Annual Report 2019-20



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SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

ANNUAL REPORT 2019-20





Satyendra Nath Bose National Centre For Basic Sciences

Annual Report 2019-2020

Satyendra Nath Bose National Centre for Basic Sciences

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ACADEMIC HIGHLIGHTS

Areas of Research Focus:

- Selected Areas of Theoretical Sciences including Quantum Field theory, Quantum information theory, Statistical Physics and Non-Linear Dynamics.
- Areas of Physical and Quantum chemistry that interface with Biological molecules, Ionic Liquids and Energy Harvesting using tools of simulation and precision ultra-fast spectroscopy.
- Advanced Materials Sciences and condensed matter physics including nanomaterials and computational materials sciences. New materials and technology development including nanomaterials, nanodevices, biomedical instrumentation for health care and related research : (Theory, Experiment and Simulations).
- Selected areas of astrophysics and cosmology like investigations on black holes, dark matter and observational astronomy.
- Translational research under the Technical Research Centre in the areas of Health care, Environment, Food security, High-end computations for developing prototypes and transfer of Technology



Electronic Classroom

Research highlights

- A new technique has been invented to pave the way for next-generation computing. (The research has been featured in the Nature India.
- Formulated a new protocol (both theory and experiment) for Certifying Quantum Entanglement: A step towards Quantum Security.
- Computationally predicted the existence of magnetism in two-dimensional (2D) magnetism, which remained elusive until recently.
- Rationalization of a traditional liver medicine using systems biology approach and its evaluation in preclinical trial have been achieved.
- A construction of novae grid model using photoionization code CLOUDY is successfully implemented to estimate physical parameters of novae.
- Spectral properties of NGC 4151 have been studied to estimation the Black-hole mass using TCAF solution.
- Combination of THz and optical spectroscopy has been utilized to understand "hydrophobic hydration"
- Evanescent-wave coupled ring-down spectroscopy has been demonstrated to be useful to probe interfacial dynamics in condensed phases
- Molecular simulations have been established to Characterize heterogeneous dynamics of soft condensed matter systems
- Developed a new numerical method to solve the quantum many system at finite temperature. This algorithm is known as ED/DMRG algorithm.
- Nano-hollow spheres of ferrites have been demonstrated to serve as better microwave absorbers than their solid counterparts.

- Quantization of constrained field theories near the horizon of a black hole has been studied.
- Studied the dynamics of fermions on curved spacetime
- Meissner like effect in holographic superconductors in the presence of Dirac-Born-Infeld electrodynamics has been established.
- Additivity and density fluctuations in Vicsek-like models of self-propelled particles have been studied.

Technology transfer :

- 'Non-invasive Quantitative Estimation of Bilirubin in Blood' 27th August, 2019
- "Non-invasive detection of Oxygen deficiency in blood" – 27th August 2019



Transfer of two technologies through NRDC from TRC project on 27th August, 2019 at Technology Bhawan, DST, New Delhi



Presentation of medical devices in India Inernational Science Festival (IISF-2019)

Important International & National collaborations:

- Bilateral exchange projects through International division of DST and collaboration in the personal level
- Three non-Govt. Sponsored projects from UK and India.
- TWAS (Third World Academy of Sciences) BOSE Fellowship Programme.
- Networked research programmes through the visitor and associateship programme and Theoretical Physics Seminar Circuit (TPSC) to promote collaborative research.

Major Events and Outreach Programmes :

- Celebration of "127th Birth Anniversary of Satyendranath Bose" and opening of "S.N Bose Archive" on 1st January, 2020 at the S N Bose Centre, Kolkata.
- C. K. Majumdar Memorial Summer Workshop for 2 weeks in Physics for Post BSc students across the nation.
- Organized North-East students conclave and hosted Foreign ministers and dignitaries from various countries in the India International Science Festival 2019,
- Organized XXth International Workshop on Physics of Semiconductor devices in December 2019 attended by 550 delegates.
- Organized DST Nanomission sponsored International Conference on Nanoscience & Technology in March 2020 attended by 450 delegates.



Centre hosted North-East Studens' Conclave, an event of IISF-2019

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Output Indicators

The Centre ranks among top three DST institutes and top 30 Indian institutes as per Nature Index ranking based on the quality of research publications in the year 2019.

Important Output Indicators for 2019-20 :

No. of Publications in refereed journal	263
No. of Other Publications	32
No. of PhD Degree awarded	18
No. of PhD theses submitted	29
Research Projects including TRC	28 (Rs.14.15 crores)
No. of Indian Patent Applied	6
No. of Indian Patent Granted	1
No. of Awards/Recognitions (Faculty/Scientist)	9
No. of Technology transfer	2
No. of M.Sc. & Ph.D. students trained	204
Manpower trained other than Ph.Ds. (B.Tech./M.Tech./M.Sc./M.Phil)	74



Source: web of science

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 10th time I have been assigned the job of compilation of Annual Report of the Centre. To prepare the Annual Report, all the faculty members and sections of the Centre spent their valuable time to provide respective data. It is a time bound work to be completed within a short span of time. This is the 4th time the Annual Report is translated and typed in Hindi within the Centre. The Office Assistant (Hindi), Ajay Kumar Shaw has given sincere fatigueless effort to translate the entire Annual Report in Hindi and library staff - Amit Roy, Gurudas Ghosh and Ananya Sarkar typed the Annual Report in Hindi itranslation team. I would like to acknowledge the sincere efforts and labour of my Library staff - Gurudas Ghosh, Ananya Sarkar and Amit Roy without whom the work could not be completed within the stipulated time. Finally, I would like to thank all the members of the Centre for their cooperation in preparation of the Annual Report of the Centre.

Saumen Adhikari Librarian – cum – Information Officer



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MESSAGE FROM THE DIRECTOR



It is my privilege to present the Annual Report of the Satyendra Nath Bose National Centre for Basic Sciences for the year 2019-20, when we are in the verge of reaching three and a half decades of its establishment. The institute continued to thrive for excellence in research and training high quality scientific manpower to reach the pinnacle of peer recognitions and achievements in the last year. There have been record number of peer reviewed journal publications, with close to nine papers per faculty having an average impactor factor of ~ 3.6 , in the reporting period. This has placed the Centre among the top three DST institutes as per the Nature Index ranking based on the quality of research publications in the year 2019. It's heartening to note that with only 30 regular Faculty /Scientists, the institute is currently mentoring more than 200 students in Ph.D, Integrated M.Sc.-Ph.D., project and external Ph.D. scholars. During the last one year the institute scaled new heights in number of PhD thesis completion with about 29 students submitting their dissertation. This has been possible only due to the commendable efforts by the faculty members and I take this opportunity to sincerely congratulate all my colleagues for the outstanding feat. The contributions of several emeritus Professors, INSPIRE and visiting faculty members are also gratefully acknowledged.

I am happy to announce that several faculty members had received National / International laurels & accolades such as the Fellowship of the World Academy of Sciences and Indian Academy of Science Bangalore, Nina Saxena Technology Innovation Award, CSRI Gold Medal for life time achievement and elected editorial board members of prestigious journals. The accomplishments of Ph.D. students are equally noteworthy by bagging several best paper awards in International & National conferences. Faculty members of the Centre have been very active in translational research under prestigious TRC project by filing six new patents and earning several new extramural projects. In continuation of the last year's accomlishment, the Centre has commercialized two additional technologies this year on "Non-invasive guantitative estimation of Bilroubin in blood" and "Noninvasive detection of oxygen deficiency in blood" to a start-up company and the negotiation of transfer of two other technologies have been initiated. In addition to TRC project, the Centre has 27 ongoing projects amounting to an annual funding of INR 14.15 crores.

As per the mandate, the Centre is also quite vibrant in science networking and outreach activities for serving the society and mentoring the junior researchers through Theoretical Physics Seminar Circuit (TPSC), EVLP visiting Associates, C. K. Majumdar Memorial Summer Workshop for post-B.Sc. students, and Vidyasagar - Satyendranath Bose National Workshop for Ph.D. students. It's noteworthy that this year we could organize all four memorial lectures in the name of S. N. Bose, C. K. Majumdar, G. N. Ramchandran and S. Chandrasekhar through EVLP. In addition, the Centre hosted the North-East students conclave during 5th India International Science festival held in Kolkata during the period 5th to 8th November, 2019. Among several Conferences and Symposia, the Centre organized two mega events viz., DST Nanomission supported International Conference on Nanoscience and Technology ICONSAT-2020) and XXth International Workshop on Physics of Semiconductor Devices (IWPSD-2019), each with more than 500 delegates. The new Bose Archive and Museum was opened for the public on 127th birth anniversary of Bose in presence of his family members.

Our gratitude to the members of the statutory and advisory and internal administrative committees of the Centre for their cooperation and support. Sincere thanks to all faculty, staff members, administration and support services and students of the Centre for their heartfelt contributions towards the growth of the Centre to a new height.

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 2019-20, the Centre was involved in several academic activities related to scientific collaborations, hosting national and international conferences, workshops, schools, and organizing outreach programmes, refurbishing of the Bose Archives, etc. Our faculty continued to publish in top quality international journals. In this fiscal year, the total number of publications was 263. A vibrant technology development programme was followed at the Technical Research Centre, with the filing of 5 patents and 2 agreements for technology transfers.

Throughout the year, we organized numerous seminars and distinguished lectures on various topics delivered by scientists ranging from young graduate students to well-established ones. Our ongoing collaborations with various institutions in India and abroad in terms of academic visits and exchange programmes including collaborations in conferences, as well as involvement in projects supported by extramural funding, further bolstered the research activities at the Centre. In the current year 8 more extramural projects were sanctioned in addition to 20 ongoing projects.

This year one new faculty member has joined in the Departments of TS. A total of 20 Post-Doctoral Research Associates have joined the Centre. One of our faculty members was promoted to Senior Professor during this year.

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

Prof. Tanusri Saha Dasgupta	Elected fellow of The World Academy of Sciences (TWAS)
Prof. Anjan Barman	Elected Fellow of the Indian Academy of Sciences Bangalore (FASc)
Prof. Samit Kumar Ray	Received MRSI-ICSC Materials Science Senior Award for the year 2020
Prof. Samir Kumar Pal	Received Nina Saxena Excellence in Technology Award, 2019from IIT Kharagpur
Prof. Ranjit Biswas	Nominated member of the JPC Editorial Advisory Board
Dr. Manik Pradhan	Inducted as an Early Career Board Member (ECB) of AnalyticalChemistry of American Chemical Society (ACS)
Prof. Arup Kumar Raychaudhuri	Awarded the SERB Distinguished Fellowship
Prof. Debashis Mukherjee	Selected for award of Gold Medal by the CSRI as a recognition of his life- time achievement

Asuajundar

Archan S. Majumdar Dean (Faculty)

DEAN, ACADEMIC PROGRAMME



We are proud to present the Annual report covering the academic year 2019-20.

This report highlights achievements in each of our programme conducted at the Centre i.e, Integrated PhD. Programme & PhD. Programme. In the academic year 2010-20, a total of 17 students joined the PhD Programme. Of these, 02 joined Astrophysics & Cosmology, 06 joined Condensed Matter Physics and Material Science, 05 joined Chemical, Biological and Macromolecular Sciences and 04 joined Theoretical Sciences. While 09 students joined I.PhD Programme of the Centre.

The academic activities expanded considerably during this time period in different areas of Basic Sciences. Our ongoing commitment towards fostering and promoting the growth of advanced studies in selected branch of basic Sciences drives us to develop Scholars through the discovery, application and communication of knowledge. and this is further facilitated by the ongoing collaborations with the national and international Scientists, helping us to prepare young minds to meet the changing and challenging needs of the society. It is indeed a great privilege for me to get an opportunity to work with incredibly thoughtful, energetic and inspiring faculty colleagues, administrative staff members and students. The innovations and 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 the program and our students has been unwavering.

COURSES TAUGHT IN 2019-20

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

1st Semester:

- PHY 101, Classical Dynamics, Rabin Banerjee;
- PHY 102, Mathematical Methods, Amitabha Lahiri;
- PHY 103, Quantum Mechanics I, Sakuntala Chatterjee;
- PHY 104, Computational Methods in Physics I, Suman Chakrabarty;
- PHY 191, *Basic Laboratory I*, Samir Kumar Pal & Soumen Mondal.

2nd Semester:

- PHY 201, Statistical Mechanics, Jaydeb Chakrabarti;
- PHY 202, Quantum Mechanics II, Manu Mathur;
- PHY 203, Electromagnetic Theory, Biswajit Chakraborty;
- PHY 204, Computational Methods in Physics II, Suman Chakrabarty;
- PHY 291, *Basic Laboratory II*, Kalyan Mandal & Pratip K Mukhopadhyay.

3rd Semester:

- PHY 301, Atomic & Molecular Physics, Anjan Barman & Rajib Kumar Mitra;
- PHY 302, Condensed Matter Physics, Kalyan Mandal & Manoranjan Kumar;
- PHY 303, Advanced Quantum Mechanics & Applications, Archan S Majumdar & Sunandan Gangopadhyay;
- PHY 304, Project Research II, Faculty Supervisors;

• PHY 391, Methods of Experimental Physics, Kalyan Mandal (Coordinator), Manik Pradhan, Ramkrishna Das & Barnali Ghosh (Saha).

4th Semester:

- PHY 401, Project Research III, Faculty Supervisors;
- PHY 402, Seminar Course, Faculty Experts;
- PHY 403, Astrophysics & Cosmology, Soumen Mondal & Ramkrishna Das;
- PHY 404, Chemical Physics, Gautam Gangopadhyay;
- PHY 405, Biological Physics, Rajib Kumar Mitra;
- PHY 406, Advanced Mathematical Methods, Amitabha Lahiri;
- PHY 407, Advanced Quantum Filed Theory, Sunandan Gangopadhyay;
- PHY 411, Optical Phyaics, M Sanjay Kumar;
- PHY 412, *Physics of Materials*, Priya Mahadevan & Ranjan Chaudhury;
- PHY 413, Quantum Information Theory, Manik Banik & Archan S Majumdar.

Ph.D. Programme

Course Work Programme

- PHY 501, Research Methodology, Atindra Nath Pal & Rajib Kumar Mitra;
- PHY 502, *Review of the Topical Research*, Faculty Supervisors;
- PHY/CB 591, Project Research, Faculty Supervisors;
- CB 523, Advanced Equilibrium Statistical Mechanics, Jaydeb Chakrabarti & Gautam Gangopadhyay;
- CB 524, *Physical Chemistry:* Experiments & Theory, Ranjit Biswas
- •• CB 527, Molecular Physics & Spectroscopy, Rajib Mitra & Anjan Barman;
- •• PHY 503, Condensed Matter Physics, Kalyan Mandal & Manoranjan Kumar;
- •• PHY 604, Advanced Quantum Mechanics & Applications, Sunandan Gangopadhyay & Archan S Majumdar;
- PHY 616, Observational Techniques in Astronomy, Soumen Mondal & Ramkrishna Das;

- CB 540, Study of Biomacromolecules, Suman Chakrabarty & Tatini Rakshit;
- •• CB 526, Fundamentals of Biophysics, Rajib Kumar Mitra;
- PHY 507, Mathematical Methods, Amitabha Lahiri;
- PHY 607, Advanced Quantum Field Theory, Sunandan Gangopadhyay;
- PHY 510, Astrophysics, Soumen Mondal & Ramkrishna
 Das
- PHY 601, Advanced Condensed Matter Physics I, Priya Mahadevan & Ranjan Chaudhury;
- PHY 602, Advanced Condensed Matter Physics II, Tanusri Saha Dasgupta & Thirupathaiah Setti;
- •• PHY 611, Optical Physics, M Sanjay Kumar;
- PHY 613, *Quantum Information Theory*, Manik Banik & Archan S Majumdar.

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

Ph.D. THESIS WORK COMPLETED

- 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 May, 2019
- Spectroscopic Studies On Hybrid-Materials Of Medicinally Important Molecules For Enhanced Biological Activity, Damayanti Bagchi, Supervisor: Samir Kumar Pal, in University of Calcutta, in May, 2019
- **3.** Multi-wavelength Studies of Novae, Anindita Mondal, Supervisor: Ramkrishna Das & Soumen Mondal, in University of Calcutta, in May, 2019
- 4. Accreting Black Hole Systems as Classical Analogue Gravity Models, Pratik Tarafdar, Supervisor: Amitabha Lahiri & Tapas Kumar Das, in University of Calcutta, in May, 2019
- 5. Dynamics of propagating modes and characterisation of ordering in coupled nonequilibrium systems, Shauri Chakrabarty, Supervisor: Sakuntala Chatterjee, in University of Calcutta, in June, 2019
- 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 June, 2019

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- 7. Magneto-Fluorescent Transition Metal Oxide Nanostructures for Biomedical Application, Indranil Chakraborty, Supervisor: Kalyan Mandal, in University of Calcutta, in July, 2019
- 8. Investigation and Control of Gigahertz Frequency Spin Wave Dynamics in Magnonic Crystals, Samiran Choudhury, Supervisor: Anjan Barman, in Jadavpur University, in July, 2019
- Ultrafast Magnetization Dynamics in Ferromagnetic Thin Films, Heterostructures & Nanostructures, Sucheta Mondal, Supervisor: Anjan Barman, in Jadavpur University, in July, 2019
- 10. Investigation of Electronic and Thermal Transport and Opto-Electronic Properties of Single Germanium Nanowires, Shaili Sett, Supervisor: Arup K Raychaudhuri, in University of Calcutta, in July, 2019
- **11.** Photophysics and dynamics of complex chemical systems, Ejaj Tarif, Supervisor: Ranjit Biswas, in University of Calcutta, in July, 2019
- **12. Canonical Formulation of Fluid Dynamics,** Arpan Krishna Mitra, Supervisor: Rabin Banerjee, in University of Calcutta, in July, 2019
- 13. 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 July, 2019
- 14. Frustrated Magnetic Ladders: A DMRG Study, Debasmita Maiti, Supervisor: Manoranjan Kumar, in University of Calcutta, in July, 2019
- 15. 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 July, 2019
- 16. Nano Scale Control On The Properties Of Perovskite Type Oxide, Putul Malla Chowdhury, Supervisor: Arup K Raychaudhuri, in University of Calcutta, in August, 2019
- 17. The Effect of Spin-Orbit Coupling on Electronic Structure and Magnetism in Low Dimensional Compounds, Poonam Kumari, Supervisor: Priya Mahadevan, in University of Calcutta, in August, 2019
- **18.** Oxide Semiconductors for Energy Applications, Keshab Karmakar, Supervisor: Kalyan Mandal, in University of Calcutta, in August 2019

- 19. 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 August, 2019
- 20. Dynamics of Magnetic Flux Tubes in Advective Flows around Galactic and Extragalactic Black holes, Arnab Deb, Supervisor: Sandip K Chakrabarti, in University of Calcutta, in August, 2019
- **21. Electronic Structure Of Perovskites And Related Compounds**, Anita Halder, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in August, 2019
- 22. Photophysical Studies On Light Harvesting Nanomaterials For Improved Solar Energy Conversion, Jayita Patwari, Supervisor: Samir Kumar Pal, in University of Calcutta, in September, 2019
- 23. Investigation Of Metal Insulator Transition In 3D Transition Metal Oxides, Ravindra Singh Bisht, Supervisor: Arup K Raychaudhuri, in University of Calcutta, in September, 2019
- **24. Field Theoretic Approach to Gravity**, Subhasish Chakrabarty, Supervisor: Amitabha Lahiri, in University of Calcutta, in September, 2019
- **25. Sound velocity and internal friction in disordered magnetic alloys,** Md Sarowar Hossain, Supervisor: Pratip Kumar Mukhopadhyay, in University of Calcutta, in October, 2019
- **26. Quantum Correlations: Preservation And Applications,** Suchetana Goswami, Supervisor: Archan S Majumdar, in University of Calcutta, in November, 2019
- 27. Influence of Accretion Disk Size on Spectral and Timing Properties of Stellar Mass Black Holes, Arindam Ghosh, Supervisor: Sandip K Chakrabarti, in University of Calcutta, in December, 2019
- 28. Molecular Modeling and Design Towards Understanding Microscopic Insights of Biomolecular Structure and Function, Piya Patra, Supervisor: Jaydeb Chakrabarti & Raja Banerjee (MAKAUT), in MAKAUT, in December, 2019
- 29. Development of Microactuator Systems Basrd On The Photoinduced Microactuation Effect Found In Ferromagnetic Shape Memory Alloys, Abhishek Bagchi, Supervisor: Pratip Kumar Mukhopadhyay, in Jadavpur University, in February, 2020

Ph.D. AWARD RECEIVED

- 1. Spontaneous Evolution of Long-range Correlations in Dynamical Systems, Biplab Bhattacherjee, Supervisor: Subhrangshu S Manna, in University of Calcutta, in April, 2019
- Cavity Ring-Down Spectroscopy And Its Application To Biomedical Diagnostics, Gourab Dutta Banik, Supervisor: Manik Pradhan, in University of Calcutta, in April, 2019
- 3. Development and application of an optical gassensor based on cavity enhanced absorption spectroscopy using diode and quantum cascade lasers, Abhijit Maity, Supervisors: Manik Pradhan, in University of Calcutta, in May, 2019
- **4.** Field theories on curved spacetimes with **boundaries**, Fernandes Karan Arthur, Supervisor: Amitabha Lahiri, in University of Calcutta, in May, 2019
- 5. Investigation On The Structure And Dynamics Of Water Molecules Around Electrolytes And Biologically Important Molecules, Debasish Das Mahanta, Supervisor: Rajib Kumar Mitra, in University of Calcutta, in May, 2019
- A Study of Geometry, Physics and Integrability of Geodesics on Curved Spaces, Sumanto Chanda, Supervisor: Partha Guha, in University of Calcutta, in June, 2019
- Numerical Studies on the Dynamics of Soft Matter Systems, Suman Dutta, Supervisor: Jaydeb Chakrabarti, in University of Calcutta, in June, 2019
- 8. Effect of extra-cellular nutrient environment and intra-cellular biochemical conditions on the chemotactic performance of E. coli, Subrata Dev, Supervisor: Sakuntala Chatterjee, in University of Calcutta, in June, 2019
- **9.** Studies of fluctuations in systems of self-propelled particles, Subhadip Chakraborti, Supervisors: Punyabrata Pradhan, in University of Calcutta, in 2019
- 10. Synthesis of Inorganic-Organic Hybrid Nanocomposites For Environmental Application, Sankar Das, Supervisors: Subhra Jana & Gautam Gangopadhyay, in University of Calcutta, in July 2019
- 11. Coarsening, Steady-State And Phase Transition In Self-Propelled Particles, Rakesh Das, Supervisor Manoranjan Kumar, in University of Calcutta, in July, 2019

- 12. Theoretical Studies on Molecular Quantum Dynamics and Electron Transport, Anirban Karmakar, Supervisor: Gautam Gangopadhyay, in University of Calcutta, in September, 2019
- **13.** *Microscopic Insight To Protein Functions,* Sutapa Dutta, Supervisors: Jaydeb Chakrabarti & Mahua Ghosh, in University of Calcutta, in November, 2019
- 14. Mechanical And Electronic Properties of Technologically Important Materials, Poulami Chakraborty, Supervisor: Tanusri Saha Dasgupta, in University of Calcutta, in December, 2019
- **15. Aspects of Two Higgs Doublet Models,** Ambalika Biswas, Supervisor: Amitabha Lahiri, in University of Calcutta, in December, 2019
- 16. Some Studies Of The Brittle To Quasi-Brittle Transition In Fiber Bundle Models, Chandreyee Roy, Supervisor: Subhrangshu S Manna, in University of Calcutta, in December, 2019
- 17. Surface Modified Transition Metal Oxide based Magnetic Nanostructures for Intrinsic Fluorescence, Catalytic Properties and Drug Delivery, Souvanik Talukdar, Supervisor: Kalyan Mandal, in University of Calcutta, in January, 2020
- 18. Studies on Superconducting Pairing Mechanism in Low Dimensional Materials, Soumi Roy Chowdhury, Supervisor: Ranjan Chaudhury, in University of Calcutta, in February, 2020

