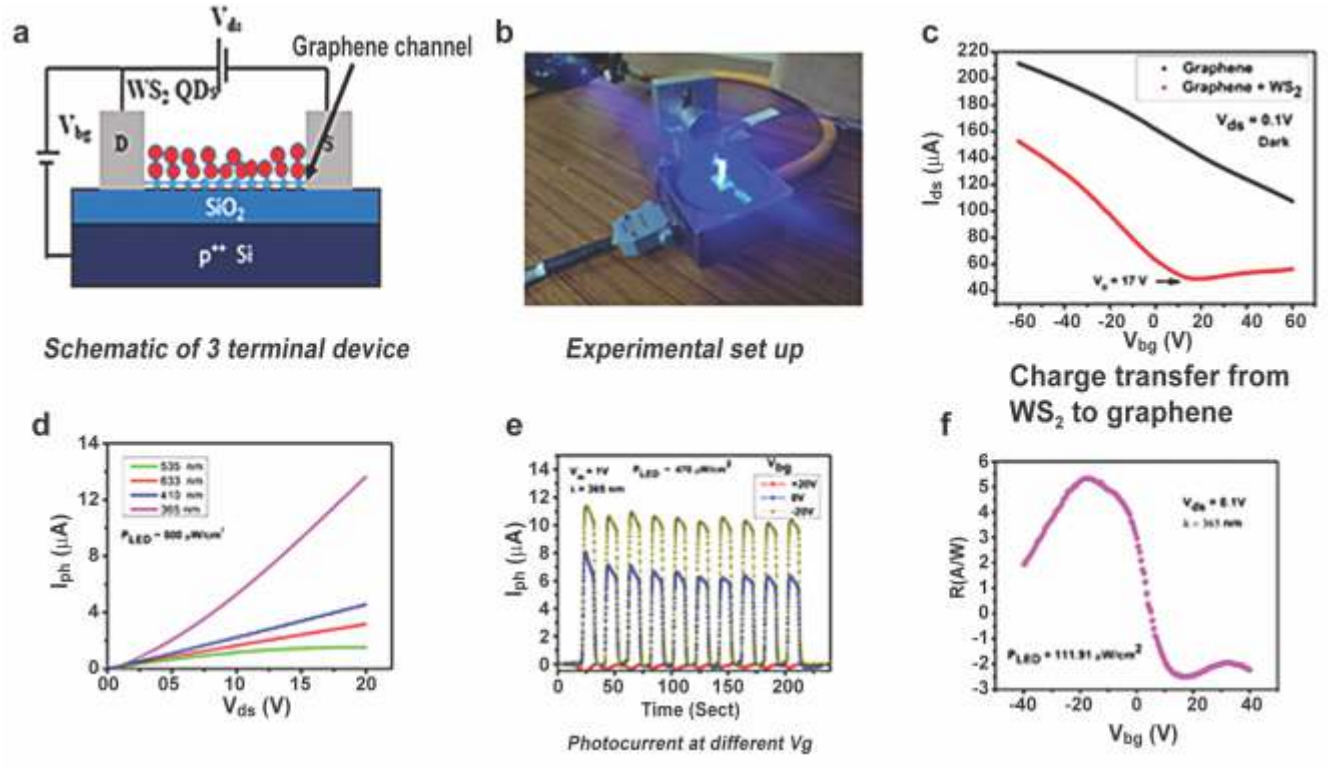

Figure 2 : (a) Optoelectronic transport measurement set up, (b) I–V characteristics at different gate voltages for a two terminal few layer Mo52 transistor, inset shows the device image, (c) IDS-Vbg characteristics in dark and, in presence of red light, showing signal.

Unconventional superconductivity coexisting with Charge density wave in non-Centro symmetric $(TaSe_4)_3I$

The following work focuses on the electronic and magnetic transport through a non-Centro symmetric $(TaSe_4)_3I$ nanowires, grown in Dr. Mintu Mondal's group, IACS. This work is part of joint collaboration with IACS, IISER Mohali, SINP and IISc. We are focusing on the electrical transport in few wire to single wire devices. We observe CDW like transition at 146K, followed by a superconducting transition below 2.2K. The magnetic property of the sample is indeed interesting and shows a field dependent magnetism below 10K. Our initial measurements indicate the coexistence of CDW, Superconductivity and magnetism at temperature below 10K. We have carried out differential conductance measurement at different temperature, showing two different energy scale, one of them corresponding to the superconductivity and the other one may be related to the CDW.

Noise spectroscopy in understanding transport phenomena in topological semimetal

Low frequency noise measurement, an important in solid state devices, used before to understand various scattering phenomena, phase transitions and even quantum transport in two-dimensional devices. Our basic motivation is to understand the transport mechanism of various topological materials where average resistance measurement is not enough to provide detail information about the underline physics. We focus on transport measurement in topological semimetals ($LaAgSb_2$ and Ta_3SiTe_6), which also exhibit CDW transition. Initial data indicate a sudden rise in noise near the transition, however, measurements need to be repeated for further conclusion.

Plan of Future Work Including Project

1. Single molecular transport: During the last three years we have been able to create mechanical

break junction set up to study single molecular junction at room temperature as well as at cryogenic temperature. We have recently got a project to investigate the relation between the orbital structure and electron transport via electronic transport and shot noise. We would like to pursue the metallocene based organic molecules which show exceptionally high conductance at room temperature. Studying these molecules with different electrodes will help us to understand the orbital hybridization effect on these molecules.

2. Van der Waal hybrids: The isolation of graphene by a simple scotch-tape based technique has created a huge playground for exploring various two-dimensional (2d) layered materials due to their excellent electronic, optical, mechanical and thermal properties. After graphene, lot of new 2D materials were discovered including insulators, semiconductors, superconductors, topological insulator, topological semimetals and two dimensional magnets. Superlattices and heterostructures have already been widely explored to tailor the electronic properties of two-dimensional electron systems. With today's nanofabrication scheme it is possible align different 2D materials almost perfectly on top of each other to form heterostructures. Proximity effect is being emerged as a radically different path to transform a given material through its adjacent regions to become superconducting, magnetic, or topologically nontrivial. Such proximity effects not only is a ubiquitous approach compared to the conventional methods of doping or functionalization but also can overcome their various limitations. Our current research focusses on the following:

   - Fabricating high quality two-dimensional devices (graphene, transition metal dichalcognides (TMDCs) etc.) in combination with various functional molecules. Our immediate attention is to create hybrid devices in combination with spin crossover molecules and understand the transport mechanism.
   - Optoelectronics with TMDC based hybrids. In particular, we intend to create large area broadband photodetector using 2D-0D hybrids (e.g., CVD graphene with MoS2 or WS2 quantum dots).
   - We intend to explore spintronics and other emerging phenomena with 2d magnetic heterostructure in future.

3. Transport in emerging materials: Our aim is to investigate some of the key issues in solid-state physics and materials science by studying new topological materials, semimetals, unconventional superconductivity, charge density wave physics. etc. in various emerging materials. Our recent experiment on layered Ta(Se4)3I, has opened possibilities to study them at lower dimension. Moreover, we aim to focus on tuning the CDW transition, studying the possible coexistence of competing orders like superconductivity and magnetism in this materials through electrical magnetostransport measurements.

Barnali Ghosh (Saha)

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Samik Roy Moulik; Synthesis and study of physical properties of binary oxide thin films and nanostructures and devices; Awarded
2. Chandan Samanta; Synthesis, Physical Properties And Application Of Metal Oxide Semiconductor Nanostructures And Thin Films; Thesis submitted
3. Avisek Maity; Synthesis, Characterization, Physical Property Studies & Applications of Perovskite Halide; Under progress
4. Purushottam Majhi; Structure And Physical Properties Of Strained Metal Oxide Films; Under progress; Prof. A.K.Raychaudhuri, CGCRI, Kolkata (Co-supervisor)
5. Snehamoyee Hazra; Investigation on Nanostructured Piezoelectric and Ferroelectric materials; Under progress
6. Sudipta Chatterjee; Investigation on transport and magneto-transport properties of transition metal based oxides and alloys; Under progress; Prof. Kalyan Mondal (Supervisor), Dr. Barnali Ghosh Saha (Co-supervisor)

b) Post-Docs

1. Arnab Ghosh; Synthesis of graphene and transition metal dichalcogenide based two dimensional nanostructures for applications in supercapacitor, gas sensor and piezoelectric nanogenerator devices

c) External Project Students / Summer Training

1. Saikat Mitra, SERB project student; Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; S.N Bose National Centre For Basic Sciences
2. Ayan Ghosh, TRC project Asistant (shared); prototype development of gas sensor; S.N Bose National Centre For Basic Sciences
3. Sohel Siraj, TRC Project Student; Development of programming and packaging of prototypes; S.N Bose National Centre For Basic Sciences
4. Chandni Das, TRC Project Student (shared); Growth of Sensing material and their characterization; S.N Bose National Centre For Basic Sciences
5. Monalisa Yadav, M.Sc. Project Student; Studies of Oxygen Defficient Barium Titanate; IISER. Kolkata
6. Soumyaranjan Rath, M.Sc. Project; Growth, characterization and physical properties study on piezoelectric nanostructured material; Vellore Institute of Technology, Vellore

Teaching

1. Autumn semester; Integrated Ph.D programme, 3rd, Semester, Methods of Experimental Physics, PHY 391; Integrated PhD; 6 students
2. Spring semester; Project Research III (PHY 401); Integrated PhD; 2 students
3. Spring semester; Summer Project Research I (PHY 292) – 2nd Semester; Integrated PhD; 1 student

Publications

a) In journals

1. Chandan Samanta, Sekhar Bhattacharya, A. K. Raychaudhuri and **Barnali Ghosh**, *Broadband (Ultraviolet to Near-Infrared) Photodetector Fabricated in n-ZnO/p-Si Nanowires Core–Shell Arrays with Ligand-Free Plasmonic Au Nanoparticles*, The Journal of Physical Chemistry C, 124, 22235-22243, 2020

b) Conference proceedings / Reports / Monographs / Books

1. Snehamoyee Hazra, Subhamita Sengupta , Ankita Ghatak , Barnali Ghosh,and A.K.Raychaudhuri, "Effect of Electrode Material on the Voltage Generation of PZT Nanowire Based Nanogeneratori" AIP Proceedings, 2265,030668, 2020

Administrative duties

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

Patents Taken and Process Developed with Details

1. Indian Patent has been granted (Grant no: 351816 , Dated 20/11/2020) Patent title: A method to grow single crystalline sharp nano needles of piezoelectric materials. The patent provides the growth of chemically synthesized ferroelectric PZT nanowire with single crystalline pencil tip by hydrothermal method. The full mechanical contact between single crystalline pencil tip PZT and electrode will enhance the performance of the device. The growth of pencil tip PZT nanowires on any flexible substrate has been achieved. The measurement of dielectric properties of single crystalline pencil tip PZT nanowires on flexible substrates shows the value of dielectric permittivity is very high which makes the nanowires promising candidate for flexible device storage applications; 351816; Granted
2. A technique to regenerate ferroelectric phase by surface and subsurface engineering of BaTio3 thin films , Barium Titanate thin film on metallic substrate comprising regenerated surface and/or subsurface modified Barium Titanate thin film on highly oriented single crystalline substrate is provided including transformed non-ferroelectric phase of said film surface and/or subsurface to ferroelectric phase. A process is also provided whereby said regeneration of ferroelectric phase in Barium Titanate (BaTiO3) thin films grown on any highly oriented single crystalline substrate by surface and subsurface engineering is made possible using a hybrid technique coupling Inductive Coupled Plasma Reactive Ion Etching (ICPRIE) along with post annealing at high temperature with excess of BaCO3." FER report submitted. on September 2020"; 201731036353 A; Applied
3. "Flexible thin film transistor using eletrcic double layer as gate dielectric and a method of fabrication 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." FER report submitted. on January2021"; 201731015268; Applied

4. A Gas-sensing system for selective detection of (Nitric Oxide) NO gas and a method for fabricating the same, The present invention relates to nitric oxide (NO) gas sensing. More specifically, the present invention is directed to develop a room-temperature operable, hand-held nanostructure based nitric oxide (NO) gas sensing system and a method for fabricating the same. The NO gas sensing system of the present invention is particularly adapted to exhibit long-lasting reusability, stability and perform the NO gas detection at room temperature and even in an open environment. "FER report submitted. on March 2021"; 201731038036; Applied

Membership of Learned Societies

1. Life member Indian Physics Association
2. Life member Indian Association for the Cultivation of Science
3. American Physical Society
4. 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; 06/07/2021- 05/07/2022; PI
2. An investigation on certain emerging aspects of Metal- Insulator Transition in thin oxide films; SERB- DST; 24/3/2017- 23/07/2021; Co-PI
3. Technical Research Centre, Centre project, One of the activity leader among others; DST; 01/01/2016 to 30/ 06/2021; PI

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

1. CGCRI Kolkata; Sl. No. 1; National

Outreach program organized / participated

1. International Science Festival (IISF) – 2020, organized by the Ministry of Science & Technology, Ministry of Earth Sciences and Ministry of Health & Family Welfare in association with Vijnana Bharati (VIBHA) during 22-25 December 2020 at New Delhi in Virtual Mode.

Areas of Research

Study of Photoresponse and gas sensing property in binary oxide hetero junction systems. Growth and physical property study of perovskite lead halide Synchrotron X-ray and Neutron diffraction study in complex oxides. Paper electronic based device for gas sensing activity of perovskite halides Study on paper electronic based Photo detector of perovskite halides Growth of binary and complex oxide nanowires and thin films by using different techniques like; wet chemistry and pulsed laser deposition methods and atomic layer deposition. Fabrication of single nanowire device of complex oxide systems by using different lithographic techniques and transport measurement on single nanowire. cross-sectional TEM study in binary and complex oxide nanowires, nanocrystals and thin films Growth of high performance thin film transistors (TFT) and physical property study

Broadband (Ultraviolet to Near-Infrared) Photodetector Fabricated in n-ZnO/p-Si Nanowires Core–Shell Arrays with Ligand-Free Plasmonic Au Nanoparticles

We show a high-response optical detector based on n-ZnO/p-Si nanowires (NWs) core – shell arrays decorated with plasmonic Au nanoparticles(NPs) that works in the broad frequency range from UV (300 nm) to NIR (1100 nm) and consumes low power (few W). The optical detector combines the visible and NIR detectability of Si NWs with the UV detectivity of ZnO through the core – shell structure and broadband detectivity in the visible range has been achieved by decorating core – shell arrays with ligand-free Au NPs synthesized by using pulsed laser ablation in liquid. The photodetector uses n-ZnO as the active photoconductive channel that is sensitive in the UV region. However, using photogating as well as favorable band alignments, the carriers generated at longer wavelengths in visible and NIR in Au

NPs and Si NWs arrays were introduced into the conduction band of ZnO, leading to its broadband performance. We observed significant enhancement of responsivity R not only in the visible range but also in the UV and NIR region with a high detectivity of 1011 cm Hz1/2 W – 1. The responsivity of the detector is 1 A/W from 700 nm to a longer wavelength (at a bias of 1 V) and, in the visible region, the responsivity of the photodetector with Au NPs is > 0.5 A/W and increases to > 1 A/W in the UV region.

One paper has been published in *The Journal of Physical Chemistry C* 2020 *124* (40), 22235-22243

Universal sensing of ammonia gas by family of lead halide perovskites based on paper sensors: Experiment and molecular dynamics

We show that, high sensitivity and high selectivity room temperature ammonia (NH_3) gas sensors with both visual and electrical response can be made from family of lead halide perovskites with different cations and anions. These sensors, based on papers, act as general platforms for new generation of solid state gas sensors for sensitive detection of NH_3 gas by simple color change (~10 ppm sensitivity) as well as electrical resistance change with sub ppm sensitivity limited by electrical noise only. The sensors with materials like $CH_3NH_3PbI_3$ (MAPI), $CH_3NH_3PbBr_3$ (MAPB) and $CH(NH_2)2PbI_3$ (FAPI), are grown on paper from solution. MAPB changes color from orange to white and FAPI and MAPI from black to yellow under NH_3 gas exposure respectively. For electrical sensor operation, a fixed concentration (20 ppm) of NH_3 gas, the sensitivity of MAPI is highest at 96 % followed by MAPB at 82 % and FAPI at 65 %. The sensors with electrical read out could trace NH_3 gas well below ppm level with only few nanowatt of power consumption. Based on experiments, a sensing mechanism has been proposed. The proposed mechanism mainly consists of decomposition of the perovskite halides to lead (Pb) halide by preferential adsorption of NH_3 gas molecules. The proposed mechanism has also been substantiated by molecular dynamics simulations. These sensors fabricated by simple solution process on paper substrates and operable at ambient temperature, are compatible with very low power (~ nW) paper electronics.

Proof of concept established, the "Indian patent has been granted (Grant no: : 317234, dated 31/07/2019)".

One paper published in Materials Research Bulletin 136 (2021) 111142.

Plan of Future Work Including Project

A) Technology development related work (under TRC project): 1) Development of Hazards Gas Detection Sensor based devices and prototypes : (see details given in serial no 13) 2) Development of nano-generator using piezoelectric nanostructures: a) Piezo-electric nanowires for energy harvesting and sensitive motion. Work is being done on self powered nano systems combine the nano generator with functional nanodevices in order to harvest mechanical energy from the environment into electricity to power nano devices. (An Indian Patent has been granted (Grant no: 351816 , Dated 20/11/2020) Patent title: A method to grow single crystalline sharp nano needles of piezoelectric materials B) Basic research: i) Study on Paper electronics based broad band photo detector using perovskite halides ii) Synthesis & optical properties, crystallographic structure microstructural study on Perovskite halide systems iii) Growth and Physical property study on piezoeletcroc nanostrcutures iv) Physical Property study on Single nanowire based devices v) Growth to Physical Properties on thin film transistors (TFT) vi)vi) Study of interface physics of complex and binary Oxide thin films and multilayers 1).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: one paper has been published: J. Phys. Chem. C 2019, 123, 2573 – 2578. Further work is under study.

Any other Relevant Information including social impact of research

1. Main area of work: i) Environment related issue: Making of sensor for Hazardas gas detection ii) Health Care Sector: Technology development for making device for detection of disease 1. Fabrication of Piezo electric nano generator :

Piezo-electric nanowires for energy harvesting and sensitive motion, Power generation from waste energy: for (a) battery application, (b) self- powered sensor for pulse rate monitoring. Indian Patent has been filed. b) Indian Patent Grant no: 351816, Dated 20/11/2020) Prototype: Packaging of the device (SMART SHOE) has been done. 2. A) Development of ultra-sensitive sensor for hazards gas detection: Ammonia gas sensor : a)"Visual color change based ammonia gas sensor (<10ppm)for stand - alone use for hazards. "Prototype is ready for use which can sense ammonia<10ppm level by visual effect (just by colour change)" patent granted (Grant no: : 317234, dated 31/07/2019 : publication: Scientific reports(2018) 8:16851) (11 citation) b)" High sensitivity NH3 gas (~10 ppb) solid state sensor with electrical readout" High sensitive sensor can be used as markers for renal disease and chronic kidney diseases (CKD). Even during dialysis of a patient exhaled NH3 can used to check the efficacy of the dialysis. Prototype under process, (Indian patent no: 201831001993, FER submitted) publication: Scientific Reports (2019) 9:7777 (42 citation) 3 .Development of Nitric oxide (NO) gas sensor: solid state sensor, detecting NO gas (sensitivity: 500ppm). Exhaled NO can be used as the markers for Asthma and Chronic obstructive pulmonary disease (COPD). Prototype under process.

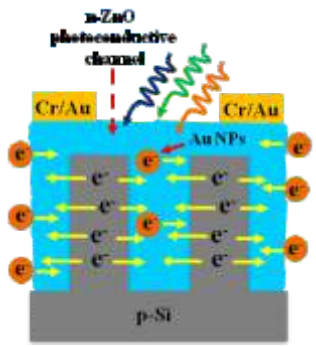

Fig 1(a) photogated device where the nZnO channel receives carriers from the core of Si NWs as well as Au NPs when they are illuminated

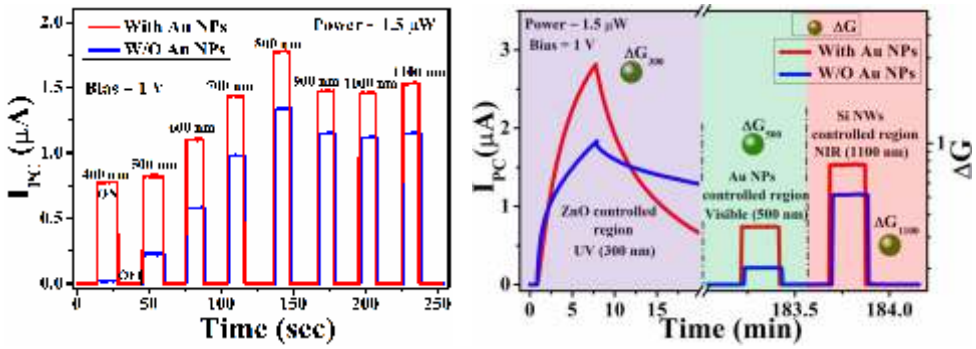

Fig 1(b) Photocurrent (IPC) under different illuminations of light of wavelength ranging from 400 to 1100 nm at a fixed power of 1.5 ᴍW. The illumination was turned ON and OFF. (c) Plot of IPC at different wavelengths for the n-ZnO/p-Si core – shell array with and without Au NPs

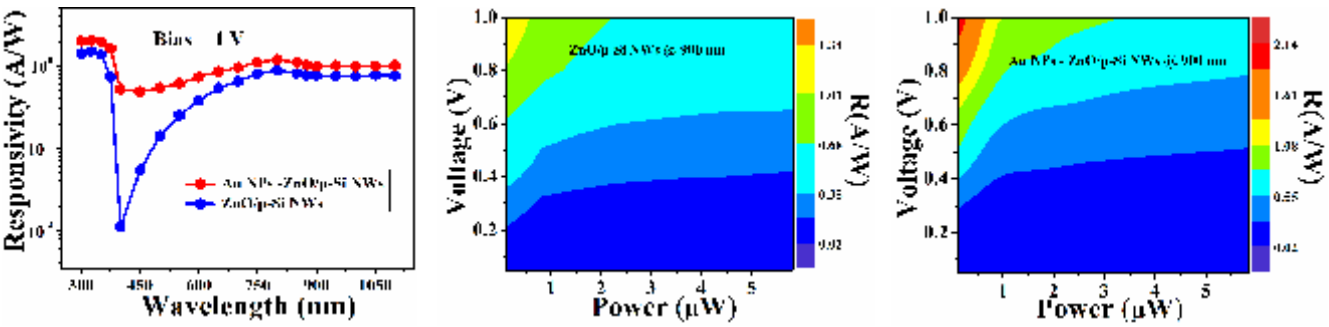

Fig 2 (a) Spectral responsivity (R) of ZnO/p-Si NW core – shell arrays with and without Au NPs under different wavelengths. Contour plot of responsivity R as a function of bias V and illumination power P of **(b)** n-ZnO/p-Si NWs and **(c)** Au NP-decorated n-ZnO/p-Si NW core – shell arrays.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Saumen Chaudhuri; 2D materials under strain; Under progress

Areas of Research

Surfaces, interfaces and thin films

(i) Surface patterning in nanoengineering with the help of ion beam irradiation is an active field of research for understanding the surface dynamics at the atomic scale and also for the nanodevice fabrication. Using in-situ scanning tunneling microscopy (STM) we have investigated the evolution of Si(111)-7x7 surfaces, prepared under ultrahigh vacuum condition, upon Ar+ ion sputtering and subsequent annealing. Sputtering makes the surface amorphous. However, annealing at 600 °C causes recrystallization with simultaneous growth of nanoislands with flat-top ordered surfaces with 5x5 and 2x2 surface reconstructions, in addition to the predominant 7x7 reconstruction. This phenomenon is similar to surface reconstructions observed around the transition temperature of the thermally induced 7x7 < – – > '1x1' order–disorder phase transition on the Si(111) surface.

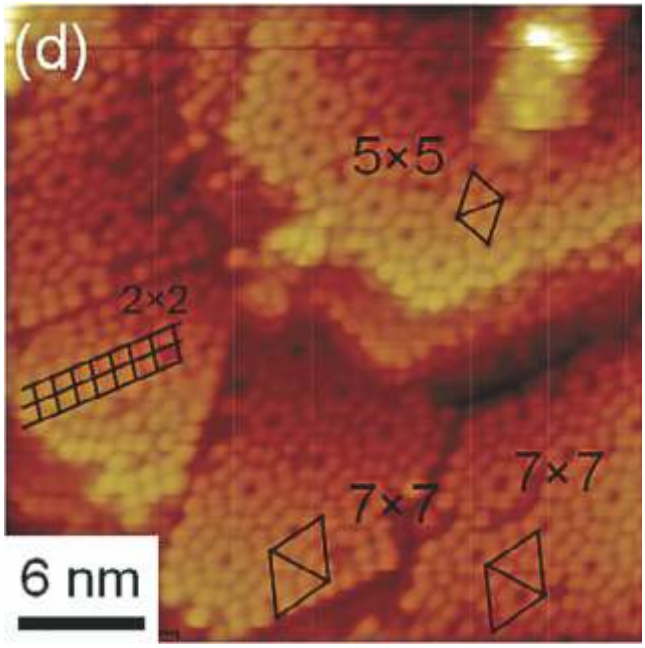

Figure: An STM image showing the sputtered and recrystallized surface with nanoscale flat-top islands with 7x7, 5x5 and 2x2 surface reconstructions. Each white dot in the image is a silicon atom. Surface unit cells are marked. Before Ar+ ion sputtering the entire surface area had a uniform 7x7 reconstruction.

(ii) Quantum technology is a rapidly developing field. Superconducting (S)-ferromagnetic (F) hybrid structures are important for applications in quantum information processing. Earlier, we have grown $CoSi_2$ (S) and -$FeSi_2$ (F) epitaxial nanostructures on clean Si surfaces individually. Now we have grown both types of structures simultaneously on the same Si surface. STM images and XPS measurements confirm the presence of both $CoSi_2$ and -$FeSi_2$ nanostructures. The interaction in the S-F hybrid structures is tuned by controlling the separation between S and F

structures. In our molecular beam epitaxy (MBE) or reactive deposition epitaxy growth, the separation between S and F structures can be controlled via the excellent control of atomic deposition and the amount of deposited materials.

(iii) Transition metal dichalcogenides (TMDs) hold a great deal of attention due to its realization in the form of a single layer and its importance in several areas of materials science. We have investigated strain-induced modifications of electronic properties and lattice dynamics in 2H and 1T' structures of MoS_2 by DFT calculations for uniaxial and biaxial tensile and compressive strains. 2H-MoS_2, under biaxial tensile strain, initially transforms from a direct band gap semiconductor to an indirect band gap semiconductor; with increasing pressure the band gap narrows and eventually becomes zero (metallic) at around 10% strain. Compressive strain did not show any transition to metallic state. Pristine 1T´ MoS_2 monolayer exhibits a nontrivial band topology. Due to the existence of band inversion at the - point and the strong spin-orbit coupling coming from the Mo atoms, there exists a band gap of about 60 meV. A transition from insulator to metal occurs at a strain of 3-4% for tensile as well as compressive strain.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Subrata Ghosh; Magnetocaloric effect; Thesis submitted
2. Dipika Mandal; Microwave properties of ferrite nanostructures; Thesis submitted
3. Dipanjan Maity; Electrochemical water splitting; Under progress
4. Priyanka Saha; Ferrites nanostructures; Under progress
5. Swarnali Hait; Multiferroic materials; Under progress
6. Anupam Garai; Microwave properties of ferrite nanostructures; Under progress
7. Sudipta Chatterjee; Transport and magneto-transport properties of Heusler alloys; Under progress
8. Saheli Samanta; Magnetocaloric effect; Under progress

b) Post-Docs

1. Deblina Majumder; Biomedical applications of magnetic nanostructures

Teaching

1. Spring semester; Magnetism and superconductivity (PHY 409); Integrated PhD; 5 students; with 1 (Ranjan Chaudhury,) co-teacher
2. Spring semester; Advanced condensed matter physics (PHY 601); PhD; 6 students; with 1 (Ranjan Chaudhury,) co-teacher
3. Spring semester; Advanced Experiments (PHY 391); Integrated PhD; 12 studnets; with 4 (T. Setti, R. Mitra, and M. PradhanR. Das) co-teachers
4. Autumn semester; Basic experiments (PHY 291); Integrated PhD; 12 students; with 1 (Pratip Kumar Mukhopadhyay,) co-teacher

Publications

a) In journals

1. Subrata Ghosh, Pintu Sen and **Kalyan Mandal**, *Magnetostructural transition and large magnetocaloric effect in* $(Mn_{0.6}Fe_{0.4})NiSi_{1-x}Al_x$ *(x = 0.06–0.08) alloys*, Journal of Magnetism and Magnetic Materials, 500, 166345, 2020
2. Subrata Ghosh, Arup Ghosh, Pintu Sen, and **Kalyan Mandal**, *Giant Room-Temperature Magnetocaloric Effect Across the Magnetostructural Transition in* $(MnNiSi)_{1-x}(FeCoGa)_x$ *Alloys*, Physical Review Applied, 14, 014016, 2020
3. SouvanikTalukdar, Priyanka Saha, Indranil Chakraborty and **Kalyan Mandal**, *Surface functionalized CoFe2O4 nano-hollowspheres: Novel properties*, Journal of Magnetism and Magnetic Materials, 513, 167079, 2020
4. Dipanjan Maity, Keshab Karmakar, Dipika Mandal, Debashish Pal, Gobinda Gopal Khan and **Kalyan Mandal**, *Earth abundant transition metal ferrite nanoparticles anchored ZnO nanorods as*

efficient and stable photoanodes for solar water splitting, Nanotechnology, 31, 475403, 2020

5. Swarnali Hait, Srabantika Ghose and **Kalyan Mandal**, *Effect of Ba and Y co-doping on the structural and magneto-electric properties of $BiFeO_3$ ceramic*, Journal of Alloys and Compounds, 822, 153614, 2020
6. Deblina Majumder, Indranil Chakraborty and **Kalyan Mandal**, *Room temperature blooming of CeO_2 3D nanoflowers under sonication and catalytic efficacy towards CO conversion*, RSC Advances, 10, 22204-22215, 2020
7. Mahebub Alam, **Kalyan Mandal** and Gobinda Gopal Khan, *Origin and tuning of room temperature ferromagnetism and ferroelectricity in double perovskite Y_2NiMnO_6 nanostructured thin films*, Journal of Alloys and Compounds, 822, 153540, 2020
8. Mahebub Alam and **Kalyan Mandal**, *Room temperature ferromagnetism and ferroelectricity in double perovskite Y_2NiMnO_6 thin film*, Journal of Magnetism and Magnetic Materials, 512, 167062, 2020
9. Keshab Karmakar, Dipanjan Maity, Debashish Pal, **Kalyan Mandal**, and Gobinda Gopal Khan, *Photo-Induced Exciton Dynamics and Broadband Light Harvesting in ZnO Nanorod-Templated Multilayered Two-Dimensional MoS_2/MoO_3 Photoanodes for Solar Fuel Generation*, ACS Applied Nano Materials, 3, 1223-1231, 2020

b) Conference proceedings / Reports / Monographs / Books

1. S Ghosh, A Ghosh, P Sen, K Mandal, "Magnetic and magnetocaloric properties in TbCo2Si2 alloy", AIP Conference Proceedings 2265 (1), 030553 (2020).
2. M Alam, S Ghosh, K Mandal, "Magnetic and magnetocaloric properties in double perovskite multiferroic Y2NiMnO6 nanoparticle", AIP Conference Proceedings 2265 (1), 030592
3. Folate modified zinc ferrite nano-hollowspheres for drug delivery and intrinsic fluorescence S Talukdar, P Saha, K Mandal AIP Conference Proceedings 2265 (1), 030131

Talks / Seminars Delivered in reputed conference / institutions

1. "Novel properties of transition metal oxide nanostructures", in the conference "Recent success and challenges in nanoscience and nanotechnology (experiment and theory) (RSCNN 2020), 25-27th September, 2020; Organized by School of Applied Sciences and Humanities, Haldia Institute of Technology; Sep 25, 2020; On-line; one hour
2. "Magnetic properties and their measurements: bulk to nano", in C. K. Majumdar Memorial Workshop in Physics; 28 December 2020 - 04 January 2021; Jan 2, 2021; On-line; one hour

Administrative duties

1. Head of the Department, Condensed Matter Physics and Materials Sciences
2. Chairman, Security Committee
3. Chairman, Library Committee
4. Chairman, Purchase Committee

Membership of Learned Societies

1. Indian Physics Teachers' Association
2. Materials Research Society of India
3. IEEE Magnetic Society (USA)
4. Non-destructive Society of India

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; Department of Science and Technology; 3 years; Co-PI

Conference / Symposia / Schools organized

1. C. K. Majumdar Memorial Workshop in Physics 2020; December 28, 2020; S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata; 8 days

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

1. Photoelectrochemical water-splitting with Dr. Gobinda Gopal Khan, Tripura Central University, Agartala, Tripura; Sl. No. 4, 7, 9; National
2. Magnetocaloric effect with Dr. Pintu Sen, Variable Energy Cyclotron Centre, Salt Lake, Kolkata; Sl. No. 1, 2; National

Areas of Research

Magnetism and magnetic materials, Nanomaterials, Energy materials

Multi-layered nano-hollow spheres for efficient electromagnetic wave absorption Ferrite nano-hollow spheres (NHS) are of great significance to improve electromagnetic (EM) wave absorption performance. The deposition of dielectric SiO_2 (SiO) and ferrimagnetic $CoFe_2O_4$(CFO) layers on $MnFe_2O_4$ (MnFO) NHS are found to be an effective strategy to enhance EM wave attenuation. EM wave absorption properties of as-synthesized bare and bi-layered samples are investigated within a widely-used frequency range of 1 - 17 GHz. MnFO/CFO bi-layered NHSs exhibit an excellent reflection loss (*RL*) of -47.0 dB at only 20 wt% filler content with an effective broad bandwidth (*BW*) of ~ 2.2 GHz (frequency region for $RL < -10$ dB). Attenuation constant is observed to increase from 191.6 Np/m to 457.8 Np/m for bare MnFO and MnFO/CFO NHSs respectively. Larger interfacial area, higher magnetic anisotropy, internal reflections and scattering from NHSs are responsible for superior absorption properties of MnFO/CFO NHSs. Moreover, best impedance matching, $|Z_{in}/Z_0| \sim 1$, promotes the optimum *RL* in MnFO/CFO at 5.96 GHz. MnFO/SiO bi-layered NHSs result in a sufficiently high $RL \sim -30.0$ dB with a composite absorber of thickness only 3mm. Analysis from /4 model for best matching thickness (t_m) displays a good agreement between experimental and simulated t_m values. This study demonstrates optimized MnFO/CFO NHS as a highly promising low-cost and light-weight EM wave absorber suitable for practical high-frequency applications.

$ZnCo_2O_4$/ZnO a p-n type –II heterojunction photoanode for PEC water splitting application

Poor light absorption, severe surface charge recombination and fast degradation are the key challenges with ZnO nanostructures based electrodes for photoelectrochemical (PEC) water splitting. In this study we have attempt to design an efficient and durable nano-heterojunction photoelectrode by electrochemical deposition of $ZnCo_2O_4$ (ZCO) over chemically grown ZnO nanorods. This nano-heterojunction photoanode exhibits improved visible light-harvesting performance due to the narrow band gap of ZCO. The type-II band alignment between $ZnCo_2O_4$ and ZnO Nanorods (NRs) accelerates the charge transfer process and reduces the photogenerated electron-hole pair recombination. The $ZnCo_2O_4$ surface layer also passivates the surface states in ZnO, resulting in a remarkable reduction in photocarrier recombination which improve the current density of bare ZnO photoanode from a value 0.35 $mA.cm^{-2}$ to 1.58 $mA.cm^{-2}$ at 1.23V vs. RHE. This work demonstrates an innovative strategy to improve the PEC water oxidation of ZnO NRs by incorporating $ZnCo_2O_4$ which acts both as an OER catalyst and a *p*-type light-harvesting semiconductor, which helps in the rapid separation of photocarrier.

Plan of Future Work Including Project

1. To prepare low-cost transition metal-based materials with high magnetocaloric properties
2. Better materials for electrochemical water-splitting will be prepared and studied in details.
3. Multilayered nano-hollow spheres of ferrites and dielectric materials for microwave absorption will be investigated.
4. Effort to prepare multiferroic materials with better magneto-electric coupling will be continued.

Manoranjan Kumar

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Debasmita Maiti; Frustrated Magnetic Ladders : A DMRG Study; Awarded
2. Monalisa Singh Roy; Edge Modes in 1D Chains of Correlated Electrons and Their Junctions; Thesis submitted
3. Sudip Kumar Saha; Thermodynamics of Low-Dimensional Interacting Quantum Systems: A Hybrid Exact Diagonalization and Density Matrix Renormalization Group Study; Under progress
4. Sk Saniur Rahaman; Quantum Phases in Quasi-One Dimensional Frustrated Spin Systems; Under progress; M Sanjay Kumar (Co-supervisor)
5. Koushik Mandal; Theoretical investigation of the properties of correlated fermionic systems in low dimension; Under progress; Ranjan Chaudhury (Supervisor)
6. Sudipta Pattanayak; Ordering kinetics, steady state and phase transition in active particle systems: Role of noise and boundary; Awarded; M Sanjay Kumar (Co-supervisor)
7. Somashree Ghosal; Hubbard model on Quasi one and two dimensional lattices; Under progress
8. Monalisa Chatterjee; Topological aspect of Frustrated low dimensional Spin Systems; Under progress
9. Jyotirmoy Sau; Topology in Strongly Correlated Systems; Under progress
10. Manodip Routh; Effect of temperature on exotic quantum phases of strongly correlated system; Under progress

b) Post-Docs

1. Joy Prakash Das; Effect of impurity in strongly correlated 1D systems

c) External Project Students / Summer Training

1. Saurav Kantha; Machine learning methods for detection of phase transitions in spin systems

Teaching

1. Spring semester; Advanced Condensed Matter Physics II; PhD; 7 students; with 1 (Prof. Tanushri Saha Dasgupta,) co-teacher

Publications

a) In journals

1. Monalisa Singh Roy, **Manoranjan Kumar**, Jay D. Sau and Sumanta Tewari, *Fermion parity gap and exponential ground state degeneracy of the one-dimensional Fermi gas with intrinsic attractive interaction*, Physical Review B, 102, 125135, 2020
2. Monalisa Singh Roy, **Manoranjan Kumar**, and Sourin Das, *Tunneling density of states in a Y junction of Tomonaga-Luttinger liquid wires: A density matrix renormalization group study*, Physical Review B, 102, 035130, 2020

3. Vinod K Gangwar, Shiv Kumar, Mahima Singh, Labanya Ghosh, Yufeng Zhang, Prashant Shahi, Matthias Muntwiler, Swapnil Patil, Kenya Shimada, Yoshiya Uwatoko, Jyotirmoy Sau, **Manoranjan Kumar** and Sandip Chatterjee, *Pressure induced superconducting state in ideal topological insulator* $BiSbTe_3$, Physica Scripta, 96, 055802, 2021
4. Sudip Kumar Saha, Hrishit Banerjee and **Manoranjan Kumar**, *Topological transitions to Weyl states in bulk* Bi_2Se_3*: Effect of hydrostatic pressure and doping*, Journal of Applied Physics 129, 085103, 2021
5. Sudip Kumar Saha, **Manoranjan Kumar** and Zoltán G.Soos, *Bond-bond correlations, gap relations and thermodynamics of spin-1/2 chains with spin-Peierls transitions and bond-order-wave phases*, Journal of Magnetism and Magnetic Materials, 519, 167472, 2021
6. Dayasindhu Dey, Sambunath Das, **Manoranjan Kumar**, and S. Ramasesha, *Magnetization plateaus of spin-1/2 system on a 5/7 skewed ladder*, Physical review B, 101, 195110, 2020
7. Sudipta Pattanayak, Jay Prakash Singh, **Manoranjan Kumar**, and Shradha Mishra, *Speed inhomogeneity accelerates information transfer in polar flock*, Physical Review E, 101, 052602, 2020
8. Shaon Sahoo, Dayasindhu Dey, Sudip Kumar Saha and **Manoranjan Kumar**, *Haldane and dimer phases in a frustrated spin chain: an exact groundstate and associated topological phase transition*, Journal of Physics: Condensed Matter, 32, 335601, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Young Investigators Meet on Quantum Condensed Matter Theory-2020; Dec 15, 2020; National Institute of Science Education and Research (Online mode), Bhubaneswar; 15-18 December, 2020

Administrative duties

1. Member of computer center working committee
2. Member of library purchase committee
3. Member of VASP
4. 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, GOI; PI

Conference / Symposia / Schools organized

1. 3rd annual conference of quantum condensed matter; Sep 7, 2020; S. N. Bose National Centre for Basic Sciences; 5 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. Sujit Sarkar, Poornaprajna Institute of Scientific Research, 4 Sadashivanagar, Bangalore 560080, India; National
3. S. Ramasesha, Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore 560012, India; National
4. Jay D. Sau, Condensed Matter Theory Center, Joint Quantum Institute, University of Maryland, College Park, Maryland 20742, USA; International
5. Sumanta Tewari, Department of Physics and Astronomy, Clemson University, Clemson, South Carolina 29634, USA; International
6. Sandip Chatterjee, Department of Physics, Indian Institute of Technology (BHU), Varanasi 221005, India; National
7. Shradha Mishra, Department of Physics, Indian Institute of Technology (BHU), Varanasi 221005, India; National

8. Sanjay Singh, Department of Physics, Indian Institute of Technology (BHU), Varanasi 221005, India; National

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

Our group has been involved in study of exotic phases and quantum phase transitions in strongly correlated low dimensional frustrated systems, e.g., spin liquids, dimers, vector chiral phases, multipolar phases etc. The study of many body systems has been a frontier area of research in quantum condensed matter physics, and it has been a challenge to solve the Hamiltonian of these systems accurately. The widely available numerical methods such as quantum Monte Carlo methods often fail due to sign-problems in presence of frustration in spin systems or fermionic systems away from half filling. Whereas, exact diagonalization (ED) can access ground state or a few excited states only for small systems. To solve large sizes of correlated systems we use the density matrix renormalization group (DMRG) method, a state of art method, based on the systematic truncation of irrelevant degrees of freedom in the system. This method is well suited to obtain low energy excitations of large system size in low dimensions and these low energy spectrums can be utilized to get low temperature thermodynamics accurately. Our group has been actively involved in developing the DMRG algorithm for various complex systems and also studying the quantum phase transition and low-temperature properties of strongly correlated systems.

Recent research output from our group are the following:

1. We have recently applied this method to shed light on the temperature dependence of structural dimerization (spin-Peierls systems) and electronic dimerization in bond-order-wave (BOW) phase in strongly correlated spin models.
2. The anomalous enhancement of tunneling density of states (TDOS) in the Y-junction system has been interesting for decades, but there was no direct study of TDOS in these systems. We studied the TDOS and explored the criteria for enhancement. Our studies also predict that the enhancement of the TDOS is restricted only in the neighborhood of the junction of the system.
3. Our group also studied one dimensional attractive Fermi gas in presence of Zeeman field and spin-orbit coupling to explore the topological state. We show that no robust Majorana modes exist in the system even at low filling.
4. A pressure induced transition from an insulating to a Weyl semi-metal state in Bi_2Se_3 due to band inversion is predicted by our group and we also studied the effect of rare earth element doping on this transition.

Plan of Future Work Including Project

1. Our goal is to study the effect of the thermal fluctuation on the exotic phases like vector chiral, dimer and spin nematic phase (two magnon condensation state). The study of vector chiral will help us to understand the mechanism of improper kind of multiferroic material. The applications of this study can be easily done in designing magnetic switches and sensor. In these systems the mechanism of flow of spin current and thermal fluctuations in these systems are beyond the current understanding, therefore this study is very crucial for designing any future quantum devices based on the vector chiral phase. The magnon condensation in spin system is one of the most recent developments in the present context and this system promises magnon based superconductors and we hope these studies will give a boost to the conceptual foundation of future applications of these systems. The valence bond states are claimed to work as one of the qubits system in quantum computers. In the strong dimer limit, the ground state of the system behaves as the product of the multiple dimers. Our study will help in understanding the robustness of the qubits and some of these concepts may be helpful in designing the quantum computers. Moreover these studies are important from the fundamental understanding of concepts in condensed matter and quantum mechanics.

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Areas of Research

Magneto transport properties of topological quantum materials

We work on the single crystal growth and electrical transport properties of topological materials of various kinds. It all starts with the growth of single crystals of many topologically important materials such as Dirac semimetals (Cd_3As_2, $HfTe_5$, $ZrTe_5$), Weyl semimetals (1T'-$MoTe_2$, Td-WTe_2, TaP, GdPtBi, WP_2, MoP_2), nodal line semimetals (ZrSiS, HfSiS), topological insulators (LaBi, LaSb) and many more. For this, we employ various crystal growth techniques such as metal flux and chemical vapor transport (CVT) to be used in this project. I also work on transport properties of van der Waals materials such as $MoTe_2$ and WTe_2, KHgSb, KMgBi (also highly air sensitive), $ZrTe_5$ and $HfTe_5$. To gain direct insight of the electronic band structure, we collaborate for angle resolved photoemission spectroscopy (ARPES) measurements and first principles calculations.

In the field of magnetic topological semimetals we work on ways to enhance anomalous Hall conductivity by maximizing Berry curvature contribution for example in ferromagnets $Co_3Sn_2S_2$, $LaCrGe_3$, MnAlGe etc. The experience gained with these materials will help us establish the relation between the bulk anomalous Hall conductivity and 3D quantum anomalous Hall effect.

Plan of Future Work Including Project

We plan to work on the magneto-transport properties of topological quantum materials under pressure and two-dimensional limits. For, high pressure we will establish the facility of diamond anvil cell and piston-based pressure cell. The work on two dimensional materials will entail growing single crystals of layered ferromagnets and exfoliate them and make devices to attain the goal of quantum anomalous Hall effect at high temperature. We will also study structurally 3D but magnetically 2D ferromagnets to realize 3D quantum anomalous Hall system analogues. We will study quasi one dimensional quantum materials to explore novel quantum states such as axion insulators.

Priya Mahadevan

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Joydeep Chatterjee; Electronic and structural properties of Semiconductor Heterostructures; Under progress
2. Sumanti Patra; Electronic structure of twisted bilayers of transition metal dichalcogenides; Under progress
3. Debayan Mondal; Electronic structure of htbrid perovskites; Under progress
4. Prasun Boyal; Spin orbit effects in transition metal dichalcogenides; Under progress
5. Shivam Mishra; Electronic structure of semiconductor nanoplatelets; Under progress
6. Krishnendu Patra; Metal insulator transitions in transition metal compounds; Under progress
7. Shinjini Paul; Electronic structure of ultrathin films of transition metal oxides; Under progress

b) Post-Docs

1. Priyanka Garg; Properties of hybrid perovskites

Publications

a) In journals

1. Sumanti Patra, Poonam Kumari, and **Priya Mahadevan**, *Evolution of the electronic structure of twisted bilayer $MoSe_2$*, Physical Review B, 102, 205415, 2020
2. Shishir K. Pandey, Ruma Das, and **Priya Mahadevan**, *Layer-Dependent Electronic Structure Changes in Transition Metal Dichalcogenides: The Microscopic Origin*, ACS Omega, 5, 15169–15176, 2020
3. Indrani Kar, Joydeep Chatterjee, Luminita Harnagea, Y. Kushnirenko, A. V. Fedorov, Deepika Shrivastava, B. Büchner, **P. Mahadevan** and **S. Thirupathaiah**, *Metal-chalcogen bond-length induced electronic phase transition from semiconductor to topological semimetal in ZrX_2 (X = Se and Te)*, Physical review B, 101, 165122, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Talk at APS March Meeting 2021; Mar 19, 2021; Americal Physical Society Meeting; 5days
2. Invited talk at National Conference on Quantum Matter Heterostructure; Feb 18, 2021; IIT Roorkee and INST Mohali; 3 days
3. Invited talk at National Level Lecture Workshop in Fronteirs in Science and Engineering by Women in Science; Feb 6, 2021; Deen Dayal Upadhyay College; 15 days
4. Talk at CMD2020GEFES; Sep 4, 2020; European Physical Society; 3 days

Administrative duties

1. Associate Dean Academic Programme till Dec 2020

2. Head of the Department, Condensed Matter Physics and Material Science
3. Members of various DST/SERB appointed review committees
4. Members of various internal committees

Awards, Recognitions

1. SERB Power fellow (2021-2024)
2. Editorial Advisory Board Member, ACS Energy Letters (2021-2022).
3. Editorial Advisory Board Member, Journal of Magnetism and Magnetic Materials (2021-2025)

Membership of Learned Societies

1. American Physical Society (since November 2020)

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

1. Ab-initio search for topological Mott insulators; DST International Division; 2021-2023; PI
2. Twistronics with transition metal dichalcogenides; SERB -IRPHA; 2020-2025; PI
3. Electronic, structural and optical properties of semiconductor nanoplatelets; DST Nanomission; 2019-2021; PI

Outreach program organized / participated

1. Speaker at outreach programme in Oxford College of Science, Bangalore, January 2021 for college students
2. Speaker at Short Term Training Programme on Emerging Trends in Research and Innovation - Tips and Techniques, SVNIT Surat, January (2021) for college students.
3. Speaker at Emerging Trends in Research Methodology in Condensed Matter, Materials Science and Nanoscience 2020, December (2020) for college students

Areas of Research

Optical properties, electronic structure, magnetism

Recently twisted bilayers of Mo and W based transition metal dichalcogenides have been found to behave like strongly correlated materials, exhibiting wigner crystal formation, semiconductor-metal-semiconductor transitions, zero resistance states on hole doping etc. We have re-examined the electronic structure of twisted bilayers of MoSe2 considering certain angles that lead to large commensurate unit cells. The unit cells we generate contain around 1500 or larger number of atoms while the primitive cell contains just 6 atoms. Consequently, one would expect no dispersional width for the bands here, with all bands folding back to a significantly small Brillouin zone. This has been the understanding of the formation of flatbands and the associated correlated electron physics that one finds. If one examined the untwisted limit, one finds small modifications in the band structure of the bilayer with respect to the monolayer. For the twisted structures, in the limit of weak perturbation one expects the untwisted or unperturbed limit to be largely retained. Therefore a measure of the perturbation with respect to the untwisted limit could help us understand the modifications in the electronic structure. With this aim, we projected the perturbed eigen functions onto the untwisted eigenfunctions. The latter represent the unperturbed limit. The effect of the perturbing potential would be to scatter the electrons into a different momentum state connected by a reciprocal lattice vector. Angles of rotation were considered so that they led to two similar sized cells. Surprisingly, one found that the low lying electronic structure for the large twist angle was very similar to the unperturbed primitive cell results. This implied that the low energy electronic structure for the large twist angles could be described by the unrotated limit, and most importantly flat bands were not a consequence of the large moire cell involved. Considering a smaller angle of 3.48 degrees, one found the emergence of bands which were localized both in real space as well as k-space, leading to split off bands. These were not restricted to only this choice of twist angle, but were found for other angles in the range 2-6 degrees also. Examining the origin of the flat band formation, we find that correlated bond disorder emerging from large patches where the interlayer interaction strengths

(perturbation) are larger is responsible for the flat band formation. This appeared in Phys. Rev. B **102**, 205415 (2020).

We have examined the electronic structure evolution with thickness in transition metal dichalcogenides MX2, where M = Mo,W and X = S,Se and Te. These are generally referred to as van der Waals materials on the one hand, yet one has band gap changes as large as 0.6 eV with thickness in some instances. This does not seem to be consistent with a description where the dominant interactions are van der Waals interactions. Mapping onto a tight binding model allows us to quantify the electronic structure changes which are found to be dictated solely by interlayer hopping interactions. This has appeared in ACS Omega **5**, 15169 (2020).

Plan of Future Work Including Project

1. The model that we have proposed to understand the properties of twisted bilayers of transition metal dichalcogenides will be extended to other transition metal dichalcogenides to examine the implications of a split off band formation there and its tunability under different external conditions. The relevant tight-binding model will be constructed to examine various features of the twisted bilayers beyond the purview of the ab-initio calculations. Our earlier work has shown the importance of interlayer coupling in determining the electronic structure evolution as a function of the number of layers. We are working on an effective low energy model to capture these trends. This will then be used to calculate the optical spectra as a function of the number of layers.

Prosenjit Singha Deo

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

a) Ph.D. Students

1. K. Meena; Mesoscopic physics; Under progress
2. S. Routh; Superconductivity; Under progress (with Thirupathaiah Setti)

Areas of Research

Mesoscopic physics

Mesoscopic physics is still a new branch of physics but a very promising area. Landauer-Buttiker formalism has emerged as a promising approach to understanding mesoscopic systems as it very easily solves the problem of quantum measurements and detection at a practical level. Larmor clock approach has the necessary ingredients to extend this approach to still not so well understood phenomena like decoherence, AC response and non-linear response of mesoscopic systems. In our works we have brought immense clarity to the issues associated with the Larmor clock and made it a practically viable approach to study all mesoscopic phenomena. One of the key obstacles was to understand negative times. We have been also able to reconcile negative times with our classical notion of time. Which means in the classical world effect can precede the cause although the details of the technology of sending the signal is quantum in nature.

Ranjan Chaudhury

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Suraka Bhattacharjee; Study of Generalized Spin and Charge Stiffness Constants of Doped Quantum Antiferromagnets on Low Dimensional Lattices Based on t-J-Like Models; Thesis submitted
2. Koushik Mandal; Investigation of the Properties of Correlated Fermionic Systems in Low-dimension; Under progress

Teaching

1. 4th semester (2020); Physics of Materials; IPhD; 7 students; with Prof. P. Mahadevan
2. 2nd semester (2020); Advanced Condensed Mattter Physics I; PMSC-PhD; 10 students; with Prof. P. Mahadevan
3. 4th semester (2021); Superconductivity and Magnetism; IPhD; 4 students; with Prof. K. Mandal
4. 2nd semester (2021); Advanced Condensed Matter Physics; PMSC-PhD; 5 students; with Prof. K. Mandal

Publications

a) In journals

1. Suraka Bhattacharjee and **Ranjan Chaudhury**, *Study of effective coupling between charge degrees of freedom in low dimensional hole-doped quantum antiferromagnets*, Canadian Journal of Physics, 99, No. 3, 2021
2. Koushik Mandal and **Ranjan Chaudhury**, *Interplay of pairing correlation and Coulomb correlation in Boson exchange superconductors*, The European Physical Journal B, 94, 46, 2021

Administrative duties

Discharged duties as a member of VASP (EVLP) at SNBNCBS

Membership of Learned Societies

(i) Continued to be an active Member of American Chemical Society (Physics Division), USA

(ii) Continued to be an active Member of Physics Division of ATINER (Athens, Greece)

Outreach program organized / participated

(a) Taught 2 courses viz.

(i) Basic Condensed Matter Physics and

(ii) Advanced Condensed Mater Physics to the Master's (M.Sc) students at RKMVERI (Belur) as Visiting Professor there.

(b) Supervised 6 Master's Projects and 1 Bachelor (B.Sc.) projects at Belur as Visiting Professor at RKMVERI.

Areas of Research

Theoretical Condensed Matter Physics Involving Strongly Correlated Electronic Systems and Superconductivity

(i) The generalized charge stiffness constant was calculated for strongly correlated hole doped quantum antiferromagnets in low dimensional systems in the form of t-J- like models. It was shown explicitly that this charge stiffness constant truly represents the effective static interaction between the mobile charge carriers. Furthermore, it was found that this effective interaction can indeed turn attractive in a narrow regime of q-space in the optimally doped to overdoped regime in 2D, signalling a genuine possibility of an electronic mechanism for superconducting pairing in some of the Cuprates. This work was carried out in collaboration with Suraka Bhattacharjee (SRF, CMPMS).

(ii) Interplay of pairing correlation and Coulomb correlation was theoretically investigated for a boson exchange superconductor under two different situations. In the first case, Coulomb correlation was introduced only in the Bardeen-Cooper-Schrieffer (BCS) ground state, keeping the parental normal phase uncorrelated. In the second case, the BCS pairing was considered from a Coulomb correlated normal phase itself. Detailed calculations were performed for the first case during this period under consideration. The calculations based on full variational approach involving Gutzwiller projected BCS state lead to superconducting gap function's dependences on both boson mediated attractive coupling constant and repulsive Coulomb coupling constant with interesting consequences. The theoretical results find good application to the experimental results from NbSe_2, a phonon exchange based superconductor. This work was carried out in collaboration with Koushik Mandal (SRF, CMPMS).

Plan of Future Work Including Project

(a) Theoretical investigation of the microscopic mechanism for superconductivity in both conventional and non-conventional systems to be continued alongwith interplay of itinerant magnetism and charge ordering with superconductivity in these systems.

(b) Several interdisciplinary projects at the interface of Physics with other branches of Science to be pursued.

Any other Relevant Information including social impact of research

(a) My research in the domain of Condensed Matter Physics, in particular the understanding of the mechanism for high temperature superconductivity in various classes of material systems, is expected to contribute to a possible technological revolution based on dissipationless electrical transport at room temperature.

(b) Some of my projects in the regime of interdisciplinary sciences are expected to lead to better environmental conditions and possible cure from many diseases.

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Didhiti Bhattacharya; Colloidal 2D nanocrsytals for optical and photo-catalytic applications; Under progress; Rajib Kumar Mitra (Co-supervisor)
2. Subhrasish Mukherjee; An investigation of electronic and optical properties of 2D semiconductors and their heterostructures; Under progress; Atindra Nath Pal (Co-supervisor)

b) Post-Docs

1. Arka Dey; Photovoltaic devices
2. Sayan Bayan; Piezoelectric/Triboelectric devices for energy harvesting

Publications

a) In journals

1. Somnath Mahato, Arup Ghorai, Sanjeev Kumar Srivastava, Mantu Modak, Sudarshan Singh and **Samit K. Ray**, *Highly Air-Stable Single-Crystalline -$CsPbI_3$ Nanorods: A Platform for Inverted Perovskite Solar Cells*, Advanced Energy Materials, 10, 2001305, 2020
2. Subhajit Jana, Subhrajit Mukherjee, Arup Ghorai, Shivakiran B. N. Bhaktha and **Samit Kumar Ray**, *Negative Thermal Quenching and Size Dependent Optical Characteristics of Highly Luminescent Phosphorene Nanocrystals*, Advanced Optical Materials, 8, 2000180, 2020
3. R. K. Chowdhury, S. Mukherjee, S. N. B. Bhaktha, and **S. K. Ray**, *Ultrafast real-time observation of double Fano resonances in discrete excitons and single plasmon-continuum*, Physical Review B, 101, 245442, 2020
4. Arijit Sarkar, Rajshekhar Bar, Sudarshan Singh, Rup Kumar Chowdhury, Sekhar Bhattacharya, Amal Kumar Das, and **Samit K. Ray**, *Size-tunable electroluminescence characteristics of quantum confined Si nanocrystals embedded in Si-rich oxide matrix*, Applied Physics Letters, 116, 231105, 2020
5. S. Bayan, D. Bhattacharya, R. K. Mitra and **S. K. Ray**, *Two-dimensional graphitic carbon nitride nanosheets: a novel platform for flexible, robust and optically active triboelectric nanogenerators*, Nanoscale, 12, 21334 – 21343, 2020
6. Tuhin Kumar Maji, Aswin J. R, Subhrajit Mukherjee, Rajath Alexander, Anirban Mondal, Sarthak Das, Rajendra Kumar Sharma, Naba Kumar Chakraborty, Kinshuk Dasgupta, Anjanashree M. R. Sharma, Ranjit Hawaldar, Manjiri Pandey, Akshay Naik, Kausik Majumdar, Samir Kumar Pal, K. V. Adarsh, **Samit Kumar Ray**, and Debjani Karmakar, *Combinatorial Large-Area MoS_2/Anatase–TiO_2 Interface: A Pathway to Emergent Optical and Optoelectronic Functionalities*, ACS Applied Materials & Interfaces, 12, 44345 – 44359, 2020

7. Manobina Karmakar, Sayantan Bhattacharya, Subhrajit Mukherjee, Barun Ghosh, Rup Kumar Chowdhury, Amit Agarwal, **Samit Kumar Ray**, Debashis Chanda, and Prasanta Kumar Datta, *Observation of dynamic screening in the excited exciton states in multilayered MoS_2*, Physical Review B, 103, 075437, 2021

8. Sudarshan Singh, Arijit Sarkar, Dipak K. Goswami, and **Samit K. Ray**, *Solution-Processed Black-Si/Cu_2ZnSnS_4 Nanocrystal Heterojunctions for Self-Powered Broadband Photodetectors and Photovoltaic Devices*, ACS Applied Energy Materials, 4, 4090-4098, 2021

9. Tamal Dey, Subhrajit Mukherjee, Arup Ghorai, Soumen Das, and **Samit K. Ray**, *Effects of Size and Localized States in Charge Carrier Dynamics and Performance of Solution-Processed Graphene Quantum Dots/Silicon Heterojunction Near-UV Photodetectors*, The Journal of Physical Chemistry C, 124, 12161-12167, 2020

10. Suparna Pal, Subhrajit Mukherjee, Ravindra Jangir, Mangla Nand, Dipankar Jana, Satish K. Mandal, S. Bhunia, Chandrachur Mukherjee, Shambhu Nath Jha, and **Samit Kumar Ray**, *WS_2 Nanosheet/Si p–n Heterojunction Diodes for UV–Visible Broadband Photodetection*, ACS Applied Nano Materials, 4, 3241 – 3251, 2021

11. Arup Ghorai, **Samit K. Ray** and Anupam Midya, *$MoSe_2$ Nanosheets with Tuneable Optical Properties for Broadband Visible Light Photodetection*, ACS Applied Nano Materials, 4, 2999-3006, 2021

12. Didhiti Bhattacharya, Sayan Bayan, Rajib K. Mitra, and **Samit K. Ray**, *Flexible Biomechanical Energy Harvesters with Colossal Piezoelectric Output (2.07 V/kPa) Based on Transition Metal Dichalcogenides-Poly(vinylidene fluoride) Nanocomposites*, ACS Applied Electronic Materials, 2, 3327 – 3335, 2020

13. John Wellington John, Veerendra Dhyani, Sarmistha Maity, Subhrajit Mukherjee, **Samit K Ray**, Vikram Kumar, Samaresh Das, *Broadband infrared photodetector based on nanostructured MoSe $_2$-Si heterojunction extended up to 2.5 m spectral range*, Nanotechnology, 31, 455208, 2020

14. Sourabh Pal, Sayan Bayan, Dipak Kumar Goswami, and **Samit Kumar Ray**, *Superior Performance Self-Powered Photodetectors Utilizing the Piezo-Phototronic Effect in SnO Nanosheet/ZnO Nanorod Hybrid Heterojunctions*, ACS Applied Electronic Materials, 2, 1716–1723, 2020

15. Sayan Dey, Swati Nag, Sumita Santra, **Samit Kumar Ray** and Prasanta Kumar Guha, *Voltage-controlled NiO/ZnO p–n heterojunction diode: a new approach towards selective VOC sensing*, Microsystems & Nanoengineering, 6, 35, 2020

16. John Wellington John, Veerendra Dhyani, Yordan M. Georgiev, Anushka S. Gangnaik, Subhajit Biswas, Justin D. Holmes, Amit K. Das, **Samit K. Ray**, and Samaresh Das, *Ultrahigh Negative Infrared Photoconductance in Highly As-Doped Germanium Nanowires Induced by Hot Electron Trapping*, ACS Applied Electronic Materials, 2, 1934-1942, 2020