PLACEMENT OF Ph.D STUDENTS

Probir Kumar Sarkar - Assistant Professor, Anandamohan College, WB

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

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

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

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

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

Ejaj Tarif - Visiting Researcher, SNBNCBS

Arpan Krishna Mitra - Postdoctoral Fellow, HRI, Allahabad

Sudipta Pattanayak - Visiting Researcher, SNBNCBS

Debasmita Maiti - Visiting Researcher, SNBNCBS

Ayan Bhattacharjee - Visiting Researcher, SNBNCBS

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

Poonam Kumari - Post-doctoral Reaearch Fellow, CRN-ICCOM, Pisa, Italy

Keshab Karmakar - Visiting Researcher, SNBNCBS

Mithun Pal - Visiting Researcher, SNBNCBS

Arnab Deb - Assistant Manager - Decision Sciences, HSBC, Financial Crime and Threat Mitigation Unit

Anita Halder - RA, TUE-CMS Project, SNBNCBS

Jayita Patwari - Visiting Researcher, SNBNCBS

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

Abhishek Bagchi - Scientist C, Technical Research Centre (TRC), SNBNCBS

Biplab Bhattacherjee - Visiting Postdoctoral Research Scholar, Institute of Physics, Bhubaneswar

Gourab Dutta Banik - PDF, University of Colorado, Boulder

Abhijit Maity - Scientist C, Technical Research Centre (TRC), SNBNCBS

Fernandes Karan Arthur - Postdoctoral Fellow, HRI, Allahabad

Debasish Das Mahanta - Postdoctoral Researcher, Ruhr University, Bochum, Germany

Sumanto Chanda - Postdoctoral Fellow, ICTS, Bangalore

Suman Dutta - CEFIPRA-PDF, Institute of Mathematical Sciences, Chennai

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

Sankar Das - Postdoctoral Research Fellow, University of Ulsan, South Korea

Rakesh Das - Postdoctoral Research Fellow, National University of Singapore, Singapore

Anirban Karmakar - Guest Faculty, Bankim Sardar College, WB / PG, Behala College, WB / PG, Midnapur City College, WB

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

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

Ambalika Biswas - Assistant Professor, Vivekananda College, Thakurpukur, WB

Chandreyee Roy - Post Doctoral Fellow, Institute of Mathematical Sciences, Chennai

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

SENIOR RESEARCH FELLOW

Supervisor

2013-2014:

- 1. Poonam Kumari (SNB) Priya Mahadevan till 31/07/2019 2. Rakesh Das (SNB) Manoranjan Kumar till 29/07/2019 3. Ravindra Singh Bisht (SNB) Arup Kumar Raychaudhuri till 31/07/2019 4. Sankar Das (SNB) Subhra Jana till 25/07/2019 5. Shaili Sett (SNB) Arup Kumar Raychaudhuri till 31/07/2019 2014-2015: 6. Anuvab Banerjee (SNB) Ramkrishna Das (O) 7. Atanu Baksi(CSIR) Ranjit Biswas 8. Debasmita Maiti (SNB) Manoranjan Kumar 9. Ejaj Tarif (SNB) Ranjit Biswas 10. Indranil Chakraborty (SNB) Kalyan Mandal till 09/01/2020 11. Juriti Rajbangshi (SNB) Ranjit Biswas 12. Priya Singh (SNB) Samir Kumar Pal till 31/12/2019
 - 13. Sudipta Pattanayak (SNB)

M. Sanjay Kumar

& Shradha Mishra

S N Bose National	Centre for	Basic Sciences
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14.	Suraka Bhattacharjee (INSPIRE	E) Manoranjan Kumar (O)	2016-2017:
15.	Joydeep Chatterjee (CSIR)	Priya Mahadevan	43. Piklu Santra (UGC) Ramkrishna Das (O)
16.	Sarowar Hossain (TWAS-BOSE)	Pratip Kumar Mukhopadhyay	44. Prantik Nandi (CSIR) Ramkrishna Das (O)
17	(111.04/10/2019)		45. Sk Imadul Islam (UGC) Rajib Kumar Mitra
17.	Anulekha De (IINSPIRE)	Anjan Barman & Rajib Kumar Mitra	46. Partha Nandi (SNB) Biswajit Chakraborty
18.	Damayanti Bagchi (INSPIRE)	Samir Kumar Pal	47. Subhamita Sengupta (UGC) Barnali Ghosh(Saha) (O)
	till 09/10/2019		48. Sumanti Patra (SNB) Priya Mahadevan
19.	Debabrata Ghorai (INSPIRE)	Sunandan Gangopadhyay & Biswajit Chakraborty	49. Sayan Kumar Pal (UGC) Biswajit Chakraborty
20.	Dhrimadri Khata (INSPIRE)	Soumen Mondal	50. Akash Das (UGC) Manik Pradhan
21.	Keshab Karmakar (INSPIRE)	Kalyan Mandal	51. Saikat Pal (CSIR) Rajib Kumar Mitra
22.	Mahebub Alam (INSPIRE)	Kalyan Mandal	52. Sasthi Charan Mandal (CSIR) Jaydeb Chakrabarti
23.	Mithun Pal (INSPIRE)	Manik Pradhan	53. Koushik Mandal (UGC) Manoranjan Kumar (O)
24.	Samrat Ghosh (INSPIRE)	Soumen Mondal	54. Priyanka Saha (INSPIRE) Kalyan Mandal
25.	Sucheta Mondal (INSPIRE)	Anjan Barman	55. Dipanjan Maity (CSIR) Kalyan Mandal
	till 10/10/2019		2017-2018:
26.	Sandip Saha (RGNF)	Gautam Gangopadhyay	56. Arka Chatterjee(INSPIRE) Samir Kumar Pal
27.	Tuhin Kumar Maji (INSPIRE)	Samir Kumar Pal	57. Edwine Tendong(TWAS-BOSE) Tanusri Saha Dasgupta
20	15-2016:		58. Souma Mazumdar(SNB) Partha Guha
28.	Kajal Kumbhakar (CSIR)	Ranjit Biswas	59. Anirban Mukherjee(INSPIRE) Punyabrata Pradhan
29.	Jayita Patwari (CSIR)	Samir Kumar Pal	60. Shubhadip Moulik Atindra Nath Pal
30.	Aniruddha Adhikari (SNB)	Samir Kumar Pal	61. Vishal Kumar Aggarwal(SNB) Arup Kumar Raychaudhuri
31.	Chandan Samanta (SNB)	Barnali Ghosh (Saha)	& Manik Pradhan
32.	Avisek Maity (SNB)	Barnali Ghosh (Saha)	62. Arundhati Adhikari(SNB) Anjan Barman
33.	Rahul Bandyopadhyay (SNB)	Ramkrishna Das	63. Parushottam Maji (SNB) Arup Kumar Raychaudhuri & Barnali Ghosh (Saha)
34.	Alik Panja (SNB)	Soumen Mondal	64. Didhiti Bhattacharya (SNB) Samit Kumar Ray
35.	Arnab Sarkar (SNB)	Archan S Majumdar	& Rajib Kumar Mitra
36.	Shounak Datta (INSPIRE)	Archan S Majumdar	65. Koustav Dutta(INSPIRE) Anjan Barman
37.	Dipika Mandal (CSIR)	Kalyan Mandal	66. Amrit Kumar Mondal(SNB) Anjan Barman
38.	Subrata Ghosh (CSIR)	Kalyan Mandal	67. Sk Saniur Rahaman(UGC) Manoranjan Kumar & M. Sanjay Kumar
39.	Sudip Kumar Saha (INSPIRE)	Manoranjan Kumar	68. Rituparna Mandal(INSPIRE) Sunandan Gangopadhyay
40.	Shreya Das (INSPIRE)	Tanusri Saha Dasgupta	69. Abhik Ghosh Moulik (INSPIRE) Javdeb Chakrabarti
41.	Bihalan Bhattacharya (INSPIRE	E) Archan S Majumdar	70. Arpan Bera (CSIR) Samir Kumar Pal
42.	Suchetana Goswami (SNB)	Archan S Majumdar	71. Biswajit Pabi (INSPIRE) Atindra Nath pal

Annual Report 2019-20

72. Dhrubajyoti Majhi(INSPIRE)	Ranjit Biswas	100. Somashree Ghosal(CSIR)	Manoranjan Kumar
73. Indrani Kar (SNB)	Thirupathaiah Setti	101. Krishnendu Sinha(SNB)	Suman Chakraborty
74. Jayanta Mondal (INSPIRE)	Ranjit Biswas	102. Amrita Mondal(SNB)	Ranjit Biswas
75. Rafiqul Alam (INSPIRE)	Atindra Nath Pal	103. Subhajit Singha(SNB)	Rajib Kumar Mitra
76. Rahul Karmakar (INSPIRE)	Jaydeb Chakrabarti	104. Soma Dutta(SNB)	Anjan Barman
77. Shuvrasish Mukherjee (INSPIRE) Samit Kumar Ray	105. Kanchan Meena(CSIR)	Prosenjit Singha Deo
	& Atindra Nath Pal	106. Sreya Pal(CSIR)	Anjan Barman
78. Siddhartha Biswas (INSPIRE)	Soumen Mondal	107. Ram Krishna Patra(CSIR)	Archan S Majumdar
JUNIOR RESEARCH FELL	WC		& Manik Banik
2018-2019:		108. S. Adarsh (SNB)	M. Sanjay Kumar & Manoranjan Kumar
79. Sumana Pyne (SNB)	Rajib Kumar Mitra	109. Krishanu Mondal (SNB)	Gautam Gangopadhyay
80. Dipanjan Mukherjee (SNB)	Samir Kumar Pal	110. Manodip Routh(SNB)	Manoranjan Kumar
81. Biswajit Panda (SNB)	Manik Pradhan	111. Abhinandan Das (SNB)	Suman Chakraborty
82. Narayan Chandra Maity (CSIR)	Ranjit Biswas	112. Sk Jeesun(SNB)	Kalyan Mandal
83. Shobhan Dev Mandal (CSIR)	Sakuntala Chetterjee	113. Subhajit Kar(SNB)	Ramkrishna Das
84. Premashis Kumar (SNB)	Gautam Gangopadhyay	114. Anirban Paul(SNB)	Jaydeb Chakrabarti
85. Anish Das (SNB)	Biswajit Chakraborty	116. Samrat Sen(SNB)	Archan S Majumdar
86. Md Nur Hasan (CSIR)	Samir Kumar Pal		& Manik Banik
87. Tanmoy Chakraborty (CSIR)	Punyabrata Pradhan	117. Ardhendu Pal(SNB)	Manik Pradhan
88. Susmita Mondal (SNB)	Samir Kumar Pal	118. Gesesew Reta Habtie (TWAS-BOSI	E) Archan S Majumdar
89. Deepsikha Das (SNB)	Sakuntala Chetterjee & Punyabrata Pradhan	RESEARCH SCHOLARS	-
90. Prasun Boyal (CSIR)	Priya Mahadevan	INTEGRATED Ph.D. PRO	JGRAMME

91. Debayan Mondal (CSIR)

94. Siddharth Kumar Sahoo

95. Susmita Changdar (UGC)

96. Pratap Kumar Pal (CSIR)

97. Shivam Mishra (INSPIRE)

98. Krishnendu Patra (SNB)

till Dec 2018

2019-2020:

99. Ria Saha(SNB)

93. Monalisa Chatterjee (INSPIRE)

92. Jyotirmoy Sau (UGC)

Priya Mahadevan	SENIOR RESEARCH FELLO	W Supervisor
Manoranjan Kumar	2011–2012:	
Manoranjan Kumar	119. Anita Halder (SNB) till 31.07.2019	Tanusri Saha Dasgupta
Thirupathaiah Setti	120. Chandreyee Roy (SNB) till 28.05.2019	Subhrangshu Sekhar Manna
Thirupathaiah Setti Anjan Barman	121. Debasish Das Mahanta (INSP till 23/07/2019	IRE) Rajib Kumar Mitra
Priya Mahadevan	122. Shauri Chakrabarty (SNB) till 30/04/2019	Sakuntala Chatterjee
	2013–2014:	
Priya Mahadevan	123. Ayan Bhattacharjee (SNB)	Sandip Kumar Chakrabarti
Rajib Kumar Mitra	124. Monalisa Singh Roy (SNB)	Manoranjan Kumar

125. Samiran Choudhury (SNE	B) Anjan Barman	2017-2018:	
till 12/01/2020		148. Nivedita Pan	Samir kumar Pal
2014–2015:		149. Riju Pal	Atin pal
126. Ankan Pandey (SNB)	Partha Guha	150. Samir Rom	Tanusri Saha Dasgupta
127. Avinash Kumar Chaurasiya	(INSPIRE) Anjan Barman	151. Shubham Purwar	Thirupathaiah Setti
128. Riddhi Chatterjee (SNB)	Archan S Majumdar	152. Manjari Dutta	Sunanadan Gangopadhyay
129. Sanchi Maithani (INSPIRE)	Manik Pradhan		
2015–2016:		PRUJECI FELLUWS / A	55151AN157
130. Ananda Gopal Maity(SNB)	Archan S Majumdar	2016 2017	Dusta et Di
131. Arunava Adak (SNB) till 16/07/2019	Jaydeb Chakrabarti	153. Arnab Samanta (Project JF	RF) Subhra Jana
132. Ruchi Pandey (SNB)	Ramkrishna Das	2017-2018	
133. Sourav Sahoo (SNB)	Anjan Barman	154. Sudipta Chatterjee (Project SRF)	Barnali Ghosh (Saha)
2016–2017:		155 Anirhan Goswami	Barnali Ghosh (Saha)
134. Anupam Gorai(SNB)	Kalyan Mandal	(Project SRF)	Damai Onosii (Jana)
135. Atul Rathod(SNB)	Manu Mathur	2018-2019	
136. Shantonu Mukherjee(SNB	3) Amitabha Lahiri	156. Sourav Kanthal (Project JF	KF) Anjan Barman &
137. Shashank Gupta(SNB)	Archan S Majumdar	till 25.07.2019	Tanusri saha DasGupta
138. Sudip Majumdar (SNB)	Anjan Barman & Rajib Kumar Mitra	157. Saikat Mitra (Project JRF)	Barnali Ghosh (saha) & Manik Pradhan
139. Surya Narayan Panda (SN	IB) Anjan Barman	158. Suman Mondal (Project As till 31/07/2019	sistant) Tatini Rakshit
140. Swarnali Hait (SNB)	Kalyan Mandal	159. Debashish Pal (Project Ass	istant) Tatini Rakshit
JUNIOR RESEARCH FE	LLOW	2019-2020	
2016-2017:		160. Aathira K. P. (Project JRF)	Priya Mahadevan
141. Achintya Low	Thirupathaiah Setti	161. Samir Rom (Project JRF)	Tanusri Saha Dasgupta
142. Ankur Srivastav	Sunandan Gangopadhyay	162. A. Darshana Yazhini	Anup Ghosh
143. Anwesha Chakraborty	Biswajit Chakraborty	(Project Assistant)	
144. Megha Dave till 10/09/2019	Ramkrishna Das	163. Suranjana Chakrabarty (Project Assistant)	Anup Ghosh
145. Raghvendra Pandey till	Tanusri Saha Dasgupta	164. Raj Kumar Sadhu (Project S till 31/08/2019	SRF) Sakuntala Chatterjee
146. Sayan Routh	Thirupathaiah Setti	165. Arun Kumar Das (Project J	RF) Archan S Majumdar
147. Neeraj Kumar	Sunandan Gangopadhyay	166. Subhankar Bera (Project J	RF) Archan S Majumdar

Project PI RF) Subhra Jana Barnali Ghosh (Saha) Barnali Ghosh (Saha) RF) Anjan Barman & Tanusri saha DasGupta Barnali Ghosh (saha) & Manik Pradhan Tatini Rakshit sistant) Tatini Rakshit istant) Priya Mahadevan Tanusri Saha Dasgupta Anup Ghosh Anup Ghosh SRF) Sakuntala Chatterjee RF) Archan S Majumdar

INTEGRATED Ph.D. PROGRAMME

2018-2019

- 167. Soham Saha
- 168. Gaurav I Patel
- 169. Varsha Jangir
- 170. Ankita Rojario
- 171. Animesh Hazra
- 172. Avik Sasmal
- 173. Ishita Jana
- 174. Shubham Shukla
- 175. Anirban Roychowdury
- 176. Soumen Mondal
- 178. Rajdeep Biswas
- 179. Arnab Chakraborty
- 180. Vishwajeet Kumar

2019-20

- 181. Ajay Sharma
- 182. Arnab Paul
- 183. Banik Rai
- 184. Dibyendu Maity
- 185. J Sridhar Mohanty
- 186. Jayarshi Bhattacharya
- 187. Kaliprasanna Majumdar
- 188. Ram Surya Sri Shourie
- 189. Sagar Kumar Maity
- 190. Soham Sen
- 191. Soumyabrata Hazra
- 192. Saurav Kantha

PART TIME RESEARCH SCHOLARS - Ph.D. PROGRAMME

- 1. Abhishek Bagchi, Condensed Matter Physics and Material Sciences, under Pratip K. Mukhopadhyay (Thesis submission: February 2020)
- Piya Patra, Chemical, Biological & Macro-Molecular Sciences, under Jaydeb Chakrabarti (Thesis submission: December 2019)
- 3. Putul Chakravorty (Malla Chowdhury), Condensed Matter Physics and Material Sciences, under Arup Kumar Raychaudhuri, Current Affiliation: School Service, WB (Thesis submission: August 2019)
- Samik Roy Moulik, Condensed Matter Physics & Material Sciences, under Barnali Ghosh (Saha), Current Affiliation: Icon Analytical Equipment Pvt. Ltd., Mumbai (Thesis submission : September 2018)
- 5. Shirsendu Dey, Theoretical Sciences, under Rabin Banerjee, Current Affiliation: Kalyani Govt. Engineering College
- 6. Soumendra Singh, Chemical, Biological & Macro-Molecular Sciences, under Samir K Pal, Current Affiliation: Bose Institute
- 7. Pratik Tarafdar, Theoretical Sciences, under Amitabha Lahiri (Thesis submission: May 2019)
- 8. Santanu Pan, Condensed Matter Physics & Material Sciences, under Anjan Barman
- 9. Kartik Adhikari, Condensed Matter Physics & Material Sciences, under Anjan Barman
- 10. Subhashis chakrabarty, Theoretical Sciences, under Amitabha Lahiri (Thesis Submission :September 2019)
- 11. J. Wellington, IIT Delhi, Condensed Matter Physics & Material Sciences, under Samit Kumar Ray
- 12. Sourav karar, Astrophysics & Cosmology, under Archan S Majumdar & Sunandan Gangopadhyay

PROJECT RESEARCH

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

Name	Affiliation	Course of Study	Supervisor/Mentor
Sipra Sinha	Diamond Harbour Women's University	M.Sc.	Dr. Soumen Mondal
Simantini Maiti	Diamond Harbour Women's University	M.Sc.	Dr. Soumen Mondal
Swagata Mukhopadhyay	Diamond Harbour Women's University	M.Sc.	Dr. Soumen Mondal
Pallabi Saha	Diamond Harbour Women's University	M.Sc.	Dr. Soumen Mondal
Vhaskar Chakraborty	Ramakrishna Mission Residential College, Narendrapur	M.Sc.	Dr. Ramkrishna Das
Riya Paul	Jadavpur University	M.Sc.	Dr. Manik Pradhan
Shreya Dey	Jadavpur University	M.Sc.	Dr. Manik Pradhan
Aheli Dey	Jadavpur University	M.Sc.	Dr. Manik Pradhan
Brateen Datta	Kalinga Institute of Industrial Technology(KIIT)	B.tech and M.tech dual degree	Dr. Tatini Rakshit
Dipranjan Chatterjee	Central University of Karnataka (CUK)	M.Sc.	Dr. M. Sanjay Kumar
Soumyaranjan Ratha	VIT, Vellore	M.Sc.	Dr. Barnali Ghosh(Saha)
Tiyasa Kar	SVNIT, Surat	M.Sc.	Prof. Biswajit Chakraborty
Monalisa Yadav	IISER Kolkata	BS-MS	Dr. Barnali Ghosh(Saha)
Archishman Saha	ISERC, Visva Bharati	B.Sc.	Prof. Partha Guha
Oindrila Sinha	Presidency University	B.Sc.	Prof. Samir Kumar Pal
Aman Soni	Jawaharlal Nehru University	M.Sc.	Prof. S S Manna
Sourav Maity	Mahishadal Raj College	B.Sc.	Prof. Anjan Barman
Surajit Basak	Jadavpur University	M.Sc.	Prof. Arup Kumar Raychaudhuri,
Kankana Bhattacharjee	National Institute of Technology, Agartala	BS-MS	Dr. Suman Chakrabarty
Surender Kumar	Central University of Haryana	M.Sc.	Prof. Priya Mahadevan
Gaurav Kumar Arya	Central University of Haryana	M.Sc.	Prof. Arup Kumar Raychaudhuri and Dr. Barnali Ghosh(Saha)
Tamanna Kumari	Central University of Haryana	M.Sc.	Prof. Arup Kumar Raychaudhuri and Dr. Barnali Ghosh(Saha)

SUMMER RESEARCH PROGRAMME:

SI	Name	Affiliation	Joined under dept. at SNB	Supervisor at SNB
1	Sumit Rout	International Institute of Information Technology Gachibowli, Hyderabad	AC	Manik Banik
2	Ayan Kumar Nai	IIT Kanpur	AC	Archan S Majumdar
3	Swati Bedi	IIT Kharagpur	CBMS	Rajib Kumar Mitra
4	Komal Punia	IIT Roorkee	CMP&MS	Priya Mahadevan

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SI	Name	Affiliation	Joined under dept. at SNB	Supervisor at SNB
5	Surender Kumar	Central University Of Haryana	CMP&MS	Priya Mahadevan
6	Kajal Tiwari	NISER	CMP&MS	Anjan Barman
7	Sankarshan Sahu	IIEST, Shibpur	TS	Biswajit Chakraborty
8	Alisha Haiderali Marchawala	The Maharaja Sayajirao University of Baroda	CBMS	Samir Kumar Pal
9	Navaneeth P K	Central University of Karnataka	AC	Soumen Mondal
10	Nopu Ongay Bhutia	IIT Kharagpur	CMP&MS	Kalyan Mandal
11	Ashith T	Central University of Tamil Nadu	CBMS	Jaydeb Chakrabarti
12	Shouvik Sadhukhan	IIT Kharagpur	AC	Ramkrishna Das
13	Pranay Sampat	IIT BHU	CMP&MS	Manoranjan Kumar
14	R.Mahalakshmi	Bharathidasan university	CMP&MS	Samit Kumar Ray
15	Hariram M.	Bharathidasan University	CMP&MS	Madhuri Mandal
16	Kanishga Amudha	Bharathidasan university	CBMS	Subhra Jana
17	P. Gayathri	Bharathidasan University	CMP&MS	Anup Ghosh
18	Saptarshi Biswas	IISER Kolkata	TS	Biswajit Chakraborty
19	Anil Behera	Gautam Buddha University	CBMS	Manik Pradhan
20	Soban Bakhtiyar	NIT, Trichy	TS	Sunandan Gangopadhyay
21	Mohammad Mudasir Khan	Ghulam Shah Badshah University, Rajouri	CMP&MS	Thirupathaiah Setti
22	Daisy Gogoi	Cotton University	CMP&MS	Anjan Barman
23	Abhinaba Sarkar	University of Calcutta	CBMS	Samir Kumar Pal
24	Samya Roychowdhury	IISER Kolkata	TS	Amitabha Lahiri
25	Kritina Boro	Tezpur University	CBMS	Gautam Gangopadhyay
26	Aniruddha Seal	National Institute Of Science Education and Research, Bhubaneswar	CBMS	Suman Chakrabarty,
27	Amal Mendalz	Christ University	CMP&MS	Milan Kumar Sanyal

Biswayit Chakvabaty

Biswajit Chakraborty Dean, Academic Programme

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EXTENDED VISITORS AND LINKAGE PROGRAMME

[Period: 1st April 2019 to 31st March 2020]

SEMINAR AND COLLOQUIA PROGRAMME

5th Chandrasekhar Memorial Lecture

Speaker: **Professor Somak Raychaudhury**, Director-IUCAA Date: **29/11/2019** Title of the Talk: Observing Black Holes: Reality and Myth

14th C. K. Majumdar Memorial Lecture

Speaker: **Professor Ganapathy Baskaran**, Emeritus Professor, IMSc., Chennai Date: **10/12/2019** Title of the Talk: *Art of Model Building in Quantum world*