17. S Bayan, D Bhattacharya, R K Mitra and **S K Ray**, *Self-powered flexible photodetectors based on Ag nanoparticle-loaded g-C_3N_4 nanosheets and PVDF hybrids: role of plasmonic and piezoelectric effects*, Nanotechnology, 31(36):365401, 2020

18. Poulomi Chakrabarty, Arup Ghorai, **Samit K. Ray**, and Rabibrata Mukherjee, *Polymer Thin-Film Dewetting-Mediated Growth of Wettability-Controlled Titania Nanorod Arrays for Highly Responsive, Water-Stable Self-powered UV Photodetectors*, ACS Applied Electronic Materials, 2, 2895-2905, 2020

19. Pratyusha Das, Subhrajit Mukherjee, Subhajit Jana, **Samit Kumar Ray** and B N Shivakiran Bhaktha, *Resonant and non-resonant coupling of one-dimensional microcavity mode and optical Tamm state*, Journal of Optics, 22, 065002, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Plasmon Enhanced 2D Semiconductor based Photonic Devices- Workshop on Advances in Electronic, Optoelectronic, Photonic Materials and Devices, IIEST Kolkata March 18th 2021; Online

2. Emerging Functional Nanomaterials for Energy and Environment Applications – IIM Platinum Jubilee Lecture, CSIR-IMMT Bhubaneswar, 28th January 2021; Online
3. Emerging Functional Nanomaterials for Next Generation Optoelectronic Devices – INST Mohali, 26th February, 202; Online
4. Plasmon triggered light-matter interactions in metal-2D quantum hybrids – 5th Intl. Conference on Emerging Materials-2020, IIT Delhi, 27th November 2020; Online
5. Nanowire and Quantum Dot based Silicon Photonic Devices – TEQUIP Workshop on "VLSI and Nanotechnology in Energy, Environment and Neuromorphic Computation", IIT Indore, 22nd December, 2020; Online
6. Tailoring light-matter interactions in 2D plasmonic hybrids- 3rd Annual Conference on Quantum Condensed Matter (QMat-2020), SNBNCBS Kolkata, 9th September 2020; Online
7. Semiconductor and 2D Nanostructures for Photonic Devices - UKIERI SPARC Webinar Series on 2D and Nanostructured phenomena, materials and devices, IIT Delhi, 1st July, 2020; Online
8. Excitements with Semiconductor Quantum Structures - Pabna University of Science & Technology, Bangladesh, 10th October, 2020; Online

Administrative duties

1. Director, S. N. Bose National Centre for Basic Sciences

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

1. IIT Kharagpur : 1-4, 7-9, 12, 14-16, 19; National
2. IIT Delhi - 10, 13, 17; National
3. BARC, IISc Banglaore, CMET Pune & IISER Bhopal : 6; National
4. RRCAT, Indore : 9; National
5. SNBNCBS : 5,11, 18 – Within the Centre

Outreach program organized / participated

1. Delivered a National Webinar for undergraduate students, Serampore Girls' College, 30/07/2020

Areas of Research

Semiconductor Physics, Quantum Materials & Devices, Nanophotonics, Energy Materials

a) All inorganic perovskites for photovolatic devices :

We have demonstrated that air stable, all inorganic -$CsPbI_3$ nanorods (NRs) could be obtained using a novel colloidal synthesis route followed by post-growth annealing of relatively unstable -$CsPbI_3$ thin films at 150ºC [Fig.1]. Rietveld refinement indicated that the annealing caused the movement of atoms inside the unit cell resulting in distortion free PbI_6 octahedra, which could be visualized through XRD micro-structure, HRTEM image analyses and DFT calculations. Formed -$CsPbI_3$ NRs based thin films have been found to be single crystalline in nature with perfectly oriented NRs exhibiting improved structural stability in comparison to as-deposited -$CsPbI_3$ due to distortion free unit cell. DFT based calculations have been utilized to calculate the electronic band structure and nature of bandgap of

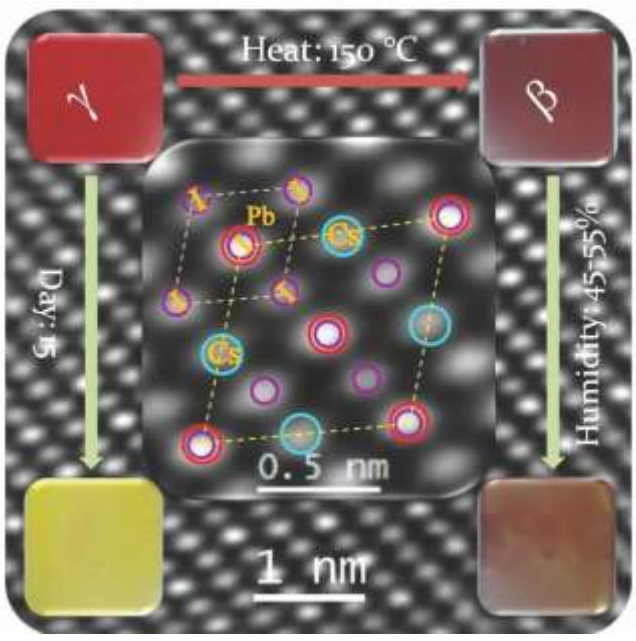


Figure 1: Schematic low temperature phase transition, air stability and atomic arrangements of crystalline -$CsPbI_3$ nanorods

-$CsPbI_3$ phase. This high quality, single crystalline -$CsPbI_3$ NRs thin films not only underscore the performance of photovoltaic devices with a moderately efficiency (>7%) but also provide highly stable colloidal synthesis of perovskite layers under 45-55% humid condition for potential use of optoelectronic devices in future.

b) Ultrafast real-time observation of double Fano resonance in Quantum Hybrids:

We have carried out the femtosecond transient absorption measurements revealing the real-time detection of double Fano resonance profiles [Fig. 2] at room temperature in a condensed-matter system (Au-MoS_2 quantum hybrid), as theoretically predicted earlier. Two-dimensional MoS_2 played a vital role in having two energetically well separated strongly bound discrete excitons (A & B), both spectrally (600-700 nm) and temporally correlated with the single metal plasmon-continuum (P), leading to the formation of double Fano lineshapes in the time domain. The ultrafast evolution of the double Fano resonance starts on a timescale of $_T > 1.0$ ps and has been found to be sustained even at ~5.0 ns, the upper time limit of our instrumental delay. The nonlinear transient modulations of the double Fano resonance have been established through measurements with variable pump power density (P_{pump} ~ 1.0 - 4.0 GW/cm^2). Extracted nonlinear Fano parameters (q_{ex} & $_{ex}$) have found to be ~1.5 and ~80 meV for both the Fano lineshapes (A-P & B-P). Our study on time-resolved double Fano resonance thus provides an imperative evidence of strongly coupled exciton-plasmon dynamics in metal-2D semiconductor hybrid platforms, which may offer new prospects in ultrafast two-level all-optical sensors and switches.

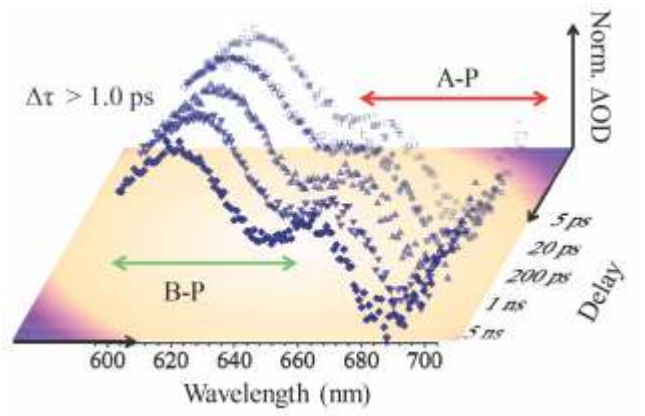
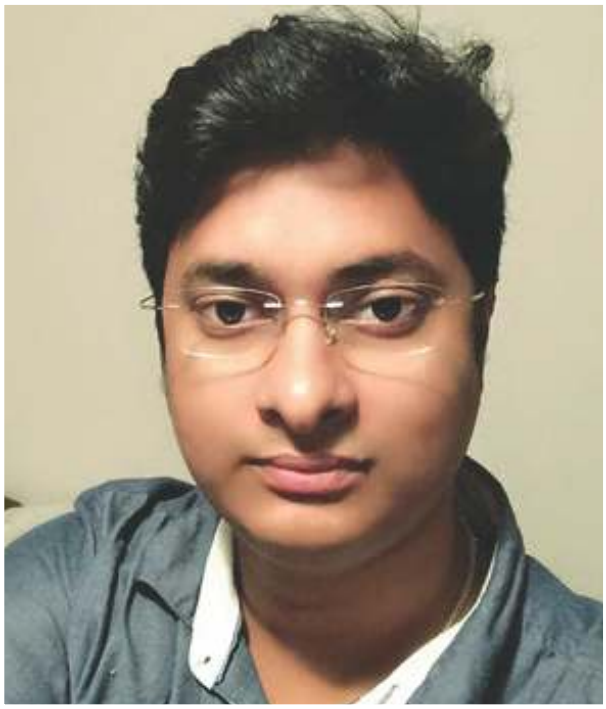


Figure 2 : Normalized double Fano spectra for $_T > 1.0$ ps probe delay in Au-MoS_2 quantum hybrid



Saumya Mukherjee

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Areas of Research

Strongly correlated electron systems (SCES)

Within the framework of SCES multiferroics and iridates showing strong spin-orbit coupling attracted special attention. Multiferroics has a unique ability to host two or more ferroic (antiferroic) order parameters simultaneously and these parameters show cross-coupling among each other. An archetypical example is the multiferrocity in orthorhombic (o-) rare-earth manganite o-RMnO3 (R = Gd -Lu) systems.

In the present field, the unique approach of using strain to modify the properties is rarely accessed and the proposed work to study multiferroics under strain by growing them as thin films will open up this field further. This will provide a tuning parameter and develop the physics of strain induced properties and improve the microscopic understanding, which are ideal ingredients for room-temperature operational devices. The advantage of sample geometry and crystallinity will allow us to perform directional studies which is still absent in this field. Device application based on spintronics which require magnetization to show sharp transitions suggest that the observed SR induced switching between FM and AFM in these system will attract enormous interest within condensed matter community. From fundamental understanding point of view these material helps us to study tailoring of strain engineered unique phenomena such as JT distortion variation, modifying the role of magnetic interactions such as exchange or Dzylanshonskii-Moriya interaction (DMI) proposed to be responsible for canted AFM order.

In relation to the physics related to iridates, the 5d Iridates such as SrIrO3 (SIO) provide huge potential and special interest since these materials naturally display large SOC. Magnetic anisotropy (MA) of a ferromagnetic (FM) La2/3Sr1/2MnO3 (LSMO) layer is found to be controlled by the nonmagnetic SIO. So far, only magnetic layers displaying metallic behavior were used in combination with the semi-metallic SIO, excluding transport measurements for a specific characterization of the SOC and anisotropy in SIO to large extend. So we are interested in studying the heterostructures.

Recently, we succeeded in the preparation of high quality LaCoO3/SrIrO3 heterostructures on SrTiO3 (STO) substrates. These heterostructures display several advantages which gives the possibility for proceeding experiments disclosing a deeper insight in the exchange/interchange mechanism of SIO with magnetic layers at the interface of FM/SOC heterostructures. The most prominent benefit is the ferromagnetic insulating (FMI) state of epitaxially strained LaCoO3. Because of the insulating properties of LCO, the electronic transport in LCO/SIO heterostructure is exclusively related to SIO. Therefore, the observation of hysteretic magnetoresistance and anomalous Hall effect, clearly demonstrates magnetic ordering in SIO.

Plan of Future Work Including Project

In relation to studying the multiferroics, my target is to employ strain and develop an external handle to tweak the onset of spin-reorientation effect and associated magnetodielectric properties of RFe(1-x)Mn(x)O3 (R = Y,

Gd, Dy, Tb, Ho). This will be acheived by growing them as epitaxial thin films on crystalline substrates with mismatch of lattice parameters ($< 2\%$) using pulsed laser deposition (PLD) technique. The understanding of microscopic mechanism with respect to magnetic interactions, structural distortions due to doping coupled with strain and probing of the magnetic anisotropy will be the central part of the studies. The magnetic and electric transitions and directional studies will be performed. The role of oxygen vacancies will be studied to map out the Jahn-Teller (JT) distortion factor as studied elsewhere. The thin film sample geometry and room-temperature properties will provide an additional benefit towards development of materials which favours the geometry of devices.

For the iridate heterostructures, a possible charge transfer from Co to Ir states at the interface of LCO and SIO has to be figured out. We will use X-ray absorption spectroscopy at the Co edge to detect changes of the valence state of Co at the interface. To probe the magnetic state we will use X-ray magnetic circular dichroism (XMCD). We will use the overlap of the Co d-O p and the Ir d-O p-orbitals. We plan to probe these systems optically and theoretically model the system using Density Functional Theory for understanding their properties.

Tanusri Saha Dasgupta

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Shreya Das; Correlated Electrons; Under progress; Tanusri Saha-Dasgupta
2. Edwine Tandong; Soft Matter; Under progress; Tanusri Saha-Dasgupta and Jaydeb Chakrabarti
3. Shiladitya Karmakar; Application Materials; Under progress; Tanusri Saha-Dasgupta
4. Samir Rom; Electronic Structure of Complex Materials; Under progress; Tanusri Saha-Dasgupta
5. Aishwaryo Ghosh; Application of Machine Learing to Materials Science; Under progress; Tanusri Saha-Dasgupta
6. Koushik Pradhan; Spin-orbit materials; Under progress; Tanusri Saha-Dasgupta
7. Manoj Gupta; Toplogical compounds; Under progress; Tanusri Saha-Dasgupta
8. Rajdeep Biswas; 2D Materials; Under progress; Tanusri Saha-Dasgupta

b) Post-Docs

1. Tanmoy Pal; Battery Materials
2. Dipayan Sen; Hybrid perovskites
3. Soumendu Datta; Alloy nanoclusters

c) External Project Students / Summer Training

1. Arnab Paul; Magnetism in Hubbard Model
2. Soham Mukherjee; 2D magnetism

Teaching

1. Autumn semester; Advanced Condensed Matter Physics; PhD; 5 students; Yes with Manoranjan Kumar (co-teachers)
2. Spring semester; Advanced Condensed Matter Physics; Integrated PhD; 12 students; Yes with Thirupathaiah Setti (co-teachers)

Publications

a) In journals

1. Rafikul Ali Saha, Anita Halder, **Tanusri Saha-Dasgupta**, Desheng Fu, Mitsuru Itoh, and Sugata Ray, *Covalency driven modulation of paramagnetism and development of lone pair ferroelectricity in multiferroic* $Pb_3TeMn_3P_2O_{14}$, Physical Review B, 101, 180406(R), 2020
2. Shreya Das, Anita Halder, Atasi Chakraborty, Indra Dasgupta, and **Tanusri Saha-Dasgupta**, *Understanding the curious magnetic state of* Sr_3OsO_6, Physical Review B, 101, 184422, 2020
3. Santu Baidya, Aabhaas Vineet Mallik, Subhro Bhattacharjee, and **Tanusri Saha-Dasgupta**, *Interplay of Magnetism and Topological Superconductivity in Bilayer Kagome Metals*, Physical Review Letters, 125, 026401, 2020
4. Dipayan Sen, Gour Jana, Nitin Kaushal, Anamitra Mukherjee, and **Tanusri Saha-Dasgupta**, *Intrinsic ferromagnetism in atomically thin two-*

dimensional organic-inorganic van der Waals crystals, Physical Review B, 102, 054411, 2020

5. Priyo Adhikary, Subhadeep Bandyopadhyay, Tanmoy Das, Indra Dasgupta, and **Tanusri Saha-Dasgupta**, *Orbital-selective superconductivity in a two-band model of infinite-layer nickelates*, Physical Review B, 102, 100501(R), 2020
6. Anita Halder, Samir Rom, Aishwaryo Ghosh and **Tanusri Saha-Dasgupta**, *Prediction of the Properties of the Rare-Earth Magnets* $Ce_2Fe_{17-x}Co_xCN$*: A Combined Machine-Learning and Ab Initio Study*, Physical Review Applied, 14, 034024, 2020
7. Essam M. Hussein, Nizar El Guesmi, Ziad Moussa, Uttam Pal, Samir K. Pal, **Tanusri Saha Dasgupta**, and Saleh A. Ahmed, *Unprecedented Regio- and Stereoselective Synthesis of Pyrene-Grafted Dispiro[indoline-3,2 -pyrrolidine-3 ,3 -indolines]: Expedient Experimental and Theoretical Insights into Polar [3 + 2] Cycloaddition*, ACS Omega, 5, 24081-24094, 2020
8. N. Roy, A. Chakrabarty, B.Koley, **T.Saha-Dasgupta** and Partha P.Jana, *Site preference and atomic ordering in the structure of* In_3Pd_5*: A theoretical study*, Journal of Solid State Chemistry, 290, 121567, 2020
9. Swati Rani, Damayanti Bagchi, Uttam Pal, Mamta Kumari, Manisha Sharma, Arpan Bera, Javaid Shabir, Samir Kumar Pal, **Tanusri Saha-Dasgupta**, and Subho Mozumdar, *The Role of Imidazolium-Based Surface-Active Ionic Liquid to Restrain the Excited-State Intramolecular H-Atom Transfer Dynamics of Medicinal Pigment Curcumin: A Theoretical and Experimental Approach*, ACS Omega, 5, 25582 – 25592, 2020
10. A. Koshelev, L. Shvanskaya, O. Volkova, K. Zakharov, F. Theuss, C. Koo, R. Klingeler, S. Kamusella, H.-H. Klauss, S. Kundu, S. Bachhar, A. V. Mahajan, P. Khuntia, D. Khanam, B. Rahaman, **T. Saha-Dasgupta** and A. Vasiliev, *Thermodynamic and resonant properties of mixed spin compounds* $ACuFe_2(VO_4)_3$ *(A = Li, Na)*, Journal of Alloys and Compounds, 842, 155763, 2020
11. Debankur Das, Jürgen Horbach, Peter Sollich, **Tanusri Saha-Dasgupta**, and Surajit Sengupta, *Wrinkles, folds, and ripplocations: Unusual deformation structures of confined elastic sheets at nonzero temperatures*, Physical Review Research, 2, 043284, 2020
12. E. S. Kozlyakova, K. N. Denisova, A. A. Eliseev, A. V. Moskin, A. Y. Akhrorov, P. S. Berdonosov, V. A. Dolgikh, B. Rahaman, S. Das, **T. Saha-Dasgupta**, P. Lemmens, A. N. Vasiliev, and O. S. Volkova, *Short-range and long-range magnetic order in Fe* $(Te_{1.5}Se_{0.5})O_5Cl$, Physical Review B, 102, 214405, 2020
13. Subhadeep Bandyopadhyay, Priyo Adhikary, Tanmoy Das, Indra Dasgupta, and **Tanusri Saha-Dasgupta**, *Superconductivity in infinite-layer nickelates: Role of f orbitals*, Physical Review B 102, 220502(R), 2020
14. Basant Roondhe, Vaishali Sharm, Hardik L. Kagdada, Dheeraj K. Singh, **Tanusri Saha Dasgupta** and Rajeev Ahuja, *Enhancing the electronic and phonon transport properties of two-dimensional hexagonal boron nitride through oxygenation: A first principles study*, Applied Surface Science, 533, 147513, 2020
15. Shiladitya Karmakar and **Tanusri Saha-Dasgupta**, *First-principles prediction of enhanced thermoelectric properties of double transition metal MXenes:* $Ti_{3-x}Mo_xC_2T_2$*;* $(x = 0.5, 1, 1.5, 2, 2.5, T = -OH/-O/-F)$, Physical Review Materials, 4, 124007, 2020
16. **Tanusri Saha-Dasgupta**, *The Fascinating World of Low-Dimensional Quantum Spin Systems: Ab Initio Modeling*, Molecules, 26(6), 1522, 2021
17. Swastika Chatterjee, Sujoy Ghosh and **Tanusri Saha-Dasgupta**, *Ni Doping: A Viable Route to Make Body-Centered-Cubic Fe Stable at Earth's Inner Core*, Minerals, 11, 258, 2021
18. Rafikul Ali Saha, Anita Halder, Desheng Fu, Mitsuru Itoh, **Tanusri Saha-Dasgupta** and Sugata Ray, *The Critical Role of Stereochemically Active Lone Pair in Introducing High Temperature Ferroelectricity*, Inorganic Chemistry, 60, 4068 – 4075, 2021

19. 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 and **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

Talks / Seminars Delivered in reputed conference / institutions

1. ICTS web seminar; Jun 2, 2020; ICTS Bangalore; 1 hour
2. Physics Symposium (Online); Dec 3, 2020; IIT Delhi; 1 hour
3. PRL colloquium; Mar 17, 2021; PRL Ahmedabad; 1 hour
4. Third International Conference on Current Trends in Materials Science and Engineering 2021(CTMSE 2021); Mar 13, 2021; Institute of Engineering & Management, Kolkata; 1 hour
5. National Level Lecture Workshop in Frontiers in Science and Engineering by Women in Science; Feb 9, 2021; Deen Dayal Upadhyaya College; 1 hour
6. Nakshatra Talks: 'Women in Science - Breaking the Glass Ceiling'; Mar 7, 2021; Bennett University; 1 hour

Administrative duties

1. Dean (Academic), Director (Additional charge)

Patents Taken and Process Developed with Details

1. Patent Appl.No.202031038150 dated 04.09.2020 on "Development of Tribo-electroceutical Fabric for Potential Application in Self Sanitizing Personal Protective Equipment (PPE)"; Applied
2. Patent Appl.No.202031038152 dated 04.09.2020 on "A Nanoceutical Fabric for source control to prevent COVID-19 spread including through expelled respiratory droplets"; Applied

Awards, Recognitions

1. J. C. Bose National Professor; Adjunct Professor of IISER Kolkata, Vice president of Indian Physics Association

Membership of Learned Societies

1. American Physical Society, Indian Physics Association

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

1. J.C.Bose Fellowship; SERB; 5 years; PI
2. TRC; DST; 5 years; PI

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

1. Subhro Bhattacharjee, ICTS, Bangalore, Joint publication, Serial 3; National
2. Indra Dasgupta, IACS, Joint publication, Serial 5, 13; National
3. Tanmoy Das, IISc, Joint publication, Serial 5, 13; National
4. A. Vasiliev, Moscow State University, Joint publication, Serial 10, 12; International
5. S. K. Pal, SNBNCBS, Joint publication, Serial 7, 9, 19; National
6. Surajit Sengupta, TIFR Hyderabad, Joint publication, Serial 11; National
7. R. Ahuja, Uppsala University, Joint publication, Serial 14; International
8. Swastika Chatterjee, IISER Kolkata, Joint publicatiom, Serial 17; National
9. Sujoy Ghosh, IIT KGP, Joint publication, Serial 17; National

Outreach program organized / participated

1. Participated in outreach program on popularization of Science in Bennett University and Pabna University, Bangladesh

Areas of Research

Computational Condensed Matter and Materials Physics

Interplay of Magnetism and Topological Superconductivity in Bilayer Kagome Metals

The binary intermetallic materials, M_3Sn_2 (M = 3d transition metal) present a new class of strongly correlated systems that naturally allows for the interplay of magnetism and metallicity. Using first principles calculations we confirm that bulk Fe_3Sn_2 is a ferromagnetic metal, and show that M = Ni and Cu are paramagnetic metals with nontrivial band structures. Focusing on Fe_3Sn_2 to understand the effect of enhanced correlations in an experimentally relevant atomistically thin single kagome bilayer, our *ab initio* results show that dimensional confinement naturally exposes the flatness of band structure associated with the bilayer kagome geometry in a resultant ferromagnetic Chern metal. We use a multistage minimal modeling of the magnetic bands progressively closer to the Fermi energy. This effectively captures the physics of the Chern metal with a nonzero anomalous Hall response over a material relevant parameter regime along with a possible superconducting instability of the spin-polarized band resulting in a topological superconductor. (Phys. Rev. Lett. **125**, 026401)

Orbital-Selective Superconductivity in infinite-layer Nickelates: Role of nonzero *f*-ness

We propose a first-principles derived low-energy model Hamiltonian in infinite-layer nickelate compounds, consisting of two orbitals: Ni x2-y2, and an axial orbital. The axial orbital is constructed out of A-site d, Ni 3z2-r2, and Ni-s characters. Calculation of the superconducting pairing symmetry and pairing eigenvalue of the spin-fluctuation mediated pairing interaction underlines the crucial role of the interorbital Hubbard interaction in

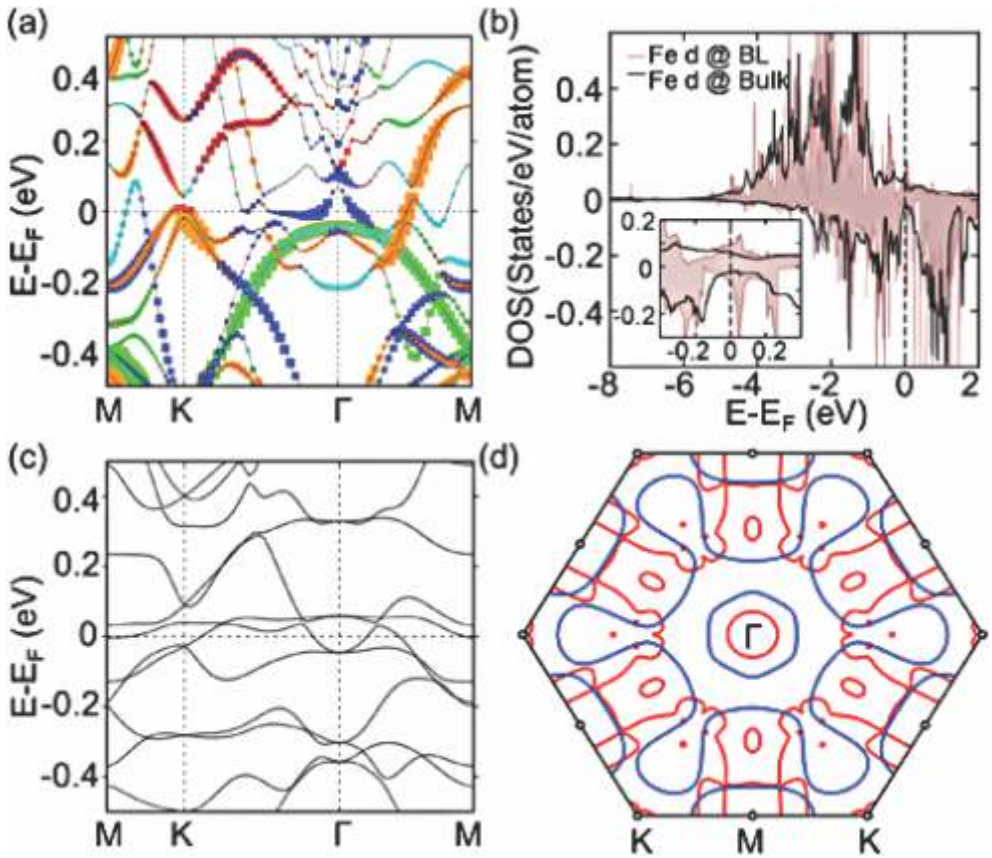


Figure 1: Calculated Band structure (a), Density of states (b) + (c), and Fermi surface of bilayer of Fe_3Sn_2 (see Phys. Rev. Lett. 125, 026401 for details)

superconductivity, which turns out to be orbital selective.The axial orbital brings in material dependence to the problem, making $LaNiO_2$ different from $NdNiO_2$ or $PrNiO_2$, thereby controlling the interorbital Hubbard interaction-assisted superconductivity (Phys. Rev. B **102**, 100501(R); Phys. Rev. B **102**, 220502(R))

Plan of Future Work Including Project

1. i) Application of machine learning for battery materials ii) Segregation trend in alloyed nanoclusters iii) Construction of force field for 2D materials iv) 2D magnets v) Oxide heterostructures vi) Spin liquids

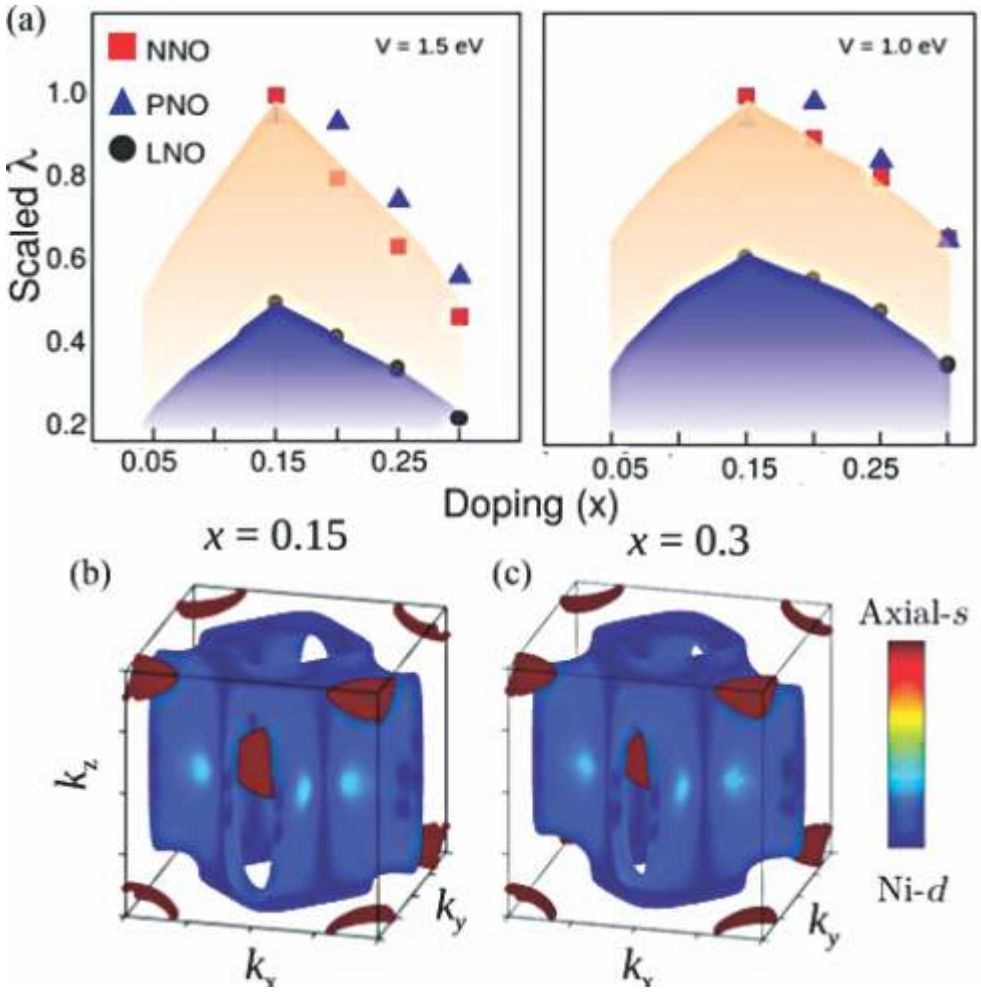
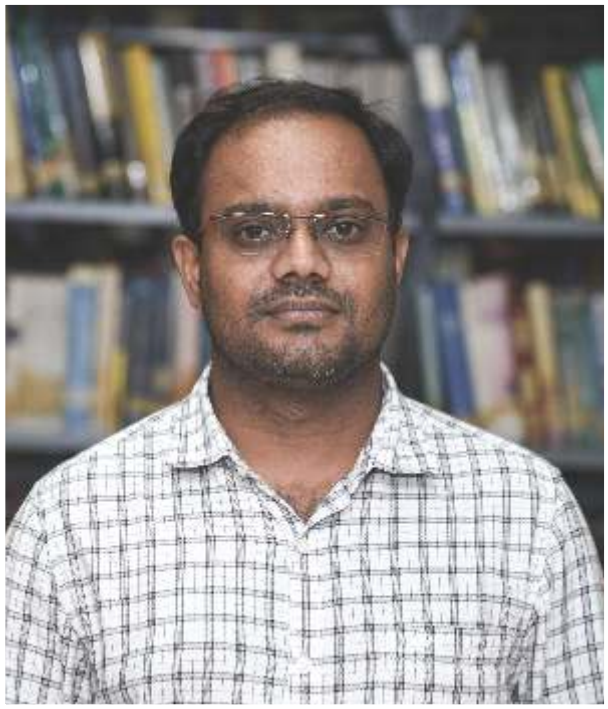


Figure 2: Calculated superconducting phase diagram (a) and Fermi surfaces for nickelate compounds.



Thirupathaiah Setti

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CMPMS
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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. Prasenjit Singha Deo (Supervisor)
5. Shubham Purwar; 2D Magnetism; Under progress
6. Susanta Ghosh; Topological Quantum Materials; Under progress

b) Post-Docs

1. Ayana Mukhopadhyay; Synthesis and characterisation of 2D magnetic single crystals
2. Reena Goyal; Synthesis and characterisation of single crystals of the high Tc superconductors

Teaching

1. Autumn semester; Condensed Matter Physics-PHY302; Integrated PhD; 16 students; with 1 (Prof. Tanusri Saha-Dasgupta,) co-teacher
2. Spring semester; Lab Course: PHY391; Integrated PhD; 12 students; with 4 (Prof. Kalyan Mandal, Prof. Rajib K Mitra, Dr. Manik Pradhan and Dr. Ramkrishna Das) co-teachers

Publications

a) In journals

1. Indrani Kar, Joydeep Chatterjee, Luminita Harnagea, Y. Kushnirenko, A. V. Fedorov, Deepika Shrivastava, B. Büchner, **P. Mahadevan** and **S. Thirupathaiah**, *Metal-chalcogen bond-length induced electronic phase transition from semiconductor to topological semimetal in ZrX_2 (X = Se and Te)*, Physical review B, 101, 165122, 2020
2. Susmita Changdar, S. Aswartham, Anumita Bose, Y. Kushnirenko, G. Shipunov, N. C. Plumb, M. Shi, Awadhesh Narayan, B. Büchner, and **S. Thirupathaiah**, *Electronic structure studies of FeSi: A chiral topological system*, Physical Review B, 101, 235105, 2020
3. **S. Thirupathaiah**, Y. S. Kushnirenk, K. Koepernik, B. R. Piening, B. Buechner, S. Aswartham, J. van den Brink, S. V. Borisenko, I. C. Fulga, *Sixfold fermion near the Fermi level in cubic $PtBi_2$*, SciPost Physics, 10, 004, 2021
4. Indrani Kar, Kapildeb Dolui, Luminita Harnagea, Yevhen Kushnirenko, Grigory Shipunov, Nicholas C. Plumb, Ming Shi, Bernd Büchner, and **Setti Thirupathaiah**, *Experimental Evidence of a Stable 2H Phase on the Surface of Layered 1T -$TaTe_2$*, The Journal of Physical Chemistry C, 125, 1150-1156, 2021

b) Conference proceedings / Reports / Monographs / Books

1. Observation of surface Dirac state in transition metal dichalcogenide NiTe2 using ARPES, Indrani Kar, Luminita Harnagea, Soma Banik, Surjeet Singh, and Setti Thirupathaiah, AIP Conference Proceedings 2265, 030361 (2020).
2. Angle Resolved Photoemission Spectroscopy Study on Electronic Band Structure of Topological Insulator Bi2Se3 in the Presence of Magnetic Impurities, Susmita Changdar, Rabia Sultana, Soma Banik, V. P. S. Awana, and Setti Thirupathaiah, AIP Conference Proceedings 2265, 030355 (2020).

Talks / Seminars Delivered in reputed conference / institutions

1. Annual Conference on Quantum Condensed Matter (QMAT 2020); Sep 10, 2020; SNBNCBS; 7th to 11th Sept. 2020
2. C. K. Majumdar Memorial Workshop 2020; Dec 31, 2020; SNBNCBS; 28th Dec. 2020 to 4th Jan. 2021

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

1. Startup Research Grants; DST-SERB; 12/2020 to 12/2022; PI

Conference / Symposia / Schools organized

1. Annual Conference on Quantum Condensed Matter (QMAT 2020); Dec 28, 2020; SNBNCBS; 28th Dec. 2020 to 4th Jan. 2021

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

1. SNBNCBS; Lab Course: PHY391; National
2. IISER Pune; Sl. No. 1, 4, and Conf. Paper 1; National
3. SSCU, IISc.; Synthesis and characterisation of 2D magnetic single crystals; National
4. NPL, Delhi; Conf. Paper 2; National
5. RRCAT, Indore; Conf. Paper 1 and 2; National
6. IFW Dresden, Germany; Sl. No. 1-4; International
7. University of Delaware, New York; 28th Dec. 2020 to 4th Jan. 2021; International
8. SLS, PSI, Switzerland; Sl. No. 1, 2 and 4; International

Areas of Research

Synthesis, Structural, Physical Properties, and Electronic Structure Studies of Quantum Materials

1. Electronic Structure Studies of FeSi: A Chiral Topological System [Susmita Changdar *et al.*, PRB 101, 235105 (2020)]

Most recent observation of topological Fermi arcs on the surface of manyfold degenerate B20 systems, CoSi and RhSi, have attracted enormous research interests. Although another isostructural system, FeSi, has been predicted to show bulk chiral fermions, it is yet to be clear theoretically and as well experimentally that whether FeSi possesses the topological surface Fermi arcs associated with the exotic chiral fermions in vicinity of the Fermi level. In this contribution, using angle-resolved photoemission spectroscopy (ARPES) and density functional theory (DFT), we present the low-energy electronic structure of FeSi. We further report the surface state calculations to provide insights into the surface band structure of FeSi near the Fermi level. Unlike in CoSi or RhSi, FeSi has no topological Fermi arcs near the Fermi level as confirmed both from ARPES and surface state calculations. Further, the ARPES data show spin-orbit coupling (SOC) band splitting of 40 meV, which is in good agreement with bulk band structure calculations. We noticed an anomalous temperature dependent resistivity in FeSi which can be understood through the electron-phonon interactions as we find a Debye energy of 80 meV from the ARPES data.

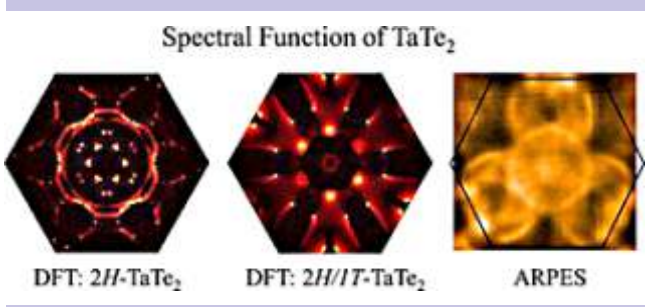
2. Metal-chalcogen bond-length induced electronic phase transition from semiconductor to topological semimetal in ZrX_2 (X = Se and Te) [Indrani Kar *et al.*, Phys. Rev. B 101, 165122 (2020)]

Using angle resolved photoemission spectroscopy (ARPES) and density functional theory (DFT) calculations

we studied the low-energy electronic structure of bulk $ZrTe_2$. ARPES studies on $ZrTe_2$ demonstrate free charge carriers at the Fermi level, which is further confirmed by the DFT calculations. An equal number of hole and electron carrier density estimated from the ARPES data, points $ZrTe_2$ to a semimetal. The DFT calculations further suggest a band inversion between Te *p* and Zr *d* states at the point, hinting at the non-trivial band topology in $ZrTe_2$. Thus, our studies for the first time unambiguously demonstrate that $ZrTe_2$ is a topological semimetal. Also, a comparative band structure study is done on $ZrSe_2$ which shows a semiconducting nature of the electronic structure with an indirect band gap of 0.9 eV between (*A*) and *M*(*L*) high symmetry points. In the below we show that the metal-chalcogen bond-length plays a critical role in the electronic phase transition from semiconductor to a topological semimetal ingoing from $ZrSe_2$ to $ZrTe_2$.

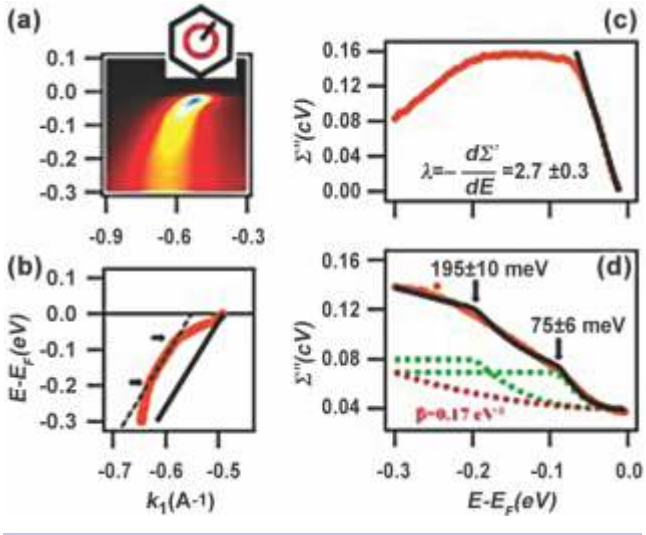
3. Experimental Evidence of a Stable 2H Phase on the Surface of Layered 1T′-$TaTe_2$ [Indrani Kar *et al.*, J. Phys. Chem. C 125, 1, 1150 (2021)]

The low-energy electronic structure of 1*T* -$TaTe_2$ is studied using high-resolution angle-resolved photoemission spectroscopy (ARPES) and density functional theory calculations. We observe that the Fermi surface of 1*T* -$TaTe_2$ is in the hexagonal symmetry, which is in contradiction to its monoclinic crystal structure. We observe a totally different electronic structure of $TaTe_2$ when compared with the isostructural compound $NbTe_2$. Further, despite being in the hexagonal symmetry, the Fermi surface topology of $TaTe_2$ is quite different when compared to the isovalent compounds $TaSe_2$ and TaS_2. To fully understand the experimentally obtained electronic band structure of $TaTe_2$, we disentangled the surface states from the bulk with the help of slab calculations. Thus, we realize that the surface states resemble the 2*H* phase electronic structure, while the bulk states replicate the 1*T* phase electronic structure of $TaTe_2$. This is an interesting discovery as $TaTe_2$ does exist neither in the 1*T* phase nor in the 2*H* phase as per the observation of the crystal structure. We further notice that the 1*T* phase electronic structure shows substantial band dispersion in the k_z direction. We realize that the band structure of $TaTe_2$ is temperature independent above and below the CDW transition temperature.



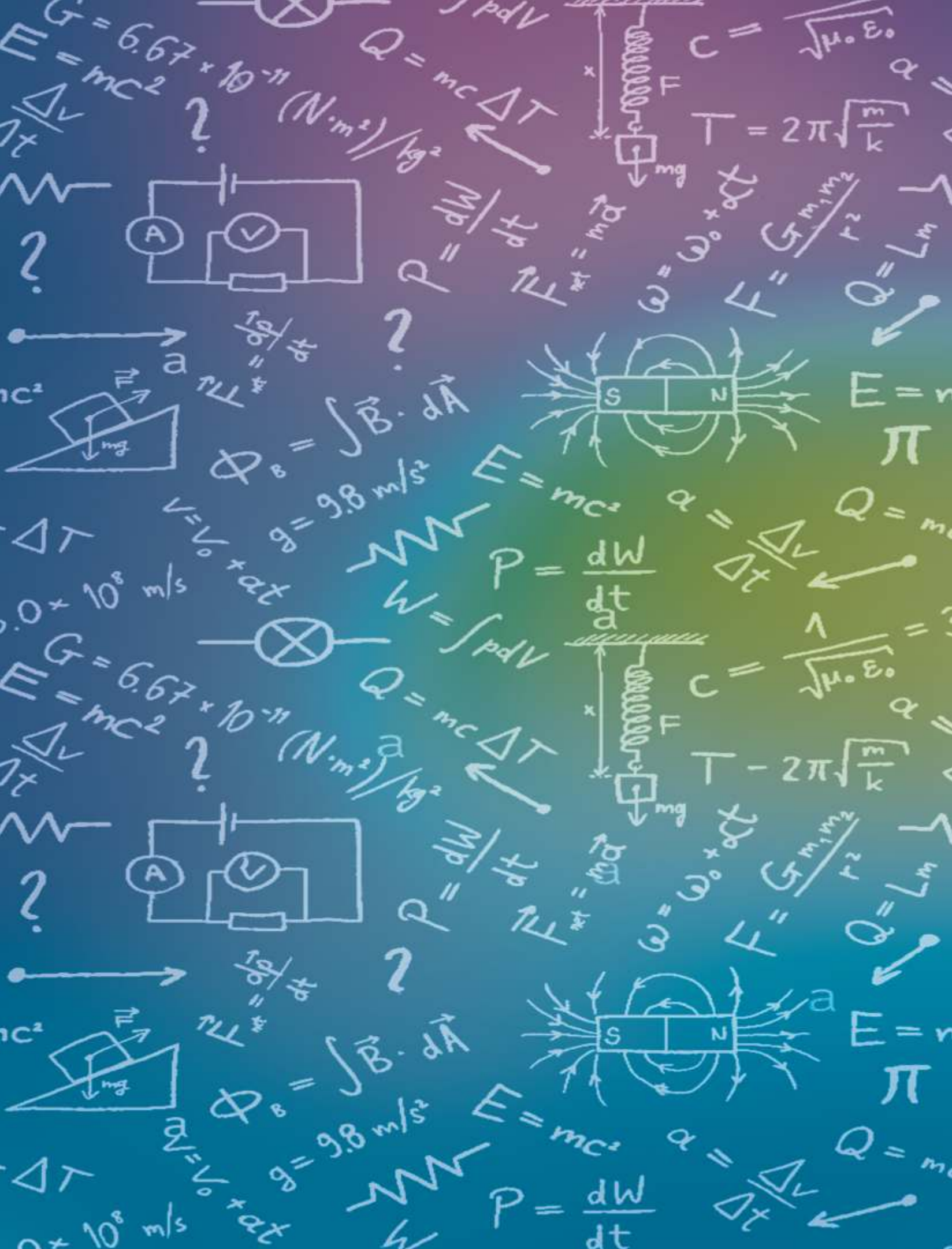
4. Anomalous band renormalization due to high energy kink in the colossal thermoelectric material $K_{0.65}RhO_2$ [Susmita Changdar et al., arXiv:2007.02016v1 (2020)]

We report on low-energy electronic structure and electronic correlations of $K_{0.65}RhO_2$, studied using 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. Since the discovery of chiral magnetic and topological properties in Mn3X systems, several research groups have been trying to understand the electronic, physical and structural properties of these systems for their technological applications in topological spintronics and quantum computations. However, to date, very few studies are available on these systems. Especially, the so-far existing studies are limited to the structural and electronic properties of the pristine Mn3Sn, Mn3Ge, Mn3Pt and Mn3Ir systems. Some of these studies suggest interesting magnetic properties of Mn3Sn systems that a magnetic phase change as a function of temperature. That means, at around 275 K a magnetic transition from non-collinear antiferromagnetic phase to a spiral magnetic structure and below 50 K the system becomes to be a spin glass. Such magnetic transitions are expected to reflect in the electronic band structure and physical properties as well. It is further anticipated that the magnetic reorientation generates a gap at the band crossing Weyl point below the transition temperature due to the time-reversal symmetry. Experimental studies in this direction are not done so far. Thus, we recently had grown the single crystals of (Mn1-xFex)3Sn (x = 0, 0.03, 0.05, and 0.1) systems and will be performing thorough physical and electronic properties studies of these systems for the next one year.


$G = 6.67 \times 10^{-11}\ (N \cdot m^2)/kg^2$
$E = mc^2$
$Q = mc\Delta T$
$P = \frac{dW}{dt}$
$W = \int p dV$
$T = 2\pi\sqrt{\frac{m}{k}}$
$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$
$\Phi_B = \int \vec{B} \cdot d\vec{A}$
$g = 9.8\ m/s^2$
$v = v_0 + at$
$\omega = \omega_0 + \alpha t$
$\alpha = \frac{\Delta v}{\Delta t}$
$F = G\frac{m_1 m_2}{r^2}$
$\tau = I\alpha$
π
S
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V
mg
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x
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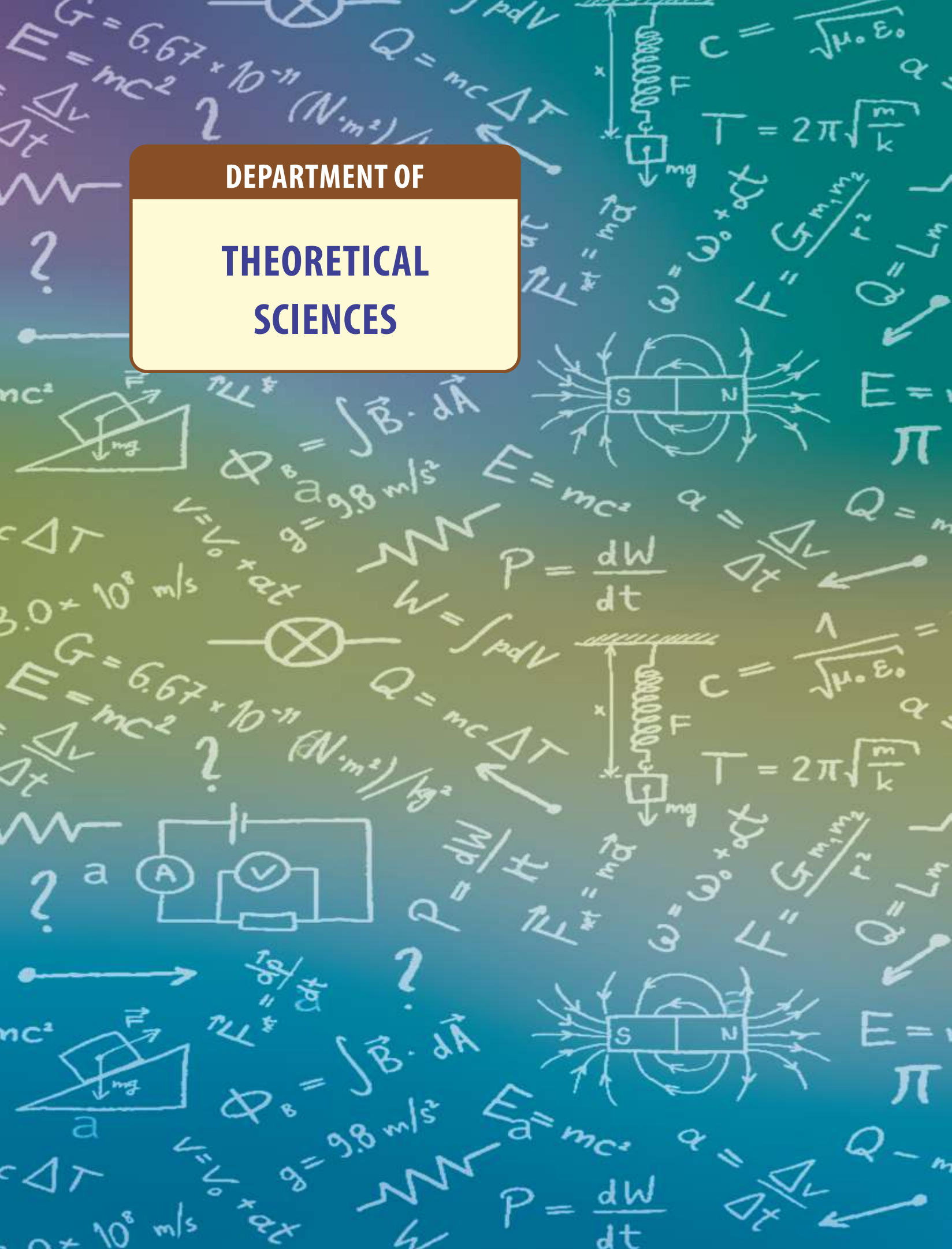

DEPARTMENT OF

THEORETICAL SCIENCES

DEPARTMENT OF
Theoretical Sciences

AMITABHA LAHIRI

Department profile indicators

Table A : Manpower and resources		
Number of faculty members		13
Number of Post –doctoral research associate (centre + project)		2 + 1
Number of Ph.D students		25
Number of other project staff		01
Number of summer students		0
Projects (ongoing)		02

Table B: Research Activities indicators		
Number of research papers in Journals		38
Number of Book-chapters/books		0
Number of other publications		0
Number of Ph.D students graduated (submitted + degree awarded)		1 + 4 = 5
Number of M.Tech/M.Sc projects		0

Table C: Academic activities and likeage		
Number of courses taught by faculty members		11
Number of Visitors (non –associates)		0
Number of associates		0
Number of Seminars organized		05
Number of Conference / Symposia /Advanced Schools organized		01
Number of talks delivered by members of department in conferences / Symposia	National	02
	International	01
Number of talks delivered by members of department in seminars other than conferences/Symposia		07

Most important research highlights

- The geometry of space time was found to contribute to effective mass of fermions in matter, thus affecting neutrino oscillations (honorable mention in Gravity Research Foundation essay competition).
- A gauge theory based on local Galilean symmetries was found, leading to a new action for a nonrelativistic particle coupled to gravity (honorable mention in Gravity Research Foundation essay competition).
- A system of interacting self-propelled particles was shown to undergo a "superfluid-like" transition

from a finitely conducting state to an infinitely conducting one.

- Geometrical phase (Berry's phase) was found to occur in a planar generalized harmonic oscillator with a non-commutative phase space.
- A method was found of deriving effective Hamiltonians for multiphoton processes for atoms in cavities that works well in general situations.
- In the gravity dual of a field theory, the entanglement temperature was holographically computed from the entanglement entropy.
- The position distribution of active particles under different stochastic resetting protocols was calculated.
- In a percolation process where k points simultaneously connect, new percolation thresholds p_{ck} were found, estimated by the average values of p at which the connections first occur.
- A performance peak for E.coli chemotaxis was found which results from a competition between sensing and adaptation modules of the signalling network.

Summary of research activities

A percolation process in which k points simultaneously connect together has been considered. New percolation thresholds p_{ck} estimated by the average values of p at which the connections first occur are found. The associated finite-size corrections scale as $1/L^{vk}$ where $v_k = v/(k + 1)$, with = 5/36 and v = 4/3 being the ordinary percolation critical exponents.

A previously developed formulation of Galilean gauge theory was used to find the actions for i) free spinless/spinning particle, ii) Newton-Hooke particle in curved nonrelativistic background. A Hamiltonian formulation for fractonic gauge theories was also developed.

The effect of intermittent resetting on active particle dynamics was studied, in particular the dynamics of Run-and-Tumble Particles and Active Brownian particles in the presence of stochastic resetting. The corresponding stationary positions distributions were exactly computed for a set of different resetting protocols.

The flow of holographic entanglement entropy has been studied using the gauge/gravity correspondence. An important observation was that a generalized temperature could be defined which gives the Hawking temperature in the infra-red limit and leads to a generalized thermodynamics like law. Various information theoretic quantities such as complexity, mutual information, etc. were also computed in the holographic framework.

It was shown, using extensive numerical simulations in a detailed theoretical model, how the competition between sensing and adaptation can result in a performance peak in E.coli chemotaxis. Receptor clustering amplifies the input signal coming from ligand binding which enhances chemotactic efficiency. But large clusters also induce large fluctuations in total activity. The activity and hence the run-tumble motility now gets controlled by methylation levels which are part of adaptation module, rather than ligand binding. This reduces chemotactic efficiency.

Hydrodynamic theory has been formulated for two classes of many-particle driven systems -- that of self-propelled particles and the Manna sandpiles, which, upon tuning density, undergoes condensation transition and absorbing phase transition, respectively. The density-dependent transport coefficients, which govern density relaxation in the systems near as well as far from criticality, were also calculated.

The question of what attributes of optical resources may be necessary and/or sufficient for quantum teleportation was examined. The results lead to the conclusion that the Einstein-Podolsky-Rosen correlation is neither necessary nor sufficient for quantum teleportation, thus leaving open the question of what attributes may be necessary and/or sufficient.

Spectral distances between time-like events, associated with the pure states of algebra describing Lorentzian noncommutative plane, were computed. Geometric phase shift in planar noncommutative quantum mechanics, where momentum noncommutativity exists along with spatial noncommutativity, was analytically

computed. Non-zero entropy of entanglement in generic noncommutative oscillatory systems was observed, and the fate of explicit breaking of scale symmetry in generalized quantum Hall system was investigated.

It was shown that the dynamics of fermions on curved spacetime leads to an effective chiral interaction between fermions. This produces flavor changing oscillations of massless neutrinos. Electrons in interaction with vortex strings in type II superconductors were considered. It was found that a dual formulation contained a nonlocal interaction.

Amitabha Lahiri

Head, Department of Theoretical Sciences

Amitabha Lahiri

Senior Professor
Theoretical Sciences
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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Pratik Tarafdar; Accreting black hole systems as classical analogue gravity models; Awarded; Tapas K. Das, HRI (Co-supervisor)
2. Subhasish Chakrabarty; Field theoretic approach to gravity; Thesis submitted
3. Shantonu Mukherjee; Some applications of quantum field theory to superconductivity and superfluidity; Under progress
4. Indrajit Ghosh; Fermions in curved spacetime (tentative); Under progress
5. Riya Barik; Neutrino interactions induced by torsion (tentative); Under progress
6. Arnab Chakraborty; Scattering from black holes (tentative); Under progress

Teaching

1. Spring semester; PHY292: Summer Project Research I; Integrated PhD; 1 student
2. Autumn semester; PHY 203: Electromagnetic Theory; Integrated PhD; 5 students
3. Autumn semester; PHY 304: Project Research II; Integrated PhD; 1 student
4. Spring semester; PHY 408: Advanced Statistical Physics; Integrated PhD; 6 students
5. Spring semester; PHY 603: Statistical Physics; PhD; 2 students
6. Spring semester; PHY401: Project Research III; Integrated PhD; 2 students

Publications

a) In journals

1. Shantonu Mukherjee and **Amitabha Lahiri**, *Emergent vortex–electron interaction from dualization*, Annals of Physics, 418, 168167, 2020
2. **Amitabha Lahiri**, *Geometry creates inertia*, International Journal of Modern Physics D, 29, 2043020, 2020

Administrative duties

1. Head, Dept. of Theoretical Sciences (w.e.f. Feb 01, 2021)
2. Chairman, Grievance redressal committee, SNBNCBS

Awards, Recognitions, if any

1. Honorable Mention, Gravity Research Foundation Essay competition, 2020

Membership of Learned Societies

1. Member, Editorial Board, Physics News

Areas of Research

Quantum Field Theory, Gravitation, Mathematical Physics

Gravitation: I studied the dynamics of spin-half fermions on curved spacetimes, using Einstein-Cartan theory of

gravitation in a first order formulation due to Sciama and Kibble. This is equivalent to General Relativity plus a field called torsion, which does not have any dynamics of its own but couples to fermions, leading to a new effective interaction between fermions. Left and right-handed components of fermions couple differently to torsion, which modifies the effective mass of fermions propagating through matter. One can thus say that the geometry of spacetime itself contributes to the inertia of matter particles.

Quantum Field Theory: I also studied, with a student, the dynamics of electrons in presence of vortex strings in the Abelian Higgs model. This can be thought of as a model of type II superconductor with itinerant fermions, analogous to the boson-fermion model of high-T_c superconductor. We investigated a dual formulation of the system and found a nonlocal interaction term between a dual tensor field and the electron field. We calculated the effective field theory by including one-loop quantum effects of the electrons, which produces a topological mass term, giving rise to an effective mass for the photon as well as the tensor field. In addition there is a Coulomb potential between the electrons, but with a large dielectric constant produced by the one-loop effects.

Plan of Future Work Including Project

1. Quantum Field Theory: With a student, I plan to investigate further the interactions of electrons with vortex strings in the Abelian Higgs model. It is known that the non-local interaction can lead to a linear potential between electrons in some cases. We plan to check if that potential can arise in some special cases of the model we have considered. We also plan to do a similar analysis for a 2+1-dimensional system of vortices and electrons, which may be applicable in the theory of fractional quantum Hall effect.
2. Gravitation: With a colleague and a student, I plan to use the energy-momentum conservation equation in a form that includes the effect of a time-varying Newton's constant G, and find the effect on the late time cosmology of a Friedmann-LeMaître-Robertson-Walker universe. With students, I plan to further investigate the effect of space-time torsion on neutrino oscillations.
3. Mathematical Physics: I also plan to continue, with colleagues elsewhere, a long running programme of investigation of categorical geometry, in particular categorical fiber bundles based on a generalization of principal 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. 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 new ideas about the origins of neutrino mass and oscillation and the dynamics of spin-half particles like electrons and neutrinos in curved space-time. It will provide a new understanding of the interactions between electrons (or holes) and vortex lines in type II superconductors, possibly new predictions as well. 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.

Bikas K. Chakrabarti
Honorary Professor (Emeritus)
Theoretical Sciences
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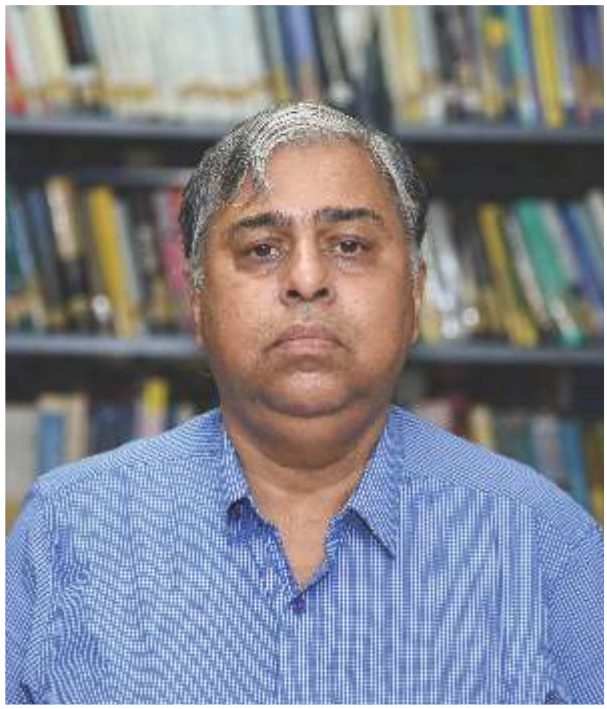
Publications

a) In journals

1. Soumyajyoti Biswas and **Bikas K. Chakrabarti**, *Flory-like statistics of fracture in the fiber bundle model as obtained via Kolmogorov dispersion for turbulence: A conjecture*, Physical Review E, 102, 012113, 2020
2. Antika Sinha and **Bikas K. Chakrabarti**, *Phase transition in the Kolkata Paise Restaurant problem*, Chaos: An Interdisciplinary Journal of Nonlinear Science, 30, 083116, 2020
3. **Bikas K. Chakrabarti** and Antika Sinha, *Development of Econophysics: A Biased Account and Perspective from Kolkata*, Entropy, 23(2), 254, 2021



Biswajit Chakraborty
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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Partha Nandi; Noncommutative Quantum Mechanics; Under progress
2. Sayan K. Pal; Noncommutative Quantum Mechanics; Under progress
3. Anwesha Chakraborty; Noncommutative Geometry; Under progress
4. Debabrata Ghorai; Aspects of Gauge/Gravity Duality and its Applications; Thesis Submitted; Biswajit Chakraborty (Co-supervisor), Sunandan Gangopadhyay (Supervisor)

b) Post-Docs

1. Dr. Kumar Das; Cosmology

Teaching

1. Spring semester; Electromagnetic Theory; Integrated PhD; 12 students
2. Spring semester; Classical Dynamics; Integrated PhD; 5 students

Publications

a) In journals

1. Anwesha Chakraborty and **Biswajit Chakraborty**, *Spectral distance on Lorentzian Moyal plane*, International Journal of Geometric Methods in Modern Physics, 17, 2050089, 2020
2. Saptarshi Biswas, Partha Nandi, and **Biswajit Chakraborty**, *Emergence of a geometric phase shift in planar noncommutative quantum mechanics*, Physical Review A, 102, 022231, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Gave a set of 2 online lectures on ``Unitary groups, Lorentz/Poincare groups and spinors" and on "Wigner's Little group",at the virtual International Workshop on ``Group theory and its Applications in Physics", organised by the Physics Department, Assam University, Silchar, Assam, during the 1st week of November' 2020, to celebrate 25th year of its foundation.