24th S. N. Bose Memorial Lecture

Speaker: Professor Supriyo Datta,

Thomas Duncan Distinguished Professor of Electrical and Computer Engineering, Purdue University, USA

Date: **01/01/2020** Title of the Talk: Mesoscopic Physics: A New Perspective on Transport

5th G. N. Ramachandran Memorial Lecture

Speaker: Professor Daan Frenkel, Department of Chemistry, University of Cambridge

Date: 13/02/2020

Title of the Talk: Counting the uncountable: Entropy, Granular Entropy and Information

Date	Speaker & Affiliati	on Speaker & Affiliation	Торіс
17/07/2019 IEEE Distinguished Lecture		ed Prof. Hyunsoo Yang Department of Electrical and Computer Engineering, National University of Singapore, Singapore	Spin-Orbit Technologies: From Magnetic Memory to Terahertz Generation
Seminar Typ	e Date	Speaker & Affiliation	Title
Bose Colloquium	10/04/2019	Prof. Somdatta Sinha IISER Mohali	Modelling Infectious Disease - from genomes to populations
Bose Colloquium	12/04/2019	Prof. David Logan University of Oxford, UK and IISc Bangalore	Percolation in Fock space and many-body localization
Bose Colloquium	19/07/2019	Dr. Dipankar Saha Secretary, International Association of Hydrogeologist - India Chapter	Groundwater- the life line of India is in peril

Seminar Type	Date	Speaker & Affiliation	Title
Bose Colloquium	21/08/2019	Dr. Sujoy Roy Advanced Light Source, Lawrence Berkeley National Laboratory	Shining coherent X-rays on topological magnetic texture: Insight into static and fluctuating properties of skyrmions
Bose Colloquium	10/01/2020	Prof. Sriram Rajagopal Ramaswamy Department of Physics, Indian Institute of Science, Bengaluru	A Journey Through Active Matter
Bose Colloquium	21/02/2020	Prof. Vikram Tripathi, Tata Institute of Fundamental Research, Mumbai	Electronic instabilities in a 'flat' topological band: the case of tin telluride
Institute Seminar	04/07/2019	Prof. Dipak K. Palit Emeritus Professor, Centre for Excellence in Basic Sciences, Mumbai	Excitation Dynamics in Organic Nanoaggregates
Institute Seminar	01/11/2019	Ms. Aishani Ghosal Inorganic and Physical Chemistry Department, IISc,Bangalore	Theoretical studies of the non- equilibrium statistical mechanics of colloidal and polymeric systems at the single molecule level
Institute Seminar	04/11/2019	Dr. Aditya N Roy Choudhury, Visiting Associate (Post Doctoral), SNBNCBS	Nonlocal vortex dynamics in type II superconducting thin films - effects of low rigidity
Institute Seminar	19/11/2019	Prof. Mukunda P Das, Department of Theoretical Physics, RSPE, The Australian National University, Canberra	Surprises, Puzzles and Ongoing Discoveries on Superconductivity in Condensed Matter Sciences
Institute Seminar	09/12/2020	Mr. Anubhav Chaturvedi University of Gdańsk	Unifying quantum theory's ontological (hidden variable) incompatibility

Lecture Series on "Spectroscopy"

by Prof. Dipak K. Palit, Emeritus Professor, Centre for Excellence in Basic Sciences, Mumbai

1) Ultrafast Spectroscopy: principles and instrumentation

2) Non-linear Spectroscopy

ADVANCED POSTDOCTORAL MANPOWER PROGRAMME (APMP)

SI. No.	Name	Status	Mentor / Department
1	Aayatti Mallick Gupta (from 16.12.2019)	PDRA-I	Prof. jaydeb Chakrabarti / CBMS
2	Amit Kumawat (from 16.09.2019)	RA-I (Adhoc)	Dr. Suman Chakrabarty / CBMS
3	Amit Mukherjee (from 06.09.2019)	PDRA-I	Prof. Archan S. Majumdar / A&C
4	Anita Halder (from 03.09.2019)	RA-I (TUECMS)	Prof. Tanusri Saha Dasgupta / CMPMS
5	Arka Chatterjee	PDRA-I	Dr. Soumen Mondal / A&C
6	Arka Dey	PDRA-I	Prof. Samit Kumar Ray / CMPMS
7	Arnab Ghosh	PDRA-II	Dr. Barnali Ghosh (Saha) / CMPMS
8	Arpan Bhattacharyya (from 11.12.2019)	PDRA-I	Prof. Anjan Barman / CMP&MS
9	Arpan Maiti (from 21.08.2019)	PDRA-I	Dr. Manik Pradhan / CBMS
10	Arun Bera	PDRA-I	Prof. Arup Kumar Raychaudhuri & Dr. Manik Pradhan / CMPMS
11	Arup Roy (from 13.05.2019)	PDRA-I	Dr. Manik Banik & Prof. Archan S. Majumdar / A&C

Sl. No.	Name	Status	Mentor / Department
12	Avijit Sen (from 26.08.2019 to 23.12.2019)	PDRA-II	Prof. Debashis Mukherjee / CBMS
13	Ayana Mukhopadhyay (from 22.08.2019)	PDRA-I	Dr. Thirupathaiah Setti / CMPMS
14	Basant Roondhe (from 03.02.2020)	RA-I (Adhoc) (TUECMS)	Prof. Tanusri Saha Dasgupta / CMPMS
15	Bibhab Bandhu Majumder (from 21.08.2019)	PDRA-I	Prof. Rajib Kumar Mitra / CBMS
16	Buddhadeb Pal (from 20.08.2019)	PDRA-I	Dr. Atindra Nath Pal / CMPMS
17	Chaitrali Sengupta (till 31.07.2019)	PDRA-I	Prof. Rajib Kumar Mitra / CBMS
18	Deepika Shrivastava (till 05.04.2019)	PDRA-I	Prof. Partha Guha / CMPMS
19	Dharmesh Jain (from 01.10.2019)	PDRA-III	Dr. Sunandan Gangopadhyay / TS
20	Gulmi Chakraborty (till 31.05.2019)	PDRA-I	Prof. Samir Kumar Pal / CBMS
21	Ipsita Basu (from 03.09.2019)	PDRA-II	Dr. Suman Chakrabarty / CBMS
22	Joy Prakash Das (from 20.02.2020)	PDRA-I	Dr. Manoranjan Kumar / CMPMS
23	Kumar Das	PDRA-I	Prof. Biswajit Chakrabarty / TS
24	Mantu Santra (till 26.12.2019)	PDRA-III	Dr. Suman Chakrabarty / CBMS
25	Prasanta Kundu (till 19.03.2020)	PDRA-I	Prof. Gautam Gangopadhyay / CBMS
26	Priyanka Garg (from 05.02.2020)	PDRA-I	Prof. Priya Mahadevan / CMPMS
27	Sandeep Agarwal (till 30.08.2019)	PDRA-III	Prof. Anjan Barman / CMPMS
28	Shauri Chakrabarty (from 02.09.2019 to 30.10.2019)	RA-I (Adhoc) (TUECMS)	Dr. Sakuntala Chatterjee / TS
29	Sirshendu Dinda (till 14.02.2020)	PDRA-I	Prof. Ranjit Biswas / CBMS
30	Srabantika Ghose (till 14.02.2020)	PDRA-I	Prof. Kalyan Mandal / CMPMS
31	Suman Chakraborty (till 14.02.2020)	PDRA-I	Dr. Ramkrishna Das / A&C
32	Supriyo Dutta (till 19.11.2019)	PDRA-I	Prof. Partha Guha / TS
33	V. Yogesh (from 06.09.2019)	PDRA-I	Dr. M. Sanjay Kumar / TS

Senior Research Associates (CSIR funded)

SI. No.	Name	Status	Mentor / Department
1	Alo Dutta (from 07.01.2020)	CMPMS	Prof. Kalyan Mandal
2	Sayan Bayan	CMPMS	Prof. Samit Kumar Ray / CMPMS

A&C: Department of Astrophysics & Cosmology

CBMS: Department of Chemical, Biological & Macro-Molecular Sciences

CMPMS: Department of Condensed Matter Physics and Material Sciences

TS: Department of Theoretical Sciences

VISITOR, ASSOCIATES AND STUDENTS PROGRAMME

Short Term Visitors

Nome of the Visitor	Affiliation / Last Attended	Period of stay		Host Faculty/
Name of the visitor	Institution	Date From	Date to	Department
Dr. Some Shankar Bhattacharyya (Short term visitor)	Post Doc Fellow, University Of Hong Kong	01.04.2019	19.04.2019	Dr. Manik Banik
Dr. Bikash Chandra Paul (Short term visitor)	University Of North Bengal	09.04.2019	15.04.2019	Prof. A.S. Majumdar
Dr. Amit Mukherjee (Short term visitor)	Post Doc Fellow, IMSc.	16.04.2019	30.04.2019	Dr. Manik Banik
Mr. Pallab Basuri (Short term visitor)	SRF , IIT Madras	23.04.2019	02.05.2019	Prof. Jaydeb Chakraborti
Ms. Ayana Mukhopadhyay (Short term visitor)	IIT, Bhubaneswar	10.05.2019	24.05.2019	Dr. Tirupattaih Setti
Dr. Samapan Sikdar (Visiting Associate- Post Doc)	PDRA, University of Oklahoma 101 Stephenson Parkway, Norman, OK 73019	21.01.2019	20.04.2019	Prof. Jaydeb Chakraborty
Dr. Kallol Mukherjee (Visiting Associate- Post Doc)	RUB, Boehum, Germany	01.02.2019	30.04.2019	Prof. Ranjit Biswas &Prof. Anjan Barman
Dr. Amit Rai (Short term visitor)	NIT, Raurkela	08.07.2019	13.07.2019	Dr. M. Sanjay Kumar
Professor Dipak Kumar Palit (Senior Associate)	Emeritus Professor, UM-DAE centre for Excellence in Basic Sciences	18.06.2019	06.7.2019	Prof. Rajib Kumar Mitra
Professor Ramesh Anishetty (Short term visitor)	Emeritus Professor, IMSc. Chennai	10.7.2019	20.7.2019	Prof. Manu Mathur
Dr. Bikash Chandra Paul	Physics Department, North Bengal University	09.4.2019 & 24.9.2019	15.04.2019 & 26.9.2019	Archan S. Majumdar
Prof. Biman Bagchi	IISC, Bangalore	09.10.2019	11.10.2019	Ranjit Biswas
Dr. Karan Fernandes	PDF , HRI Allahabad	15.10.2019	18.10.2019	Amitabha Lahiri
Dr. Sujit sarkar	Associate Professor, PISR, Bangalore	18.10.2019	02.11.2019	P. Singh Deo.
Dr. Kumar Abhinav	Lecturer, IF Naresuan University, Thailand	27.10.2019	31.10.2019	Partha Guha
Dr. Samaday Choudhury	Macquarie University, Sydney, Australia	18.12.2019	20.12.2019	Soumen Mondal
Dr. Arpan Bahttacharyya (Visiting Associate- Post Doc)	Post Doctoral Fellow,SINP	01.07.2019	28.09.2019	Anjan Barman
Mr Joyprakash Das	PhD. Scholar ,IIT Guwahati	27.05.2019	30.05 2019	Manoranjan Kumar
Dr. Sreeraj T.P (Visiting Associate- Post Doc)	Post Doctoral Fellow , IMSc.	20.4.2019	24.07.2019	Manu Mathur
Dr. Samapan Sikdar (Visiting Associate- Post Doc)	Post Doctoral Fellow, University of Oklahoma, USA	21.1.2019	20.04.2019	Jaydeb Chakraborti
Dr. Som Sankar Bhattacharya	Post Doctoral Fellow University of Hongkong	01.04.2019	19.04.2019	Manik Banik
Mr. Pallab Basuri	SRF , IIT Madras	23.04.2019	02.05.2019	Jaydeb Chakraborti
Dr. Amit Mukherjee	Post Doctoral Fellow , IMSc.	16.4.2019	30.4.2019	Manik Banik

BOSE FEST

The Center Celebrated the **BOSE FEST 2020 – The Annual Science Celebration & Alumni Day** of the Center during 24-25 January, 2020 with great enthusiasm. The invited folk band *Bolepur Bluez* has performed with his musical troupe followed by in-house cultural programme by the students and staff members of the Centre, coordinated by Muktangan Performing Arts Group.

PROGRAMME (CWEP) FROM 01.04.2019 TO 31.03.2020 FOR THE ANNUAL REPORT

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

- 1. A two-days discussion meeting on "Nonlinear Dynamics in Chemistry and Biology (NLDCB)" held at the Centre during 08-09 April, 2019. Convener: Prof. Gautam Gangopadhyay, Co-Convener: Prof. Partha Guha.
- 2. C.K. Majumdar Memorial Summer Workshop in Physics, 2019 held at the Centre during 28 May to 07 June, 2019. Convener: Dr. Saswati Dasgupta, Former Teacher-in-charge, Rammohan College, Kolkata and Member, Indian Association of Physics Teachers, Regional Council-15, Kolkata. Co-Convener: Prof. Kalyan Mandal, SNBNCBS.
- **3.** A workshop on "Nanolithography and Nanofabrication" on 09 July, 2019 followed by a Discussion Meeting on 10 July, 2019 was joined organized by the Centre with Raith India Pvt. Ltd. Convener: Mr. Masum Khan, CEO, Raith India Pvt. Ltd., Co-Convener: Dr. Atindra Nath pal, SNBNCBS.

- 4. A Three-days International Conference on Current Trends in Materials Science and Engineering was jointly organized by the Centre with Institute of Engineering & Management, Kolkata during 18–20 July, 2019. There was no financial requirement by the organizers, the Centre only provided the infrastructure. Convener: Prof. Saswati Barman and Prof. Ruchira Mukherjee, Institute of Engineering & Management. Co-Convener: Prof. Anjan Barman and Prof. Rajib Mitra, SNBNCBS.
- 5. A two-days conference on "Flatlands and Beyond (2019) – A meet on 2D materials" was held at the Centre during 05-06 September, 2019. Conveners: Prof. Priya Mahadevan and Dr. Atindra Nath Pal.
- 6. A three days National Conference on Electronic Structure (NCES-2019) was held during 27-29 November, 2019 at the Centre. Convener: Dr. Thirupathaiah Setti.
- 7. A discussion meeting on "Young Investigator Meet on Quantum Condensed Matter Theory" held during 11-13 December, 2019 at the Centre. Convener: Dr. Manoranjan Kumar.
- 8. The XXth International Workshop on Physics of Semiconductor Devices: IWPSD-2019 was held during 17-20 December, 2019 at Novotel Hotel and Residences, Newtown, Kolkata. Chairman of the workshop : Prof. Samit K. Ray, Director, SNBNCBS.
- 9. International Conference on Nano Science and Technology (ICONSAT-2020) was held during March 5-7, 2020 at Biswa Bangla Convention Centre, New Town, Kolkata, under the aegis of DST Nanomission, Govt. of India. Chairman of he Conference : Prof. Samit K. Ray, Director, SNBNCBS.

Outreach Activities

India International Science Festival 2019 (IISF 2019):

IISF 2019 organized at Kolkata during 5 - 8 November, 2019, at the Science City Kolkata. A Series of 29 Programs, including Foreign Ministers' Conclave; Scientific Conferences; Scientists' Interactions with Students, Public and Industrialists; A Mega Science, Technology & Industry Expo with many innovative competitions were conducted as part of IISF 2019 Celebrations.

The Mega Science Expo highlighted of IISF 2019, showcasing the achievements and success stories of Indian Scientific Organizations, R & D Labs and Indian Industry; with a focus on the flagship programmes undertaken by GOI during last five years.

IISF-2019 Curtain Raiser Ceremony, Public Outreach Day celebrated on 18/10/2019 at Silver Jubilee Hall, S N Bose National Centre for Basic Sciences.

Participating Institutes:

- Maharajadhiraj Uday Chand Women's College
- Vivekananda College, Thakurpukur
- Ramakrishna Mission Residential College, Narendrapur
- Lady Brabourne College
- St. Xavier's College, Kolkata
- Ramakrishna Mission Vivekananda Educational and Research Institute
- Jadavpur University

University of Calcutta

The North East Students' Conclave as a part of IISF 2019 was organized by the Centre at Biswa Bangla Convention Centre, Hall No. 3 during 7-8th November, 2019. Nearly 180 school students from 08 different NE states of the Country visited the Centre as a part of this event.

105th Indian Science Congress at Bangalore

The Centre participated in the recent ISC at Bangalore from 3^{rd} -7th January 2020. Four students from different department showcased the activities of the Centre at ISC.

Scholars of the Centre also participated at Science Fairs namely Acharya Satyendranath Basu Bijnan 'O' Projukti Mela at Hedua Park, Kolkata and Science & Cultural Fair 2020 at Belgharia.

11th Vidyasagar –Satyendra Nath Bose National Workshop " Physics of Novel Functional Materials" (PNFM-2020)

Duration: 8th -10th Jaunary, 2020; Supported by SNBNCBS from TPSC Grant. Almost more than 200 Participants including UG & PG students, research scholars, college & university teachers.

National Science Day celebrated on 28th February 2020 at the Centre about 100 college students participated the day long programme of popular Scientific lectures by Prof. Sudipta Sengupta, (Santiswarup Bhatnagar awardee), Dr. Suprakash Roy(Editor –in –chief, Science & Culture), visit to newly inaugurated "Bose Archive" and different research laboratories.

Alibelit Kova

Nibedita Konar

Debarkish Schettachije

Debashish Bhattacharjee

Rupan Porel

Rupam Porel

Celebration of 127th Birth Anniversary of S N Bose



127th Birth Anniversary of S. N. Bose celebrated on 1st January 2020. The new Bose Archive and Museum was opened for public in presence of S. N. Bose's family members



24th S. N. Bose Memorial Lecture delivered by Professor Supriyo Datta on "Mesoscopic Physics: A New Perspective on Transport on 1st January, 2020.



Inauguration of the International Conference on Nano Science and Technology (ICONSAT-2020)

Foreign delegates visited the Centre during the India International Science Festival (IISF-2019)



5th G.N. Ramachandran Memorial Lecture

11th Vidyasagar – Satyendra Nath Bose National Workshop

Theoretical Physics Seminar Circuit

Academic visits

Sl No	Seminar Date	Speaker	Affiliation	Duration of Visit	Title of the Talk
1.	01-11-2019	Ms. Aishani Ghosal	Inorganic and Physical Chemistry Department, IISc, Bangalore	November 1, 2019	Theoretical studies of the non-equilibrium statistical mechanics of colloidal and polymeric systems at the single molecule level

Grant released to TPSC Centres in the Country

Institute of Dhusics	(1.00.000 INP)
	(1,00,000 IIVII)
Indian Institute of Technology, Roorkee	(50,000 INR)
Cochin University of Science and Technology	(50,000 INR)
Benaras Hindu University	(44,000 INR)
Bharathidarsan University	(38,855 INR)
Punjab University	(25,000 INR)
Indian Physical Society	(25,000 INR)

Advanced Research Workshop

- 2,00,000 INR TPSC grant released to Vidyasagar University for organizing the 11th Vidyasagar-Satyendranath Bose National Workshop on "Physics of Novel Functional Materials (PNFM-2020)" by Department of Physics & Technophysics, Vidyasagar University during 8th to 10th January 2020 at Vidyasagar University Campus, Midnapore.
- 10,000 INR TPSC Grant released to Materials Research Society of India for holding Young Scientists' Colloquium 2019 (YSC-2019) on 17th September 2019 at Saha Institute of Nuclear Physics,

Kolkata with the motivation of identifying, nurturing and encouraging young talents doing frontline research works in materials science in India.

- 50,000 INR TPSC Grant released to Materials Research Society of India for holding 2nd Materials Conclave and 31st AGM during 11th to 14th February 2020 at Saha Institute of Nuclear Physics, Kolkata.
- 25,000 INR TPSC Grant released to the Jadavpur University for holding National Seminar on Nonlinear and Complex Phenomena (NCP-2020) during 18th to 19th February 2020 at the main campus of Jadavpur University, Kolkata.

Sakuntala Chatterjee

Sakuntala Chatterjee Convener, Theoretical Physics Seminar Circuit

REGISTRAR



Report on Administrative Matters

The Centre has rendered administrative support to its academic activities through its administrative and technical staff members who have very professionally and sincerely carried out their duties for making the various activities of the Centre in the year 2019-2020 successful. The Centre has a staff strength of 22 in permanent, 11 in temporary and 32 in contractual category as on 31st March 2020, 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 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. 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 2019-2020. The Centre has also adhered to the norms of the Right to Information Act and so far has received 11 (eleven) cases under the said Act in the last financial year all of which has been successfully disposed off.

As part of Vigilance Awareness Week 2019 during 28th October 2019 to 2nd November 2019, the Centre organised Vigilance Pledge and an Essay Competition (Topic: "Integrity - A Way of life"). The essay competition carried a cash award of Rs.5,000/- (1st prize), Rs.3,000/- (2nd prize) and Rs.1,000/- (3rd prize) with winners as:

- 1st Prize Ms. Monalisa Singh Roy, Senior Research Fellow
- 2nd Prize Ms. Sonali Sen, Office Assistant
- 3rd Prize Mr. Akash Das, Junior Research Fellow

The Centre celebrated 'Swachhta Hi Seva' campaign theme: Plastic Waste Management] from 11th September 2019 to 2nd October 2019. As a part of the campaign, Extempore / Poster Competition was organised highlighting Environmental Pollution/Health & Hygiene through Plastic Waste Management on 24.09.2019 and a Street Play was organised by the students of the Centre followed by Shramdaan on 30.09.2019. Banners titled : Swachhta Hi Seva – 11.09.2019 – 02.10.2019; Theme: Plastic Waste Management were prepared bilingually and displayed in the Main gate and other prominent places of the Centre for wider publicity. The result of the Extempore Competition was as follows:

- 1st Prize: Mr. Supriyo Ganguly, Junior Engineer (Electrical)
- 2nd Prize : Mr. Tuhin Majhi, Senior Research Fellow
- 3rd Prize : Ms. Jayita Patwari, Senior Research Fellow

The Centre also organised an interactive yoga session conducted by Yoga Instructor, Ms. Chandni Kumari on the occasion of the International Yoga Day on 21st June 2019. The staff and students participated enthusiastically in the session. A Slogan & Article Writing Competition was also organised among the staff and students of the Centre with the focus on highlighting the potential health benefits of adopting Yoga in day to day lifestyle in which Mr. Amit Roy, Technical Assistant (Library) was adjudged the winner and received cash award of Rs.2000/- for his article in the Article Writing Competition.

Meetings of the Statutory Committees of the Centre :

- (i) The 59th & 60th Governing Body (GB) meetings of the Centre were held on 13.09.2019 and 04.02.2020 respectively.
- (ii) The 38th Finance Committee (FC) meeting of the Centre was held on 13.09.2019.
- (iii) The 27th Academic & Research Programme Advisory Committee (ARPAC) meeting of the Centre was held on 29.08.2019.

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 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 for its staff. The students residing in the Centre run their own mess and the hostels have facilities like dining rooms, common rooms etc. The Centre also provides accommodation to Post Doctoral Fellows, on request. The newly constructed Integrated Hostel Building and Transit Quarter (by the name 'Basundhara') is being moderately put into use through its dining hall facilities and housing of summer students.

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

'Muktangan' has been successfully organising various recreational activities within the Centre in Performing Arts, Literary Arts, Visual Arts, Sports Activities and Social Outreach. 'Muktangan' organised several programmes under its aegis during the year 2019-20.

The Centre also successfully organised a number of conferences and workshops during this period, hosted within and outside the Centre premises namely IISF (North East Student Conclave) - 2019, India-Nano-2019, CTMSE-2019, Flatlands and Beyond (2019), NCES-2019, Young Investigator Meet on Quantum Condensed Matter Theory 2019, IWPSD-2019, ACTSM-2020 & ICONSAT-2020 with full support from the administrative staff.

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

Sonafunder

Shohini Majumder Registrar

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Hindi (Rajbhasha) Implementation in the Centre

Activities of the Hindi Cell

The Centre implemented the provisions of the Official Language Act in the year 2019-20. 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.

Miscellaneous jobs like calendar, greetings cards and banners for different Seminars etc. are done in bi-lingual format.