Administrative duties

1. I was the Dean (Academic Program) till June 2020
2. I was the Chairperson of the Student Curriculum and Research Evaluation Committee (SCREC) till June 2020
3. I was a member of the Consultative Advisory Committee (CAC) till June 2020

Conference / Symposia / Schools organized, if any

1. I was the co-convenor for organizing the "International Virtual Workshop on Group theory and its Application in Physics"; Nov 2, 2020;

Physics Department, Assam University, Silchar, Assam held during 2nd to 7th May, 2020.

Areas of Research

Noncommutative Geometry, Noncommutative Quantum theories

During the last academic year, I had mainly focused my attention to the following four problems:

(i) The occurrence of geometrical phase shift or the so-called Berry's phase in a system of planar generalized harmonic oscillator living in the Moyal plane, where the momentum components also satisfy non-vanishing commutator algebra.

(ii) The construction of a complete spectral triple for the fuzzy sphere with grading and real structure, using Watamura's Dirac operator.

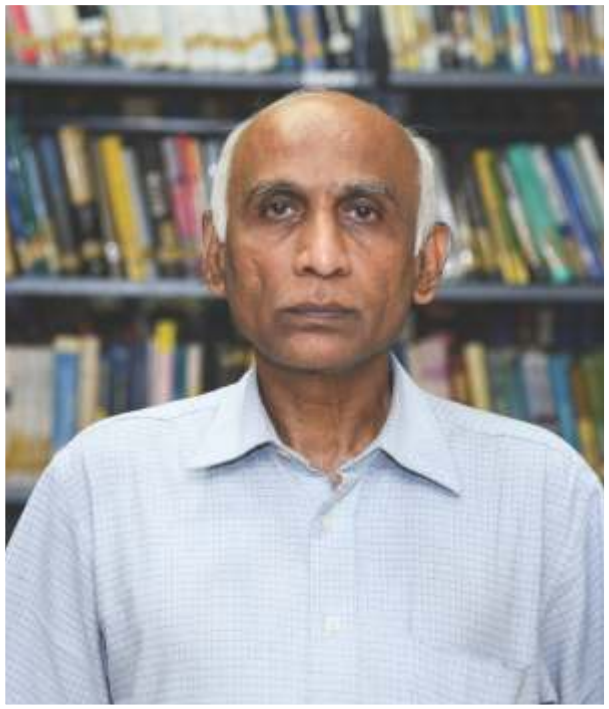
(iii) Computing the spectral distance on Lorentzian Moyal plane using a recently proposed axiomatic construction of Lorentzian spectral triple, which goes beyond the original Euclidean spectral triple construction, due to Alain Connes.

(iv) Computing the entropy induced by noncommutativity for a simple system of a harmonic oscillator in the Moyal plane, with or without momentum space noncommutativity. This was finally extended to study certain physical implications in the context of two/three wave mixing processes in quantum optics.

Plan of Future Work Including Project

1. Generalization of computation of Berry's phase in presence of phase space noncommutativity to the case of a harmonic oscillator in a line, but in the presence of space-time noncommutativity i.e here time is also an operator now and satisfy a non-vanishing commutator algebra with space coordinate. This is expected to give a footprint of any space-time noncommutativity, if present, in the corresponding geometrical phase.

2. We would like to investigate a toy model to study the physics beyond the Standard model of particle physics, using Watamura's Dirac operator, since we could show that the first order condition is not satisfied by this Dirac operator.



Makhtedar Sanjay Kumar

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Theoretical Sciences
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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Sk. Saniur Rahaman; Quantum Information in Many-Body Systems; Under progress; Manoranjan Kumar (Supervisor), M. Sanjay Kumar (Co-supervisor)
2. Prosenjit Maity; Geometric Phase in Quantum Information Science; Under progress; Dr. Malay Purkait (Supervisor), M. Sanjay Kumar (Co-supervisor)

b) Post-Docs

1. V. Yogesh; Quantum Optics and Quantum Information

Teaching

1. Autumn semester; Quantum Mechanics I; Integrated PhD; 5 students
2. Spring semester; Quantum Information Theory; Integrated PhD; 6 students
3. Spring semester; Quantum Information Theory; PhD; 4 students

Publications

a) In Journals

1. Soumyakanti Bose and **M. Sanjay Kumar**, *Analysis of necessary and sufficient conditions for quantum teleportation with non-Gaussian resources*, Physical Review A, 103, 032432, 2021

Administrative duties

1. Head, Department of Theoretical Sciences (until January, 2021)
2. Chairman, Medical Committee
3. Member, Admission Committee and Admission Coordinator
4. Member, APMP
5. Member, SCRE

Areas of Research

Quantum Optics and Quantum Information
Work with Prosenjit Maity, external student from RKM College, Narendrapur

Our recent work has focussed on designing schemes for building geometric phase based 3 qubit gates using Rydberg atoms in cavities. In this context, a theoretical problem we encountered was how to derive effective Hamiltonians for multiphoton processes for atoms in cavities in nonresonant situations. Earlier approaches in the literature worked only in resonant situations. We have formulated a method of deriving effective Hamiltonians for multiphoton processes for atoms in cavities that works well in general situations.

Plan of Future Work Including Project

1. Further studies of geometric phase in quantum information

Manu Mathur

Professor
Theoretical Sciences
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Teaching

1. Spring semester; Quantum Mechanics; Integrated PhD; 5 students

Administrative duties

1. Member of VASP Committee, Member of Medical Committee, Member of Hindi committee.

Areas of Research

Lattice Gauge Theory, Mathematical Physics

A New Disorder Operator For SU(N) Lattice Gauge Theory:

The Wilson loop order operator creates and destroys fundamental SU(N) electric fluxes in the various SU(N) representations. Therefore, it is characterised by the eigenvalues of (N-1) Casimir operators of the SU(N) group. On the other hand, the dual t' Hooft operator creates or destroys magnetic fluxes only in the center Z_N group of the SU(N) gauge group. Therefore, t' Hooft operators are characterized by only a single magnetic quantum number for all SU(N) gauge theories. This huge mismatch or imbalance between the equivalent electric and magnetic field descriptions has been noticed in the past. We remove this discrepancy by constructing the most general magnetic disorder operator for SU(N) lattice gauge theories in (2 + 1) dimension using exact duality transformations. This new disorder operator is characterized by (N-1) angular variables and hence it is at par with the Wilson loop order operator. The most general order-disorder algebra is also obtained.

Plan of Future Work Including Project

1. The behavior of the above new disorder operator with (N-1) angles in the confining and non-confining phases will be an important problem to study.

Punyabrata Pradhan

Associate Professor
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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 Mukherjee; 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 many-particle system with time-dependent drive; Under progress; Sakuntala Chatterjee (Co-supervisor)
5. Animesh Hazra; Studies of absorbing phase transition; Under progress

Teaching

1. Autumn semester; PHY 104; Integrated PhD; 7 students
2. Spring semester; PHY 204; Integrated PhD; 5 students

Publications

a) In journals

1. Tanmoy Chakraborty, Subhadip Chakraborti, Arghya Das, and **Punyabrata Pradhan**, *Hydrodynamics, superfluidity, and giant number fluctuations in a model of self-propelled particles*, Physical Review E, 101, 052611, 2020
2. Dhiraj Tapader, **Punyabrata Pradhan**, and Deepak Dhar, *Density relaxation in conserved Manna sandpiles*, Physical Review E, 103, 032122, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Hydrodynamics,"superfluidity" and "giant" fluctuations in a model of self-propelled particles; Dec 3, 2020; Online presentation (at International Centre for Theoretical Sciences (ICTS), Bengaluru); One hour

Administrative duties

1. Library committee, Newsletter committee, various interview committees

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

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

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

1. Joint publication with Deepak Dhar, Indian Institute of Science, Education and Research (IISER), Pune; Sl. No. 2; National

Areas of Research

Fluctuation relations in systems out of equilibrium, hydrodynamics of mass transport processes, single-file diffusion and transport through nanopores, etc.

We have been working along mainly two directions: The large-scale relaxation properties in active-matter systems (such as self-propelled particles) and that in threshold-activated systems (such as sandpile models). These two broad class of systems violate detailed balance due to the lack of time reversal symmetry and, upon tuning suitable parameter like global density, undergo two different kinds of nonequilibrium phase transitions. The active matter systems undergo a clustering transition, where, beyond a certain parameter value, a macroscopic cluster forms in the systems and mass fluctuation diverges in the translation-symmetry broken "ordered" phase (the phenomenon called "giant fluctuation"). On the other hand, the sandpile models exhibit, below a critical global density, an absorbing-phase transition, where mass fluctuation vanishes (the phenomenon called "hyper-uniformity"). Though these systems have been studied intensively throughout the past several decades, the theoretical understanding of the exact hydrodynamic structure, which is governed by various density-dependent transport coefficients, is still lacking. Following are the two important results we obtained in the previous year. First, in a model of interacting self-propelled particles, we show that the system undergoes a "superfluid-like" transition from a finitely conducting state to an infinitely conducting one, characterized by a divergence in the conductivity; the diverging conductivity greatly increases particle mobility and thus induces "giant" mass (particle number) fluctuations in the system. Second, in a variant of the Manna sandpile, which exhibits absorbing phase transition, we show that the bulk diffusivity diverges at the critical point and the particle transport becomes anomalous; indeed, relaxation of initially localized density profiles on infinite critical background exhibits a self-similar structure, where the width of the density perturbation grows in a super-diffusive fashion.

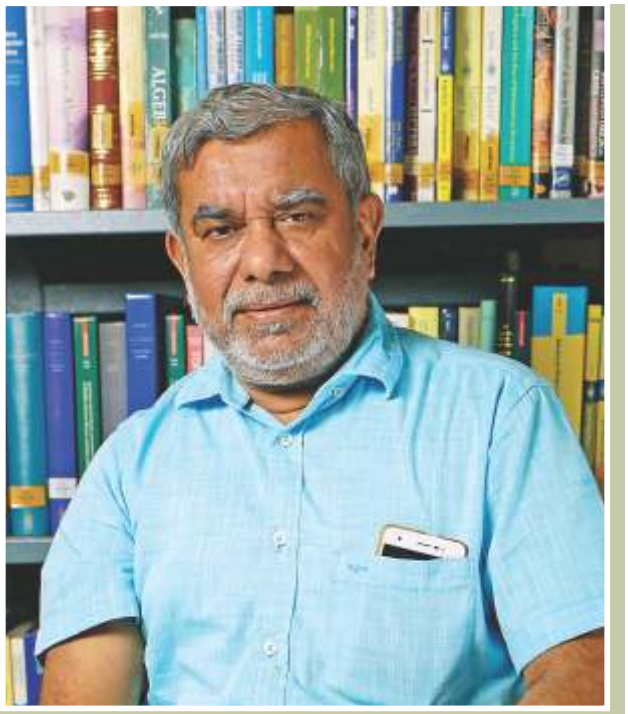
Plan of Future Work Including Project

1. Characterization of transport in interacting self-propelled particles: Large-scale spatio-temporal properties of systems consisting of self-propelled particles, which have been intensively explored in the past couple of decades, are usually characterized through phenomenological theories based on symmetries and conservation laws. However, the theoretical understanding of the exact hydrodynamic structure of these systems, except in a few special cases (e.g., those having product measure steady-state), is still lacking. Recently we have exactly calculated two density-dependent transport coefficients in a simple model of self-propelled particles (modeled through generalized exclusion processes having long-ranged particle hopping); we have shown that, upon tuning certain parameters, the system exhibits a "superfluid-like" phase transition where the particle mobility diverges in the symmetry-broken "ordered" phase (Phys. Rev. E 101, 052611, 2020). Indeed it would be quite interesting to characterize various other interacting self-propelled particle systems in terms of the transport coefficients, which govern large-scale hydrodynamic properties of the systems.
2. Characterization of transport in systems having absorbing phase transition: We aim to understand the exact hydrodynamic structure in a broad class of model systems, called conserved stochastic sandpiles, which are known to exhibit an absorbing phase transition upon tuning the global density. Recently, we have obtained hydrodynamics of a special class of stochastic sandpile models - the celebrated Manna sandpile and its variants (Phys. Rev. E 97, 062142, 2018; Phys. Rev. E 103, 032122, 2021). However, it is not clear that the other stochastic sandpiles (such as the Oslo ricepile model) would also possess the similar hydrodynamic structure. In future, we would like to characterize the relaxation properties of sandpiles in general.
3. Understanding the role of interactions on particle transport in systems with time-dependent driving: Recently we have studied the phenomenon of current reversal in the presence of space-time dependent driving in symmetric exclusion process having only hardcore interaction and in systems of

colloidal particles interacting through Weeks-Chandler-Anderson (WCA) potential. In these systems, under certain driving protocols and upon tuning certain parameters such as particle concentration, the time-averaged particle current is shown to reverse its direction (Phys. Rev. E 98, 052142, 2018). However, in the presence of inter-particle interactions (attractive or repulsive), there is no good analytic understanding of the above mentioned phenomenon of current reversal. In future, we would like to investigate the role of interaction on particle transport in simple analytically tractable model systems in the presence of a time-dependent driving force.

Any other Relevant Information including social impact of research

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



Rabin Banerjee

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Arpan Krishna Mitra; Canonical formulation of fluid dynamics; Awarded
2. Shirsendu Dey, Aspects of anomalous hydrodynamics, Thesis submitted (External candidate)

Teaching

1. 1st semester; Mathematical Physics; IPh.D; 5 students; Sunandan Gangopadhyay (Co-teacher)

Publications

a) In journals

1. **Rabin Banerjee**, *Demystification of nonrelativistic theories in curved background*, International Journal of Modern Physics D, 29, 2043015, 2020
2. **Rabin Banerjee** and Pradip Mukherjee, *Canonical formulation of a new action for a nonrelativistic particle coupled to gravity*, Physical Review D, 101, 126013, 2020
3. **Rabin Banerjee** and Bibhas Ranjan Majhi, *Fluctuation–dissipation relation from anomalous stress tensor and Hawking effect*, The European Physical Journal C, 80, 435, 2020
4. **Rabin Banerjee** and Pradip Mukherjee, *Canonical formulation for a non-relativistic spinning particle coupled to gravity*, Classical and Quantum Gravity, 37, 235004, 2020
5. **Rabin Banerjee**, Sk. Moinuddin, and Pradip Mukherjee, *New approach to the study of nonrelativistic bosonic string in flat spacetime*, Physical Review D, 103, 046020, 2021

Awards, Recognitions

1. Received Honorable Mention in the Annual Essay contest of the Gravity Research Foundation
2. Received mention in the top two percent (2%) of scientists, world-wide, in Nuclear and Particle Physics, in Stanford University's report
3. Awarded the CSIR emeritus scientist followed by the NASI senior scientist platinum jubilee fellowship

Outreach program organized / participated

1. Participated in the write-up of DST coffee table book

Areas of Research

Nonrelativistic theories in flat and curved backgrounds

I have continued and extended my studies on nonrelativistic theories, especially in a curved background. Also, I have looked at the fluctuation-dissipation theorem in the context of Hawking effect.

A new action for a nonrelativistic particle coupled to gravity was found using our approach of localizing Galilean symmetries, called Galilean gauge theory. Its equation of motion was found to satisfy the geodesic

equation involving the Newton-Cartan structures. The analysis was then extended for spinning particles where the geodesic equation is no longer satisfied. Several results could be interpreted as the nonrelativistic limit of the relativistic spinning particles coupled to gravity worked out earlier by Mathiesson-Papapetrou-Dixon. For both spinning and spinless examples a canonical Hamiltonian analysis was performed. The Schroedinger equation was derived which paved the way for a possible quantization of such theories.

A new approach to discuss the formulation of nonrelativistic bosonic string theories in flat background was developed. Using the constraints of the usual nonrelativistic bosonic string, an interpolating action was found. In one case it gave the Nambu-Goto form while in another, the Polyakov form was obtained.

It is known that the Hawking effect can be understood from the structure of anomalous stress tensors. We have used this correspondence to give an alternative interpretation or understanding of the fluctuation-dissipation theorem due to Kubo.

Plan of Future Work Including Project

As a continuation of my earlier research I plan to study the motion of nonrelativistic strings in a curved background. Incidentally some results have already been derived in the flat background and these have been recently published in Phys. Rev. D. For the curved case, I hope to use our technique of Galilean gauge theory, developed over the last few years, to get some new insights into the problem.

On a different note, recently there has been great interest in the study and application of symmetric higher rank tensor theories. In these theories the motion is restricted in the sense that the particles may be frozen or, alternatively, their motion is confined to a dimension less than from which they were initially defined. Such theories are called Fractonic gauge theories.

I have started working in this area and found certain preliminary results. I wish to extend and elaborate on these findings.

Sakuntala Chatterjee

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Shobhan Dev Mandal; Bacterial chemotaxis; Under progress
2. Deepsikha Das; Nonequibrium systems with periodic drive; Under progress; Punyabrata Pradhan, SNBNCBS (Co-supervisor)

Publications

a) In journals

1. Shobhan Dev Mandal and **Sakuntala Chatterjee**, *Effect of receptor clustering on chemotactic performance of E. coli: Sensing versus adaptation*, Physical Review E, Letters 103, L030401, 2021

Talks / Seminars Delivered in reputed conference / institutions

1. Invited talk in an online International conference "Statistical Biological Physics: From Single Molecule to Cell"; Dec 7-18,2020; Online
2. Invited seminar at ICTS Bangalore.

Administrative duties

1. Served in many internal committees of the centre

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

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

Outreach program organized / participated

1. Organized virtual lab visits and online talks 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

Nonequilibrium statistical physics, biological systems

Sensing vs adaptation in bacterial chemotaxis: With the advent of sophisticated techniques to measure single-cell response in experiments, an important question has emerged: how the behavior of a cell is affected by the fluctuations present at the intracellular biochemical reaction network. We address this question within the framework of E.coli chemotaxis, one of the best characterized systems in biology. The chemotaxis describes the migration tendency of the Escherichia coli cell towards the region of higher nutrient concentration. In the underlying reaction network, methylation is the slowest step. Any fluctuation present at this step acts as a slow noise which cannot be integrated out in the downstream processes. As a result, methylation noise was

considered to be the most important source of biochemical noise for E.coli chemotaxis. Recent experiments have recorded strong fluctuation in the chemoreceptor activity even in the absence of methylation. It was shown that the cooperativity of the receptors which gives rise to clustering tendency among the neighboring receptors, is an important source of noise. We ask the question: how this newly found noise source is ralated to the chemotactic performance of the cell. Our numerical simulations within a detailed theoretical model shows that there is an optimum size of the receptor cluster at which the cell shows most efficient chemotaxis. We explain this surprising result from the competition between sensing and adaptation, which are two principal modules of the reaction network.

Plan of Future Work Including Project

1. A detailed study of bacterial chemotaxis in presence of external and internal noise
2. Understanding the effect of periodic drive in systems out of equilibrium

Subhrangshu Sekhar Manna

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Publications

a) In journals

1. **S. S. Manna** and Robert M. Ziff, *Bond percolation between k separated points on a square lattice*, Physical Review E, 101, 062143, 2020

Areas of Research

Statistical Physics

We consider a percolation process in which k points separated by a distance proportional the system size L simultaneously connect together $(k > 1)$, or a single point at the center of a system connects to the boundary $(k = 1)$, through adjacent connected points of a single cluster. These processes yield new thresholds $p$ck defined as the average value of p at which the desired connections first occur. These thresholds not sharp, as the distribution of values of $p$ck for individual samples remains broad in the limit of L . We study p_{ck} for bond percolation on the square lattice and find that p_{ck} are above the normal percolation threshold $p_c = 1/2$ and represent specific supercritical states. The p_{ck} can be related to integrals over powers of the function P (p) equal to the probability a point is connected to the infinite cluster; we find numerically from both direct simulations and from measurements of P (p) on $L \times L$ systems that for L , $p_{c1} = 0.517\ 55(5)$, $p_{c2} = 0.532\ 19(5)$, $p_{c3} = 0.544\ 56(5)$, and $p_{c4} = 0.555\ 27(5)$. The percolation thresholds p_{ck} remain the same, even when the k points are randomly selected within the lattice. We show that the finite-size corrections scaleas $L_{-1/k}$ where $k = /(k + 1)$, with $= 5/36$ and $= 4/3$ being the ordinary percolation critical exponents, so that $1 = 48/41$, $2 = 24/23$, $3 = 16/17$, $4 = 6/7$, etc. We also study three-point correlations in the system and show how for $p > pc$, the correlation ratio goes to 1 (no net correlation) as L , while at p_c it reaches the known value of 1.022.

Sunandan Gangopadhyay

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Debabrata Ghorai; Holographic superconductors; Thesis Submitted; Biswajit Chakraborty (Co-supervisor)
2. Ankur Srivastav; Applications of gauge/gravity duality; Under progress
3. Sourav Karar; Holographic entanglement entropy and complexity; Under progress; Archan Majumdar (Co-supervisor)
4. Rituparna Mandal; Renormalization group approach to quantum gravity; Under progress
5. Neeraj Kumar; Black hole thermodynamics and phase transitions; Under progress
6. Anish Das; Black hole shadow; Under progress
7. Manjari Dutta; Noncommutative quantum mechanics; Under progress
8. Anirban Roy Chowdhury; Holographic investigation of quantum information theoretic quantities; Under progress

b) Post-Docs

1. Dharmesh Jain; String theory

Teaching

1. Autumn semester; Advanced Quantum Mechanics and Applications (PHY303); Integrated PhD; 12 students; with 1 (Archan Majumdar) co-teacher
2. Autumn semester; Mathematical Methods (PHY 102); Integrated PhD; 5 students; with 1 (Rabin Banerjee) co-teacher
3. Spring semester; Advanced Quantum Field Theory (PHY 407); Integrated PhD; 9 students

Publications

a) In journals

1. Neeraj Kumar and **Sunandan Gangopadhyay**, *Phase transitions in D-dimensional Gauss-Bonnet-Born-Infeld AdS black holes*, General Relativity and Gravitation, 53, 35, 2021
2. Anish Das, Ashis Saha and **Sunandan Gangopadhyay**, *Investigation of circular geodesics in a rotating charged black hole in the presence of perfect fluid dark matter*, Classical and Quantum Gravity, 38, 065015, 2021
3. Manjari Dutta, Shreemoyee Ganguly and **Sunandan Gangopadhyay**, *Exact Solutions of a Damped Harmonic Oscillator in a Time Dependent Noncommutative Space*, International Journal of Theoretical Physics, 59, 3852 – 3875, 2020
4. **Sunandan Gangopadhyay**, Dharmesh Jain, and Ashis Saha, *Universal pieces of holographic entanglement entropy and holographic subregion complexity*, Physical Review D, 102, 046002, 2020
5. Sukanta Bhattacharyya, **Sunandan Gangopadhyay** and Anirban Saha, *Generalized uncertainty*

principle in resonant detectors of gravitational waves, Classical and Quantum Gravity, 37, 195006, 2020

6. Ashis Saha, **Sunandan Gangopadhyay**, and Jyoti Prasad Saha, *Generalized entanglement temperature and entanglement Smarr relation*, Physical Review D, 102, 086010, 2020

7. Sourav Karar and **Sunandan Gangopadhyay**, *Holographic information theoretic quantities for Lifshitz black hole*, The European Physical Journal C, 80, 515, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. Talk delivered in Inter University Centre for Astronomy And Astrophysics (IUCAA), Pune on "Information theoretic quantities from gauge/gravity correspondence"; Jul 15, 2020; Online; 1 hour

2. Talk delivered in DAEHEP 2020, National Institute of Science Education and Research, Odisha; Dec 15, 2020; Online; 20 minutes

Administrative duties

1. Member of various interview committees

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

1. Jyoti Prasad Saha, Physics department, Kalyani University; Sl. No. 6; International

2. Ashis Saha, Physics department, Kalyani University; Sl. No. 2, 4, 6; International

3. Anirban Saha, Physics department, West Bengal State University; Sl. No. 5; International

4. Sukanta Bhattacharyya, Physics department, West Bengal State University; Sl. No. 5; International

Outreach program organized / participated

1. Talk given in University of Engineering and Management on Quantum Physics in 2020

Areas of Research

Gauge/gravity duality, black hole shadow, renormalisation group approach to quantum gravity, quantum gravity phenomenology

I have been working with my Ph.D. students in research areas which include applications of gauge/gravity correspondence in quantum information and condensed matter physics, cosmology, minimal length theories such as non commutative quantum mechanics and the generalised uncertainty principle, black hole thermodynamics and quantum optics.

In the area of gauge/gravity duality and its connection with information theoretic quantities, I have observed that in the presence of excitation, a thermodynamic Smarr like relation corresponding to a generalized entanglement temperature can be holographically obtained for the entanglement entropy of a subsystem. We demonstrate this for three spacetime geometries, namely, a background with a nonconformal factor, a hyperscaling violating geometry background, and a charged black hole background which corresponds to a field theory with a finite chemical potential. This work got published in Phys.Rev.D 102 (2020) 8, 086010.

I have also investigated the holographic entanglement entropy for a linear subsystem in a $3+1$-dimensional Lifshitz black hole. The entanglement entropy has been analysed in both the infra-red and ultra-violet limits, and has also been computed in the near horizon approximation. The notion of a generalized temperature in terms of the renormalized entanglement entropy has been introduced. This once again leads to a generalized thermodynamics like law $E = T_g S_{REE}$. We have then computed the holographic subregion complexity. Then the Fisher information metric and the fidelity susceptibility for the same linear subsystem have also been computed using the bulk dual prescriptions. It has been observed that the two metrics are not related to each other. This work got published in Eur.Phys.J.C 80 (2020) 515.

I have then proposed that the definition of holographic subregion complexity (HSC) needs a slight modification for supergravity solutions with warped anti-de Sitter (AdS) factors. Such warp factors can arise due to the nontrivial dilaton profile, for example, in AdS_6 solutions of type IIA supergravity. This modified definition ensures that the universal piece of the HSC is proportional to that of the

holographic entanglement entropy, as is the case for supergravity solutions without warp factors. This also means that the leading behaviour at large N is the same for both these quantities, as we show for some well-known supergravity solutions (with and without warp factors) in various dimensions. We also show that this relation between the universal pieces suggests "universal" relations between field theoretical analogue of HSC and the sphere partition function or Weyl a-anomaly in odd or even dimensions, respectively.

I have obtained a charged black hole solution in the presence of perfect fluid dark matter (PFDM) and discuss its energy conditions. The metric corresponding to the rotating avatar of this black hole solution is obtained by incorporating the Newman-Janis algorithm. We then compute two types of circular geodesics, namely, the null geodesics and time-like geodesics for this rotating space time geometry. For the case of time-like geodesics, we consider both neutral as well as charged massive particles. The effective potentials of the corresponding circular geodesics has also been studied. We then present our results by graphically representing the collective effects of the black hole parameters, namely, the charge of the black hole (Q), spin parameter (a) and the PFDM parameter ( ) on the energy (E), angular momentum (L) and effective potential (V_{eff}) of the concerned particle. Finally, we discuss the Penrose process in order to study the negative energy particles having possible existence within the ergosphere, and which in turn leads to the energy gain of the emitted particle. This work got published in Classical and Quantum Gravity 38 (2021) 065015.

I have then studied FLRW cosmology, taking into account quantum gravitational corrections in the formalism of the exact renormalization group flow of the effective action for gravity. We calculate the quantum corrected scale factor, energy density, and entropy production at late times, taking different cut-off functions. Our approach differs from previous ones in the way energy-momentum conservation is imposed - we include the running Newton constant G(k) in the definition of energy-momentum tensor, keeping in mind the covariant conservation identity of the Einstein tensor. The quantum corrections obtained in this approach are different from what are found by letting the conservation equation remain the same as for a scale-independent Newton constant. We also find that for a specific choice of the cut-off scale, the quantum corrected behaviour of the Newton constant and the cosmological constant lead to a bouncing emergent universe solution. This work is under communication.

In the area of black hole thermodynamics, I have investigated the phase transition in black holes when Gauss-Bonnet corrections to the spacetime curvature and Born-Infeld extension in stress-energy tensor of electromagnetic field are considered in a negative cosmological constant background. It is evident that the black hole undergoes a phase transition as the specific heat capacity at constant potential shows discontinuities. Further, the computation of the free energy of the black hole, the Ehrenfest scheme and the Ruppeiner state space geometry analysis are carried out to establish the second order nature of this phase transition. The effect of non-linearity arising from Born-Infeld electrodynamics is also evident from our analysis. Our investigations are done in general D-spacetime dimensions with $D > 4$, and specific computations have been carried out in $D = 5, 6, 7$ space time dimensions. This work got published in General Relativity and Gravitation 53 (2021) 35.

In the area of non commutative quantum mechanics, I have obtained the exact eigenstates of a two dimensional damped harmonic oscillator in time dependent noncommutative space. It has been observed that for some specific choices of the damping factor and the time dependent frequency of the oscillator, 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. We then obtain expressions for the matrix elements of the coordinate operators raised to a finite arbitrary power. From these general results we then 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 and the time dependent frequency of the oscillator. This work got published in International Journal of Theoretical Physics 59 (2020) 3852.

With the direct detection of gravitational waves by advanced LIGO detector, a new "window" to quantum gravity phenomenology has been opened. At present,

these detectors achieve the sensitivity to detect the length variation (L), O $10^{-17} - 10^{-21}$ meter. Recently a more stringent upperbound on the dimensionless parameter $_0$, bearing the effect of generalized uncertainty principle has been given which corresponds to the intermediate length scale $\ell_{im} = {}_0\ell_{pl} \sim 10^{-23}$m. Hence the flavour of the generalized uncertainty principle can be realised by observing the response of the vibrations of phonon modes in such resonant detectors in the near future. In this paper, therefore, we calculate the resonant frequencies and transition rates induced by the incoming gravitational waves on these detectors in the generalized uncertainty principle framework. It is observed that the effects of the generalized uncertainty principle bears its signature in both the time independent and dependent part of the gravitational wave-harmonic oscillator Hamiltonian. We also make an upper bound estimate of the GUP parameter. This work got published in Classical and Quantum Gravity 37 (2020) 195006.

Plan of Future Work Including Project

1. The work that I plan to carry out in the future would be focussed in the following directions: I would like to investigate various information theoretic quantities from gauge/gravity correspondence. In particular I would like to calculate the entanglement entropy and complexity of field theoretical systems and try to see whether they agree with the holographic dual computations. I would also like to investigate the standard model of cosmology using the renormalisation group approach to quantum gravity. I also intend to find out a connection between time dependent harmonic oscillators and geometric phases in quantum mechanics.

Any other Relevant Information including social impact of research

1. The societal impact of the research carried out by me would be to train Ph.D. students in Theoretical Physics. This would help in forming a solid foundation of our country's think tank who would be prepared to develop innovative ideas that would help in the development of science and technology. Fundamental research is always important since it is the only way by which future technology can be invented and implemented for the betterment of mankind. I feel the kind of research that I pursue would definitely make way for modern technology in future.

Urna Basu

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Guidance of Students/Post-Docs/Scientists

a) External Project Students / Summer Training

1. Durgesh Ajgaonkar; Inertial active particles; IISER Pune
2. Aniket Zodage; Coupled passive-active particle system; IISER Pune

Teaching

1. Autumn semester; Stochastic Process and numerical Methods; PhD; 13 students

Publications

a) In journals

1. Ion Santra, **Urna Basu** and Sanjib Sabhapandit, *Run-and-tumble particles in two dimensions under stochastic resetting conditions*, Journal of Statistical Mechanics: Theory and Experiment, 2020, 113206, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. IISc Physics Colloquium; Nov 27, 2020; online
2. Edinburgh Statistical Physics Seminar; Jan 13, 2021; online
3. RRI TP seminar; Mar 23, 2021; online

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

1. Sanjib Sabhapandit, Raman Research Institute. Sl. No. 1, National

Areas of Research

Statistical Physics: active particle dynamics, nonequilibrium fluctuation response, nonequilibrium critical phenomena

Active particles are self-propelled agents which consume energy from environment and convert it into directed motion. Apart from various interesting collective phenomena, active particles also show a lot of novel behaviour even at the level of individual particles. Recently I have been focussing on the effect of stochastic resetting on active particle dynamics. In two recent publications we have studied the dynamics of Run-and-Tumble Particles (RTP) and Active Brownian particles (ABP) in the presence of stochastic resetting.

In the first work we study the effect of stochastic resetting on a run and tumble particle (RTP) in two spatial dimensions. We consider a resetting protocol which affects both the position and orientation of the RTP: with a constant rate the particle undergoes a positional resetting to a fixed point in space and orientation randomization. We compute the radial and x-marginal stationary state distributions and show that while the former approaches a constant value as r 0, the latter diverges logarithmically as x 0. On the other hand, both the marginal distributions decay exponentially with the same exponent far away from the origin. We also study the temporal relaxation of the RTP and show that the position distribution undergoes a dynamical transition to a

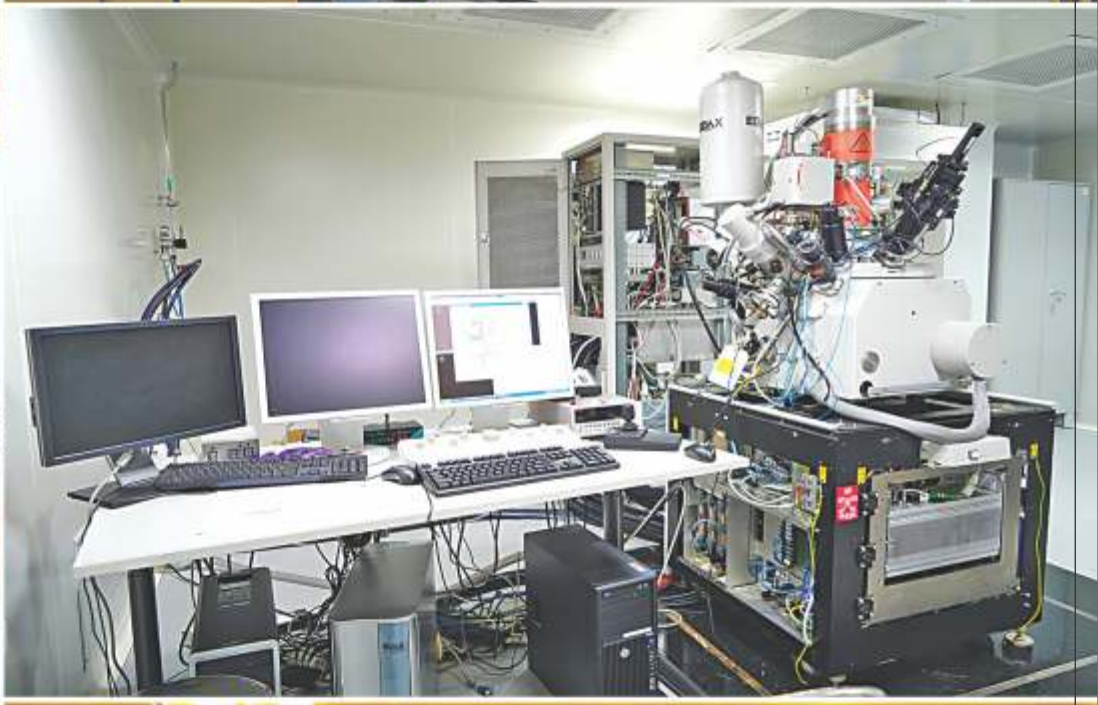
stationary state. We also study the first passage properties of the RTP in the presence of the resetting and show that the optimization of the resetting rate can minimize the mean first passage time. We also give a brief discussion on the stationary states for resetting to the initial position with fixed orientation.

In another recent work we have studied the position distribution of an active Brownian particle in the presence of stochastic resetting in two spatial dimensions. We consider three different resetting protocols : (I) where both position and orientation of the particle are reset, (II) where only the position is reset, and (III) where only the orientation is reset with a certain rate r. We show that in the first two cases the ABP reaches a stationary state. Using a renewal approach, we calculate exactly the stationary marginal position distributions in the limiting cases when the resetting rate r is much larger or much smaller than the rotational diffusion constant DR of the ABP. We find that, in some cases, for a large resetting rate, the position distribution diverges near the resetting point; the nature of the divergence depends on the specific protocol. For the orientation resetting, there is no stationary state, but the motion changes from a ballistic one at short-times to a diffusive one at late times. We characterize the short-time non-Gaussian marginal position distributions using a perturbative approach.

Plan of Future Work Including Project

1. Presently we are studying the properties of active particle motion with directional reversals. Some bacteria, like Myxococcus xanthus and Pseudomonas putida, exhibit a unique kind of direction reversing active motion, whereby, in addition to a diffusive change of direction, the motion also completely reverses its direction intermittently. How far does such microorganisms typically disperse in a given time? How long does it take (first-passage time) to find a food source? These questions are crucial in characterizing this kind of direction reversing motion. A simple model to describe such motion is a Direction Reversing Active Brownian Particle (DRABP). The interplay of the two time scales set by the rotational diffusion constant and the reversal rate is expected to lead to a complex dynamical behaviour as well as interesting phases in the stationary state in the presence of external potential. We are presently studying the DRABP model analytically with particular focus to the position distribution and first-passage time distribution.

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 16500 books and 8000 bound volume journals. The Library subscribes many useful journals published by reputed publishers mostly in electronic version. In addition, being a member of National Knowledge Resource Consortium (NKRC), library gets access to a wide range of online journals. The library is also equipped with databases like Web of Science, SciFinder Scholar, Mathscinet, ICSD (Inorganic Crystal Structure Database) etc. Library has a Fiction Section with popular books on English, Hindi and Bengali literature. It includes novels, short stories, biographies, dramas, and books on general interests aiming to satisfy all type of readers. Library has a good collection of audio-visual materials. In the magazine and newspaper reading section, 25 popular magazines and 13 daily newspapers in different languages have been subscribed regularly. The library is enriched with a valuable archive of S N Bose. This archive includes some personal belongings of S N Bose and some of his personal book collections. Digital version of the archive is available in the website.

Library Hours

The Library is open from morning 9.00 AM to 12.00 at night. During examination Library is open for whole night. Saturday 9.00 AM to 8.00 PM. However, circulation counter is open from 9:00 AM to 5:30 PM. Library is closed on Sundays and national holidays.

Library Users

On an average 50 users visit the library per day. Online journals and databases are accessible within the campus through campus LAN and outside the campus through VPAN. Therefore users may use those online resources from their convenient places.

Services

1. **Reading Facility:** Library provides reading facility to its members as well as outside visitors. All the books including reference collections are classified and open-accessed.
2. **Document Lending Service:** Each member is entitled to issue 6 books and 2 bound volumes of journals at a time.
3. **Reference Service:** Reference service is provided via e-mail, telephone or personal interaction with the help of different reference tools like encyclopedias, directories, dictionaries, yearbooks, web of science, annual report etc.
4. **OPAC:** Library offers Online Public Access Catalogue (OPAC) which allows user to browse library collection by author, title, subject, classification number, etc. through web OPAC.
5. **E-resources and Internet Facility:** Library is well equipped with sufficient number of computers with internet connectivity through cable LAN and wireless networking facility for laptop users. Library is having access to plenty of electronic journals, databases, archives and consortium resources. Users are having full access to the subscribed e-resources.
6. **Reprographic Services:** Library has printer cum copier, good colour printer, photocopy machine and poster printer for providing extensive reprographic service.
7. **Audio-visual Room:** Library has a separate Audio-visual Room for showing multimedia

presentations, video lectures, documentaries etc. The room is equipped with projector, screen, white board and sitting arrangements. The room is used as a discussion room for teachers and students.

8 **Bibliometric Services:** Library helps to prepare various bibliometric reports specially usage statistics, citation analysis, h-index, Impact factor of Journals etc. as per users' requirements.

9 **Library Resource Sharing Activities:** The library shares its resources with all important academic/research institutions in India. As a member of National Knowledge Resource Consortium (NKRC), the library keeps close contacts with libraries under DST and CSIR. SNB library has institutional membership in the British Council Library (BCL), Kolkata and American Library Kolkata.

10 **Library is for Leisure:** Library has a separate section for Bengali, Hindi, and English literature, fiction, classic literature, novel, history, and books on general interest.

11 **Map Section:** Library created a map section containing 5 large wall fixed maps. i.e. map of World, India, West Bengal, North 24 Parganas and Salt Lake City.

12 **Documentation Service:** Library has been compiling the Annual Report in Hindi and English versions, Diary, and Calendar of the Centre and coordinating the process of printing. Printing and designing of different documents of the Centre like poster, conference brochure etc.

13 **New arrival Section:** Library has a section where newly processed books are displayed for users in every month. Same list is uploaded in the website in every month and e-mail intimation is given to all library members.

14 **Research publication status and citation received:** Every month Library has been preparing pictorial research publication status of the Centre and citation received by those publications. The report also includes h-index, citation received per year etc. It is being uploaded in the website on regular basis.

15 **Institutional Repository:** Library has an institutional digital repository with search engine facility. It is enriched with pre-published version of the published research papers of the S.N. Bose Centre. Library has also developed the S.N. Bose Archive containing photographs and scanned documents related to S. N. Bose. The archive is linked to the Centre's website. Library has repository of Ph.D. thesis of the Centre.

Resources and Services Added in the F.Y. 2020-21

1 Approximately 400 new books and some new journals have been added in the library collection during the above mentioned financial year.

2 Library has developed an institutional digital repository with multiple way search facility. It is enriched with pre-published version of the published research papers of the S.N. Bose Centre. In this financial year retrospective papers for the years 2019 have been uploaded in the repository.

3. In the Financial Year 2020-21, the Fiction Section has been enriched by procuring 15 books of classic literature, novel, short story, biography and books of general interests.

4. 24 Hindi books are added in the Library collection the mentioned financial year.

Saumen Adhikari
Librarian-cum-Information Officer

Engineering Section

A. Civil Work

Construction of RCC Foundation for Installation of Waste Compactor Machine at SNBNCBS:

There is no regular garbage collection from Local Municipality due to which accumulation of garbage is taking place which created unhygienic conditions in the premises. The Centre has decided to install a Compactor Machine which will dense and confine the wastes inside the compactor till disposal. A suitable foundation for installation of the compactor has been constructed with the provision of RCC raft, pedestals, shear walls etc.

Compactor Machine

RCC Foundation

Repairing Renovation and Face lifting work at Reception area of Main Building.

Renovated Reception

The Reception area was untidy due to wear and tear of the walls. The wall was required fresh look which has been attained by decorating interior with Heritage wall surface granule texture. The focal point was aesthetic issue and a Holistic approach has been observed in beautifying the

reception area exhibiting comfort to visitors and the Centre.

Renovation of CKM Laboratory

The C.K.Majumder Lab is one of the oldest Lab of SNBNCBS which has been renovated fully as the Lab was not in a good shape for use due to dampness and natural wear and tear. The wall surfaces have been repaired by damp proofing, new plastering and painting. Some damaged False Ceiling was also renovated. Electrical wiring and illumination work also fully renewed.

Providing Roof Treatment of Main Building and Bhagirathi Guest House

It was observed that vigorous water leakage has been taking place from the roof as well as from the walls which is damaging not only the parent RCC roof slab, but also the false ceiling beneath the slab, as well as the internal painting of the walls due to normal weathering conditions and ageing factor. Similar phenomenon has been observed at many places at both the wings on the roof of the Bhagirathi building also. Besides the hazard of water dropping and moist wall as well as poor aesthetics, a severe damage is likely to take place to the reinforcement while subjected to be in contact with water creating rusting-related corrosion and premature loss of the strength of the slab and development of cracks in concrete slab.

B) Estate

Upkeepment of furniture and fixture of allotted hostel rooms and office space, labs. Maintenance of all records of the allotted offices, hostels etc. Proper co-ordination during allotment and surrender of office/living areas by new entrants and outgoing.

C) Electrical

1) Supply, Installation, Testing and commissioning of 750KVA new DG set has undertaken to cater the Centre's power backup demands.

2) 11 KV ELECTRIC SUB-STATION:

   The Centre has 2 Nos. of indoor type 11KV/0.433KV Electric Sub-stations at its premises which is delivering power to all its desired locations through 02 nos. of 630 KVA dry type Transformers and 02 nos. of 630 KVA OLTC based transformers.

   i) Power fed at the newly constructed 02 nos. Laboratory buildings and Basundhara G+5 Integrated Hostel building from these 02 nos. OLTC based oil cooled type 630 kva Transformers situated in the new 11KV/0.433 KV Sub-Station. Secondary power distribution is done from these 02 nos. MV-LT Distribution panels.

   ii) The required electrical power supply is given from these two electrical panels to the various Scientific Instruments for Research facilities at the Centre.

750 KVA new DG set

3) **Automatic Power Factor Controller Panels :** The Centre has a total capacity of 870 KVAR power factor controllers to reduce the electricity cost/power factor benefit from WBSEDCL.

4) The Centre has entire VRF Air-Conditioning facility in both the newly built Laboratory Buildings to provide proper cooling effect to the Scientific Instruments for Research facilities at the Centre.

5) **Street Lights of the SNBNCBS campus :** Maintenance of Campus lighting system is done periodically and retrofitting of some street lights

damaged due to Aamphan Tornado in the year 2020.

6) Maintenance and up keeping of solar water heating system to a capacity of 2500 Litre per day on the roof top of the Krishnachura students hostel.

7) New electrical installation works for various Laboratories as and when required at the Centre were carried out.

8) Maintenance of D.G. sets: D.G. sets are maintained to provide emergency power back up purpose at the time of power shutdown from the WBSEDCL end or at the time of suitable preventive maintenance of Transformers/Switch Gears etc.

9) Air-Conditioners & Lifts: The Centre has approximately 550 Nos. of Air Conditioning machines of various capacities and various makes which need to be maintained and serviced periodically to take care of the requirement of various Labs, Office spaces and Computer Centre Server Rooms.

Mithilesh Kumar Pande
Campus Engineer cum Estate Officer

Computer Services Cell

Sanjoy Choudhury
Scientist – D

Publications

a) Conference proceedings / Reports / Monographs / Books

1. N. A. Choudhury, S. Moulik, S. Choudhury, "Cloud-based Real-time and Remote Human Activity Recognition System using Wearable Sensors", IEEE ICCE-TW, Taoyouan, Taiwan, Sep. 2020. DOI: 10.1109/ICCE-Taiwan 49838.2020.9258050. [Awarded Second Place in DEMO Paper Award]
2. Motahar Reza; Sanjoy Choudhury; Jatindra Kumar Dash; Diptendu Sinha Roy "An AI-based Real-Time Roadway-Environment Perception for Autonomous Driving" IEEE ICCE-TW, Taoyouan, Taiwan, Sep. 2020. DOI: 10.1109/ICCE Taiwan49838.2020.9258145

Administrative duties

The nature of work has two distinct regions:

1. **Administrative nature**: Handling Central Computational facilities under Computer Services Cell as Scientist I/C of the Cell.
2. **Academic nature**: Research Activities individual and along with Collaborative research.

a) Academic Work - General research areas and problems worked on:

1. **Perusing PhD in Computer Science and Engineering at National Institute of Technology, Meghalaya on Artificial Intelligence and machine learning, IoT and Edge/Fog Computing.**

   Apart from my principle technical administrative responsibility, I am working on Edge Computing /Fog Computing research on IoT. Currently, I am working on an Edge/Fog Computing based real-time human activity recognition system. First, we develop a wearable system that contains an Accelerometer sensor, an analog to digital converter, and a WiFi module in order to sense human movement data and transmit the sensed data to the cloud. Then we apply Machine Learning algorithm to classify different human activities. The proposed system is able to achieve an average of 93% accuracy in classifying the different activities efficiently. The above work "Cloud-based Real-time and Remote Human Activity Recognition System using Wearable Sensors has been accepted for the 2020 IEEE International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan) - Artificial Intelligence Applications and Technologies in the Internet of Things.

   Ph.D. Progress: PhD registration successfully completed on 10-08-2020 at National Institute of Technology (NIT), Meghalaya.

2. **Exploring Fuzzy based Combinatorial Auction for allocation of VM instances in Edge/Fog Computing for sustainable smart city**- A Greedy Approach. As well as exploring Dynamic QoS approach for the Edge/Fog Computing Exploring Fuzzy based Combinatorial Auction for allocation of VM instances in Edge/Fog Computing - A Greedy Approach. As well as exploring Dynamic QoS approach for the Edge/Fog Computing.

3. **Cloud-based Real-time and Remote Human Activity Recognition System using Wearable Sensors.**

   The Proposed work has described that even though usage of EMR has been underway for decades The above-proposed work will help us to remotely monitor activities of elderly people like fall detection through a wearable device that will contain an Accelerator sensor, an analog to digital converter and a WiFi module in order to sense human movement data and transmit the sensed data to the cloud or edge/fog computing for real-time actions.

Membership of Learned Societies

1. Computer Society of India - Life Membership
2. IEEE- Life Membership
3. Member of Indian Registry for Internet Names and Numbers (IRINN)

Areas of Research

IoT , Machine Learning , Fog Computing

Apart from my principle technical administrative responsibility, I am working on Edge Computing /Fog Computing research on IoT. Currently, I am working on an Edge/Fog Computing based real-time human activity recognition system. First, we develop a wearable system that contains an Accelerometer sensor, an analog to digital converter, and a WiFi module in order to sense human movement data and transmit the sensed data to the cloud. Then we apply Machine Learning algorithm to classify different human activities.

Exploring Fuzzy based Combinatorial Auction for allocation of VM instances in Edge/Fog Computing for sustainable smart city- A Greedy Approach. As well as exploring Dynamic QoS approach for the Edge/Fog Computing Exploring Fuzzy based Combinatorial Auction for allocation of VM instances in Edge/Fog Computing - A Greedy Approach. As well as exploring Dynamic QoS approach for the Edge/Fog Computing.

Plan of Future Work Including Project

1. Exploring sustainability of smart development initiatives issues in the field of urban planning like a gap in demand and supply of infrastructure services and utilities, traffic congestions, pollution, reduction in natural green cover, peri-urban settlement typology etc, thus affecting the natural and built environment adversely.

Any other Relevant Information including social impact of research

1. In this context, a sustainable smart city is an innovative city that uses ICT and other means to improve the efficiency of urban operations, functions, and services as well as enhance the quality of life of citizens, 'while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspect.

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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 2019-20, there were more than 900 users including faculty members, administrative staffs, PDRAs, and students. The Centre is backboned with a fibre optic based internal network capable to support up to 1Gbps. Internet facility had been pulled up to support up to 1Gbps access supported by NKN and an 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
AMRU1	36	06 Tb	31
AMRU2	48	-	27

Summary of project sponsored computational facilities

Machine Name	Processor Core	Storage	User
ATHENA	320	-	12
CRAY	7808	255	50
TRC CRAY	960	120	30

CSC-AC Members: Sr. Prof. Priya Mahadevan, Sr. Prof. Jaydeb Chakrabarti, Dr. Sakuntala Chatterjee, Dr. Soumen Mondal, Dr. Manoranjan Kumar, Deputy Registrar(Finance), Deputy Registrar(Administration) Campus Engineer cum Estate Officer, Mr. Sanjoy Choudhury.

CSC-WG Members: Sr. Prof. Priya Mahadevan, Sr. Prof. Jaydeb Chakrabarti, Dr. Manoranjan Kumar, Mr. Sanjoy Choudhury, Ms. Nibedita Konar, Deputy Registrar(Administration) , Dr. Soumen Adhikari, Mr. Sanjoy Choudhury, Mr. Abhijit Ghosh, Mr. Sagar S. De, Ms. Deblina Mukherjee, Ms.Somasree Mal

Central Computational Resources (2020-21):

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

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 design and proposed for the entire computer centre, which will be implemented very soon.

30. CSC have started to do security audit of the Centre network and systems recently and identified various vulnerabilities -- and we plan to carry this out as a yearly exercise to ensure that the institute network and systems is less risk prone. Currently the Centre are also working on awareness of digital governance in the center.

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.(under Process)

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 class room 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 Solution.
- 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 2020-21:

- Prof. Samir Kumar Pal - Convener
- Prof. Gautam Gangopadhyay - Member
- Dr. Soumen Mondal - Member
- Dr. Atindra Nath Pal - Member
- Deputy Registrar (Administration) - Member
- Deputy Registrar (Finance) - Member
- Office Assistant / Assistant (General), Office of Dean (F) - Member
- Office Assistant, Academic Section - Member
- Mr. Achyut Saha, PA to Director renders secretarial assistance to the Project & Patent Cell.

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.)
2016-2017	35	4,05,49,788=00
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

Apart from this, the Centre has also received the TRC project during January 2016.

S. N. Bose National Centre for Basic Sciences

Projects during 2020-21

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
"Thematic Unit of Excellence on Computational Materials Science at the SNBNCBS, Kolkata"	Prof. Tanusri Saha Dasgupta	DST SR/NM/NS-29/2011	2-7-2012 to 1-7-2017 Extended up to 31-12-2017 Further extended up to 31-08-2018 Again extended up to 31-8-2020 Again extended up to 31-03-2021	9,98,46,000/- Extended further with additional grant of 50,36,800/- (General)	
CSIR/RB/13-14/116 – "Jump Dynamics in Ionic Liquids and non-exponential Relaxation"	Prof. Ranjit Biswas	(CSIR) 01(2811)/14/ EMR-II	19-2-2018 to 18-2-2021	2,10,000/-	
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/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
SERB/SKP/16-17/173 – "Exploration of key photoinduced dynamics in inorganic nanohybrids for enhanced biological activities"	Prof. S.K. Pal	SERB EMR/2016/004698	17-6-2017 to 16-6-2020	19,98,000/-	
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)	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. Priya Mahadevan	DST DST/NM/NS/2018/18 (G)	28-12-2018 to 27-12-2021	30,83,480/-	
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	57,00,000/-	
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	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	31,96,600/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
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	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/-	
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	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/-	
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/-	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
CSIR/RB/20-21/259 – "Gauge and Gravitational Symmetries in Nonrelativistic Theories: Formalism and Applications"	Prof. Rabin	CSIR – HRDG 21(1125)/20/EMR-II (Emeritus Scientist Scheme – Application ID: ES1920Y7322)	02-10-2020 to 01-10-2023 *** Resigned on 05-01-2021 ***	5,37,000/- (Sanctioned fund for 01-10-2020 to 31-03-2021)	
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/-	
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	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 05-01-202	44,60,000/- (1st year)	
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(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	12,70,000/-	Received Grant on 24-03-2021: FY: 2020-21
"Ramanujan Fellowship Award"	Dr. Debanjan Bose	SERB SB/S2/RJN-038/2017	From 04-12-2020	29,00,000/-	Received Grant Rs.29,00,000/- on 07-07-2021

*** Apart from this, the Centre has also received the TRC project during January 2016. Completed in June 2021.

List of Postdocs, Scientists, DST INSPIRE Faculty, etc. under projects for the Year 2020-21

Sl.	Name	Designation	Project Name	P. I. of Project	Joined on	Appt. upto
1	Dr. Madhuri Mandal	Visiting Faculty Fellow	Design of biocompatible fluorescent magnetic nanoparticles for imaging the cancer cells and their possible theranostic use	Self	01.12.2017	30.11.2020
2	Dr. Jayeta Banerjee, NPDF	National Post Doctoral Fellow	Theoretical and experimental investigations on transition metal dichalcogenide based surface plasmon resonance structure with applications in sensing	Self / Dr. Manik Pradhan	31.12.2020	30.12.2022
3	Dr. Debarshi Das, NPDF	National Post Doctoral Fellow	Characterizing and utilizing quantum resources in the context of information processing tasks	Self / Prof. Archan S Majumdar	15.01.2021	14.01.2023
4	Dr. Debashis Saha	National Post Doctoral Fellow	Self-testing of quantum devices and device-independent information processing	Self/ Prof. Archan S Majumdar	15.03.2021	14.03.2023
5	Ms. Anita Halder	Research Associate – I (Ad-hoc)	Thematic Unit of Excellence on Computational Materials Science	Prof. Tanusri Saha-Dasgupta	01.09.2020	Resigned on 25.11.2020
6	Gourhari Jana	Research Associate – I (Adhoc)	Thematic Unit of Excellence on Computational Materials Science	Prof. Tanusri Saha-Dasgupta	28.10.2020	Resigned on 31.01.2021
7	Dr. Soumendu Datta	Research Associate – III (Adhoc)	J.C. Bose Award (Fellowship)	Prof. Tanusri Saha-Dasgupta	01.12.2020	31.05.2021
8	Dr. Soumya Bhattacharyya	Research Associate – I (CSIR)	Gauge and Gravitational Symmetries in Nonrelativistic Theories : Formalism and Applications	Prof. Rabin Banerjee	21.12.2020	Resigned on 05.01.2021
9	Dr. Soumita Mondal	Research Associate – I (Adhoc)	Twistronics with transition metal dichalogenides	Prof. Priya Mahadevan	15.02.2021	Resigned on 31.05.2021
10	Dr. Sumit Halder	Research Associate – I (Adhoc)	Exploring Quantum and Thermal fluctuations in Frustrated Magnets at Low Temperature	Dr. Manoranjan Kumar	01.03.2021	31.08.2021

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	12.08.2023
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	*Studying materials showing multiferroicity and unique spin reorientation*	Self	09.11.2020	08.11.2025
5	**Dr. Debanjan Bose**	Ramanujan Fellow (Transferred from IIT, KGP)		Self	04.12.2020	14.11.2022

List of Students Under Project (2020-21)

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	Saikat Mitra	Project - JRF	Barnali Ghosh (Saha) & Manik Pradhan	CMPMS	Understanding of growth of vertically aligned Nanowires or nanotubes of binary oxides and ohysics of isotopic fractionation of gases by them	27.12.2018	Up to the duration of the project based on the periodic / yearly assessment		05.07.2021 (Extended till 05.01.2022)	05.07.2021	
2	Samir Rom	Project - JRF	Tanusri Saha Dasgupta	CMPMS	Thematic Unit of Excellence on Computational Material Science	03.09.2019	Till the end of the project i.e.,31.08.2020		Extended Till 31.03.2021	31.03.2021	
3	Suranjana Chakrabarty	Project Assistant	Anup Ghosh	CMPMS	Ultrafast 2D-IR Spectroscopy on the Structural Dynamics of DNA/G Quadruplex (DST INSPIRE Faculty)	13.10.2020	31.12.2023		31.12.2023	31.12.2023	
			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 (DST INSPIRE Faculty)	26.10.2020	Initially for One Year + To be continued after evaluation		12.08.2023	12.08.2023	
2	Brateen Datta	Project Assistant (Ad-hoc)	Tatini Rakshit	CBMS	Biophysical Characterization of Extracellular Vesicle (Evs) using Single Molecule Detection (SMD) Methods: A Potential Non-invasive Diagnostic Tool (DST INSPIRE Faculty)	17.12.2020	6 Months		12.08.2023	16.06.2021	31.03.2021
			DEPT. TOTAL					**2**			
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					**7**			

Patents Granted / Applied during 2020-21

Patents Granted:

(1)
Patent No.: 338829
Application No.: 201631038296
Date of Filing: 09/11/2016
Date of Grant: 19/06/2020
DIOXO VANADIUM (V) COMPLEX AS CARBONIC ANHYDRASE INHIBITOR
Legal Status: Inforce

(2)
Patent No.: 351256
Application No.: 201731043481
Date of Filing: 04/12/2017
Date of Grant: 10/11/2020
A CLAY BASED NANO CONFINED REACTOR (Under TRC)
Legal Status: Inforce

(3)

Patent No.: 351816
Application No.: 201931015347
Date of Filing: 16/04/2019
Date of Grant: 20/11/2020
A METHOD TO GROW SINGLE CRYSTALLINE SHARP NANO NEEDLES OF PIEZOELECTRIC MATERIALS (Under TRC)
Legal Status: Inforce

Patents Applied:

(1)
An Active Respirator with attached exhalation valve and suspended particulate matter filter for Comfortable and Hygienic Breathing (Under TRC)
(Prof. S.K. Pal & others)
Patent Application No: 202031026595 dated 23/06/2020 (Provisional)
(Filed through NRDC)

(2)
A Nano-Sanitizer with a Dispensing Antimicrobial Layer (Under TRC)
(Prof. S.K. Pal & others)
Patent Application No: 202031026596 dated 23/06/2020 (Provisional)
(Filed through NRDC)

(3)
Development of Tribo-electroceutical Fabric for Potential Application in Self Sanitizing Personal Protective Equipment (PPE) (Under TRC)
(Prof. S.K. Pal, Prof. Tanusri Saha-Dagupta, Prof. Samit K. Ray & others)
Patent Application No: 202031038150 dated 04/09/2020

(4)

A Nanoceutical Fabric for source control to prevent COVID-19 spread including through expelled respiratory droplets (Under TRC)
(Prof. S.K. Pal, Prof. Tanusri Saha-Dagupta, Prof. Samit K. Ray & others)
Patent Application No: 202031038152 dated 04/09/2020

Samir Kumar Pal
Convenor, Project & Patent Cell

Technical Research Centre

The **Technical Research Centre (TRC)**, funded by Department of Science & Technology, Ministry of Science & Technology, Government of India at S. N. Bose National Centre for Basic Sciences has been launched on 1st January 2016. The aim is to establish an innovation cum translational research centre within the S. N. Bose National Centre that would build harnessable science and technology platforms by leveraging on its existing core strength in materials science and spectroscopic techniques.

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 :

- 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 CO_2 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.