The year also saw Hindi Mahina being celebrated in great zeal, in the month of September from 01.09.2019 to 30.09.2019. The month commenced with Hindi Extempore & Hindi Essay Competition. The extempore competition carried a cash award of Rs.1,500/- (1st prize), Rs.1,000/- (2nd prize) and Rs.800/- (3rd prize) & 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 Extempore and Essay Competition were:

Extempore Competition:

- 1st Prize Mr. Shashank Gupta, Senior Research Fellow
- 2nd Prize Ms. Mitali Bose, Office Assistant
- 3rd Prize Ms. Suchismita Banerjee, Project Assistant, TRC

Essay Competition:

- 1st Prize Mr. Shivam Mishra, Junior Research Fellow
- 2nd Prize Ms. Mitali Bose, Office Assistant
- 3rd Prize Mr. Suvodip Mukherjee, Office Assistant

On 16th September 2019 "Hindi Diwas Samaroh" was organised in the presence of Shri Nirmal Dubey, Assistant Director, Rajbhasha Bibhag, Nizam Palace, Kolkata, Shri Rajesh Chaturvedi, Chief Manager, State Bank of India, Kolkata, Shri Vipati, Assistant Director, Hindi Teaching Scheme, Dept. of OL, MHA, Govt. of India. On the said day a cultural programme was staged by the staff members of the Centre. The Centre also organised Hindi Debate Competition, Hindi Quiz and a Hindi Play "Chor Machaye Shor" in which the Centre's staff and students participated with great zeal and enthusiasm.

The Centre also organised two 'Hindi Workshops' during 2019-2020:

- (i) Talk on "Hindi Patrachar Me Machino Anubad Ki Bhumika" by Shri Rajesh Chaturvedi, Chief Manager, State Bank of India, Kolkata on 27.06.2019;
- (ii) Talk on "Karyalay mein Hindi ka Prayog" by Shri L.K.Singh, Hindi Teacher, Hindi Teaching Scheme, Rajbhasha Bibhag, Nizam Palace, Kolkata on 21.02.2020.

Smajunder

Shohini Majumder Registrar

COMMITTEES (As on 31.03.2020)

Governing Body

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Dr. Srikumar Banerjee Chairma Homi Bhabha Chair Professor Department of Atomic Energy Bhabha Atomic Research Centre, Mumbai **Prof. Ashutosh Sharma** Memb Secretary Department of Science & Technology Government of India, New Delhi Prof. Archana Bhattacharyya, Memb **INSA Senior Scientist** Centre of Studies in Resources Engineering IIT, Mumbai Dr. D.K. Aswal Memb Director CSIR-National Physical Laboratory, New Delhi **Prof. Debashish Chowdhury** Memb Professor Dept. of Physics IIT, Kanpur Prof. Samit Kumar Ray Memb 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 Shri B. Anand Member Additional Secretary & Financial Advisor Department of Science & Technology Government of India, New Delhi Member Chief Secretary, Government of West Bengal Kolkata Ms. Shohini Majumder Non-Member Registrar Secretary S. N. Bose National Centre for Basic Sciences Kolkata

Finance Committee

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

Invitee

Academic & Research Programme **Advisory Committee**

Prof. Praveen Chaddah Former Director UGC-DAE Consortium for Scientific Research Indore	Chairman
Prof. Somak Raychaudhury Director, Inter-University Centre For Astronomy and Astrophysics, Pune	Member
Prof. Sanjay Puri Professor, JNU, New Delhi	Member
Prof. Amitabha Raychaudhuri Professor Emeritus, Calcutta University, Kolkata	Member
Prof. Satrajit Adhikari Professor, IACS, Kolkata	Member
Prof. Gautam Basu Senior Professor, Bose Institute, Kolkata	Member
Prof. S.M.Yusuf Scientific Officer (H+), BARC, Mumbai	Member
Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Archan S Majumdar Dean (Faculty) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Biswajit Chakraborty Dean (Academic Programme) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Von –Member Secretary
Dr. Saumen Mondal Head, Department of Astrophysics and Cosmology S. N. Bose National Centre for Basic Sciences Kolkata	Permanent Invitee

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

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

Head, Department of Chemical, Biological and Macromolecular Sciences S. N. Bose National Centre for Basic Sciences Kolkata

Building Committee

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

Consultative Advisory Committee

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

Official Language Implementation Committee

Prof. Samit Kumar Ray Director S. N. Bose National Centre for Basic Sciences Kolkata	Chairman
Ms. Shohini Majumder Registrar S. N. Bose National Centre for Basic Sciences Kolkata	Member
Prof. Manu Mathur Professor S. N. Bose National Centre for Basic Sciences Kolkata	Member
Dr. Manoranjan Kumar Associate Professor S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Debashish Bhattacharjee Deputy Registrar (Administration) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Ms. Nibedita Konar Deputy Registrar (Academic) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Shiladitya Chatterjee Deputy Registrar (Finance) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Santosh K Singh Assistant Registrar (Purchase) S. N. Bose National Centre for Basic Sciences Kolkata	Member
Mr. Sirsendu Ghosh In-charge, Hindi Cell S. N. Bose National Centre for Basic Sciences Kolkata	Member

ACADEMIC MEMBERS

Faculty Members

1	Samit Kumar Ray	Senior Professor, CMPMS& Director
2	Amitabha Lahiri	Senior Professor, TS
3	Anjan Barman	Senior Professor, CMPMS & Associate Dean (Faculty)
4	Archan S. Majumdar	Senior Professor, A&C & Dean (Faculty)
5	Atindra Nath Pal	Assistant Professor, CMPMS
6	Barnali Ghosh (Saha)	Scientist-F, CMPMS
7	Biswajit Chakraborty	Senior Professor, TS & Dean (AP)
8	Gautam Gangopadhyay	Senior Professor, CBMS
9	Jaydeb Chakrabarti	Senior Professor & HOD, CBMS
10	Kalyan Mandal	Senior Professor & HOD, CMPMS
11	Manik Pradhan	Associate Professor, CBMS
12	Manoranjan Kumar	Associate Professor, CMPMS
13	Manu Mathur	Professor, TS
14	M. Sanjay Kumar	Associate Professor & HOD, TS
15	Partha Guha	Senior Professor, TS
16	Priya Mahadevan	Senior Professor, CMPMS & Associate Dean (AP)
17	Prosenjit Singha Deo	Professor, CMPMS
18	Punyabrata Pradhan	Associate Professor, TS
19	Rajib Kumar Mitra	Professor, CBMS
20	Ramkrishna Das	Assistant Professor, A&C
21	Ranjit Biswas	Senior Professor, CBMS
22	Sakuntala Chatterjee	Associate Professor, TS
23	Samir K. Pal	Senior Professor, CBMS
24	Sanjoy Choudhury	Scientist-D (Computer Services Cell)
25	Soumen Mondal	Associate Professor & HOD, A&C
26	Suman Chakrabarty	Assistant Professor, CBMS

27	Sunandan Gangopadhyay	Associate Professor, TS
28	Swapan Rana (from 25.11.2019)	Assistant Professor, TS
29	Tanusri Saha Dasgupta	Senior Professor, CMPMS
30	Thirupathaiah Setti	Assistant Professor, CMPMS

S. N. Bose Chair Professor

1 Debashis Mukheijee CBMS

Distinguished Professor (Emeritus)

1	Arup Kumar Raychaudhuri	CMPMS
	(till 01.09.2019)	

Emeritus Professors

1	Bikash K. Chakrabarti	TS
2	Milan Kumar Sanyal	CMPMS
3	Rabin Banerjee	TS
4	Subhrangshu Sekhar Manna	TS

Honorary Fellow

1	Pratip Kr. Mukhopadhyay	CMPMS
2	Ranjan Chaudhury	CMPMS
3	Samir Kumar Paul (till 31.07.2019)	TS
4	Sugata Mukherjee	CMPMS

DST INSPIRE Faculty

1	Anup Ghosh	CMPMS
2	Dipanwita Majumdar	CMPMS
3	Manik Banik (till 14.02.2020)	A&C
4	Tatini Rakshit	CBMS

Visiting Fellow/Scientist

1	Madhuri Mandal Goswami	CMPMS
2	Mausumi Ray (till 26.04.2019)	CBMS

Young Scientist

1 Alo Dutta (till 01.08.2018)

CMPMS

Post Doctoral Research Associates

1	Aayatti Mallick Gupta (from 16.12.2019)	CBMS
2	Amit Kumawat (from 16.09.2019)	CBMS
3	Amit Mukherjee (from 06.09.2019)	A&C
4	Anita Halder (from 03.09.2019)	CMPMS
5	Arka Chatterjee	A&C
6	Arka Dey	CMPMS
7	Arnab Ghosh	CMPMS
8	Arpan Bhattacharyya (from 11.12.2019)	CMP&MS
9	Arpan Maiti (from 21.08.2019)	CBMS
10	Arun Bera	CMPMS
11	Arup Roy (from 13.05.2019)	A&C
12	Avijit Sen (from 26.08.2019 to 23.12.2019)	CBMS
13	Ayana Mukhopadhyay (from 22.08.2019)	CMPMS
14	Basant Roondhe (from 03.02.2020)	CMPMS
15	Bibhab Bandhu Majumder (from 21.08.2019)	CBMS
16	Buddhadeb Pal (from 20.08.2019)	CMPMS
17	Chaitrali Sengupta (till 31.07.2019)	CBMS
18	Deepika Shrivastava (till 05.04.2019)	CMPMS
19	Dharmesh Jain (from 01.10.2019)	TS
20	Gulmi Chakraborty (till 31.05.2019)	CBMS
21	Ipsita Basu (from 03.09.2019)	CBMS
22	Joy Prakash Das (from 20.02.2020)	CMPMS
23	Kumar Das	TS

24	Mantu Santra (till 26.12.2019)	CBMS
25	Prasanta Kundu (till 19.03.2020)	CBMS
26	Priyanka Garg (from 05.02.2020)	CMPMS
27	Sandeep Agarwal (till 30.08.2019)	CMPMS
28	Shauri Chakrabarty (from 02.09.2019 to 30.10.2019)	TS
29	Sirshendu Dinda (till 14.02.2020)	CBMS
30	Srabantika Ghose (till 14.02.2020)	CMPMS
31	Suman Chakraborty (till 14.02.2020)	A&C
32	Supriyo Dutta (till 19.11.2019)	TS
33	V. Yogesh (from 06.09.2019)	TS

Senior Research Associate

1	Alo Dutta (from 07.01.2020)		CMPMS
2	Sayan Bayan		CMPMS
A&C	C : Department of Astrophysics & Cosmology		
CBMS	5	: Department of Chemical, B Macro-Molecular Sciences	iological &
CMPMS : Department of Condensed Ma and Material Sciences		atter Physics	
TS		: Department of Theoretical Scien	nces
TUEC	CMS	: Thematic Unit of Excellence on Computational Materials Science	e
TUEN	IDT	Thematic Unit of Excellence on Nanodevice Technology	
UNAN	NST	: Unit for Nanoscience and Techn	ology



ADMINISTRATIVE AND TECHNICAL STAFF MEMBERS

Shohini Majumder	Registrar
Jaydeb Chakrabarti	Vigilance Officer
Debashish Bhattacharjee	Public Information Officer
Other Members	
Nibedita Konar	Deputy Registrar (Academic)
Debashish Bhattacharjee	Deputy Registrar (Administration)
Shiladitya Chatterjee	Deputy Registrar (Finance)
Saumen Adhikari	Librarian cum Information Officer
Santosh Kumar Singh	Assistant Registrar (Purchase)
Sirsendu Ghosh	Programme Coordinating Officer
Achyut Saha	Personal Assistant to Director
Swapnamoy Datta	Stenographer
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
Sushanta Kumar Biswas	Driver
Partha Mitra	Attendant
Ratan Acharya	Attendant
Swapan Ghosh	Attendant
Swarup Dutta	Project Assistant
Rajarshi Barman	Attendant [joined on 10.02.2020]
Sabyasachi Mondal	Attendant [joined on 10.02.2020]

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)
A.K.Sarkar	Advisor (Finance)
B.S.Panda	Consultant (Legal) [joined on 02.12.2019]
Sujit Kr. Dasgupta	Superintending Engineer [till 30.09.2019]
Amitabha Haldar	Executive Engineer
Ayan Deb	Assistant Engineer (Electrical)
Sutapa Basu	PS to Registrar
Sadhana Tiwari	Hindi Officer [till 03.09.2019]
Abhijit Ghosh	Junior Computer Engineer
Sagar Samrat De	Junior Computer Engineer
Somasree Mal	Junior Computer Engineer [till 12.04.2019]
Deblina Mukherjee	Junior Computer Engineer

S N Bose National Centre for Basic Sciences

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
Moumita Banik	Office Assistant [till 03.03.2020]

Suvendu Dutta	Office Assistant
Sonali Sen	Office Assistant
Sudipta Das	Office Assistant [till 04.07.2019]
Lina Mukherjee	Jr. Office Assistant
Debasish Mitra	Telephone Operator
Amit Kumar Ghosh	Mechanic
Sani Amed Ali Molla	Technician (AC & Refrigeration)
Kalyani Ghosh	Caretaker (Creche) [till 12.02.2020]
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 faculties	04
Number of Post –doctoral research associate (centre+project)	05
Number of Ph.D students	22
Number of other project staff	04
Number of summer students	03
Projects (ongoing)	04

Table B: Research Activities indicators

Number of research papers in Journals	23
Number of Book-chapters/books	-
Number of other publications	08
Number of Ph.D students graduated (submitted+degree awarded)	03
Number of M.Tech/M.Sc projects	01

Table C: Academic activities and likeage

Number of courses taught by faculties	08
Number of Visitors (non –associates)	06
Number of associates	-
Number of Seminars organized	12
Number of Conference/Symposia/Advanced Schools organized	03

	Number of talks delivered by members of department in	con	A construction of novae grid model using photoionization ferences Symposia to National to 10 code CLOUDY is successfully implemented to estimate physical parameters of noternational 01
Most important research highlights		•	Optical/Near-IR spectra of several planetary nebulae are
•	Multi-wavelength studies on Galactic star-forming		analyszed to estimate their physical parameters.
	regions.	•	Spectral prperties of NGC 4151 and the estimation of Black hole mass using TCAE solution
•	Spectroscopic studies of Low-mass Galactic M-dwarts,		Diack-hole mass using TCAI solution.
	M giants and AGB stars.	٠	Evidence of Outflow-induced Soft Lags of Galactic
•	Photometric variability properties in very low mass stars and brown dwarfs in star-formating regions.		Black Holes
		•	Nonclassical correlations in local bipartite states can act

- Formalism for detection of non-Markovianity through uncertainty relations.
- Possibility of multiple usage of a single genuine entangled state by considering a scenario consisting of three spin-1/2 particles.
- Constraining the state space in any physical theory with the principle of information symmetry.
- Genuinely nonlocal product bases: Classification and entanglement-assisted discrimination.

Summary of research activities

- Stellar clusters are recognized as promising astrophysical sites as their formation and early evolution take place primarily in the Galactic spiral arms. Systematic studies of young clusters probe several dominant astrophysical problems, such as the formation of stars and planetary systems to the evolution of open clusters. Identification and characterization of the young stellar population associated with an active starforming site Sh2-242 are presented here. We used our own new optical imaging and spectroscopic observational data, as well as several archival catalogs in optical and Infrared wavelengths, e.g., Pan-STARRS 1, Gaia DR2, IPHAS, WIRCam, 2MASS, and Spitzer. Slit spectroscopic results confirm the classification of the main ionizing source BD+26 980 as an early-type star of spectral type B0.5 V. The spectrophotometric distance of the star is estimated as 2.08 ± 0.24 kpc. Using the infrared color excess, a total of 33 Class I and 137 Class II young objects are classified within the region. In total, 201 young objects are classified toward S242 from this study (Alik Panja, et al., The Astronomical Journal, 159, 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 Earthlike planets orbiting in 'habitable zones', increases with decreasing stellar mass and radius. Medium resolution ($\lambda/\lambda \sim 1200$) H- and K-band spectra of 53 M-type dwarfs covering the wavelength ranges 1.50–1.80 μ m and 1.95–2.45 μ 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, we have created new empirical relationships among those fundamental parameters and spectral indices. The masses of M dwarfs could be

determined using the luminosity (L/L) and we establish a new empirical relation for this. We also compare and contrast our results with other similar work from the literature (Dhrimadri Khata, et al., MNRAS, 493, p.4533, 2020).

- To investigate the physical conditions in the novashell, an **extensive grid of models for novae are constructed here**. Covering a wide range of different parameters, e.g. hydrogen density (n_H), black body temperature (T_{BB}) and luminosity (L), inner radius (Rin) and thickness of ejecta (ΔR), a total of 1792 models have been generated for solar metallicity. From the model generated spectra, from UV to IR, we calculate ratios of H and He emission lines, which are generally strong in novae spectra. We show how the physical parameters associated with novae system could be estimated by comparing these line ratios with those obtained from observed spectra (Anindita Mondal et al. MNRAS, 483, p. 4884, 2019).
- Morphology and ionization characteristics of two less studied compact planetary nebulae PB 1 and PC 19 are studied, using observed and archival/ literature data. We generated 3D models and predicted structures of the objects. We estimate the elemental abundances, and different physical parameters of the central stars (e.g. T_{BB} , L and gravity), and of the nebula, (e.g. n_{H} profiles, radii) from photoionization modeling. We estimate distances to the PNe (4.3 kpc and 5:6 kpc respectively) from photoionization modeling and progenitor masses (1.67 and 2.38 solar mass respectively) from theoretical evolutionary trajectories. (Rahul Bandopadhay et al., MNRAS, 496, p. 814, 2020).
- X-ray spectral analysis of Seyfert 1.5 Active Galactic Nuclei (AGNs) NGC 4151 using NuSTAR observations during 2012 are presented here. This is the first attempt to fit AGN data using the physical Two Component Advective flow (TCAF) solution. We disentangle the continuum emission properties of the source in the energy range 3.0-70.0 keV using the spectrum obtained from the TCAF model. This model was used as an additive local model directly in XSPEC. Additionally, we used a power-law component, to take care of possible X-ray contribution from the jet, which is not incorporated in the present version of TCAF. Our primary aim is to obtain the flow properties and the mass of the central supermassive black hole from the available archival data (Prantik Nandi et al. APJ, 877, 2019).
- Using soft (1.5-3 keV) and hard (3-12 keV) photon counts of All Sky Monitor (ASM) in Rossi X-ray Timing Explorer (RXTE) satellite, we have proposed recently that there is a significant

time lag between the in-fall time-scales of two components in the Two-Component Advective Flow paradigm, where a standard slow moving Keplerian disc is surrounded by a fast moving halo. The time lag is clearly due to the difference in viscosity in the flow components and the size of the Keplerian disc may be considered to be proportional to this arrival time lag. In this paper, using RXTE/ASM (1.5-12 keV) data, we examine eight successive outbursts of the low-mass X-ray binary H 1743-322 since 2003 from a new perspective (Arindam Ghosh, et al., MNRAS, 485, 2019).

• The stochastic gravitational wave background produced by primordial black hole binaries during their early inspiral stage while accreting highdensity radiation surrounding them in the early Universe are investigated here. We first show that the gravitational wave amplitude produced from a primordial black hole binary has correction terms because of the rapid rate of increase in masses of the primordial black holes. These correction terms arise due to nonvanishing first and second time derivatives of the masses and their contribution to the overall second time derivative of the quadrupole-moment tensor. We find that some of these correction terms are not only significant in comparison with the main term but may be even dominant over the main term for certain ranges of time in the early Universe. The significance of these correction terms persists for the overall stochastic gravitational wave background produced from them. We show that the spectral density produced from such accreting primordial black hole binaries lies within the detectability range of some present and future gravitational wave detectors (Arnab Sarkar et al, Physical Review D, 100, 2019)

How nonclassical correlations in local bipartite states can act as a resource for quantum information processing are shown here. Considering the task of quantum random access codes (RACs) through separable Bell-diagonal states, we demonstrate the advantage of superunsteerability over classical protocols assisted with two bits of shared randomness. We propose a measure of superunsteerability which quantifies nonclassicality beyond quantum steering and obtain its analytical expression for Bell-diagonal states in the context of two- and three-setting steering scenarios that are directly related to the quantum $2 \rightarrow 1$ and 3 \rightarrow 1 RAC protocols, respectively. The maximal values of our quantifier yield the optimal quantum efficiency for both of the above protocols, thus showing that superunsteerability provides a precise characterization of the nonclassical resource for implementing RACs (T. Guha, et al., Quanta 8, 57 2019).

unen Mondal

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; Thesis submitted
- 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. Bihalan Bhattacharya; Quantum Information; Under progress
- 6. Ananda Gopal Maity; Quantum Information; Under progress
- 7. Shashank Gupta; Quantum Information; Under progress
- 8. Ramkrishna Patra; Quantum Information; Under progress; Manik Banik (Supervisor)
- 9. Samrat Sen; Quantum Information; Under progress; Manik Banik (Supervisor)

- 10. 10. Arun Kumar Das; Quantum Information; Under progress; Dipankar Home (Bose Institute) (Cosupervisor)
- 11. Subhankar Bera; Quantum Information; Under progress

b) Post-Docs

- 1. Samyadeb Bhattacharya (up to November 2019); Quantum thermodynamics
- 2. Amit Mukherjee (from September 2019); Quantum Foundations
- 3. Arup Roy (from February 2020 in lieu of Dr. Manik Banik); Quantum Information

Teaching

- 1. Autumn semester; Advanced Quantum Mechanics (PHY303); Integrated PhD; 13 students; with 1 (Sunandan Gangopadhyay) co-teachers
- Autumn semester; Quantum Physics and Applications (PHY604); PhD; 4 students; with 1 (Sunandan Gangopadhyay) co-teachers
- 3. Spring semester; Quantum Information theory (PHY413); Integrated PhD; 2 students; with 1 (Manik Banik) co-teachers

Publications

a) In journals

- C. Jebaratnam, D. Das, S. Kanjilal, R. Srikanth, D. Sarkar, I. Chattopadhyay, A. S. Majumdar, Superunsteerability as a quantifiable resource for random access codes assisted by Bell-diagonal states, Phys. Rev. A 100, 012344 (2019)
- T. Guha, B. Bhattacharya, D. Das, S. S. Bhattacharya, A. Mukherjee, A. Roy, K. Mukherjee, N. Ganguly, A. S. Majumdar, Environmental effects on nonlocal correlations, Quanta 8, 57 (2019)
- 3. A. Sarkar, K. R. Nayak, **A. S. Majumdar**, Stochastic gravitational wave background from accreting primordial black hole binaries during early inspiral stage, Phys, Rev D 100, 103514 (2019)
- M. Banik, S. Saha, T. Guha, S. Agrawal, S. S. Bhattacharya, A. Roy, A. S. Majumdar, Constraining the state space in any physical theory with the principle of information symmetry, Phys. Rev. A 100, 060101 (R) (2019)
- 5. Z. Bian, A. S. Majumdar, C. Jebaratnam, K. Wang,

L. Xiao, X. Zhan, Y. Zhang, P. Xue, *Experimental* demonstration of one-sided device-independent self-testing for any pure two-qubit entangled state, Phys. Rev. A 101, 020301 (R) (2020)

Independent publication of student/post-doc

- S. Rout, A. G. Maity, A. Mukherjee, S Halder, and M. Banik, Genuinely nonlocal product bases: Classification and entanglement-assisted discrimination, Phys. Rev. A 100, 032321 (2019)
- Jian Li, Tong-Jun Liu, Si Wang, C. Jebarathinam, and Qin Wang, Experimental violation of Mermin steering inequality by three-photon entangled states with nontrivial GHZ-fidelity, Optics Express 27, 13559 (2019)
- 8. Manik Banik, Some Sankar Bhattacharya, Nirman Ganguly, Tamal Guha, Amit Mukherjee, Ashutosh Rai, Arup Roy, Two-Qubit Pure Entanglement as Optimal Social Welfare Resource in Bayesian Game, Quantum 3, 185 (2019)
- 9. C. Jebarathinam, Dipankar Home, Urbasi Sinha, Pearson Correlation Coefficient as a measure for Certifying and Quantifying High-Dimensional Entanglement, Phys. Rev. A 101, 022112 (2020)
- Amit Mukherjee, Arup Roy, Some Sankar Bhattacharya, Biswajit Paul, Kaushiki Mukherjee, Debasis Sarkar, Revealing genuine steering under sequential measurement scenario, Quant. Inf. Proc. 19, 143 (2020)
- 11. Kaushiki Mukherjee, Biswajit Paul, Arup Roy, Characterizing Quantum Correlations in a Fixed-Input n-Local Network Scenario, Phys. Rev. A 101, 032328 (2020)

Talks / Seminars Delivered in reputed conference / institutions

- 1. Quantum information revolution: impact to foundations; Jun 12, 2019; Linneaus University, Vaxjo, Sweden
- 2. Quantum information and quantum technology; Jul 12, 2019; IISER Kolkata
- 3. Quantum information and applications; Sep 12, 2019; CDAC, Kolkata
- 4. Quantum Foundations, Technologies and Applications; Oct 21, 2019; IISER Mohali
- 5. National Mission on Quantum technology and application; Nov 5, 2019; IISER Thiruvananthapuram

- 6. Quantum Information and Computation; Dec 8, 2019; IIT Jodhpur
- 7. Quantum frontiers and fundamentals; Jan 13, 2020; RRI Bangalore

Administrative duties

1. Dean (Faculty)

Awards, Recognitions

1. Member of Editorial Boards of Journals: (i) Quanta; (ii) Journal of Quantum Information Science

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

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

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

- 1. Bose Institute; Sl. No. 1, 9; National
- 2. PPISR, Bangalore; Sl. No. 1; National
- 3. Calcutta University; Sl. No. 1, 10, 11; National
- 4. BITS Pilani, Hyderabad; Sl. No. 2, 8; National
- 5. IISER Kolkata; Sl. No. 3; National
- 6. ISI Kolkata; Sl. No. 2, 4, 8, 10; National
- 7. RRI, Bangalore; Sl. No. 9; National
- 8. University of Hong Kong; Sl. No. 4,10; International
- 9. Beijing Computational Research Centre, & USTC, Hefei; Sl. No. 5; International
- 10. NCKU, Taiwan; Sl. No. 7; International

Outreach program organized / participated

1. Talk at the North-East Students Conclave, India International Science Festival, Biswa-Bangla Convention Centre, November 2019

H2 Time-tagg Computer Bob D RRO D Couple Alice a-BBO HI 10-14 $S_h(\omega)^{1/2}$ in Hz^{-1/2} 10-16 10-18 10-20 **FPTA** 10-22 LISA 10-24 BBO 10-2 aLIGO 10-28 iLIGO 10-30 1 10 1.×10⁻⁹ 1.×10⁻⁶ 0.001 1000 ET ω in rad/sec

Areas of Research

Quantum Information Science, Gravitation & Cosmology

We show how nonclassical correlations in local bipartite states can act as a resource for quantum information processing. Considering the task of quantum random access codes (RACs) through separable Bell-diagonal states, we demonstrate the advantage of superunsteerability over classical protocols assisted with two bits of shared randomness. We propose a measure of superunsteerability which quantifies nonclassicality beyond quantum steering and obtain its analytical expression for Bell-diagonal states in the context of two- and three-setting steering scenarios that are directly related to the quantum $2 \rightarrow 1$ and $3 \rightarrow$ 1 RAC protocols, respectively. The maximal values of our quantifier yield the optimal quantum efficiency for both of the above protocols, thus showing that superunsteerability provides a precise characterization of the nonclassical resource for implementing RACs.

Symmetry shares an entwined history with the structure of physical theory. We propose a consequence of symmetry towards the axiomatic derivation of Hilbert space quantum theory. We introduce the notion of information symmetry (IS) and show that it constraints the state-space structure in any physical theory. We study the minimal error binary state discrimination problem in the framework of generalized probabilistic theories. A theory is said to satisfy IS if the probability of incorrectly identifying each of two randomly prepared states is the same for both the states. It is found that this simple principle rules out several classes of theories while being perfectly compatible with quantum theory.

We demonstrate one-sided device-independent self-testing of any pure two-qubit entangled state based on a finegrained steering inequality. The maximum violation of a fine-grained steering inequality can be used to witness certain steerable correlations, which certify all pure twoqubit entangled states. Our experimental results identify which particular pure two-qubit entangled state has been self-tested and which measurement operators are used on the untrusted side. Furthermore, we analytically derive the robustness bound of our protocol, enabling our subsequent experimental verification of robustness through state tomography.

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

Plan of Future Work Including Project

1. 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 Choistates 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.

- 2. 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 the violations of which certify genuine tripartite entanglement in a deviceindependent 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.
- 3. We explore a thermodynamical effect of anharmonicity present in quantum mechanical oscillators. We show

that small quartic perturbations to the quantum harmonic oscillator potential lead to the enhancement of performance of quantum refrigerators. Our results are illustrated for both the Otto and Stirling quantum refrigeration cycles. A similar nonlinearity driven enhancement of performance for quantum refrigerators is also observed in the case of an analogous spinqubit model. We further investigate the energy cost for creating anharmonicity and demonstrate the robustness of improvement of the coeffcient of performance versus the energy cost. It is shown that such an anharmonicity driven improvement in performance is a generic effect at the quantum level for the experimentally realizable Otto refrigerator.

Any other Relevant Information including social impact of research

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



Manik Banik

DST INSPIRE Faculty Astrophysics & Cosmology manik.banik@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Ananda G. Maity; Quantum Information Theory; Under progress; Prof. Archan S Majumdar

b) Post-Docs

1. Arup Roy; Quantum foundations

c) External Project Students / Summer Training

1. Sumit Rout; Quantum Entanglement Theory; Visva-Bharati University

Publications

a) In journals

1. Sumit Rout, Ananda G. Maity, Amit Mukherjee, Saronath Halder, and **Manik Banik**; Genuinely nonlocal product bases: Classification and entanglement-assisted discrimination, Phys. Rev. A 100, 032321 (2019) **2. Manik Banik**, Sutapa Saha, Tamal Guha, Sristy Agrawal, Some Sankar Bhattacharya, Arup Roy, and A. S. Majumdar; *Constraining the state space in any physical theory with the principle of information symmetry*, Phys. Rev. A 100, 060101(R) (2019)

Areas of Research

Quantum Information Theory, Quantum Foundations

In a multipartite scenario quantum entanglement manifests its most dramatic form when the state is genuinely entangled. Such a state is more beneficial for information theoretic applications if it contains distillable entanglement in every bipartition. It is, therefore, of significant operational interest to identify subspaces of multipartite quantum systems that contain such properties apriori. In one of our work, we introduce the notion of unextendible biseparable bases (UBB) that provides an adequate method to construct genuinely entangled subspaces (GES). We also show that the GES is indeed a bidistillable subspace, i.e., all the states supported on it contain distillable entanglement across every bipartition.

An orthogonal product basis of a composite Hilbert space is genuinely nonlocal if the basis states are locally indistinguishable across every bipartition. From an operational point of view such a basis corresponds to a separable measurement that cannot be implemented by local operations and classical communication (LOCC) unless all the parties come together in a single location. In one of our another work we classify genuinely nonlocal product bases into different categories. Our classification is based on state elimination property of the set via orthogonality-preserving measurements when all the parties are spatially separated or different subsets of the parties come together. We then study local state discrimination protocols for several such bases with additional entangled resources shared among the parties. Apart from consuming less entanglement than teleportation based schemes our protocols indicate operational significance of the proposed classification and exhibit nontrivial use of genuine entanglement in local state discrimination problem.

Symmetry shares an entwined history with the structure of physical theory. We propose a consequence of symmetry towards the axiomatic derivation of Hilbert space quantum theory. We introduce the notion of information symmetry (IS) and show that it constraints the state-space structure in any physical theory. To this end we study the minimal error binary state discrimination problem in the framework of generalized probabilistic theories. A theory is said to satisfy IS if the probability of incorrectly identifying each of two randomly prepared states is same for both the states. It is found that this simple principle rules out several classes of theories while being perfectly compatible with quantum theory.



Ramkrishna Das

Assistant Professor

Astrophysics & Cosmology

ramkrishna.das@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Anindita Mondal; Multi-wavelength Study of Novae; Thesis submitted; Dr Soumen Mondal, SNBNCBS (Cosupervisor)
- 2. Rahul Bandyopadhyay; Multi-wavelength Study of Planetary Nebulae; Under progress
- Dhrimadri Khata; Understanding Physical Properties of M-dwarfs: Optical and Near-IR Spectroscopic Studies; Under progress
- 4. Ruchi Pandey; Study of Novae Properties; Under progress
- 5. Subhajit Kar; Massive stars (tentative); Under progress
- 6. Gessesaw Reta Habtie; Novae (tentative); Under progress

b) Post-Docs

1. Suman Chakrovorty (Joint mentor, with Prof. Sandip K Chakrabarti); Atmospheric and Ionospheric Science

c) External Project Students / Summer Training

- 1. Shouvik Sadhukhan; Astronomical Telescopes & Detectors; IIT Kharagpur
- 2. Bhaskar Chakraborty; Astronomical observation techniques & interpretation of data; Ramakrishna Residential College, Narendrapur, Kolkata

Teaching

- 1. Autumn semester; Advanced Experimental Method in Astronomy (PHY 391); Integrated PhD; 9 students
- Autumn semester; Observational Technique in Astronomy (PHY 616); PhD; 1 student; with 1 (Dr Soumen Mondal) co-teacher
- 3. Spring semester; Astronomy (PHY 403); Integrated PhD; 9 students; with 1 (Dr. Soumen Mondal) co-teacher
- 4. Spring semester; Astrophysics (PHY 510); PhD; 3 students; with 1 (Dr Soumen Mondal) co-teacher
- 5. Spring semester; Astronomy (PHY 403); Integrated PhD; 8 students; with 1 (Dr Soumen Mondal) co-teacher
- 6. Spring semester; Astrophysics (PHY 510); PhD; 1 student; with 1 (Dr Soumen Mondal) co-teacher

Publications

a) In journals

- 1. Anindita Mondal, **Ramkrishna Das**, Anupama, G.C. et al., *Photoionization modelling of quiescence-phase spectra of novae and a symbiotic star*, MNRAS, 492, 2326, 2020
- Dhrimadri Khata, Soumen Mondal, Ramkrishna Das, Supriyo Ghosh, Samrat Ghosh, Understanding the Physical Properties of Young M dwarfs: NIR spectroscopic studies, MNRAS, 493, 4533, 2020
- 3. Alik Panja, Soumen Mondal, Somnath Dutta, Santosh Joshi, Sneh Lata, **Ramkrishna Das**, Census of the young stellar population in the Galactic H II region Sh2-242, The Astronomical Journal, 159, 153, 2020
- 4. Somnath Dutta, Soumen Mondal, Santosh Joshi and **Ramkrishna Das**, Optical photometric variable stars towards Cygnus OB7, MNRAS, 487, 1765, 2019

b) Conference proceedings / Reports / Monographs / Books

1. Alik Panja, Soumen Mondal, Somnath Dutta, Santosh Joshi, Sneh Lata, Ramkrishna Das, Siddhartha Biswas, Characterization of pre-main sequence population in

HII region Sh2-242, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 270-274, October 2019

- Somnath Dutta, Soumen Mondal, Santosh Joshi, Ramkrishna Das, Rotation rates of pre-main sequence stars: role of circumstellar disk, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 103-109, October 2019
- Samrat Ghosh, Soumen Mondal, Ramkrishna Das, Santosh Joshi, Sneh Lata, Siddhartha Biswas, A search for fast photometric variability in very low mass stars and brown dwarfs, Bulletin de la Société Royale des Sciences de Liège, in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 275-278, October 2019

Talks / Seminars Delivered in reputed conference / institutions

- "Understanding the Universe through Invisible Lights" at C K Majumdar Memorial Summer Workshop; May 24, 2019; SNBNCBS; 60 Min
- 2. Invited colloquium on "Space Exploration: Why the Moon?"; Sep 4, 2019; Presidency University; 60 Min
- "Exoplanets: Planets Around Other Suns", Indian International Science Festival 2019, Curtain Raiser Programme; Oct 18, 2019; SNBNCBS; 40 Min
- Invited talk on "Observing the sky: why and how?", UNIEXPLORE 2019; Nov 7, 2019; Vivekananda College; 60 Min
- Invited talk "Elemental Abundances in Novae" at the International conference on 150 Years of Periodic Table; Dec 17, 2019; Indian institute of Astrophysics; 20 Min
- "Observation of Transient Objects", One Day Discussion Meeting on the Upcoming Astronomical Observing Facility of S N Bose Centre; Feb 12, 2020; SNBNCBS; 20 Min
- Invited talk on "Astronomical Observation Facilities Around the World"; Mar 6, 2020; Department of Physics, Jadavpur University; 60 Min

Administrative duties

1. Liason Officer, SC & ST' and 'Grievance Redressal Officer – Persons with Disabilities'

- 2. Member of Seminar, Colloquium Programme (SCOLP)
- 3. Member of Newsletter Committee
- 4. Member of Selection Committee for the post of Upper Division Clerk
- 5. Member, Committee to fix the Technical Specifications of Bio-metric based attendance system
- 6. Member, Faculty Search Committee 2019
- 7. Member, Conference, Workshop and Extension Programme (CWEP)
- 8. 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
- 9. Member, Committee for Selection of Junior Research Fellow, Department of Astrophysics & Cosmology
- 10. Member, Committee for Selection of Integrated PhD

Conference / Symposia / Schools organized

- 1. Bose Fest 2019; Mar 6, 2020; SNBNCBS; 2 Days
- "Observation of Transient Objects", One Day Discussion Meeting on the Upcoming Astronomical Observing Facility of S N Bose Centre; Feb 12, 2020; SNBNCBS; 1 Day

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

- 1. Dr Gargi Shaw, Tata Institute of Fundamental Research, Mumbai; Sl. No. 1; National
- 2. Prof G. C. Anupama, Indian Institute of Astrophysics, Bangalore; Sl. No. 2; National
- 3. Dr Santosh Joshi, ARIES, Nainital; Sl. No. 4, 6; National

Outreach program organized / participated

- Delivered a talk on "Understanding the Universe through Invisible Lights", C K M Memorial Summer Workshop at S N Bose National Centre for Basic Sciences, Kolkata, May 23 - June 02, 2019
- Organized sky-watching program for the participants of C K M Memorial Summer Workshop, S N Bose National Centre for Basic Sciences, Kolkata, May 23 - June 02, 2019

- "Exoplanets: Planets Around Other Suns", Indian International Science Festival 2019, S N Bose National Centre for Basic Sciences, Kolkata, Curtain Raiser Programme, 8 Nov. 2019
- Organized sky-watching program for the participants of Indian International Science Festival 2019, S N Bose National Centre for Basic Sciences, Kolkata, 12 Feb 2020

Areas of Research

My research interests lie in the observational studies of novae, planetary nebulae, variable stars, modeling of spectra and astronomical instrumentation. I am also working for the S N Bose Centre's Telescope project.

We have observed various astronomical objects of our interest using the national facilities, e.g., 2m Himalaya Chandra Telescope, 1.3m Devasthal Fast Optics Telescope etc. and used published and archival data during the previous year. Part of these data has been analyzed, interpreted and modeled (using photoionization code Cloudy and morphokinematic code Shape); and the results have been published in peer reviewed journals. Few of the important results are briefly described below.

1. In order to investigate the physical conditions in the nova-shell, we constructed an **extensive grid of models for novae**. Covering a wide range of different parameters, e.g. hydrogen density (n_H) , black body temperature (T_{BB}) and luminosity (L), inner radius (Rin) and thickness of ejecta (ΔR) , a total of 1792 models have

been generated for solar metallicity. From the model generated spectra, from UV to IR, we calculate ratios of H and He emission lines which are generally strong in novae spectra. We show how the physical parameters associated with novae system could be estimated by comparing these line ratios with those obtained from observed spectra (Figure 1). (MNRAS, vol. 483, 4884, 2019)

- 2. We have modeled observed guiescence-phase spectra of few novae and a symbiotic stars, e.g., T CrB, GK Per, RS Oph, V3890 Sgr, V745 Sco, and BX Mon. The spectra show presence of low-ionization emission features of H, He, Fe, O and absorption feature of TiO from the cool secondary component. From the best-fit models, we have estimated the physical parameters (e.g. T_{BB} , L, and n_{H}), the elemental abundances and other parameters related to the system. By matching the observed absorption features with spectra of various giants, we have determined the types of secondaries and their contribution to the spectra. We also made rough idea about the stage of the accretion disks around the white dwarfs (MNRAS, 492, 2326, 2020).
- 3. We have analyzed NIR (1.50-1.80 μ m, 1.95-2.45 μ m) spectra of a sample of 53 **M-type dwarf stars** (MOV-M7V) and established new empirical relationships among the fundamental parameters (temperature, luminosity and radii) and spectral indices. Using spectral-type standards along with known parallaxes, we calibrate both H- and K-band H2O indices as a tracer of spectral type and absolute Ks magnitude. The masses of



Figure 1: Left: Contour plot of the H α line flux ratio w.r.t. H β for log(Rin) =15.0 (in cm), log(ΔR) = 14.0 (in cm) and log(TBB) = 5.5 (in K); log(L) (in erg s⁻¹) and log($n_{\rm H}$) (in cm⁻³) are plotted along the x- and y-axis, respectively. The values of H α /H β are marked on each contour. Right: Plots of various extracted contour lines for nova RS Oph, 12 days after outburst. The red solid, blue short-dashed, green dotted, and pink dot-dashed lines represent the extracted plots of line flux ratios of H α , H γ , H δ and H ϵ respectively w.r.t. H β . The lines intersect at log(L) – 36.65 (in erg s⁻¹) and log(nH) = 10.2 (in cm⁻³).



Figure 2: (a) Archival [N ii] image of PC 19, used for the 3D reconstruction (see references in Sec. 2.2.1). The position and width of the slit used for HCT spectroscopic observation is marked with dotted line on the image. (b) The rendered grayscale 2D model image for comparison with the observed image. The (c) side-view, (d) sky-view from the Earth, (e) top-view and (f) front-view of the 3D model of PC 19 constructed using SHAPE.

M dwarfs could be determined using the luminosity (L/ $\{L_\odot\}$) and we establish a new empirical relation for this. (MNRAS, 493, 4533, 2020)

4. We studied morphology and ionization characteristics of two less studied compact planetary nebulae PB 1 and PC 19, using observed and archival/literature data. We generated 3D models and predicted structures of the objects (Figure 2). We estimate the elemental abundances, and different physical parameters of the central stars (e.g. $T_{\rm BB}$, L and gravity), and of the nebula, (e.g. n_{μ} profiles, radii) from photoionization modeling. We estimate distances to the PNe (4.3 kpc and 5:6 kpc respectively) from photoionization modeling and progenitor masses (1.67 and 2.38 solar mass respectively) from theoretical evolutionary trajectories. (submitted to MNRAS 2020, under review).

Plan of Future Work Including Project

- 1. We are working to complete reduction of remaining observed data. We are modeling the reduced data, using different astronomical codes involving different types of mechanisms, to interpret them.
- 2. We are also planning to observe and study more astronomical objects using the national facilities. We aim to investigate several problems like understanding the chemical composition, geometry (morphology) and velocity (kinematics) of the material in ejecta of novae, to understand the properties of novae, dust formation process in novae, details analysis of planetary nebulae etc. We shall collaborate with other academic persons

and expand our area of researches.

3. We are also working to establish S N Bose Centre's Astronomical Observatory at Panchet hill, Purulia. Earlier we have received stage-II approval for land and demarcation of the land has been completed. We have invited more number of researchers to participate in this project with their own scientific proposals and preparing a proposal for submission.

Any other Relevant Information including social impact of research

- 1. I have acted as 'Officiating Supervisor' of the following PhD students: Ayan Bhattacharjee, Arindam Ghosh.
- 2. I am acting as 'Co-supervisor' of the following PhD students: Arnab Deb, Anuvab Banerjee, Abhishek Roy, Prantik nandi, Piklu Santra.
- 3. I am acting as Joint metor (with Prof. Sandip K Chakrabarti) of Ayan Bhattacharjee, ESRF.
- 4. I have guided the following student for her project work: Megha Dave, 4th Semester, IPhD, "Study of WR Stars"
- 5. Social impact: i. Progress in the basic sciences helps in solving the problems and understanding 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. Generation of manpower for worldwide astronomical projects.



Soumen Mondal

Associate Professor Astrophysics & Cosmology

soumen.mondal@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Supriyo Ghosh; Studies on Cool and Evolved stars; Thesis submitted
- 2. Anindita Mondal; Multi-wavelength studies of Novae; Thesis submitted; 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 Starforming Regions; Under progress
- 6. Siddhartha Biswas; Studies of Pre-main Sequence stars in the Galactic Starforrmation processes; Under progress
- 7. Diya Ram; Observational Astronomy (TBD); Under progress

b) Post-Docs

1. Arka Chatterjee; Astrophysics of compact objects

c) External Project Students / Summer Training

- 1. Lopamudra Roy; Spectroscopy techniques for understanding of Milk Adulteration; Technical Reserach Center, SNBNCBS
- 2. Supratik Sen; Spectroscopy techniques for understanding of Milk Adulteration; Technical Reserach Center, SNBNCBS
- 3. Navaneeth P K; Study of star formation : The Orion nebula cluster; Central University of Karnataka

Teaching

- 1. Autumn semester; Basic Laboratory -I (PHY 191); Integrated PhD; 13 students; with 1 (Prof. Samir K. Pal) co-teacher
- Spring semester; Astrophysics and Astronomy (PHY 403); Integrated PhD; 11 students; with 1 (Dr. Ramkrishna Das) co-teachers
- 3. Spring semester; Astrophysics and Astronomy (PHY 510); PhD; 03 students; with 1 (Dr. Ramkrishna Das) co-teachers

Publications

a) In journals

- Dhrimadri Khata, Soumen Mondal, Ramkrishna Das, Supriyo Ghosh, G Samrat Ghosh, Understanding the physical properties of young M dwarfs: NIR spectroscopic studies, Monthly Notices of the Royal Astronomical Society, Volume 493, Issue 3, p.4533-4550, 2020
- Alik Panja, Soumen Mondal, Somnath Dutta, Santosh Joshi, Sneh Lata, Ramkrishna Das, Census of the Young Stellar Population in the Galactic H II Region Sh2-242, The Astronomical Journal, Volume 159, Issue 4, page 153, 2020
- 3. Anindita Mondal, Ramkrishna Das, G. C. Anupama, **Soumen Mondal**, *Photoionization modeling of quiescence-phase spectra of novae and a symbiotic star*, Monthly Notices of the Royal Astronomical Society, Volume 492, Issue 2, p.2326-2334,2020
- Lopamudra Roy, Animesh Halder, Soumendra Singh, Jayita Patwari, Priya Singh, Kallol Bhattacharya, Soumen Mondal, Samir Kumar Pal, Spectroscopy of an intrinsic fluorophore in animal and plant milk for potential identification of their quality, Journal of Dairy Science, 103 (2), 1366-1376, 2020

 Somnath Dutta, Soumen Mondal, Santosh Joshi, Ramkrishna Das, Optical photometric variable stars towards Cygnus OB7, Monthly Notices of the Royal Astronomical Society, Volume 487, Issue 2, p.1765-1776, 2019

b) Conference proceedings / Reports / Monographs / Books

- Ghosh, Samrat; Mondal, Soumen; Das, Ramkrishna; Joshi, Santosh; Lata, Sneh; Biswas, Siddhartha, "A search for fast photometric variability in very low mass stars and brown dwarfs", Bulletin de la Société Royale des Sciences de Liège (BSRSL), in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 275-278,2019
- Panja, Alik; Mondal, Soumen; Dutta, Somnath; Joshi, Santosh; Lata, Sneh; Das, Ramkrishna, Biswas, Siddhartha, "Characterization of pre-main-sequence population in HII region Sh2-242", Bulletin de la Société Royale des Sciences de Liège (BSRSL), in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 270-274, 2019
- Dutta, Somnath; Mondal, Soumen; Joshi, Santosh; Das, Ramkrishna, "Rotation rates of pre-main-sequence stars: role of circumstellar disk", Bulletin de la Société Royale des Sciences de Liège (BSRSL), in Proceedings of the Second Belgo-Indian Network for Astronomy & Astrophysics (BINA) workshop, October 2018, held in Brussels, Belgium, Vol. 88, pp. 103-109, 2019
- Fitzgerald, Michael; Bailey, Vanessa; Baranec, Christoph; Mondal, Soumen, et al., "The Planetary Systems Imager for TMT", Astro2020: Decadal Survey on Astronomy and Astrophysics, APC white papers, no. 251; Bulletin of the American Astronomical Society, Vol. 51, Issue 7, id. 251, 2019
- B. Mazin; Étienne Artigau; V. Bailey, Mondal, Soumen, et al., "Directly Imaging Rocky Planets from the Ground", Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 128; Bulletin of the American Astronomical Society, Vol. 51, Issue 3, id. 128, 2019
- Dutta, Somnath; Mondal, Soumen; Samal, Manash R.; Jose, Jessy, "VizieR Online Data Catalog: Planck cold clump G108.37-01.06 YSO candidates (Dutta+, 2018)", VizieR On-line Data Catalog: J/ApJ/864/154. Originally published in: 2018ApJ...864..154D, August 2019

Talks / Seminars Delivered in reputed conference / institutions

- 1. Invited talk "Understanding of Very Low-Mass stars and Brown Dwarfs with TMT" at I-TMT Science and Instrumentation Workshop, held at ARIES, Nainital during 16 -19 October 2019; Oct 16, 2019; ARIES, Nainital; 20 minutes
- Invited talk "Variability and Flares in Pre-main Sequence stars" in National Seminar on "Nonlinear & Complex Phenomena", held at Jadavpur University during February 18-19, 2020; Feb 19, 2020; Jadavpur University, Kolkata; 30 minutes
- Invited talk "High Angular Resolution Astronomy: Black hole Imaging" at C. K. Majumdar Memorial Summer Workshop in Physics at SNBNCBS during 28 May -07 June 2019; Jun 4, 2019; SNBNCBS, Kolkata; 30 minutes

Administrative duties

- 1. Head of the Department of Astrophysics and Cosmology, S. N. Bose National Centre of Basic Sciences
- 2. Nodal Officer of Technical Research Centre (TRC), S. N. Bose National Centre of Basic Sciences
- 3. 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.