B. Transfer of Technology (TOT) to an Industry under TRC during 01-04-2020 – 31-03-2021 :

Sl No.	Technology Transfer	Name of Industrial Partner/ Date of commercialization
1.	**AJO-Neo** – Non-Invasive Screening for Neonatal Hyperbilirubinemia.	M/s. Zyna Medtech Private Limited on 13th July 2020.
2.	**BoseShield** - An active respirator with attached exhalation valve and suspended particulate matter filter for comfortable and hygienic breathing.	M/s. Paulmech Infrastructure Private Limited on 13th July 2020.
3.	**Bosetizer** - Long-lasting nano-sanitizer with a dispensing antimicrobial layer.	M/s. Paulmech Infrastructure Private Limited on 13th July 2020.
4.	**Breathe Analyzer** – A System and Kit for non-invasive detection of peptic ulcer diseases, Non-Ulcerous Dyspesis, and Helicobacter pylori infection	M/s HPA Instruments on 5th March 2021

*Transfer of four Technologies **(AJO-NEO, Bose-Shield, Bosetizer and Breathe Analyzer)** through NRDC, New Delhi in the video-conference meeting held on 13th July 2020 (AJO-NEO, Bose-Shield and Bosetizer) and on 5th March 2021 (Breathe Analyzer)*

C. Number of Patents (submitted during 01.04.2020 – 31.03.2021) :

Sl.	Title	Inventors	Country	File No.	Status
1.	A Nanoceutical Fabric for source control to prevent COVID-19 spread including through expelled respiratory droplets	Aniruddha Adhikari, Uttam Pal, Sayan Bayan, Tanusri Saha Dasgupta, Samit Kumar Ray, Samir Kumar Pal	INDIA	202031038152	Filed on 04/09/2020
2.	Development of Tribo-electroceutical Fabric for Potential Application in Self Sanitizing Personal Protective Equipment (PPE)	Sayan Bayan, Aniruddha Adhikari, Uttam Pal, Tanusri Saha Dasgupta, Samit Kumar Ray, Samir Kumar Pal	INDIA	202031038150	Filed on 04/09/2020
3.	A nano-sanitizer with a dispensing antimicrobial layer	Samir Kumar Pal	INDIA	202031026596	Provisionally filed on 23/06/2020
4.	An Active Respirator with Attached Exhalation Valve and Suspended Particulate Matter Filter for Comfortable and Hygienic Breathing	Samir Kumar Pal	INDIA	202031026595	Provisionally filed on 23/06/2020
5.	A Method to Grow Single Crystalline Sharp Nano Needles of Piezoelectric Materials	Barnali Ghosh, A. K. Raychaudhuri, Ankita Ghatak, Snehamoyee Hazra	INDIA	Granted Patent No. 351816	Granted on 20/11/2020
6.	A Clay Based Nano Confined Reactor	Sankar Das and Subhra Jana	INDIA	Granted Patent No. 351256	Granted on 10/11/2020

D. A few prototypes developed under the TRC Project ready for Transfer of Technology :

E. List of consultancy projects/Industrial Partners under TRC:

Sl. 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 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

F. Knowledge Based Services at TRC:

The TRC offers knowledge based services in a number of highly sophisticated instrumentation, ranging from several spectroscopic to microscopic instruments. For more information, please visit our web site -:
http://newweb.bose.res.in/departments/TRC

Soumen Mondal

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 2020 - March 2021 are reported in the following sections:

I. Equipments available under technical cell

Sl. No.	Name of the equipment
1.	Transmission electron Microscope (TEM) with other attachments
2.	Thermo Gravimetry/Differential Thermal Analyzer (TG-DTA)
3.	Dynamic Light Scattering(DLS)
4.	Clean Room
5.	E-beam evaporator
6.	ICP-RIE
7.	Dual beam FIB/SEM
8.	Wire Bonder
9.	Mask aligner
10.	3K Resistivity Measurement Setup
11.	Field Emission Scanning Electron Microscopy (FESEF) Quanta FEG 250
12.	X-ray Diffraction
13.	UV Visible Spectrometer(UV-VIS)(2600)
14.	UV Visible Spectrometer(UV-VIS)(2450)
15.	Circular Dichroism (CD)
16.	Chemical Lab
17.	Ellipsometer
18.	Viscometer
19.	Densitymeter
20.	X-ray Diffractometer(XRD) (PANalytical X-PERT PRO
21.	Pulsed Laser Deposition (PLD) Unit
22.	Helium Leak Detector
23.	Liquid Nitrogen and Gases for Laboratory Use
24.	Fluorescence spectrometer(Fluorolog)
25.	Spevtrofluorometer(Fluoromax)
26.	Fourier Transform Infrared Spectrometer(FTIR)
27.	Mechanical workshop, Sputtering Unit, Millipore Water
28.	Vibrating Sample Magnetometer (VSM)
29.	Differential Scanning Calorimeter (DSC)
30.	Atomic Force Microscope (AFM)

II. Support to research activities:

About 97 students of our centre used the above experimental facilities extensively for their Ph.D. thesis work. 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.

V. Major maintenance and up-gradation:

Name of Instrument	Major repair and up-gradation
1. FESEM	PM combined DSGS/HT. F/G, FEG RETIP
2. PLD	Install the new 16 bit energy monitor, mechanical part, beam splitter & plash for terminal.
3. FLUOROLOG	Installation of Xenon Lamp
4. FTIR	
5. UV SPECTROMETERE	Installation of D2 Lamp
6. XPERT PRO	Gonio Motor Pw3050 (Qty-2) Poscon 2 Board (Qty-2)
7. DSC	LN2 module has been replaced
8. VSM	Cooling fan of linear amplifier unit of vsm system has been replaced as it was mal functioning
9. PPMS	Ppms is installed in the month of December 2020
10. RIGAKU smartlab XRD	Machine has been operational from 2.2.21

VI. Utilization of equipment

Item	Usage (Time & Hour)	Up Time%	Down Time %	No. of External Users
PLD	232	75%	25%	9
FESEM	400	80%	20%	NILL
XPERT PRO	200	40%	60%	NILL
MINI XRD	135	70%	30%	3
TG/DTA	480	65%	35%	5
AFM	227	55%	45%	NILL
VSM	802	70%	30%	3
DSC	405	65%	35%	3
HRTEM	1040	68%	32%	NILL
DLS	90	30%	70%	5
ELLIPSOMETER	5	10%	90%	0
PPMS	700	95%	5%	0
RIGAKU Smartlab XRD	352	97%	3%	NILL

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

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. Due to pandemic situation, however, it was closed as whole country was under lock down. 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: mechanical workshop – 90. Month wise breakups are given below: (2020 – 2021). 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

Atindra Nath Pal

Atindra Nath Pal
In-charge, Mechanical Workshop

Guest House

BHAGIRATHI – THE GUEST HOUSE

The Centre has its own upfront modern guest house named 'Bhagirathi' located within the premises. It houses five (5) fully air conditioned suites and three (3) fully air conditioned transit rooms each having attached bath and kitchenette. There are also eight (8) double-bedded rooms and forty six (46) single bedded rooms. All the double and single bedded rooms are air-conditioned and are fully furnished and have attached baths. All rooms are provided with basic amenities like hot and normal water, telephone, television with DTH connection, electric kettle etc. The Guest House is Wi-Fi enabled. A state-of-the-art display unit is installed in the Guest House Front Desk displaying various information about the Guest House. These guests' rooms spread across the ground floor, first floor and second floor of the Bhagirathi building. Presently, the third floor of the building comprising of twenty two (22) single bedded rooms and four (4) double bedded rooms are being used for accommodating 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 a Doctor's Chamber with oxygen and other first-aid facilities. Doctors are available regularly during weekdays. 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 also extends its guest house facilities to various government departments, organizations, research laboratories, universities etc during normal time. Various academic and research organizations also use the guest house for accommodating their visitors from abroad. The guest house has been providing satisfactory service and warm hospitality to all the guests staying in it. However, the guest house activities were restricted due to COVID-19 pandemic situation.

Smajumder

Shohini Majumder
Registrar

Special Days of Celebration

The Centre organized the following events by maintaining COVID-19 restrictions:

- On the occasions of the 72nd Republic Day on 26th January 2021 and 74th Independence Day on 15th August 2020, 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 2021, the Centre celebrated 128th Birth Anniversary of Prof. Satyendra Nath Bose with the following events through webinar:
  - Garlanding the bust of Satyendra Nath Bose;
  - Inauguration ceremony of 128th birth anniversary of Satyendra Nath Bose;
  - Welcome address by Prof. Samit Kumar Ray, Director, S.N.Bose National Centre for Basic Sciences;
  - Inaugural address by Professor B.N. Jagatap, Chief Guest Professor, Indian Institute of Technology, Bombay and Chairman, Governing Body, S.N.Bose National Centre for Basic Sciences;
  - 25th S.N.Bose Memorial Lecture delivered by Professor Anton Zeilinger Wolf Prize Winner in Physics (2010), Institute for Quantum Optics and Quantum Information, Vienna and Prseident, Austrian Academy of Sciences, Austria on "From Einstein and Bose to quantum teleportation and beyond";
  - Lecture on History of Science by Dr. Rajinder Singh, Institute for Physics, Carl von Ossietzky University of Oldenburg, Germany.
  - Screening of documentary on Satyendra Nath Bose "An Iconic Genius".
  - The Centre celebrated Rastriya Ekta Diwas on 31.10.2020 by taking pledge through virtual pledge.
  - Constitution Day was celebrated on 26.11.2020 through on-line pledge taking ceremony.

Shohini Majumder
Registrar

PUBLICATIONS

List of Publications 2020-2021

Department of Astrophysics & Cosmology

1. Alik Panja, **Soumen Mondal**, Somnath Dutta, Santosh Joshi, Sneh Lata, and **Ramkrishna Das**, *Census of the Young Stellar Population in the Galactic H ii Region Sh2-242*, The Astronomical Journal, 159, 153, 2020
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26. Sudip Garai and **Partha Guha**, *Higher-order saddle potentials, nonlinear curl forces, trapping and dynamics*, Nonlinear Dynamics, 103, 2257 – 2272, 2021

27. Anish Das, Ashis Saha and **Sunandan Gangopadhyay**, *Investigation of circular geodesics in a rotating charged black hole in the presence of perfect fluid dark matter*, Classical and Quantum Gravity, 38, 065015, 2021

28. Jay Prakash Singh, Sudipta Pattanayak and Shradha Mishra, *Ordering kinetics and steady state of self-propelled particles with random-bond disorder*, Journal of Physics A: Mathematical and Theoretical, 54, 115001, 2021

29. Shobhan Dev Mandal and **Sakuntala Chatterjee**, *Effect of receptor clustering on chemotactic performance of E. coli: Sensing versus adaptation*, Physical Review E, 103, L030401, 2021

30. Kang-Da Wu, Tulja Varun Kondra, **Swapan Rana**, Carlo Maria Scandolo, Guo-Yong Xiang, Chuan-Feng Li, Guang-Can Guo, and Alexander Streltsov, *Resource theory of imaginarity: Quantification and state conversion*, Physical Review A, 103, 032401, 2021

31. Neeraj Kumar and **Sunandan Gangopadhyay**, *Phase transitions in D-dimensional Gauss-Bonnet-Born-Infeld AdS black holes*, General Relativity and Gravitation, 53, 35, 2021

32. Kang-Da Wu, Tulja Varun Kondra, **Swapan Rana**, Carlo Maria Scandolo, Guo-Yong Xiang, Chuan-Feng Li, Guang-Can Guo, and Alexander Streltsov, *Operational Resource Theory of Imaginarity*, Physical Review Letters, 126, 090401, 2021

33. **Rabin Banerjee**, Sk. Moinuddin, and Pradip Mukherjee, *New approach to the study of nonrelativistic bosonic string in flat spacetime*, Physical Review D, 103, 046020, 2021

34. **Bikas K. Chakrabarti** and Antika Sinha, *Development of Econophysics: A Biased Account and Perspective from Kolkata*, Entropy, 23(2), 254, 2021

35. Dhiraj Tapader, **Punyabrata Pradhan**, and Deepak Dhar, *Density relaxation in conserved Manna sandpiles*, Physical Review E, 103, 032122, 2021

36. Soumyakanti Bose and **M. Sanjay Kumar**, *Analysis of necessary and sufficient conditions for quantum teleportation with non-Gaussian resources*, Physical Review A, 103, 032432, 2021

37. **S. S. Manna** and Robert M. Ziff, *Bond percolation between k separated points on a square lattice*, Physical Review E, 101, 062143, 2020

38. **Rabin Banerjee** and Pradip Mukherjee, *Canonical formulation of a new action for a nonrelativistic particle coupled to gravity*, Physical Review D, 101, 126013, 2020

Inter-Departmental Publications

1. Didhiti Bhattacharya, Subhrajit Mukherjee, **Rajib Kumar Mitra** and **Samit K Ray**, *Size-dependent optical properties of MoS2 nanoparticles and their photo-catalytic applications*, Nanotechnology, 31, 145701, 2020

2. E Tendong, **T Saha Dasgupta** and **J Chakrabarti**, *Dynamics of water trapped in transition metal oxide-graphene nano-confinement*, Journal of Physics: Condensed Matter, 32, 325101, 2020

3. S Bayan, D Bhattacharya, **R K Mitra** and **S K Ray**, *Self-powered flexible photodetectors based on Ag nanoparticle-loaded g-C_3N_4 nanosheets and PVDF hybrids: role of plasmonic and piezoelectric effects*, Nanotechnology, 31(36):365401, 2020

4. Essam M. Hussein, Nizar El Guesmi, Ziad Moussa, Uttam Pal, **Samir K. Pal, Tanusri Saha Dasgupta**,

and Saleh A. Ahmed, *Unprecedented Regio- and Stereoselective Synthesis of Pyrene-Grafted Dispiro[indoline-3,2 -pyrrolidine-3 ,3 -indolines]: Expedient Experimental and Theoretical Insights into Polar [3 + 2] Cycloaddition*, ACS Omega, 5, 24081-24094, 2020

5. Tuhin Kumar Maji, Aswin J. R, Subhrajit Mukherjee, Rajath Alexander, Anirban Mondal, Sarthak Das, Rajendra Kumar Sharma, Naba Kumar Chakraborty, Kinshuk Dasgupta, Anjanashree M. R. Sharma, Ranjit Hawaldar, Manjiri Pandey, Akshay Naik, Kausik Majumdar, **Samir Kumar Pal**, K. V. Adarsh, **Samit Kumar Ray**, and Debjani Karmakar, *Combinatorial Large-Area MoS_2/Anatase–TiO_2 Interface: A Pathway to Emergent Optical and Optoelectronic Functionalities*, ACS Applied Materials & Interfaces, 12, 44345 – 44359, 2020

6. Swati Rani, Damayanti Bagchi, Uttam Pal, Mamta Kumari, Manisha Sharma, Arpan Bera, Javaid Shabir, **Samir Kumar Pal**, **Tanusri Saha-Dasgupta**, and Subho Mozumdar, *The Role of Imidazolium-Based Surface-Active Ionic Liquid to Restrain the Excited-State Intramolecular H-Atom Transfer Dynamics of Medicinal Pigment Curcumin: A Theoretical and Experimental Approach*, ACS Omega, 5, 25582 – 25592, 2020

7. Md. Nur Hasan, Tuhin Kumar Maji, Uttam Pal, Arpan Bera, Damayanti Bagchi, Animesh Halder, Saleh A. Ahmed, Jabir H. Al-Fahemi, Tahani M. Bawazeer, **Tanusri Saha-Dasgupta** and **Samir Kumar Pal**, *Wide bandgap semiconductor-based novel nanohybrid for potential antibacterial activity: ultrafast spectroscopy and computational studies*, RSC Advances, 10, 38890 - 38899, 2020

8. Didhiti Bhattacharya, Sayan Bayan, **Rajib K. Mitra**, and **Samit K. Ray**, *Flexible Biomechanical Energy Harvesters with Colossal Piezoelectric Output (2.07 V/kPa) Based on Transition Metal Dichalcogenides-Poly(vinylidene fluoride) Nanocomposites*, ACS Applied Electronic Materials, 2, 3327 – 3335, 2020

9. S. Bayan, D. Bhattacharya, **R. K. Mitra** and **S. K. Ray**, *Two-dimensional graphitic carbon nitride nanosheets: a novel platform for flexible, robust and optically active triboelectric nanogenerators*, Nanoscale, 12, 21334 – 21343, 2020

10. 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 and **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

Technical Research Centre

1. Banabithi Koley Seth, Abhishek Sau, Uttam Pal, Samita Basu and Brotati Chakraborty, *Interaction of proflavin with tryptophan in reverse micellar microenvironment of AOT: Photoinduced electron transfer probed by magnetic field effect*, Journal of Luminescence, 220, 116953, 2020

2. Prasenjit Mondal, Priti Sengupta, Uttam Pal, Sutapa Saha and Adity Bose, *Biophysical and theoretical studies of the interaction between a bioactive compound 3,5-dimethoxy-4-hydroxycinnamic acid with calf thymus DNA*, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 245, 118936, 2021

3. S. Bhowmick, S. Pal, A. Singh, S. A. Khan, D. R. Mishra, R. J. Choudhary, D. M. Phase, T. K. Chini, A. K. Bakshi and Aloke Kanjilal, *Carbon doping-induced defect centers in anodized alumina with enhanced optically stimulated luminescence*, Journal of Materials Science: Materials in Electronics, 32, 10635–10643, 2021

Total number of Journal Publications: 240

Other Publications

Department of Astrophysics & Cosmology

1. Ramkrishna Das, "Elemental abundances in novae", Journal of Astrophysics and Astronomy, Volume 42, Issue 2, article id. 13, 2021

Department of Chemical, Biological & Macro-Molecular Sciences

1. Dheeraj Singh, Manik Pradhan and Arnulf Materny, "Modern Techniques of Spectroscopy:

Basics, Instrumentation and Applications": Springer Nature (ISSN: 2363-5096), 2021

2. Abhijit Maity, Mithun Pal and Manik Pradhan, "Cavity Ring-Down Spectroscopy": "Modern Techniques of Spectroscopy: Progress in Optical Science and Photonics, vol 13": Springer Nature (ISBN: 978-981-33-6083-9), 2021
3. Mithun Pal and Manik Pradhan, "Quantum Cascade Laser Spectroscopy": "Modern Techniques of Spectroscopy: Progress in Optical Science and Photonics, vol 13": Springer Nature (ISBN: 978-981-33-6083-9), 2021
4. Mithun Pal and Manik Pradhan, "Exhaled Breath CH4 and H2S Sensing using Mid-IR Quantum Cascade Laser (QCL)": Progress in Optomechatronics: Springer Nature (ISBN: 978-981-15-6467-3), 2020
5. Abhijit Maity, Sanchi Maithani and Manik Pradhan, "Cavity Ring-Down Spectroscopy: Recent Technological Advances and Applications": "Molecular and Laser Spectroscopy: Advances and Applications Volume 2, Elsevier, (ISBN: 978-0-12-818870-5), 2020
6. Suman Chakrabarty, "Role of Buried Water in the Mechanism of Photoactivation of KR2 Rhodopsin" Biophysical Journal 120, 131a (2021)

Department of Condensed Matter Physics and Material Sciences

1. Snehamoyee Hazra, Subhamita Sengupta , Ankita Ghatak , Barnali Ghosh,and A.K.Raychaudhuri, "Effect of Electrode Material on the Voltage Generation of PZT Nanowire Based Nanogeneratori" AIP Proceedings, 2265,030668, 2020
2. S Ghosh, A Ghosh, P Sen, K Mandal, "Magnetic and magnetocaloric properties in TbCo2Si2 alloy", AIP Conference Proceedings 2265 (1), 030553 (2020)
3. M Alam, S Ghosh, K Mandal, "Magnetic and magnetocaloric properties in double perovskite multiferroic Y2NiMnO6 nanoparticle", AIP Conference Proceedings 2265 (1), 030592
4. Folate modified zinc ferrite nano-hollowspheres for drug delivery and intrinsic fluorescence S Talukdar, P Saha, K Mandal AIP Conference Proceedings 2265 (1), 030131
5. Observation of surface Dirac state in transition metal dichalcogenide $NiTe_2$ using ARPES, Indrani Kar, Luminita Harnagea, Soma Banik, Surjeet Singh, and Setti Thirupathaiah, AIP Conference Proceedings 2265, 030361 (2020).
6. Angle Resolved Photoemission Spectroscopy Study on Electronic Band Structure of Topological Insulator Bi_2Se_3 in the Presence of Magnetic Impurities, Susmita Changdar, Rabia Sultana, Soma Banik, V. P. S. Awana, and Setti Thirupathaiah, AIP Conference Proceedings 2265, 030355 (2020)

Total number of Other Publications : 13

Impact Factor for Publications

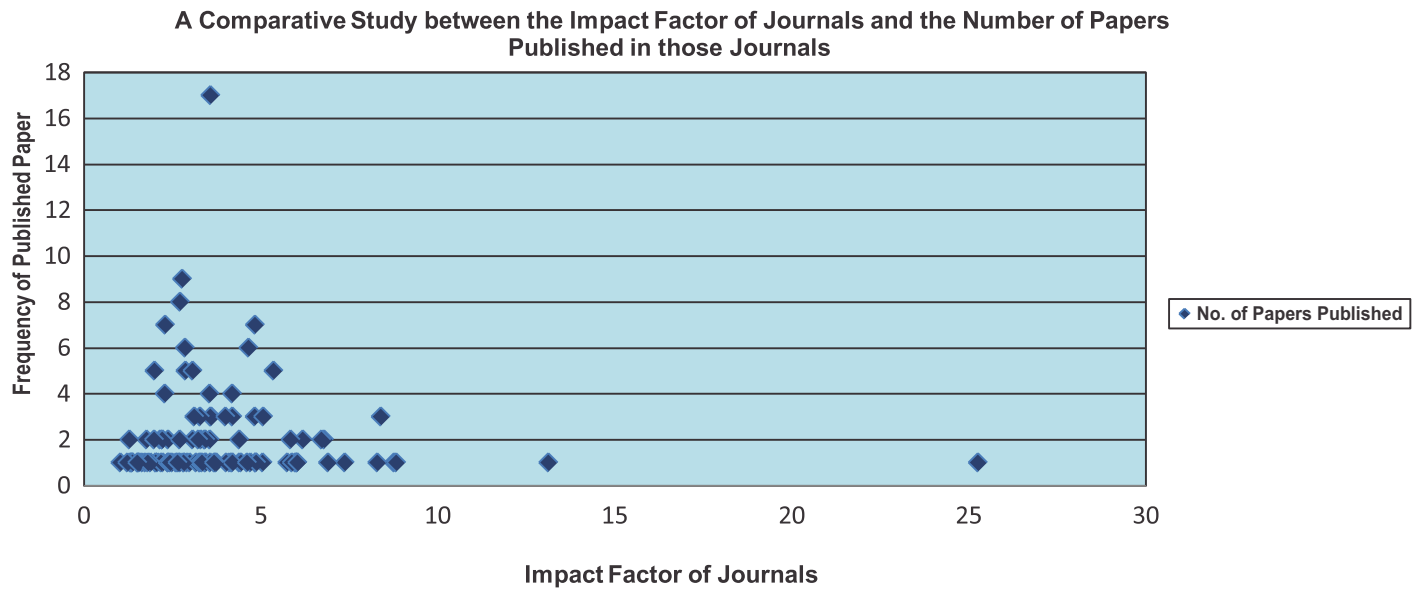
During 01-04-2020 – 31-03-2021

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
1	ACS Applied Bio Materials		1	0
2	ACS Applied Electronic Materials		4	0
3	ACS Applied Energy Materials	6.024	1	6.024
4	ACS Applied Materials & Interfaces	8.758	1	8.758
5	ACS Applied Nano Materials		5	0
6	ACS Omega	2.87	5	14.35
7	ACS Pharmacology & Translational Science		1	0
8	Advanced Energy Materials	25.245	1	25.245
9	Advanced Healthcare Materials	7.367	1	7.367
10	Advanced Materials Technologies	5.969	1	5.969
11	Advanced Optical Materials	8.286	1	8.286
12	Analytical Chemistry	6.785	2	13.57
13	Annals of physics	2.083	1	2.083
14	Applied Physics Letters	3.597	3	10.791
15	Applied Surface Science	6.182	2	12.364
16	Astronomical Journal	5.838	2	11.676
17	Astrophysical Journal	5.745	1	5.745
18	Biochimica et Biophysica Acta (BBA) - General Subjects	3.422	1	3.422
19	Biopolymers	2.23	1	2.23
20	Canadian Journal of Physics	1.032	1	1.032
21	Carbon	8.821	1	8.821
22	Chaos: An Interdisciplinary Journal of Nonlinear Science	2.832	1	2.832
23	Chemical Communications	5.996	1	5.996
24	Chemical Physics	1.771	2	3.542
25	Chemical Physics Letters	2.029	1	2.029
26	Classical and Quantum Gravity	3.071	5	15.355
27	Colloids and Surfaces B: Biointerfaces	4.389	1	4.389
28	Communications in Nonlinear Science and Numerical Simulation	4.115	1	4.115
29	Dalton Transactions	4.174	1	4.174
30	Entropy	2.494	1	2.494
31	The European Physical Journal B	1.347	1	1.347

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
32	European Physical Journal C	4.389	2	8.778
33	The European Physical Journal D	1.366	1	1.366
34	Fluctuation and Noise Letters	1.53	1	1.53
35	Frontiers in Oncology	4.848	1	4.848
36	General Relativity and Gravitation	2.03	1	2.03
37	Industrial & Engineering Chemistry Research	3.573	3	10.719
38	IEEE Sensors Journal	3.073	2	6.146
39	IEEE Transactions on Electron Devices	2.913	1	2.913
40	IEEE Transactions on Plasma Science	1.309	1	1.309
41	Inorganic Chemistry	4.825	3	14.475
42	International Journal of Applied and Computational Mathematics	1.65	1	1.65
43	International Journal of Energy Research	3.741	1	3.741
44	International Journal of Geometric Methods in Modern Physics	1.287	2	2.574
45	International Journal of Modern Physics D	2.154	2	4.308
46	International Journal of Pharmaceutics	4.845	1	4.845
47	International Journal of Theoretical Physics	1.347	1	1.347
48	Japanese Journal of Applied Physics	1.376	1	1.376
49	Journal of Alloys and Compounds	4.65	6	27.9
50	Journal of Applied Physics	2.286	4	9.144
51	Journal of Chemical Physics	2.991	1	2.991
52	Journal of Chemical Sciences	1.573	1	1.573
53	Journal of Cluster Science	1.731	1	1.731
54	Journal of High Energy Physics	5.875	1	5.875
55	Journal of Luminescence	3.28	3	9.84
56	Journal of Magnetism and Magnetic Materials	2.717	8	21.736
57	Journal of Materials Science: Materials in Electronics	2.22	2	4.44
58	Journal of Modern Optics	1.544	1	1.544
59	Journal of Molecular Liquids	5.065	3	15.195
60	Journal of Molecular Spectroscopy	1.229	1	1.229
61	Journal of the Optical Society of America B	2.18	1	2.18
62	Journal of Optics	2.379	2	4.758
63	Journal of Photochemistry and Photobiology A: Chemistry	3.306	2	6.612

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
64	Journal of Physical Chemistry A	2.6	1	2.6
65	Journal of Physical Chemistry B	2.857	6	17.142
66	Journal of Physical Chemistry C	4.189	4	16.756
67	The Journal of Physical Chemistry Letters	6.71	2	13.42
68	Journal of Physics A: Mathematical and Theoretical	1.996	5	9.98
69	Journal of Physics D: Applied Physics	3.169	1	3.169
70	Journal of Physics: Condensed Matter	2.707	2	5.414
71	Journal of Physics and Chemistry of Solids	3.442	1	3.442
72	Journal of Solid State Chemistry	2.726	1	2.726
73	Journal of Statistical Mechanics: Theory and Experiment	2.215	2	4.43
74	Langmuir	3.557	2	7.114
75	Laser Physics Letters	1.884	1	1.884
76	Materials Advances		1	0
77	Materials Chemistry and Physics	3.408	2	6.816
78	Materials Research Bulletin	4.019	1	4.019
79	Materials Science and Engineering: B	4.706	1	4.706
80	Materials Today Communications	2.678	1	2.678
81	Materials Today: Proceedings		2	0
82	Microbes and Infection	2.373	1	2.373
83	Microsystems & Nanoengineering	5.048	1	5.048
84	Minerals	2.38	1	2.38
85	Molecules	3.267	1	3.267
86	Monthly Notices of the Royal Astronomical Society	5.356	5	26.78
87	Nano-Structures & Nano-Objects		1	0
88	Nanoscale	6.895	1	6.895
89	Nanotechnology	3.551	4	14.204
90	Neurocomputing	4.438	1	4.438
91	New Journal of Chemistry	3.288	1	3.288
92	Nonlinear Dynamics	4.867	1	4.867
93	Nuclear Physics B	2.817	1	2.817
94	Nucleus	4.197	1	4.197
95	Optics Letters	3.714	1	3.714
96	Physica D: Nonlinear Phenomena	1.807	1	1.807
97	Physica E	3.57	1	3.57

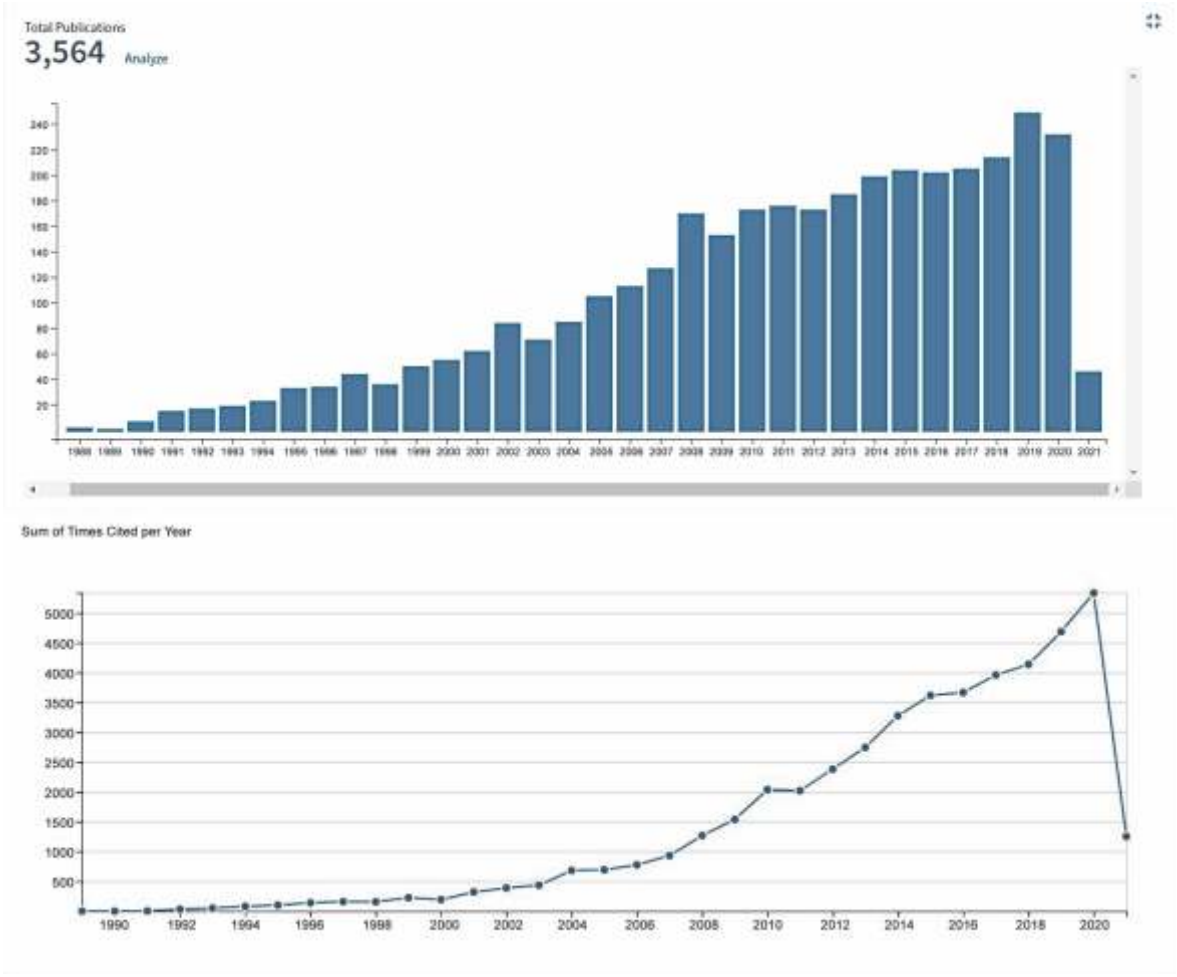
Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
98	Physica Scripta	1.985	2	3.97
99	Physical Chemistry Chemical Physics	3.43	2	6.86
100	Physical Review A	2.777	9	24.993
101	Physical Review Applied	4.194	3	12.582
102	Physical Review B	3.575	17	60.775
103	Physical Review D	4.833	7	33.831
104	Physical Review E	2.296	7	16.072
105	Physical Review Letters	8.385	3	25.155
106	Physical Review Materials	3.337	1	3.337
107	Physical Review Research		1	0
108	Quantum Information Processing	2.433	1	2.433
109	Research in Astronomy and Astrophysics	1.512	1	1.512
110	Royal Society Open Science	2.647	1	2.647
111	RSC Advances	3.119	3	9.357
112	Science Advances	13.116	1	13.116
113	Scientific Reports (Nature Publishing Group)	3.998	3	11.994
114	SciPost Physics	6.03	1	6.03
115	Soft Matter	3.679	1	3.679
116	Solar Energy	4.608	1	4.608
117	Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy	3.232	2	6.464
	TOTAL	**421.371**	**240**	**830.065**



Research publication status

Citation Report (On 6th April, 2021)

Time span = All years. Database = SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.



No. of Publications	:	3564
Sum of the Times Cited	:	47351
Sum of Times Cited without self-citations	:	37942
Citing Articles	:	31073
Citing Articles without self-citations	:	28574
Average Citations per Item	:	13.29
h-index	:	79

Total no. of Papers published	Total no. of Citation received	Citations per paper	Citation per year*	h-index
3564	47351	47351 / 3564= 13.29	47351 / 34 =1392.68	79

* Year of establishment of the Centre is 1986. Citations received from 1988 to 2021 = 34 years

Source : web of science
Address : (SN Bose Natl Ctr Basic Sci OR Satyendra Nath Bose Natl Ctr Basic Sci OR SNBNCBS)
Prepared by : Dr. Saumen Adhikari, Librarian – cum – Information Officer


ACCOUNTS

Satyendra Nath Bose National Centre for Basic Sciences

Block JD, Sector-III, Salt Lake, Kolkata - 700 106

BUDGET SUMMARY 2020-2021

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the year 2020-2021.

(Figure in Lakhs)

	Actuals 2019-2020	Budget Estimate 2020-2021	Revised Estimate 2020-2021
Plan	3788.13	4128.67	4363.86*
TOTAL	**3788.13**	**4128.67**	**4363.86***

* Sanctioned by DST Plan **Rs.** 4469.00 released as under:

Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/SAL/003/2020/1	24.04.2020	3,42,00,000.00
2	AI/SNB/GEN/003/2020/1	24.04.2020	1,94,00,000.00
3	AI/SNB/GEN/003/2020/2	29.05.2020	5,00,00,000.00
4	AI/SNB/CAP/003/2020/1	29.06.2020	3,50,00,000.00
5	AI/SNB/SAL/003/2020/2	30.06.2020	2,66,00,000.00
6	AI/SNB//GEN/03/2020/3	30.06.2020	3,00,00,000.00
7	AI/SNB/GEN/003/2020/4	30.07.2020	2,35,00,000.00
8	AI/SNB/GEN/003/2020/5	26.08.2020	1,00,00,000.00
9	AI/SNB/SAL/003/2020/3	25.09.2020	2,48,00,000.00
10	AI/SNB/GEN/003/2020/6	25.09.2020	2,00,00,000.00
11	AI/SNB/SAL/003/2020/4	23.10.2020	19,00,000.00
12	AI/SNB/GEN/003/2020/7	14.12.2020	1,00,00,000.00
13	AI/SNB/CAP/003/2020/2	14.12.2020	2,00,00,000.00
14	AI/SNB/SAL/003/2020/5	29.12.2020	6,39,00,000.00
15	AI/SNB/CAP/003/2020/3	29.12.2020	3,05,00,000.00
16	AI/SNB/GEN/003/2020/8	29.12.2020	2,71,00,000.00
17	AI/SNB/CAP/003/2020/4	23.03.2021	2,00,00,000.00
	TOTAL (PLAN)		Rs. **44,69,00,000.00**

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, 2021, 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. T.D.S liability as per as per 26AS statement of Rs 1,20,339.00 has not been provided 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) Expenditures of Capital nature purchased out of Spare & Repairs Expenses of Equipment Allocation are charged to revenue-as per accounting policy clause 4.4 of schedule-24.

b) Bank interest on Savings Bank Accounts & Fixed Deposit accounts refundable to DST is Rs.1,52,06,049.00. Refer to schedule-7 and the note on accounts - 2.2.4 of schedule-25.

c) Long unadjusted travelling advance of Rs.63,000/- and Rs.70,000/- may be written off from the books of accounts. Refer to the note on accounts-2.2.3

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 Trustees.
- 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: 21060694AAAART1626

Place: Kolkata
Date: 24.08.2021

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

BALANCE SHEET AS AT 31ST MARCH 2021 **Amount (Rs.)**

	Schedule	Current Year	Previous Year
FUNDS AND LIABILITIES			
Capital / Corpus Fund	**1**	1198723826.32	1053452329.61
Reserves And Surplus	**2**	–	
Earmarked/Endowment Funds	**3**	335681997.22	511608573.70
Secured Loans And Borrowings	**4**		
Unsecured Loans And Borrowings	**5**		
Deferred Credit Liabilities	**6**		
Current Liabilities And Provisions	**7**	77819370.41	75093543.31
TOTAL		**1612225193.95**	**1640154446.62**
ASSETS			
Fixed Assets	**8**	674291535.95	676825377.77
Investments-From Earmarked/Endowment Funds	**9**	181977240.00	314297298.00
Investments - Others	**10**	519520689.00	333483551.00
Current Assets, Loans, Advances Etc.	**11**	236435729.00	315548219.85
Miscellaneous Expenditure (to the extent not written off or adjusted)			
TOTAL		**1612225193.95**	**1640154446.62**
Significant Accounting Policies	**24**		
Contingent Liabilities And Notes On Accounts	**25**		

As Per our report of even date

Date: 24/08/2021
Place: Kolkata

For **Roy & Bagchi**
Chartered Accountants
FRN: 301053E

(**Amit Mitra**)
Partner
Membership no:060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES
BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2021 **Amount (Rs.)**

	Schedule	Current Year	Previous Year
INCOME			
Income from Services	12	8678679.00	10503233.00
Grants/Subsidies	13	341400000.00	273211000.00
Fees/Subscriptions(Student Admission & Semester Fees)	14	1,059,750.00	404500.00
Income from Investments (Income on Investment)	15		
from earmarked/endowment Funds transferred to Funds)			
Income from Technology Transfer & Contract Project	16	2,625,000.00	1050000.00
Interest on loan(HBA etc.) to employees	17	188428.00	223164.00
Other Income	18	516141.12	510272.80
Increase/(decrease) in stock of finished goods and	19		
works-in-progress			
TOTAL (A)		**354467998.12**	**285902169.80**
EXPENDITURE			
Establishment Expenses	20	165668263.00	163779626.00
Other Administrative Expenses etc.	21	115539713.59	156376092.38
Expenditure on Grants, Subsidies etc.	22		
Bank interest adjustable (refunded to DST shown separately in schedule 7			
TOTAL (B)		**281207976.59**	**320155718.38**
Balance being excess of Income over Expenditure(A-B)		73260021.53	(34253548.58)
Prior period adjustments (Credit)		592819.00	3082522.65
Transfer to/from Capital Fund			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/CAPITAL FUND		73852840.53	-31171025.93
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date

Date: 24/08/2021
Place: Kolkata

For **Roy & Bagchi**
Chartered Accountants
FRN: 301053E

(Amit Mitra)
Partner
Membership no:060694

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

RECEIPTS AND PAYMENTS ACCOUNTS

For the year ended 31st March 2021

Amount (Rs.)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Expenses :**		
a) Cash in hand	40650.00	32161.00	a) Establishment Expenses	192086966.00	179124691.00
b) Bank Balances :			b) Administrative Expenses	92726026.20	128941810.43
i. In current accounts(Schd 11A)	50204316.87	67299391.44	c) Maintenance	36743186.00	51584815.00
ii. In deposit accounts			**II. Payments made against funds for**		
Schedule - 10	476771951.00	595324963.00	**various Projects**		
Schedule - 11A	163055800.94	26326381.00			
iii. Savings accounts (Schd 11A)	61441229.47	60880054.85	**III. Investments and deposits made**		
iv. Remittance-in-Transit			a) Out of Earmarked/Endowment	28854396.00	0.00
II. Grants Received			b) CPWD Deposit and NBCC Deposit		
a) From Government of India			c) Bank Gurantee & LC A/C	6167669.00	140671099.94
-For the year	536751918.00	502623969.00	d) Out of Own Fund	270424738.94	510195994.00
-For the previous year					
b) From State Government			**IV. Expenditure on Fixed Assets &**		
c) From Other sources (details)			**Capital Work-in-Progress**		
(Grants for capital & revenue exp.			a) Purchase of Fixed Assets	205575670.00	124173335.00
To be shown separately)			b) Expenditure on Capital Work-in-Progress		2839156.00
			V. Refund of Interest		
III. Interest Received			a) To the Government of India		33917073.00
a) On Bank deposits	17152146.00	9829482.00	b) To the State Government		
			c) To other providers of funds		
IV. Other Income	8619579.12	4160210.00	**VI. Finance Charges (Interest)**		
V Amount Borrowed			**VII. Other Payments**	92869194.94	48233320.94
VI. Any other receipts	9361790.17	21600624.36	**VIII. Closing Balances**		
			a) Cash in hand	9083.00	40650.00
VII. Amount transferred from Current Account/	320222267.94	459685273.94	b) Bank Balances :		
Savings Account to Deposit Account.			i. In current accounts(Schd 11A)	72750444.15	50204316.87
			ii. In deposit accounts		
VIII. Amount transferred from Deposit Account		223432733.00	Schedule - 10	519520689.00	476771951.00
to Savings Account & Currect Account.			Schedule - 11A	57715447.00	163055800.94
			iii. Savings accounts(Schd.11A)	68178139.28	61441229.47
			iv. Remittance-in-Transit		
	1643621649.51	**1971195243.59**		**1643621649.51**	**1971195243.59**

Per our report of even date
For Roy & Bagchi
Chartered Accountants
FRN: 301053E

(Amit Mitra)
Partner
Membership no: 060694

Date :24.08.2021
Place: Kolkata

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

	Current Year		Previous Year	
SCHEDULE 1 -CAPITAL FUND:				
Balance as at the beginning of the year	1053452329.61		1060635560.63	
Add : Contributions towards Corpus/ Capital Fund	105500000.00		70653000.00	
Less:Depreciation for the year	34081343.82		46665205.09	
Add : Surplus during the year	73852840.53		–31171025.93	
		1198723826.32		1053452329.61
BALANCE AS AT THE YEAR - END		**1198723826.32**		**1053452329.61**

	Current Year		Previous Year	
SCHEDULE 2 - RESERVES AND SURPLUS:				
1. **Capital Reserve:** As per last Account Addition during the year Less: Deductions during the year				
2. **Revaluation Reserve:** As per last Account Addition during the year Less: Deductions during the year				
3. **Special Reserves:** As per last Account Addition during the year Less: Deductions during the year				
4. **General Reserve:** As per last Account				
Add : Surplus during the year		-		-
TOTAL		**-**		**-**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 — **Amount (Rs.)**

FUND-WISE BREAK UP — **TOTAL**

SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS

	Technical Research Centre	Project Fund	Retirement Benefits Fund	Medical Fund	Corpus Fund	Current Year	Prev. Year
a) **Opening balance of the funds**	277813716.94	106423354.76	102642914.00	7491351.00	17237237.00	511608573.70	523723174.73
b) **Additions to the Funds**							
i) Donations/grants/ Contributions	39500000.00	50619262.00	417438.00	1296368.00	743074.00	92576142.00	166162301.00
ii) Income from investments made on account of funds	9921231.00	3446580.00	8159087.00	378125.00	943739.00	22848762.00	26282989.62
iii) Other additions -Provision during the year							
TOTAL (a + b)	327234947.94	160489196.76	111219439.00	9165844.00	18924050.00	627033477.70	716168465.35
c) Utilisation/Expenditure towards objectives of funds							
i) Capital Expenditure							
Fixed Assets	198092628.00	4,124,415.00				202217043.00	108938801.54
Others							
Total							
ii) Revenue Expenditure							
Salaries, Stipen and allowances etc.	19735975.00	25,972,408.00				45708383.00	44111239.00
Rent							
Other Administrative expenses							
Other Payments	18809649.46	6,571,731.02	4137590.00	378125.00	0.00	29897095.48	21684308.11
iii) Adjustment (Interest)							
Interest Refunded to DST	13528959.00					13528959.00	29825543.00
TOTAL (c)	**250167211.46**	**36668554.02**	**4137590.00**	**378125.00**	**0.00**	**291351480.48**	**204559891.65**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**77067736.48**	**123820642.74**	**107081849.00**	**8787719.00**	**18924050.00**	**335681997.22**	**511608573.70**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

	Current Year	Previous Year	
SCHEDULE 4 - SECURED LOANS AND BORROWINGS:			
1. Central Government			
2. State Government (Specify)			
3. Financial institutions			
a) Term Loans b) Interest accrued and due			
4. Banks:			
a) Term Loans Interest accrued and due b) Other Loans (Specify) Interest accrued and due			
5. Other Institutions and Agencies			
6. Debentures and Bonds			
7. Others (Specify)			
TOTAL **Nil**	**Nil**	**Nil**	**Nil**

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

	Current Year	Previous Year	
SCHEDULE 5 - UNSECURED LOANS AND BORROWINGS			
1. Central Government			
2. State Government (Specify)			
3. Financial Institutions			
4. Banks:			
a) Term Loans b) Other Loans (Specify)			
5. Other Institutions and Agencies			
6. Debentures and Bonds			
7. Fixed Deposits			
8. Others (Specify)			
TOTAL Nil	Nil	Nil	Nil

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

	Current Year		Previous Year	
SCHEDULE 6 - DEFERRED CREDIT LIABIILTIES:				
a) Acceptances secured by hypothecation of capital equipment and other assets				
b) Others				
TOTAL	Nil	Nil	Nil	Nil

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS				
A. CURRENT LIABILITIES				
1. Acceptances				
2. Sundry Creditors:				
a) For Capital expenditure	25193310.00			9620879.00
b) Others - Revenue expenditure (including TRC & Project)	8335058.00			13354778.00
3. Other Liabilities	4812041.88			10760441.88
4. Deposit from Contractors (including Project & TRC)	12050812.00			11271865.00
5. Deposit from Students	1979500.00			1858500.00
6. Deposit from Contractual Employees	1636746.00			1705199.00
7. Provident Fund Account (Payable)	53.10			1042076.00
8. Project Overhead Fund	6963221.43			6125684.43
9. Interest earned on fixed deposit and savings bank (Refundable to DST)	15206049.00			19354120.00
10. Employees Welfare Fund	100000.00			0.00
11. EVLP Overhead Fund	1542579.00			0.00
TOTAL (A)	**77819370.41**			**75093543.31**
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)	**77819370.41**			**75093543.31**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021

Amount (Rs.)

SCHEDULE 8 -FIXED ASSETS

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	0	0.00	10950654.60	10950654.60
2. BUILDINGS:										
a) On Leasehold Land	446972023.86	2084712.00		449056735.86	66612852.80	7077363.62		73690216.42	375366519.44	380359171.06
b) On Freehold Land										
c) Ownership Flats/Premises										
d) Superstructures on Land not belonging to the entity										
3. PLANT MACHIENRY & EQUIPMENT	493043762.22	17041337.00		510085099.22	423629008.19	20316110.17		443945118.36	66139980.86	69414754.03
4. VEHICLES	1042199.00	0.00		1042199.00	459913.40	85640.84		545554.24	496644.76	582285.60
5. FURNITURE, FIXTURES	41733020.22	254873.00		41987893.22	33605006.67	2091423.62		35696430.29	6291462.93	8128013.55
6. OFFICE EQUIPMENT	6155904.29	0.00		6155904.29	5084561.95	348560.17		5433122.12	722782.17	1071342.34
7. COMPUTER & LAN INSTALLATION	85305340.44	8268753.00		93574093.44	69615440.58	3165281.20		72780721.78	20793371.66	15689899.86
8. ELECTRIC INSTALLATIONS	11699040.00	0.00		11699040.00	7536896.61	996964.20		8533860.81	3165179.19	4162143.39
9. LIBRARY BOOKS	251077242.11	5816565.00		256893807.11	69586478.05	0		69586478.05	187307329.06	181490764.06
10. TUBEWELLS & W.SUPPLY	-	-		0.00	-	-		0.00	0.00	-
11. OTHER FIXED ASSETS	84225.55	0.00		84225.55	80014.27			80014.27	4211.28	4211.28
TOTAL OF CURRENT YEAR	**1348063412.29**	**33466240.00**	**0.00**	**1381529652.29**	**676210172.52**	**34081343.82**	**0.00**	**710291516.34**	**671238135.95**	**671853239.77**
PREVIOUS YEAR	**1306965076.29**	**43950066.00**	**2,851,730.00**	**1348063412.29**	**632254110.93**	**46665205.09**	**2,709,143.50**	**676210172.52**	**671853239.77**	**674710965.36**
B. CAPITAL WORK IN PROGRESS	**4972138.00**		**1918738.00**	**3053400.00**					**3053400.00**	**4972138.00**
TOTAL (A + B)	**1353035550.29**	**33466240.00**	**1918738.00**	**1384583052.29**	**676210172.52**	**34081343.82**	**0.00**	**710291516.34**	**674291535.95**	**676825377.77**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

SCHEDULE 9 - INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS

	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Project Fund Investment	51193466.00	48491523.00
7. Retirement Benefit Fund Investment	111545038.00	104608149.00
8. Staff Medical Fund Investment	6789112.00	6275397.00
9. Corpus Fund Investment (Project Overhead)	12449624.00	11633829.00
TOTAL	**181977240.00**	**171008898.00**

SCHEDULE 10 - INVESTMENTS - OTHERS

	Current Year	Previous Year
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Others - Fixed Deposit with Indian Overseas Bank (including Project Overhead Investment)	346589084.00	217757716.00
Fixed Deposit with Union Bank of India	88981721.00	115725835.00
• 7. TRC Fund Investment	83949884.00	143288400.00
TOTAL	**519520689.00**	**476771951.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.

	Current Year		Previous Year	
A. CURRENT ASSETS:				
1. Inventories:				
a) Stores and Spares		36425.57		32969.57
2. Cash balances in hand		9083.00		40650.00
3. Bank Balances:				
a) With Scheduled Banks:				
On Current Accoutns:				
Indian Overseas Bank (CA-089302000000220	54509553.85		5851734.83	
Indian Overseas Bank (CA-089302000000273)	16140086.91		24960392.69	
Union Bank of India (CA-460901010034252)	579798.39		19392189.35	
HDFC Bank (GEM)(373218248)	1521005.00	72750444.15	0.00	50204316.87
On Deposit Accounts for LC&BG:				
Indian Overseas Bank CA-089302000000220)	35672983.00		44145695.00	
Indian Overseas Bank (SB-089301000018598 TRC)	15874795.00		118910105.94	
Indian Overseas Bank (CA-089302000000273 PROJECT)	6167669.00	57715447.00	0.00	163055800.94
On Savings Accounts:				
Indian Overseas Bank (SB-089301000010662 UNAST)	3558873.20		3426009.30	
Indian Overseas Bank (SB-089301000012029 SYNC.)	793282.76		768078.30	
Indian Overseas Bank (SB-089301000011479 NANO TECH)	562482.46		544634.00	
Union Bank of India (SB-460901110050013)	8047075.57		8047146.37	
Axis Bank (SB-775010100024408)	5838931.00		7023124.00	
Axis Bank (SB-775010100017860)	1795.00		1742.00	
Union Bank of India (SB-460902010097273 TRC)	13753.80		8901589.80	
Indian Overseas Bank (SB- 089301000018598 TRC)	9777155.68		8923516.10	
HDFC Bank (SB-6771192)	602083.01		5000.00	
Indian Overseas Bank- (SB-089302000019902)	38982706.80	68178139.28	23800389.60	61441229.47
5. Remittance - in - Transit				
6. Post Office-Savings Accounts				
TOTAL (A)		**198689539.00**		**274774966.85**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021 **Amount (Rs.)**

SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC. (Contd.)

	Current Year		Previous Year	
B. LOANS, ADVACNES AND OTHER ASSETS				
1. Loans:				
a) Staff including HBA ,Vehicle & PC Advance (includes Project A/c)		571225.00		2051063.00
Project Account		0.00		
Technical Research Centre		0.00		
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)	24608684.00		26453690.00	
b) On investmetns - Others	3408118.00		5885337.00	
c) Income tax (TDS) Refundable		28016802.00	175000.00	32514027.00
4. Sundry Debtors - National Research Development Corporation		2940000.00		
5. Security Deposit (including Project)		98618.00		88618.00
TOTAL (B)		**37746190.00**		**40773253.00**
TOTAL (A + B)		**236435729.00**		**315548219.85**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2021

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	397033.00	2346620.00
b) Hostel Charges (Recovery of HRA)	5973018.00	5515540.00
c) Equipment Utilisation Fees	120800.00	570800.00
d) Hostel Maintenance Fees	1741641.00	1508452.00
e) Project Overhead	297230.00	433783.00
f) Income from BSNL	142932.00	113038.00
g) Seminer Hall Rent	0.00	15000.00
h) Dining Hall Rent	0.00	0.00
i) Recovery of Water Charges	6025.00	0.00
TOTAL	**8678679.00**	**10503233.00**

SCHEDULE 13 - GRANTS/SUBSIDIES

(Irrevocable Grants & Subsidies Received)

	Current Year	Previous Year
1. Central Government	341400000.00	273211000.00
2. State Government(s)		
3. Government Agencies		
4. Institutions/Welfare Bodies		
5. International Organsations		
6. Others		
TOTAL	**341400000.00**	**273211000.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2018

SCHEDULE 14 - FEES/SUBSCRIPTIONS

Amount (Rs.)

	Current Year	Previous Year
1) Student Admission Fees	100500.00	94500.00
2) Annual Fees/Subscriptions		
3) Student Seminar Fees	959250.00	310000.00
4) Consultancy Fees		
5) Others		
TOTAL	**1059750.00**	**404500.00**

Note: Accounting Policies towards each item are to be disclosed

Amount (Rs.)

SCHEDULE 15 - INCOME FROM INVESTMENTS

(Income on Invest. From Earmarked/ Endowment Funds transferred to Funds)	Investment from Earmarked Fund		Investment - Others	
	Current Year	Previous Year	Currnet Year	Previous Year
1) Interest				
a) On Govt. Securities				
b) Other Bonds/Debentures				
2) Dividents:				
a) On Shares				
b) On Mutual Fund Securities				
3) Rents				
4) Others				
TOTAL	**Nil**	**Nil**	**Nil**	**Nil**
TRANSFERRED TO EARMARKED/ ENDOWMENT FUNDS	**Nil**	**Nil**	**Nil**	**Nil**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2021

SCHEDULE 16 - INCOME FROM TECHNOLOGY TRANSFER & CONTRACT PROJECT

Amount (Rs.)

	Current Year	Previous Year
1. Income from Technology Transfer	2625000.00	1050000.00
2. Income from Contract Project		
3. Others		
TOTAL	2625000.00	1050000.00

SCHEDULE 17 - INTEREST EARNED

	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.)	188428.00	223164.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	**188428.00**	**223164.00**

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2021

Amount (Rs.)

SCHEDULE 18 - OTHER INCOME	Current Year	Previous Year
1) Profit on Sale/disposal of Assets:		
a) Owned assets		
b) Assets acquired out of grants, or received free of cost		
2) Export Incentives realized		
3) Fees for Miscellaneous Services		
4) Miscellaneous Income	516141.12	510272.00
TOTAL	**516141.12**	**510272.00**

SCHEDULE 19 - INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS	Current Year	Previous Year
a) Closing stock		
Finished Goods		
Work-in-progress		
b) Less: Opening Stock		
Finished Goods		
Work-in-progress		
NET INCREASE/(DECREASE) [a-b]	**Nil**	**Nil**

SCHEDULE 20 - ESTABLISHMENT EXPENSES	Current Year	Previous Year
a) Salaries and Wages	106995987.00	99862201.00
b) Other Allowances and Bonus	0.00	0.00
c) Employer's Contribution to Provident Fund	3867187.00	3759139.00
d) Contribution to Retirement Benefits Fund	417438.00	3146563.00
e) Staff Welfare Expenses (Medical)	2480006.00	2397859.00
f) Employer's Contribution to NPS	3578652.00	3265073.00
f) Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	3326660.00	2650877.00
g) Fellowships(Phd. Students & Post Doc. Fellows)	45002333.00	48697914.00
TOTAL	**165668263.00**	**163779626.00**

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2021

Amount (Rs.)

SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.	Current Year	Previous Year
a) Extended Visitors Programme.(Including Seminars & Workshops)	259600.72	4038786.80
b) Meeting Expenses	517229.00	968718.00
c) Library General Expenses	75330.00	98582.00
d) Electricity and Power	31313071.00	37260989.00
e) Laboratory Expenses	6372273.00	12037347.00
f) Insurance	16859.00	17007.00
g) Repairs and Maintenance	51345473.00	67322811.57
h) TPSC Programme	0.00	662217.00
I Parliamentary Committee Meeting Exps	0.00	0.00
j) Vehicles Hire Charges	2140247.00	2117535.00
k) Postage, Telephone and Communication Charges	763219.00	886278.00
l) Printing and Stationary	511039.00	895500.00
m) Travelling and Conveyance Expenses	598990.00	2743821.00
n) Contingency to Faculty	10000.00	12966.00
o) Auditors' Remuneration	59000.00	48200.00
p) Bank Charges	154863.60	692888.92
q) Professional Charges (Legal Charges)	251461.00	386319.00
r) Staff Training & Welfare	46295.00	204651.00
s) Patent & Trademark	86208.00	171202.00
t) Integrated Ph.D.	1519805.00	5334145.00
u) Hindi Programme	25870.00	64196.00
v) Advertisement and Publicity	1085879.00	458003.00
w) Others	616146.27	1100004.09
x) Municipal Tax	141388.00	146968.00
z) Bose Archive Expenses	0.00	6300.00
z1) Contract Services	17629467.00	18700657.00
TOTAL	**115539713.59**	**156376092.38**

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2021

Amount (Rs.)

SCHEDULE 22 - EXPENDITURE ON GRANTS, SUBSIDIES	Current Year	Previous Year
a) Grants given to Institutions/Organisations b) Subsidies given to Institutions/Organisations		
TOTAL	**Nil**	**Nil**

SCHEDULE 23 - INTEREST	Current Year	Previous Year
a) On Fixed Loans b) On Other Loans (including Bank Charges) c) Others		
TOTAL	**Nil**	**Nil**

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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.

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

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6. FOREIGN CURRENCY TRANSACTIONS

6.1 Transactions denominated in foreign currency are accounted at the exchange rate prevailing at the date of transaction.

7. RETIREMENT BENEFITS

7.1 Liability towards gratuity payable on death/retirement of employees is computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.2 Provision for accumulated leave encashment benefit to the employees is accrued and computed on the assumption that employees are entitled to receive the benefit as at each year end.

7.3 Liabilities under above accounts are invested separately in fixed deposit accounts with nationalized bank.

SCHEDULE 25 : CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Centre not acknowledged as debts – Rs. Nil (Previous year Rs. Nil).

1.2 In respect of

- Bank guarantees given by/on behalf of the Centre – Rs.1,05,00,000.00 against 100% margin money by way of fixed deposit (Previous year Rs.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– 3,13,40,652.00 (Previous year Rs.1,77,52,725.94) 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).

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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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, 2020 was Rs. 49,72,138/- addition during the year is Rs.Nil -, totaling to Rs.49,72,138/- an amount of Rs.19,18,738/- has been capitalized, leaving balance of Rs.30,53,400/- 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/-	Unadjusted since 2012-13
Venkata Kamalakar	Rs. 70000/-	Unadjusted since 2008-09

2.2.4. Amount payable to DST Rs.1,52,06,049/- relates to Interest Earned on SB & Fixed. Deposits during the Financial Year 2020-21

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 As per IT Return for the AY (2020-21) , the Centre claimed refund of T.D.S amounting to Rs.31,56,940.00. The assessment of the said IT Return by the Income Tax authority is under process. The refund claimed has not been accounted for in the books of accounts.

2.2.7 As per 26AS statement for the AY (2021-22), Rs.26,15,077.00 and Rs.6,019.26 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. Tax deducted at source and tax collected at source have not been accounted for in the books of accounts.

2.2.8 Foreign Currency Transactions

i) Value of Imports Calculated on C.I.F basis :

(Amount in Rs.)

	Current Year	Previous Year
- Capital Goods	4,33 50,822/-	5,87,56,981 /-
- Consumables	15,14,277/-	13,83,430 /-

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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

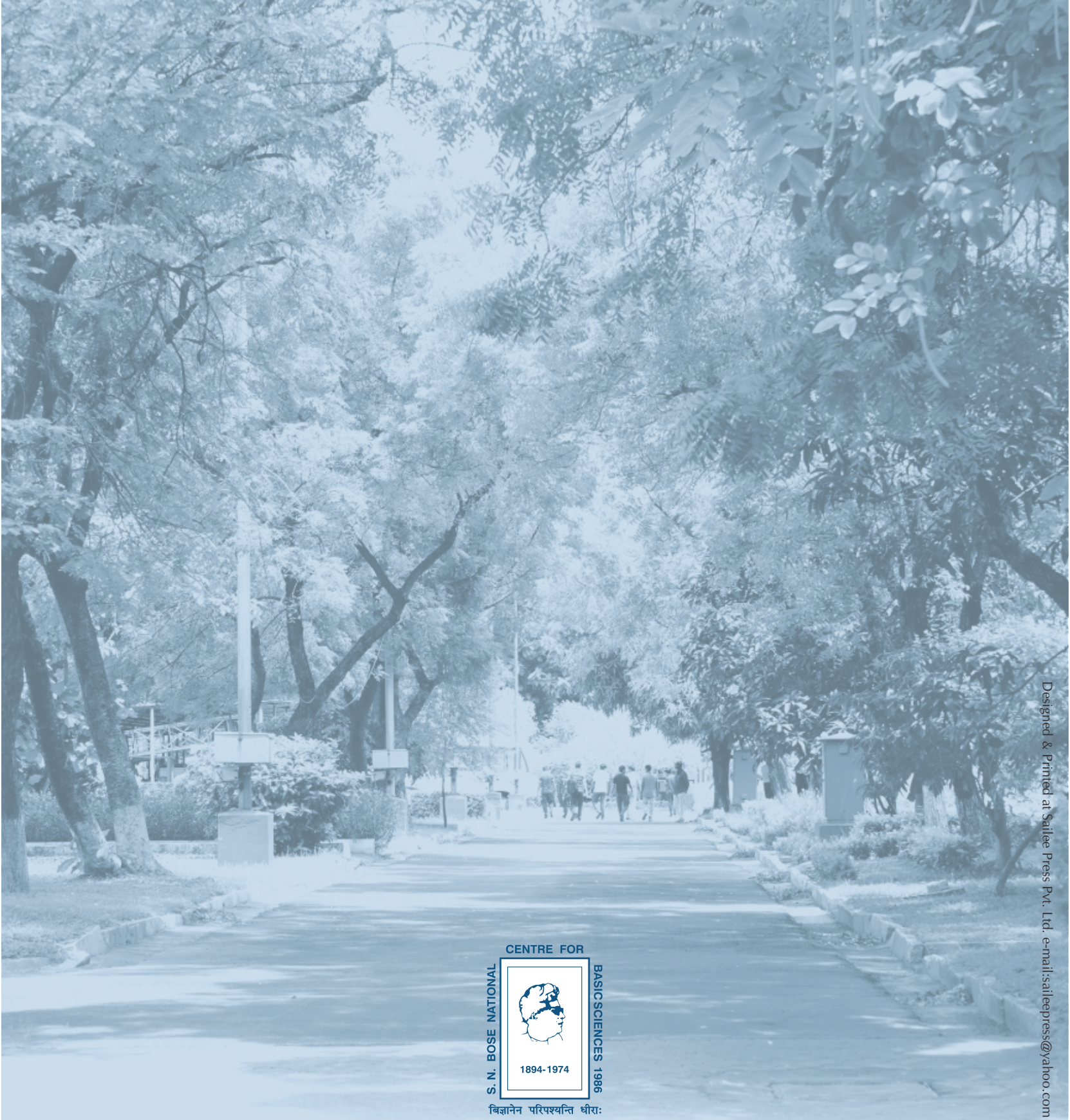
iii) Earnings:
Value of Exports on FOB basis: Nil

2.2.9 Corresponding figures for the previous year have been re-grouped/re-arranged, wherever necessary.

Kolkata
Dated: 24.08.2021

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.	A fresh physical verification of fixed assets is under process in order to identify obsolete / unserviceable items. The said physical verification will be completed very soon and necessary adjustments will be given in the Accounts accordingly.
2	T.D.S liability as per as per 26AS statement of Rs 1,20,339.00 has not been provided in the accounts.	The audit observation has been noted for immediate compliance.



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