Patents Taken and Process Developed with Details

 A Spectroscopy-based Optical Device for estimation of milk quality by Soumen Mondal and Samir K. Pal; 201931028306, dated15/07/2019; Applied

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

1. Technical Research Centre (TRC), SNBNCBS; DST; 5 years; Co-PI

Conference / Symposia / Schools organized

 Member in the Organizing Committee of C. K. Majumdar Memorial Summer Workshop in Physics at SNBNCBS, 28 May - 07 June 2019; May 28, 2019; SNBNCBS, Kolkata; 11 days

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

- Dr. Santosh Joshi, Aryabhatta Research Institute of Observational Sciences, Nainital-263 002, India; Sl. No. 2, 5; National
- Dr. Sneh Lata, Aryabhatta Research Institute of Observational Sciences, Nainital-263 002, India; Sl .no. 2; National
- 3. Prof. G. C. Anupama, Indian Institute of Astrophysics, Bengaluru, Karnataka 560034, India; Sl. No. 3; National

Outreach program organized / participated

- 1. Telescope demonstartion to North-East students as a part of NORTH EAST CONCLAVE: IISF 2019 during visit at SNBNCBS on 8 November 2019
- Sky watching program with our roof-top telescope during C K. Mazumder Memorial Summer Workshop, June, 2019

Areas of Research

 (i) Multi-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 Census of young stellar population in the Galactic H II region $Sh2\ensuremath{\text{Sh2-242}}$

Stellar clusters are recognized as promising astrophysical sites as their formation and early evolution take place primarily in the Galactic spiral arms. Systematic studies of young clusters probe several dominant astrophysical problems, such as the formation of stars and planetary systems to the evolution of open clusters. Most of the stars originate in populous groups within giant regions of molecular clouds. We present here identification and characterization of the young stellar population associated with an active starforming site Sh2-242. We used our own new optical imaging and spectroscopic observational data, as well as several archival catalogs in optical and Infrared wavelengths, e.g., Pan-STARRS 1, Gaia DR2, IPHAS, WIRCam, 2MASS, and Spitzer. Slit spectroscopic results confirm the classification of the main ionizing source BD+26 980 as an early-type star of spectral type B0.5 V. The spectrophotometric distance of the star is estimated as 2.08 ± 0.24 kpc, which confirms the source as a member of the cluster. An extinction map covering a large area (diameter 58 500) is generated with H and K photometry toward the region. From the map, three distinct locations of peak extinction complexes (AV \sim 7–17 mag) are identified for the very first time. Using the infrared color excess, a total of 33 Class I and 137 Class II young objects are classified within the region. In total, 201 young objects are classified toward S242 from this study. Using the optical and infrared color-magnitude diagrams, the young stellar objects are characterized by an average age of 58 1 million years, and the masses in the range 0.1-3.0 Solar Mass (Alik Panja, Soumen Mondal et al., The Astronomical Journal, 2020).



Figure 1: Spatial distribution of the PMS sources in S242, overplotted on the WISE W1 $3.4 \,\mu$ m mosaic image, where Class I, Class II, and H Alpha emitting sources are represented by red circles, blue triangles, and green boxes, respectively. The main ionizing source BD+26 980 is represented by a black star symbol, is shown on the left. The K-band extinction map generated with (H - K) colors from the 2MASS catalog is shown in the right, and three high extinct regions A, B, C are identified.

Understanding the physical properties of young M dwarfs: NIR spectroscopic studies

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 Earthlike planets orbiting in 'habitable zones', increases with decreasing stellar mass and radius. Due to their proximity, small size and low mass, M dwarfs are becoming attractive targets for potentially habitable exoplanet searches via almost all current search methods. M dwarfs also represent a complete archaeological record of the chemical evolution and star-formation history of the Milky Way Galaxy. The characterization of low-mass stars is crucial, and NASA's Kepler mission suggests that M dwarfs are swarming with rocky planets. We present here medium resolution ($\lambda // \lambda \sim 1200$) H- and K-band spectra of M-type dwarf stars covering the wavelength ranges 1.50–1.80 μ m and 1.95–2.45 μ m from new observations using the TIFR Near-Infrared Spectrometer and Imager instrument on the 2-m Himalayan Chandra Telescope. Using interferometrically measured effective temperature (Teff), radius, and luminosity of nearby bright calibrator stars, we have created new empirical relationships among those fundamental parameters and spectral indices. The masses of M dwarfs could be determined using the luminosity (L/L/) and we establish a new empirical relation for this. We also compare and contrast our results with other similar work from the literature (Dhrimadri Khata, Soumen Mondal et al., Monthly Notices of Royal Astronomical Society, 2020).



Figure 2: The plots of our best-fitting calibration relationships for Teff (top left), radius (top right) and log (Lbol) (bottom) are shown here. The horizontal axes show the interferometrically measured stellar parameters. In the upper panel of each plot, the vertical axes represent our inferred parameters; in the lower panel, the vertical axes show the residual between our best-fitting values and the directly measured values. The data points are colour-coded by the [Fe/H] values calculated in this work.

Plan of Future Work Including Project

- 1. Scientific programs in the observational Astronomy : (i) Spectrophotometric studies of late M-type stars (dwarfs and giants) and Miras: Spectrophotometric studies of low-to-intermediate mass stars represent a vital test of theoretical models of stellar evolution, structure, and atmospheres. In stellar evolution. Optical/Near-IR spectrophotometric studies of these RGB/AGB objects are undertaken to understand their atmospheres and pulsation. Furthermore, studies of M dwarfs have been recognized as promising targets in the search for small extra-solar planets. (ii) Multi-wavelength studies of Galactic star-forming regions: Multi-wavelength studies of such regions provide a census of Young Stellar Objects, their fundamental parameters e.g., masses, ages, effective temperatures, circumstellar disks around them (if any), etc. We are studying these regions in optical, near-infrared (near-IR) and midinfrared (mid-IR) wavelengths from the ground and space-based national/international facilities. To provide comprehensive observations and in-depth study of the physical properties of Very Low Mass (VLM) objects and brown dwarfs in the galactic field as well as in young star-forming regions, we have started an observational program on "Photometric variability studies and characterization of very-low-mass (VLM) stars and brown dwarfs " using the National telescope facilities. (iii). Astronomical Instrumentation: With our expertise in the Optical/IR instrument design and development, we are working to establish an Astronomical Instrumentation Laboratory at the Centre for building the state-ofart backend instruments for the telescopes. We have planned one fiber-fed low-intermediate resolution spectrograph for our own telescope and other national facility telescopes as a visitor instrument.
- 2. Establishment of S. N. Bose Centre Telescope project at Panchet Hill, Purulia: At S. N. Bose Centre, recently we have initiated to establish the World-class Astronomical observing facility at Panchet hill. This project envisages establishing initially a small one-meter-class relatively wide-field telescope, which will be first in the eastern part of the country. Recently, we got the approval for 2 hectares land at Panchet hill-top, Purulia (about 220 km from the Centre) for this Astronomical Observatory site from the Forest department of Govt. Of India and state Govt. Of West Bengal and processes of hand-over the land to the Centre is on-going. 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.).
- A spectroscopic based low-cost instrument "Mil-Q-Way" is being developed under 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 project is intended for societal benefit and valuable Knowledge resource for food sector and security.





Department of CHEMICAL BIOLOGICAL & MACRO-MOLECULAR SCIENCES

TTA

Department of Chemical Biological & Macro Molecular Sciences

Jaydeb Chakrabarti

Department profile indicators

Table A : Manpower and resources

Number of faculties	10
Number of Post –doctoral research associate (Centre + Project)	11
Number of Ph.D students (including all)	41
Number of other project staff	
Number of summer students	8
Projects (ongoing)	11

Table B: Research Activities indicators

Number of research papers in Journals	70
Number of Book-chapters/books	
Number of other publications	2
Number of Ph.D students graduated (submitted + degree awarded)	14
Number of M.Tech/ M.Sc projects	10

Table C: Academic activities and likeage

Number of courses taught by faculties	8	
Number of Visitors (non –associates)	1	
Number of associates	0	
Number of Seminars organized	9	
Number of Conference/Symposia/Advanced Schools organized	10	
Number of talks delivered by members of department in conferences/Symposis	National	25
Number of tarks derivered by members of department in conferences/Symposia	International	6

Most important research highlights

- Combination of THz and optical spectroscopy to understand "hydrophobic hydration"
- Evanescent-wave coupled ring-down spectroscopy to probe interfacial dynamics in condensed phases
- Probing Stokes shift dynamics of a dipolar solute in ionic acetamide deep eutectic solvents (DESs) in presence of electrolytes
- Rational design and optimization of fluorescence-Raman bimodal nanoparticles (FRNPs)

- Synthesis of nano-materials and nano-bio conjugate
- Development of Nanomedicines and Biomedical instrumentation
- Molecular simulations to Characterize heterogeneous dynamics of soft condensed matter systems
- Carrying out analytical studies to design of generalized Rayleigh and Van der Pol families of oscillators
- Development and validation of a Support Vector Regression (SVR) based model of flexible water clusters

Summary of research activities

Spectroscopic investigations:

- Development of a combined complementing spectroscopic approaches (using THz time domain spectroscopy and optical (one color and two color) pump probe spectroscopy) to understand the highly debated topic of "hydrophobic hydration" in various liquid mixtures and self-assembled systems.
- Development of a prototype evanescent-wave coupled ring-down to study interfacial dynamics in condensed phases. The aggregation dynamics through surface imaging has been reported, thus demonstrating an alternative approach to monitor interfacial phenomena using EW-CRDS technique.
- Probing Stokes shift dynamics of a dipolar solute in ionic acetamide deep eutectic solvents (DESs) in presence of electrolytes: Fluorescence up-conversion (~250 fs instrumental response) coupled with time correlated single photon counting measurements explore complete Stokes shift dynamics of a dipolar solute probe, coumarin 153 (C153), in several ionic acetamide deep eutectic solvents (DESs) that contained lithium nitrate/bromide/perchlorate as electrolyte. These studies establish micro heterogeneous nature of these ionic DESs.
- Rational design and optimization of fluorescence-Raman bimodal nanoparticles (FRNPs): Rational design and optimization of fluorescence-Raman bimodal nanoparticles (FRNPs) which enable highly efficient image-guided photo-thermal ablation of tumors, widening the scope of the NPs into the therapeutic realm. DNA-enabled molecular engineering allows the rational design of FRNPs with a detection limit as low as 5×10^{-15} M. FRNPs selectively accumulate in tumor tissue mouse cancer models and enable real-time fluorescence imaging for tumor detection, resection, and subsequent Raman-based verification of clean margins.

Synthesis of nano-materials and nano-bio conjugate:

The synthesis has been done in various technologically relevant materials, like (a) Transition metal doped oxide

nanoclews for potential application in electrocatalysis via novel solution chemistry route; (b) Bio-nano conjugate by selective attachment of inorganic semiconductor/ metal quantum dots (QD) to various biological macromolecules.

Development of Nanomedicines and Biomedical instrumentation:

The efforts to bring the frontier research to common people in our society in terms of lost cost spectroscopic gadgets for the biomedical/environmental usage have been fruitful, granted patents and given commercial venture.

Highlights of theoretical researches:

- Molecular simulations to Characterize heterogeneous dynamics of soft condensed matter systems: Two dimensional colloidal particles subjected to a spatially periodic external potential and Zn²⁺ in presence of surface exposed acidic residues of ubiquitin. Both systems despite diversity show dynamic heterogeneity which may be useful in material design.
- Carrying out analytical studies to design of generalized Rayleigh and Van der Pol families of oscillators: A unified scheme has been studied to express a class of system of equations in two variables into a Liénard -Levinson – Smith (LLS) oscillator form. The condition has been derived 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 an LLS oscillator. Based on this approach, a scheme is proposed for systematic designing of generalized Rayleigh and Van der Pol families of oscillators with a desired number of multiple limit cycles.
- Development and validation of a Support Vector Regression (SVR) based model of flexible water clusters: Development and validation of a Support Vector Regression (SVR) based model of flexible water clusters. It is demonstrated that they have significantly better accuracy than classical force fields, whereas preserving the accuracy of ab initio (quantum chemical) theories.

fayleb Chabrabarti

Jaydeb Chakrabarti Head, Department of Chemical, Biological & Macro-Molecular Sciences



Debashis Mukherjee

S N Bose Chair Professor CBMS demu.sb@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

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

Publications

a) Other Publications (including conferences)

 Interlacing and Avoided Crossings of a Manifold of Potential Energy Surfaces Studied by a Spin-Free State Specific Many-Body Approach; Debashis Mukherjee, Riya Kayal, Dibyajyoti Chakravarti, Koustav Hazra; 9th Conference of the Asia-Pacific Association of Theoretical and Computational Chemists; September 30 – October 3, 2019

Talks / Seminars Delivered in reputed conference / institutions

1. Inaugural Talk in the International Conference Computation and Understanding in Quantum Molecular Science; Toulouse, France, September 3-6, 2019.

- 2. Invited Talk in the International Conference by the Asia-Pacific Association for Theoretical and Computational Chemistry, Sydney, September 30-October 3, 2019.
- 3. Plenary Talk at the International Conference on strongly correlated electrons, Qingdao, Oct.9 Oct.13, 2019.
- 4. Inaugural Talk in the Conference on Modern Methods on Quantum Chemistry, Hsinchu, October 28, 2019.
- 5. Inaugural Talk in the International Meeting on International Conference on the Theme Structure and Dynamics of Molecular and Condensed Matter Systems, Puri, March 1-4, 2020.

Awards / Recognitions

- 1. Awarded the Life-time Achievement Gold Medal of the Chemical Research Society of India, 2019.
- 2. Offered the Distinguished Visiting Professorship of the IIT, Mumbai, 2020-.
- 3. Inducted to the Board of Directors of the International Society of the Theoretical Chemical Physics (ISTCP), 2019-.

Scientific collaborations with other national / international institutions

- I. (1) A Shee, Univ of Michigan, Ann Arbor, USA; (2) S. Sen, Hylleraas Centre, Univ. of OSLO,Norway (3) T Saue, Paul Sabatier University, Toulouse, France; (4) B P Das, Tokyo Institute of Technology, Japan; (5) A Sen, previously at MPI, Muelheim, Germany; (6) T Helgaker, Hylleraas Centre, Univ. of Oslo, Norway; (7) L Cheng, Johns Hopkins University, USA;
- II. Professor Yvon Maday, Universite Pierre et Marie Curie, Sorbonne, Paris: European Research Council funded collaborator

Areas of Research

Development and Validation of Many-Body Theories for Electronic Structure; Relativistic and Electro-weak Quantum Chemistry

Interplay of correlation, relativity and orbital relaxation in electronic properties

Theoretical prediction of the inner valence processes such as core ionization potential (IP) poses a special challenge to any high level correlation theory. As an example, an accurate description of the core ionization phenomenon requires proper quantitative modeling of not only the differential

correlation attendant on ionization, but also of the orbital relaxation which is huge. For molecules containing one medium-heavy atom, the scalar relativistic effect tends to become important In the series of example molecules of the generic formula [XH] with X as the non-hydrogen atom, our continued research using our recently developed relativistic coupled cluster theory in both non-relativistic (NR) and spin-free Dirac-Coulomb (DC) Hamiltonian regime clearly establishes this with quantitative accuracy. Since spin-orbit coupling is relatively small up to medium heavy atoms, the spin-free DC Hamiltonian has been studied in both a four-component and a two-component framework. The most widely accepted approach for the two component theories is the exact two-component one-electron (X2C-1e) Hamiltonian, and we have invoked its spin-free version in our numerical implementation.

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

Use of self-consistent propagator theories to study excitation energies:

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



Gautam Gangopadhyay

Senior Professor CBMS gautam@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Sandip Saha; Nonlinear dynamics in open chemical and biological systems; Under progress
- 2. Premasish Kumar; Nonlinear nonequilibrium systems; Under progress
- 3. Krishanu Mondal; Nonlinear nonequilibrium systems; Under progress

b) Post-Docs

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

c) External Project Students / Summer Training

1. Kritina Bora; Ultrasensitivity in enzyme kinetics; Tezpur University

Teaching

1. Autumn semester; Equilibrium Statistical Mechanics; PhD; 8 students; with 1 (Jaydeb Chakrabarty) coteacher

Publications

a) In journals

- K. Banerjee, B. Das, G. Gangopadhyay, The guiding role of dissipation in kinetic proofreading networks: Implications for protein synthesis, J. Chemical Physics, 152 (2020)111102
- Krishnendu Pal and Gautam Gangopadhyay, Termination Of Action Potential Due To Site Selective Ion Channel Blockers, Fluctuation and Noise Letters, Vol. 19, No. 2 (2020) 2050015
- 3. Anirban Karmakar and **Gautam Gangopadhyay**, A strong enhancement in electronic current due to conical-intersection, Physica Scripta, 94 (2019) 125401
- Prasanta Kundu, Soma Saha, and Gautam Gangopadhyay, Application of dynamic disorder approach to the temperature dependent non-exponential electron transfer kinetics in Rhodopseudomonas viridis, J. Stat, Mech. Theo. Expt. 1742-5468 (2019)
- 5. S. Saha and **G. Gangopadhyay** and D. S. Ray, Systematic designing of bi-rhythmic and tri-rhythmic models in families of Van der Pol and Rayleigh oscillators, Comm. Monlin. Sci. Numer. Simul, 85 (2020) 105234

Talks / Seminars Delivered in reputed conference / institutions

 Talk On bi-rhythmic and tri-rhythmic systems in families of van der Pol and Rayleigh oscillators in 12th National conference on Nonlinear Systems and Dynamics at IIT Kanpur, 12-15'Decc'2019; 04 days (12-15 Dec'2019)

Administrative duties

- 1. Transparency Officer of the Centre
- 2. Member project and patent cell

Membership of Learned Societies

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

Conference / Symposia / Schools organized

 Two days Meeting on Nonlinear Dynamics in Chemistry and Biology(NLDCB) during 8-9th April'2019; Apr 8, 2019; S N Bose Centre; 02 days (8-9th April'2019)

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

1. Prof. D S Ray, IACS, Kolkata; 04 days (12-15 Dec'2019); National

Areas of Research

Theoretical Chemical Physics

1. 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.

2. Dynamic disorder and conformational fluctuations in reaction kinetics:

The decay of the nonexponential kinetics at the microsecond timescale, points to the relevance of having possible influence of dynamic disorder on the reaction kinetics. To rationalize the experimental results by 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.

3. Quantum transport through molecular system:

To construct the theory of quantum transport through molecular system we have developed the formulation of quantum system coupled to a fermionic bath and the model is applied in various coherent processes. In continuation of our earlier work we have studied the electronic and nuclear entanglement with nonadiabatic effects in conical intersection regime.

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, to understand these phenomena, we have already constructed complex Ginzberg-Landau equation using multiscale Krylov-Bogolyubov averaging method. It 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 freeenergy and concentration profiles.



Jaydeb Chakrabarti

Senior Professor CBMS jaydeb@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Sashthi Charan Mandal; soft matter physics; Under progress
- 2. Edwine Tendong; Material science; Under progress; Tanusri Saha-Dasgupta (Co-supervisor)
- 3. Abhik Ghosh Moulik; Bimolecular systems; Under progress
- 4. Rahul Karmakar; Soft matter physics; Under progress

b) Post-Docs

1. Ayatti Gupta; Biomolecular systems

c) External Project Students / Summer Training

1. Suravi Pal; Soft matter physics; TRC, SNBNCBS

Teaching

1. Spring semester; Statistical mechanics; Integrated PhD

2. Autumn semester; Advanced statistical mechanics; PhD; with 1 (Gautam Gangopadhyay) co-teacher

Publications

a) In journals

- 1. S. Pal, **J. Chakrabarti**, *Heterogeneity of dynamics in a modulated colloidal liquid*, Journal of Physics Condensed Matter, 32 (12), 124001, 2019
- 2. S. Dutta, M. Ghosh, R. Karmakar, **J. Chakrabarti**, Dynamic signature of ligand binding over a protein surface, Physical Review E,100 (6), 062411, 2019
- 3. S. Dutta, P. Patra, **J. Chakrabarti**, Self-assembly in amphiphilic macromolecules with solvent exposed hydrophobic moieties, Biopolymers, 110, e23330, 2019
- S. Dutta, M. Ghosh, J. Chakrabarti, In-silico studies on conformational stability of flagellin-receptor complexes, Journal of Biomolecular structure and Dynamics, 38, 2240-2252, 2020
- S. Sikdar, M. Ghosh, A. Adak, J. Chakrabarti, Structural and dynamic responses of calcium ion binding loop residues in metallo-proteins, Biophysical Chemistry, 252, 106207, 2019

Talks / Seminars Delivered in reputed conference / institutions

- Students' participation in KOLKATA X: a) Rahul Karmakar (poster on Self-assembly under Thermophoresis; awarded 3rd Best poster); b) Suravi Pal (poster on Dynamics of modulated colloid); c) Edwine Tendong (poster on: Dynamics of nano-confined water by asymmetric walls); and d) Abhik Ghosh Moulik (poster on Correlation between dipolar and dihedral fluctuations in proteins); Nov 26, 2019; Presidency University; 3 days
- 2. Students' participation in DAE Solid State Physics Symposium 2019: Abhik Ghosh Moulik (poster on Correlation between dipolar and dihedral fluctuations in proteins); Dec 18, 2019; IIT Jodhpur; 5 days
- Students' participation in 13th International Conference CompFlu 2019: a) Edwine Tendong (oral presentation on Nanoconfined water in asymmetric walls; awarded best oral presentation); and b) Suravi Pal (poster on Dyamanics of modulated colloids); Dec 5, 2019; IISER, Bhopal; 3 days

Administrative duties

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

Membership of Learned Societies

- 1. Indian Biophysical Society
- 2. Biophysical Society, US

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

- 1. TUE; DST; Co-PI
- 2. TRC, SNBNCBS; DST; Co-PI

Conference / Symposia / Schools organized

- 1. International conference, Statphys Kolkata-X; Nov 26, 2019; Presidency University; 03 days
- 2. Mini-school on Advanced techniques in soft matter computation; Feb 14, 2020; SNBNCBS; 02 days

Areas of Research

Soft matter physics

Dr Jaydeb Chakrabarti's group has been actively working in several aspects of soft matter systems:

- 1. Dynamics of soft matter systems:
- (a) Dynamics of a system of two dimensional colloidal particles subjected to a spatially periodic external potential using Brownian Dynamics simulations: We characterize the dynamics in the system by the mean square displacements and the self-van Hove function. The static density plots suggest that system gets into modulated liquid phase in presence of the external potential. We find that diffusion coefficients, obtained from long time mean square displacements, decay exponentially with increasing potential strength. The self-van Hove functions computed from the distribution of particle displacemets in a given time interval show non-gaussian behaviour in directions both parallel and transverse to the external modulation. This suggests

heterogeneous dynamics and is supported by particle mobilities and residence times.

- (b) Dynamics of Zn^{2+} in presence of surface exposed acidic residues of ubiquitin: From μ s long molecular dynamics trajectories, we observe that unlike normal diffusive liquid, strongly trapped ions show linear tail in self-van Hove functions. Weak localization caused by mutations leads to double Gaussian self-vHfs. We model effect of localization in terms of trapping potential that reproduces linear tail. The self-vHf which can be measured by scattering experiments can thus be an approach to find binding pockets over protein surface.
- 2. Conformational stability of protein-protein complexes:

Flagellin is a protein, responsible for virulent activities of bacteria. The host cell surface receptor protein TLR5 is known to interact with flagellin in order to activate immune response. However, the underlying microscopic details of this immune response are still elusive. In this study, we report on conformational stability of flagellin of two different organisms known as fliC and flaD in bilayer with reference to water. We find that both the flagellin is conformationally more stable in bilayer than in water. We also observe that fliC-TLR5 and flaD-TLR5 complexes are conformationally stable when the extracellular domain of the protein binds to conserved D1 domain of both fliC and flaD, although the binding interface between fliC-TLR5 and flaD-TLR5 is not identical. Our studies suggest that this might lead to differences in coreceptor bindings involved in immune response and thus have potential application in pharmaceutical developments.

Plan of Future Work Including Project

- 1. Dynamics of fluids under nanometer scale confinement and external forces
- 2. Conformational stability of nucleic acids and disordered proteins
- 3. Microscopic theory of nano-bio conjugate systems
- 4. Understanding the kinetics of time dependent phenomena in systems of technological interest



Manik Pradhan

Associate Professor CBMS manik.pradhan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Sanchi Maithani; Cavity Ring-down Spectroscopy and Evanescent Wave; Under progress
- 2. Biswajit Panda; High-resolution Gas-phase Molecular Spectroscopy; Under progress
- 3. Mithun Pal; Quantum Cascade Laser Spectroscopy; Thesis submitted
- 4. Akash Das; Optical Properties of 2D Materials; Under progress
- 5. Ardhendu Pal; Laser Spectroscopy using Quantum Cascade Lasers; Under progress
- 6. Vishal Agarwal; Nanomaterials and Spectroscopy; Under progress; Manik Pradhan (Co-supervisor)

b) Post-Docs

- 1. Arpan Maiti; Nano Materials and gas sensing
- 2. Arun Bera; Gas sensing and nanodevice

c) External Project Students / Summer Training

- 1. Sayani Bhattacharya; Breath Analysis and Biomedical Sciences; TRC Project Student (SNBNCBS)
- 2. Swarnava Biswas; Biomedical Diagnostics; TRC Project Student (SNBNCBS)
- 3. Saikat Ghosh; Nano Materials and Isotopic Fractionations; SERB Project Student (Co-PI)
- 4. Debatri Ghosh; Biomedical Science; TRC Project Assistant

Teaching

1. Spring semester; Methods in Experimental Physics (PHY391) (Shared); Integrated PhD; 13 students

Publications

a) In journals

- Biswajit Panda, Sanchi Maithani and Manik Pradhan, High-resolution investigation of temperature and pressure-induced spectroscopic parameters of ¹³C-isotopomer of CH₄ in the ν₄ band using cavity ringdown spectroscopy, Chemical Physics, 535, 110769, (2020)
- Mithun Pal, Sayoni Bhattacharya, Abhijit Maity, Sujit Chaudhuri and Manik Pradhan, Exploring Triple-Isotopic Signatures of Water in Human Exhaled Breath, Gastric Fluid, and Drinking Water Using Integrated Cavity Output Spectroscopy, Analytical Chemistry, 92, 8, 5717-5723 (2020)
- 3. Mithun Pal and **Manik Pradhan**, High-resolution cwcavity ring-down spectroscopy of allowed $(\nu 4 + \nu 5)^{\circ}$ and forbidden $(\nu 4 + \nu 5)^2$ bands of C_2H_2 using externalcavity quantum cascade laser, Journal of Molecular Spectroscopy, 370, 111276 (2020)
- 4. Sanchi Maithani, Biswajit Panda, Abhijit Maity and **Manik Pradhan**, Gas-Phase Isotopic Fractionation Study of Singly and Doubly Deuterated Isotopologues of Water in the H–D Exchange Reaction by Cavity Ring-Down Spectroscopy, Journal of Physical Chemistry A, 124, 6, 1104-1111 (2020)
- Sanchi Maithani, Abhijit Maity and Manik Pradhan, A Prototype Evanescent Wave-Coupled Cavity Ringdown Spectrometer for Probing Real-Time Aggregation Kinetics of Gold and Silver Nanoparticles, Analytical Chemistry, 92, 5, 3998-4005 (2020)

b) Conference proceedings / Reports / Monographs / Books

 Sayoni Bhattacharya, Swarnava Biswas, Abhijit Maity, Sujit Chaudhuri and Manik Pradhan, "A comparison between rapid urease test and 13C-Urea breath test: identifying a precise diagnostic method for Helicobacter pylori infection": Journal of Gastroenterology and Hepatology 34, 205, (2019)

Talks / Seminars Delivered in reputed conference / institutions

- One Day Discussion Meeting on Spectroscopy, Photonics and Dynamics (SPD-2020); Mar 7, 2020; IISER Kolkata, India; 7 March, 2020
- The VIII International Conference on Perspectives in Vibrational Spectroscopy (ICOPVS-2020); Feb 24, 2020; JNCASR, Bangalore; 24-29 February, 2020
- 3. ISCBC-NIPiCON-2020; Jan 22, 2020; Nirma University, Gujrat; 22-24 January, 2020
- 4. PHASE-2020, An Indo-UK workshop on Applied Photonics; Jan 10, 2020; IIT Gandhinagar; 10-14 January, 2020
- 5. Joint Conference by ISO-ISMPO; Nov 1, 2019; Indore; 1-3 November, 2019
- International Conference on Atomic, Molecular, Optical & Nano Physics with applications (CAMNP-2019); Dec 18, 2019; DTU, Delhi; 18-20th December, 2019
- International Conference on Modern Approaches of Chemical Science and Nanomaterials (ICMACSN); Aug 26, 2019; Rajasthan; 26-27th August, 2019
- BIT's 7th Annual Conference of Analytix-2019; Apr 12, 2019; Singapore; 12-14th April, 2019

Administrative duties

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

Awards, Recognitions

 Inducted as an Early Career Board Member (ECB) of Analytical Chemistry of American Chemical Society (ACS)

Membership of Learned Societies

- 1. Americal Chemical Society (ACS)
- 2. Chemical Research Society of India (CRSI)
- 3. Indian Society of Chemists and Biologists (ISCB)
- 4. Indian Spectroscopy Society (ISS)
- 5. 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; 2017-2020; Co-PI

Conference / Symposia / Schools organized

- International Conference on Nano Science and Technology (ICONSAT-2020) [Local Organizing Committee Members]; Mar 5, 2020; Biswa Bangla Convention Centre, Kolkata; 5-7th March, 2020
- The VIII International Conference on Perspectives in Vibrational Spectroscopy (ICOPVS-2020) [National Organizing Committee Members]; Feb 24, 2020; JNCASR, Bangalore; 24-29th February, 2020

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

1. Collaboration with Dr. Sujit Chaudhuri, MD, Gastroenterologist, AMRI Hospital, Salt Lake, Kolkata; Sl. No. 2; National

Outreach program organized / participated

- 1. PHASE-2020: An Indo-UK workshop on Applied Photonics, Participated and delivered a talk at IIT Gandhimagar, 10-14 January, 2020
- INDIA INTERNATIONAL SCIENCE FEST (IISF)-2019: Technology Showcase to NORTH EAST STUDENTS' CONCLAVE on 8th November, 2019

Areas of Research

High-Resolution Molecular Spectroscopy, Applied Analytical Spectroscopy and Photonics, Analytical Chemistry, Applications of Laser Spectroscopy in Biomedical and Environmental Sciences

1. Development of an Evanescent Wave-Coupled Cavity Ring-down Spectrometer for Probing Real-Time Aggregation Kinetics of Gold and Silver Nanoparticles:

We have developed a simple, linear optical cavitybased system combining evanescent wave (EW) with high-sensitive cavity ring-down spectroscopy (CRDS) technique using a diode laser at 644 nm and a right-angled prism for evanescent field generation on prism surface. We utilized this setup to investigate the salt-induced aggregation kinetics of gold (Au) and silver (Ag) nanoparticles (NPs) at the prism interface with high-sensitivity. We evaluated the extinction rates on the surface due to Au and Ag NPs aggregation and examined the variations due to their respective concentrations. To demonstrate the applicability of the developed EW-CRDS prototype setup to different molecular systems, we investigated the urease-bound aggregation kinetics of the Au and Ag NPs which has not been explored earlier by this linear cavity geometry. We finally illustrated the aggregation dynamics through surface imaging, thus demonstrating an alternative

analytical approach to monitor interfacial phenomena using EW-CRDS technique.

2. Isotopic Fractionation Study of Singly and Doubly Deuterated Isotopologues of Water in the H–D Exchange Reaction by Cavity Ring-Down Spectroscopy:

The underlying mechanisms of the triple-oxygen (160, 170, and 180) isotopic content of deuterated (D) isotopologues of water in H–D exchange reactions in the gas phase remain elusive. Herein, we have demonstrated a high-resolution gas-phase spectral analysis of doubly (D2O) and singly (HDO) deuterated isotopologues of water in the region around 7.8 μ m using quantum cascade laser-based cavity ring-down spectroscopy. Isotopic fractionations among doubly and singly deuterated species of water, D216O, HD16O, HD17O, and HD18O, in the gas phase were carried out by probing the fundamental and hot band transitions in the ν 2 (bending) mode of D2O and the fundamental ν 2 transitions for the other water isotopes. We subsequently investigated the fractionations of different D-enriched water isotopologues for the H-D exchange reaction using various mixtures of D2O in H2O. We explored the potential role of triple-oxygen isotopic contents through enrichments and depletions of HD16O, HD17O, and HD18O, involved in the H-D reaction. Our first clear, direct, and quantitative experimental evidence reveals a new picture of gas-phase isotopic fractionation chemistry in a mixture of light and heavy water (H2O–D2O).





Plan of Future Work Including Project

- 1. Investigation of optical beam shifts of 2D materials using quantum weak measurements (QWM) technique.
- 2. Exploration of spin-isomers of D2O in the gas-phase
- 3. Development of Broadband CRDS experimental technique

Any other Relevant Information including social impact of research

1. Currently few prototype breath analyzers have been developed for the detection of H. pylori stomach infection and ulcer diseases. They are under the clinical trials in hospital environments as a prelude to technology transfer and subsequent commercialization.



Rajib Kumar Mitra

Professor CBMS rajib@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Sk. Imadul Islam; Studies on ultrafast dynamics and spectroscopic investigations on fluorescent probes in bimolecular and biomimetic recognition; 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; Under progress; Prof. Anjan Barman (Supervisor)
- 5. Didhiti Bhattacharya; Opto-electronic, Electrical and Spectroscopic studies of two dimensional materials; Under progress; Prof. Samit K. Ray (Supervisor)
- 6. Sumana Pyne; Application of Ultrafast Spectroscopy in Biological Systems; Under progress
- 7. Sudip Majumder; Nanomagnetism; Under progress; Prof. Anjan Barman (Supervisor)

- 8. Ria Saha; Studies on the Effects of Different Crowding agents on Protein Folding Unfolding Process; Under progress
- 9. Subhajit Singha; Application of Ultrafast Spectroscopy in Biological Systems; Under progress

b) Post-Docs

1. Bibhab Bandhu Majumdar; Protein folding under stressed environments

c) External Project Students / Summer Training

- 1. Swati Bedi; Spectroscopic studies of D-luciferin in TFE-Water and EtOH-Water Binary mixture; IIT, Kharagpur
- 2. Rihan Naz; Effect of salts on protein folding; Jadavpur University

Teaching

- 1. Autumn semester; PHY 301 (Atomic and Molecular Physics); Integrated PhD; 13 students; with 1 (Prof. Anjan Barman) co-teacher
- 2. Autumn semester; CB 527 (Molecular Physics & Spectroscopy); PhD; 3 students; with 1 (Prof. Anjan Barman) co-teacher
- Autumn semester; PHY 501 (Research Methodology); PhD; 35 students; with 1 (Prof. Atindra Nath Pal) coteacher
- 4. Spring semester; PHY 405 (Biological Physics); Integrated PhD; 3 students
- 5. Spring semester; CB 526 (Fundamentals of Biophysics); PhD; 2 students

Publications

a) In journals

- S. Pal, P. Pyne, N. Samanta, S. Ebbinghaus, and R. K. Mitra, Thermal stability modulation of the native and chemically-unfolded state of bovine serum albumin by amino acids, Physical Chemistry Chemical Physics 22, 179-188, 2020
- D. Bhattacharya, S. Mukherjee, R. K. Mitra and S. K Ray, Size-dependent optical properties of MoS₂ nanoparticles and their photo-catalytic applications, Nanotechnology, 31, 145701 (2020)
- C. Sengupta, A.K. Maity, S. Chakraborty and R.K. Mitra, Complexation and fluorescence behavior of proflavin with chemically engineered amine capped carbon nanodots and its subsequent release into DNA environments, New J. Chem. 44, 1045-1053, 2020

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- P. Pyne, N. Samanta, A. Patra, A. Das, P. Sen and R.K. Mitra, Polyethylene glycols affect electron transfer rate in phenosafranin-DNA complex, Spectrochim. Acta A 225, 117464, 2020
- A. De, C. Banerjee, A.K. Chaurasiya, R. Mandal, Y. Otani, **R.K. Mitra** and A. Barman, Anisotropic spinwave dispersion in two-dimensional Ni₈₀Fe₂₀ diatomic nanodot array, J. Mag. Mag. Mat. 491, 165557, 2019
- D. Das Mahanta, Sk. I. Islam, D.K. Das, **R.K. Mitra** and A. Barman, Contrasting hydration dynamics in DME and DMSO aqueous solutions: A combined optical pumpprobe and GHz-THz dielectric relaxation investigation, J. Mol. Liq. 290, 111194, 2019

Talks / Seminars Delivered in reputed conference / institutions

- "Excited State Proton Transfer Rate of D-luciferin in Different Reverse Micellar Systems: Effect of Surfactant Charge Type, Temperature and Solvent Polarity" at National Conference on "Surfactants, Emulsions and Biocolloids (NATCOSEB-XIX)" held at Amity University Kolkata, India from October 18-20, 2019; Oct 20, 2019; Amity University, Kolkata
- 2. "Contrasting hydration behavior of some solvent mixtures and electrolytes" at Ruhr University, Bochum, Germany; Aug 14, 2019; Ruhr University, Germany
- "Application of THz Spectroscopy in Chemistry and Biology: Recent Advances and Challenges" in One-Day Discussion Meeting on Dynamics of Chemical and Biological Systems at IIT Kanpur; Jan 7, 2020; IIT Kanpur

Administrative duties

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

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

Conference / Symposia / Schools organized

- XXth International Workshop on The Physics of Semiconductor Devices (IWPSD-2019); Dec 16, 2019; Hotel Novotel, Kolkata; 16- 20 December, 2019
- International Conference on Nano Science and Technology (ICONSAT-2020); Mar 5, 2020; Biswa Bangla Convention Centre, Kolkata; 05- 07 March, 2020

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

- Collaboration with Prof. Pratik Sen, IIT Kanpur; Sl. No. 4; National
- Collaboration with Prof. Simon Ebbinghaus, Technical University, Braunschweig, Germany; Sl. No. 1; International

Areas of Research

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

- We have investigated the effect of amino acids on the stability of a model globular protein bovine serum albumin (BSA) upon thermal and urea-induced unfolding. We have used three complementary techniques, viz. emission spectroscopy (to investigate the effect on subdomain II which hosts Trp212), circular dichroism (to investigate the effect on the protein's overall a-helical content) and differential scanning calorimetry (to investigate the overall melting energetics of the protein). We have found that these amino acids do modulate the unfolding process, however, without following any particular trend with either the hydrophobicity scale or the solvent accessible surface area (SASA) of the added amino acids.
- We have studied the H-bond dynamics of water in presence of two co-solvents, 1,2-dimethoxy ethane (DME) and dimethyl sulfoxide (DMSO) using two complementary experimental techniques to compare

global (through dielectric relaxation study in the GHz-THz frequency domain) as well as local (through FTIR and optical single color pump-probe studies) hydration environment and dynamics in the two binary mixtures. The difference in the affinity of H-bond formation and self-aggregation properties of the co-solvents have been found to modulate the hydration dynamics in contrasting manners as evidenced from the experimental findings.

- We have reported the efficacy of MoS₂ nanocrystals for their size tunable properties for optical and photocatalytic applications. We have synthesized different sized (10-70 nm), crystalline, hexagonal 2H-MoS₂ nanoparticles (NPs) dispersed in DMF. Synthesized NPs were found to exhibit size dependent optical properties and excitation dependent fluorescence characteristics in the visible region, which are intriguing for industrial applications. Charge carrier emission dynamics of different sized MoS₂ NPs were investigated using time correlated single photon counting (TCSPC) spectroscopic technique. A noticeable photocatalytic activity of the synthesized MoS₂ NPs under visible light illumination for the degradation of Brilliant Green dye was also demonstrated for the first time.
- Carbon nanodots (CNDs) and proflavin (PF) have been used as constituents of a drug delivery carrier, where PF is a very good DNA intercalator. Amine capped carbon dots with particle diameter of 80-100 nm were prepared by pyrolysis of citric acid. Excited-state interactions like fluorescence resonance energy transfer (FRET), Photoinduced ET (PET) etc. between PF and CNDs have been studied using steady-state absorption and emission spectroscopy. Time-correlated-single-photon counting (TCSPC) was used to measure fluorescence decay kinetics in sub-ns time regime. We found that fluorescence intensity of CNDs get quenched by PF. After addition of calf thymus (CT) DNA the quenched fluorescence intensity of CNDs got recovered. This indicates a controlled release of PF into the DNA micro environment by CNDs which infers their utility as an efficient drug delivery agent.
- We have studied steady state and ps and fs -resolved emission properties of a phenosafranine (PSF) intercalated to calf thymus (CT) DNA in the presence of ethylene glycol (EG) and polyethylene glycols (PEG) of different chain lengths (PEG 200, 400 and 1000). The emission of PSF gets considerably quenched when intercalated to DNA; the quenching is released when PEGs are added into it. ps-resolved fluorescence measurements showed significant decrease in the contribution of the DNA induced quenched time-constant of PSF upon the addition of PEGs, however, fs-resolved measurements showed less noticeable changes in the time constants. Our study shows that the electron hopping rate through the guanine base in DNA core remains unaffected whereas the 'through space' electron transfer process does get affected in the presence of molecular crowders.

Plan of Future Work Including Project

- 1. We plan to combine two experimental approaches namely THz time domain spectroscopy (which probes the low frequency collective vibration models of water, and therefore very sensitive to the global network dynamics of water around hydrophobic surfaces) and optical pump-probe (transient absorption) spectroscopy (which is extremely sensitive to the local environment of a chromophore) to monitor the expected change in overall hydration of a protein during their self-aggregation. The results of this proposed work would render positive impetus for advancement in the research on the proteinaggregation based neurodegenerative diseases.
- 2. 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.
- 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 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 underline the inherent role of solvation dynamics on the excited state proton transfer (ESPT) process of some photo-acids. We would use various constrained aqueous medium (e.g. solvent mixtures, reverse micelles, vesicles) and two different time-resolved techniques (fluorescence and transient absorption) to accomplish this.
- 5. We plan to synthesize and characterize various optical and mechanical proprieties of MoS_2 and other dichalcogenite materials in their two-dimensional layered as well as in nanoparticle forms. We also plan to dope these materials with suitable dopants to enhance their optical and mechanical properties.



Ranjit Biswas

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Ejaj Tarif; Pico-second resolved studies of deep eutectic solvents; Thesis submitted
- 2. Atanu Baksi; Computer simulation studies of confined systems and complex fluids; Under progress
- Juriti Rajbangshi; Computational studies of ionic liquids, binary mixtures and other complex systems; Under progress
- Kajal Kumbhakar; Time-resolved spectroscopic studies of energy materials and other related systems; Under progress
- 5. Dhrubajyoti Majhi; Computer Simulations of Deep eutectic solvents; Thesis submitted
- 6. Jayanta Mondal; Dielectric relaxation and fluorescence studies of deep eutectics; Thesis submitted
- 7. Narayan Maity; Time-resolved fluorescence and Dielectric relaxation studies of complex fluids and protein solutions; Under progress

b) Post-Docs

1. Sirshendu Dinda (Left in Feb 2020); Experimental studies of ionic deep eutectic solvents

Teaching

1. Autumn semester; Physical Chemistry: Theory and Experiments (CB524); PhD; 5 students

Publications

a) In journals

- 1. Navin Subba, Ejaj Tarif, Pratik Sen, and **Ranjit Biswas**, Subpicosecond Solvation Response, and Partial Viscosity Decoupling of Solute Diffusion in Ionic Acetamide Deep Eutectic Solvents: Fluorescence Upconversion and Fluorescence Correlation Spectroscopic Measurements, Journal of Physical Chemistry B, 2020, 124, 1995-2005
- Navin Subba, Kamil Polok, Piotr Piatkowski, Bozena Ratajska Gadomska, **Ranjit Biswas**, Wojciech Gadomski, and Pratik Sen, *Temperature-Dependent* Ultrafast Solvation Response and Solute Diffusion in Acetamide-Urea Deep Eutectic Solvent, Journal of Physical Chemistry B, 2019, 123, 9212-9221
- 3. Ejaj Tarif, Jayanta Mondal, and **Ranjit Biswas**, How frictional response during solute solvation controls solute rotation in naturally abundant deep eutectic solvent (NADES)? A case study with amino acid derivative containing DES, Journal of Molecular Liquids, 2020, 303, 112451(1-11)
- 4. Kajal Kumbhakar, Biswajit Saha, Priyadarsi De, and **Ranjit Biswas**, Cloud Point Driven Dynamics in Aqueous Solutions of Thermoresponsive Copolymers: Are They Akin to Criticality Driven Solution Dynamics?, Journal of Physical Chemistry B, 2019, 123, 11042– 11054
- 5. Kallol Mukherjee, Anjan Barman, and **Ranjit Biswas**, Hydration Dynamics in Aqueous Pluronic P123 Solution: Concentration and temperature dependence, Journal of Chemical Physics, 2019, 151, 184901(1-7)
- Ejaj Tarif, Kallol Mukherjee, Kajal Kumbhakar, Anjan Barman, and **Ranjit Biswas**, Dynamics at the Non-Ionic Micelle/Water Interface: Impact of Linkage Substitution, Journal of Chemical Physics, 2019, 151, 154902/1-9
- 7. Ejaj Tarif, Jayanta Mondal, and **Ranjit Biswas**, Interaction and Dynamics in a Fully Biodegradable Glucose-Containing Naturally Abundant Deep Eutectic Solvent (NADES): Temperature-Dependent Time-

Resolved Fluorescence measurements, Journal of Physical Chemistry B 2019, 123, 9378-9387

Talks / Seminars Delivered in reputed conference / institutions

- Crowded or Confined Environments: The Slow Down Continues; Feb 3, 2020; IISc, Bangalore; Feb02-04, 2020
- Heterogeneity in Deep Eutectic Solvents: Signatures from Experiments and Theory; Jan 28, 2020; IIT Madras; Jan27-28, 2020

Membership of Learned Societies

- 1. Elected Member, Editorial Advisory Board, Journal of Physical Chemistry, American Chemical Society
- 2. Elected Member, Editorial Advisory Board, Journal of Chemical Science, National Academy of Science, Bangalore, India

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

- 1. Navin Subba, Ejaj Tarif, Pratik Sen, and Ranjit Biswas, Sub-picosecond Solvation Response, and Partial Viscosity Decoupling of Solute Diffusion in Ionic Acetamide Deep Eutectic Solvents: Fluorescence Upconversion and Fluorescence Correlation Spectroscopic Measurements, Journal of Physical Chemistry B, 2020, 124, 1995-2005; Sl. No. 1; National
- Navin Subba, Kamil Polok, Piotr Piatkowski, Bozena Ratajska Gadomska, Ranjit Biswas, Wojciech Gadomski, and Pratik Sen, Temperature Dependent Ultrafast Solvation Response and Solute Diffusion in Acetamide–Urea Deep Eutectic Solvent, Journal of Physical Chemistry B, 2019, 123, 9212-9221; Sl. No. 2; International
- Kajal Kumbhakar, Biswajit Saha, Priyadarsi De, and Ranjit Biswas, Cloud Point Driven Dynamics in Aqueous Solutions of Thermoresponsive Copolymers: Are They Akin to Criticality Driven Solution Dynamics?, Journal of Physical Chemistry B, 2019, 123, 5892-5901; Sl. No. 4; National

Areas of Research

Physical Chemistry, Theory, Experiments and Simulations

Fluorescence up-conversion (\sim 250 fs instrumental response) coupled with time correlated single photon counting measurements were performed to explore the complete

Stokes shift dynamics of a dipolar solute probe, coumarin 153 (C153), in several ionic acetamide deep eutectic solvents (DESs) that contained lithium nitrate/bromide/perchlorate as electrolyte. Combined measurements near room temperature reflected a total dynamic Stokes shift of approximately 800-1100 cm⁻¹, and tri-exponential solvation response functions. Interestingly, the average rate of solvation became faster upon successive replacement of bromide by nitrate in these deep eutectics, and a sub-picosecond timescale emerged in the measured solvation response when bromide was fully replaced by nitrate. Temperature dependent solute diffusion in these deep eutectics at the single molecule level, monitored by tracking the translational motion of rhodamine 6G (R6G) via fluorescence correlation spectroscopic (FCS) technique, revealed pronounced fractional viscosity dependence of the solute's translational motion. Subsequently, this partial decoupling of solute translation was attributed to the microheterogeneous nature of these ionic DESs after examining the diffusion-viscosity relationship via the FCS measurements of R6G in several normal solvents at room temperature, and in a liquid amide solvent at different temperatures.

We have explored, via molecular dynamics simulations, layer-wise structural and spatio-temporal heterogeneity features of confined water inside rigid spherical reverse micelles of 55 Å inner diameter. These confined aqueous pools were divided into four fictitious concentric layers of 5 Å thickness, and a central core layer. Reverse micellar confinements were constructed by using model potentials mimicking AOT (charged) and IGEPAL (neutral) surfactant molecules for encapsulating SPC/E water. Density profiles for confined water were obtained and compared to validate the present simulations. The simulated layer-wise structural features were: dipole orientation distributions, tetrahedral angle distributions, tetrahedral order parameter and the average number of H-bonds per water molecule and the relevant population distributions. Simulated dynamical features included mean-squared displacements, velocity auto-correlation functions, non-Gaussian parameters, single particle displacement distributions, dynamic susceptibilities and the collective single-particle reorientational relaxations of first and second ranks. Analyses of simulation results revealed a strong impact of the confinement on bulk water structure and dynamics. The chemical nature of the confinement was found to influence both structure and dynamics. Interfacial water molecules were found to be the most severely affected ones and successive progression toward the centre revealed a tendency for restoration of the bulk limit, although the bulk values were never fully recovered. A close inspection of the simulated results revealed an overlap among the layerwise structural and dynamical features. These observations suggest a break-down of the two-state core-shell model even for large RMs where ample amount of 'free' water is available. The simulated collective reorientational relaxations of reverse micellar water agree well with the existing timeresolved 2D-IR measurements.

In addition, we have explored structure and dynamics of binary mixtures of ionic liquids with common organic solvents, other complex fluids, and studied experimentally a few more deep eutectic systems via time resolved spectrospic measurements and dielectric relaxation measurements.

Plan of Future Work Including Project

1. Stimuli responsive polymer in deep eutectic solvents (DESs): Interaction and dynamics For the above project, project, we have already designed, synthesized and characterized (NMR, DLS, SEM, SEC) a few stimuli (pH, temperature, viscosity modifier) responsive polymers to generate primary data. At present time-resolved fluorescence and Hz-GHz dielectric spectroscopic facilities are available in our centre, which have produced encouraging yet incomplete set of results. This

will be pursued further. For the successful completion of this project and generate an application-oriented sound basic scientific knowledge of translational character, we require a higher frequency setup of dielectric measurements pushing the limit to the terra Hertz regime. This will bridge the gap as well link the picosecond resolved ultrafast fluorescence dynamics results. A project proposal has been submitted for extramural funding.

2. Computational and Experimental studies of Azeotropic Systems Azeotropic systems are complex liquid solvent mixtures which may be useful as reaction media for large scale application in chemical industry. Our initial study has produced encouraging results. We would like to pursue that in the next year or so. A project proposal has been submitted.



Samir Kumar Pal

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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; Thesis submitted
- 2. Probir Sarkar; Spectroscopic Studies on Molecules and Nanomaterials for Potential Applications in Medical Diagnosis and Environmental Pollution Monitoring; Thesis submitted
- 3. Priya Singh; Spectroscopic Studies on Structure, Function and Dynamics of Biological Macromolecules in Physiologically Relevant and Engineered Environments; Thesis submitted
- 4. Jayita Patwari; Photophysical Studies on Light Harvesting Nanomaterials for Improved Solar Energy Conversion; Thesis submitted
- 5. Tuhin Maji; Combined experimental and computational investigation on optical and catalytic properties of functionalized metal oxides; Under progress

- 6. Aniruddha Adhikari; Studies on Therapeutic Potential of Various Nanomaterials and Ethnobotanical Ingredients in Preclinical Disease Model; Under progress
- 7. Soumendra Singh; Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications; Under progress
- 8. Arka Chatterjee; Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis; Under progress
- 9. Arpan Bera; Spectroscopic Studies on Functional Nanohybrids and their Potential Biological Application; Under progress
- 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)
- 11. Md. Nur Hasan; Optical spectroscopy and Ab-initio study on biocompatible nanohybrids for their potential biomedical and environmental applications; Thesis submitted
- 12. Susmita Mondal; Studies on Biochemical and Molecular aspects of Redox Modulatory Theranostic Nanomaterials in Preclinical Disease Model; Under progress
- Animesh Halder; Development and Validation of Optical Methodologies for Potential Biomedical and Environmental Applications; Under progress; Professor R. Chakraborty, Calcutta University (Supervisor)
- 14. Pritam Biswas; Biophysical and Biochemical Investigation on the Structure, Function and Dynamics of Biomolecules Under Physiologically Relevant Environments; Under progress; Professor S. S. choudhury,, st. xavier's college kolkata (Supervisor)
- 15. Arnab Samanta; Synthesis and Characterization of Nanoscale Alloys and Metal Oxides for Potential Application in Catalysis; Under progress; Dr. S. Jana, SNBNCBS (Supervisor)

b) External Project Students / Summer Training

- 1. Abhinaba Sarkar; Invasive and non-invasive spectroscopic studies on human blood for potential diseases diagnosis; Department of Biochemistry, University of Calcutta
- 2. Rajdeep Biswas; Spectroscopic Studies for Clinical Diagnosis of Diseases SNBNCBS

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Teaching

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

Publications

a) In journals

- T. K. Maji, N. Hasan, S. Ghosh, D. Wulferding, C. Bhattacharya, P. Lemmens, D. Karmakar and S. K. 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 & Photobiology, A: Chemistry 397 (2020) 112575
- R. Kumar, D. P. Panda, D. Das, A. Chatterjee, B. Tongbram, J. Saha, S. Upadhyay, R. Kumar, S. K. Pal and S. Chakrabarti, *Realization of high-quality InGaAs/GaAs Quantum Dot growth on Ge substrate and Improvement of Optical property through Ex-situ Ion Implantation*, J. Luminescence 223 (2020) 117208
- S. Nag, D. Bagchi, D. Chattopadhyay, M. Bhattacharyya and S. K. Pal, Protein-assembled Nano-vehicle Entrapping Photosensitizer Molecules for Effcient Lung Carcinoma Therapy, International J. Pharmaceutics 580 (2020) 119192
- A. Chatterjee, P. Kar, D. Wulferding, P. Lemmens and S. K. Pal, Flower-Like BiOI Microspheres Decorated with Plasmonic Gold Nanoparticles for Dual Detoxification of Organic and Inorganic Water Pollutants, ACS Applied Nano Materials 3 (2020) 2733
- M. Biswas, R. Kumar, A. Chatterjee, Y. Wu, Z. Mi, P. Bhattacharya, S. K. Pal and S. Chakrabarti, Effects of Rapid Thermal Annealing in InGaN/GaN Quantum Disk-in-GaN Nanowire Arrays, J. Luminescence 222 (2020) 117123
- P. Biswas, A. Adhikari, U. Pal, P. Singh, M. Das, T. Saha-Dasgupta, S. S. Choudhury, R. Das, and S. K. Pal, Flexibility Modulates the Catalytic Activity of a Themostable Enzyme: Key Information from Optical Spectroscopy and Molecular Dynamics Simulation, Soft Matter 16 (2020) 3050
- T. K. Maji, D. Bagchi, N. Pan, A. Sayqal, M. Morad, S. A. Ahmed, D. Karmakar and S. K. 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 (2020) 5636
- 8. S. Singh, A. Halder, O. Sinha, P. K. Sarkar, P. Singh, A. Banerjee, S. A. Ahmed, A. Alharbi, R. J. Obaid,

S. K. Ghosh, A. Mitra and **S. K. Pal**, Nanoparticlebased 'turn-on' scattering and post-sample fluorescence for ultrasensitive detection of water pollution in wider window, PLOS ONE 15 (2020) e0227584

- A. Adhikari, P. Biswas, S. Mondal, M. Das, S. Darbar, A. M. Hameed, A. Alharbi, S. A. Ahmed, S. S. Bhattacharya, D. Pal and S. K. Pal, A Smart Nanotherapeutic Agent for in vitro and in vivo Reversal of Heavy-Metal-Induced Causality: Key Information from Optical Spectroscopy, ChemMedChem (Front Cover Article) 15 (2020) 420
- L. Roy, A. Halder, S. Singh, J. Patwari, P. Singh, K. Bhattacharya, S. Mondal and S. K. Pal, Spectroscopy of an Intrinsic Fluorophore in Animal and Plant Milk for Potential Identification of Their Quality, Journal of Dairy Science 103 (2020) 1366
- D. Mukherjee, P. Singh, T. Rakshit, T. P. P. Purayil, P. K. Vemula, J. Sengupta, R. Das and S. K. Pal, Deciphering the Response of Asymmetry in the Hydrophobic Chains of Novel Cationic Lipids towards Biological Function, Phys. Chem. Chem. Phys. 22 (2020) 1738
- A. Halder, Deep Shikha, A. Adhikari, R. Ghosh, S. Singh, T. Adhikari and S. K. Pal, Development of A Nano-sensor (FeNSOR) Based Device for Estimation of Iron ions in Biological and Environmental Samples, IEEE Sensors Journal 20 (2020) 1268
- A. Adhikari, S. Darbar, M. Das, S. Mondal, S. S. Bhattacharya, D. Pal and S. K. Pal, Rationalization of a Traditional Liver Medicine Using Systems Biology Approach and Its Evaluation in Preclinical Trial, Computational Biology and Chemistry 84 (2020) 107196
- 14. S. A. Ahmed, D. Bagchi, H. A. Katouah, N. Hasan, H. M. Altass and S. K. Pal, Enhanced Water Stability and Photoresponsivity in Metal-Organic Framework (MOF): A Potential Tool to Combat Drug-resistant Bacteria, Scientific Reports 9 (2019) 19372
- P. Singh, D. Mukherjee, S. Singha, V. K. Sharma, I. I. Althagafi, S. A. Ahmed, R. Mukhopadhyay, R. Das and S. K. Pal, Probing Relaxation Dynamics of a Cationic Lipid Based Non-viral Carrier: A Time-Resolved Fluorescence Study, RSC Advances 9 (2019) 35549
- A. Adhikari, S. Mondal, S. Darbar, and S. K. Pal, Role of Nanomedicine in Redox Mediated Healing at Molecular Level, Biomolecular Concepts 10 (2019) 160
- A. Halder, M. Banerjee, S. Singh, A. Adhikari, P. K. Sarkar, A. M. Bhattacharya, P. Chakrabarti, D. Bhattacharyya, A. K. Mallick, and S. K. Pal, A Novel Whole Spectrum-based Non-invasive Screening Device for Neonatal Hyperbilirubinemia, IEEE J. Biomed. Health Informatics 23 (2019) 2347

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- A. Bera, D. Bagchi and S. K. Pal, Improvement of Photostability and NIR Activity of Cyanine Dye through Nanohybrid Formation: Key Information from Ultrafast Dynamical Studies, J. Phys. Chem A 123 (2019) 7550
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- T. Dutta, D. Bagchi, A. Bera, S. Das, T. Adhikari and S. K. Pal, Surface Engineered ZnO-Humic/Citrate Interfaces: Photoinduced Charge Carrier Dynamics and Potential Application for Smart and Sustained Delivery of Zn Micronutrient, ACS Sustainable Chemistry & Engineering 7 (2019) 10920
- 24. P. Singh, S. Singha, D. Mukherjee, R. Das and and S. K. Pal, Modulation of Kinetic Pathways of Enzyme-Substrate Interaction in a Microfluidic Channel: Nanoscopic Water Dynamics as a Switch, Chem. Eur. J. 25 (2019) 9728
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- A. Adhiakari, M. Das, S. Mondal, S. Darbar, A. K. Das, S. S. Bhattacharya, D. Pal and S. K. Pal, Manganese Neurotoxicity: Nano-oxide Compensates the Iondamage in Mammals, Biomaterials Science 7 (2019) 4491

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- 28. A. Chatterjee, D. Panda, J. Patwari, B. Tongbram, S. Chakrabarti, S. K. Pal, Strain Relaxation in InAs Quantum Dots through Capping Layer Variation and Its Impact on The Ultrafast Carrier Dynamics, Semiconductor Science and Technology 34 (2019) 095017
- 29. T. K. Maji, K. Vaibhav, S. K. Pal, K. Majumdar, K. V. Adarsh, and D Karmakar, Intricate modulation of interlayer coupling at the graphene oxide/MoSe₂ interface: Application in time-dependent optics and device transport, Phys. Rev. B 99 (2019) 115309

Talks / Seminars Delivered in reputed conference / institutions

- Modulation of Biomolecular Recognition and Function in a Microfluidic Channel: Nanoscopic Water Dynamics as a Switch in a Indo-Japan Workshop; Nov 13, 2019; Kobe University, Japan; 13-16 Nov 2019
- Probing Structure and Crucial Interfacial Dynamics of Nanohybrids for Emerging Biomedical Functionalities in keynote lecture in the conference 'International Conference on Current Trends in Materials Science and Engineering 2019 (CTMSE 2019); Jul 19, 2019; SNBNCBS/IEM, Kolkata; 18-20 July 2019
- Crucial Interfacial Dynamics of "Soft-Hard" Nanohybrids for Emerging Biomedical Functionalities in Invited Speaker in the session of Polymer/Soft/Bio-materials and devices in 2nd Indian Materials Conclave and 31st MRSI-AGM; Feb 13, 2020; CGCRI, Kolkata; 11-14 Feb 2020
- Probing Crucial Interfacial Dynamics of Nanohybrids for Emerging Biomedical Functionalities in a seminar under CAS -II programme of Department of Chemistry, Jadavpur University; Jan 7, 2020; Jadavpur University, Kolkata; 7-8 Jan 2020
- A Special Seminar on Technology Driven Basic Research in Umm AlQura University, Saudi Arabia, Nov 19, 2019; 18-27 Nov 2019
- Probing Crucial Interfacial Dynamics of Nanohybrids for Emerging Biomedical Functionalities in International Conference on Nano Science and Technology-2020 (ICONSAT-2020); Feb 7, 2020; Biswa Bangla Convention Centre; 5-7 Feb 2020

Administrative duties

- 1. Chairman, Pest Control
- 2. Convener, Project and Patent cell

Patents Taken and Process Developed with Details

- A Spectroscopy Based Fluoride Sensor for Drinking Water; Indian Pat. Appl. (2019), TEMP/E-1/29847/2019-KOL dated 13th July 2019; Applied
- A Spark Spectrometry-Based Point of Care Portable Device for Simultaneous Detection of Na+, Li+ And K+ Concentration in Body Fluid; Indian Pat. Appl. (2019), TEMP/E-/27873/2019-KOL dated 2nd July 2019; Applied
- A Noninvasive Screening System for Neonatal Hyperbilirubinemia; PCT (International Patent) Appl. (2019), PCT/IN2019/050355 dated 3rd May 2019; Applied
- Spectroscopy-Based Optical Device for Estimation of Milk Quality; Indian Pat. Appl. (2019), TEMP/E-1/29986/2019-KOL dated 15th July 2019; Applied
- A Chromogenic Nanocomposite-based Optical Device CapNanoScope for detection and quantification of CO₂, Indian Pat. Appl. (2020), TEMP/E-1/1450/2020-KOL dated 11th January 2020; Applied

Membership of Learned Societies

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

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

1. Exploration of key photoinduced dynamics in inorganic nanohybrids for enhanced biological activities; Department of Science and Technology (DST); 3years; PI

Conference / Symposia / Schools organized

1. International Conference on Nano Science and Technology- 2020 (ICONSAT-2020) Feb 5, 2020; Biswa Bangla Convention Centre; 5-7 Feb 2020

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

- Collaboration with Prof. Subhananda Chakrabarti, Professor Dept. of Electrical Engineering Indian Institute of Technology Bombay Powai Mumbai 400076 Maharashtra India; Sl. No. 2,5,17,18,25,25; National
- Professor Peter Lemmens Institute for Condensed Matter Physics Institut f
 ür Physik der Kondensierten Materie TU Braunschweig, Germany; Sl. No. 1,4,22; International
- 3. Professor Saleh Ahmed Umm Al-Qura University Department of Chemistry, Saudi Arabia; Sl. No. 7,8,9,14,15,27; International
- 4. Professor Chinmoy Bhattacharya Department of Chemistry, Indian Institute of Engineering Science & Technology; Sl. No. 2,5,17,18,25,25; National
- 5. Professor Asim Kumar Mallick NRS Medical College; Sl. No. 2,5,17,18,25,25; National
- Professor Rajib Chakraborty Department of Applied Optics & Photonics, University of Calcutta; Sl. No. 19,20; International
- 7. Professor Ranjan Das, Department of Chemistry, West Bengal State University; Sl. No. 6,11,15,19,24; National
- Professor Sudeshna Shyam Choudhury (bhattacharya) Department: Microbiology & Envs, St.Xavier's College, 30 Park Street, Kolkata 700 016; Sl. No. 6; National

Outreach program organized / participated

- Speaker for lecture at North-East Students Conclave, India International Science Festival (IISF) 2019. November 5th- 8th, 2019 at Kolkata, IISF 2019
- Speaker for National Conference on Science and Technology: Rural Development ISCA Kolkata Chapter & Surendranath College held on 20th -21st January at Surendranath Banerjea Auditorium, Surendranath College, 24/2 MG Road, Kolkata
- 3. Speaker in a seminar on Science communication in Bengali - road ahead organized by Vigyan Prasar, an institution under the Department of Science and Technology, Govt. of India. Two-day conference at CGCRI Kolkata during 26-27 April 2019
- Speaker of a popular lecture in 11th Vidyasagar Satyendra Nath Bose National Workshop on Physics of Novel Functional Materials (PNFM-2020). Physics

Department Vidyasagar University, Midnapore 8-10 January 2020

Areas of Research

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

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

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

Research in the field of Experimental Nano-physics and Bio-nano Interface: The interface between the biological sciences and nanoscience constitutes one of the most interesting and technologically promising frontiers in modern science. Our group is involved in the synthesis of various bio-nano conjugates. Selective attachment of inorganic semiconductor/metal quantum dots (QD) to various biological macromolecules is the key feature of the nano-conjugates. **Research in the field of Experimental Biomimetics:** Our activities in the area of biomimetic systems, which are very useful to understand the complex biomolecular systems and works excellent as templates for the synthesis of nanomaterials are also evident from our publications.

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

Development of Nanomedicines: We are also involved in the development of various nanomedicines. The developed nanomedicines are shown to have intelligence to decrease and/or increase oxidative stress (ROS) in our body depending on the situation and cures several diseases.

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 biomimetic systems
- 6. Development of Nanomedicines



Suman Chakrabarty

Assistant Professor CBMS sumanc@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- Amit Kumawat; Molecular mechanism of allostery and signalling in biomolecules; Awarded; Dr. Kumar Vanka (CSIR-NCL, Pune) (Supervisor)
- Vrushali Hande; Structure and dynamics of water molecules in heterogenous environment; Thesis submitted; Dr. Sarika Bhattacharyya (CSIR-NCL, Pune) (Supervisor)
- 3. Abhinandan Das; Rational design and mechanism of action of potent inhibitors for Acetylcholinesterase enzyme; Under progress
- 4. Krishnendu Sinha; Phosphorylation code in RhoGDI regulation; Under progress

b) Post-Docs

- 1. Ipsita Basu; Understanding the role of protein-membrane interactions towards function of GPCR class of proteins
- 2. Amit Kumawat; Tuning the interaction between PCSK9 and LDLR towards design of allosteric drugs

c) External Project Students / Summer Training

- 1. Rajarsi Pal; Novel algorithms for enhanced sampling near first order phase transition; Ramakrishna mission Vidyamandira, Belur
- 2. Sandipan Manna; Nucleation and growth in gas-liquid phase transition; Ramakrishna mission Vidyamandira, Belur

Teaching

- 1. Autumn semester; PHY104 Computational Methods in Physics I; Integrated PhD; 12 students
- 2. Spring semester; PHY204 Computational Methods in Physics II; Integrated PhD; 12 students
- 3. Spring semester; CB540 Study of Bio-Macromolecules; PhD; 10 students

Publications

a) In journals

- V. C. Wakchaure, L. V. Pillai, Goudappagouda, K. C. Ranjeesh, S. Chakrabarty, S. Ravindranathan, P. R. Rajamohanan and S. S. Babu, *Charge transfer liquid: a stable donor-acceptor interaction in the solvent-free liquid state*, Chem. Commun., 55, 9371 (2019)
- D. K. Sahoo, S. Jena, K. D. Tulsiyan, J. Dutta, S. Chakrabarty and H. S. Biswal, Amino-Acid-Based Ionic Liquids for the Improvement in Stability and Activity of Cytochrome c: A Combined Experimental and Molecular Dynamics Study, J. Phys. Chem. B, 123, 47, 10100 (2019)
- S. Das, S. Chakrabarty and N. Chattopadhyay, Origin of Unusually High Fluorescence Anisotropy of 3-Hydroxyflavone in Water: Formation of Probe-Solvent Cage-like Cluster, J. Phys. Chem. B, 124, 173 (2020)
- S. Bose, S. Chakrabarty and D. Ghosh, Support Vector Regression-Based Monte Carlo Simulation of Flexible Water Clusters, ACS Omega 5, 13, 7065 (2020)

Talks / Seminars Delivered in reputed conference / institutions

- Modern Approaches in Chemistry and Biology 2020; Feb 18, 2020; JNCASR, Bangalore; February 18-20, 2020
- 2. A day out with Chemical Dynamics; Feb 2, 2020; IISc, Bangalore; February 02-04, 2020

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
- 2. Tuning electrostatics and dynamics of the flexible areas of PCSK9 protein towards controlling interactions with LDLR: A computational approach; Sarfez Cure India (industry); 1 year; PI

Conference / Symposia / Schools organized

 Theme School on Advanced Computational Techniques in Soft Matter; Feb 14, 2020; SNBNCBS, Kolkata; February 14-15, 2020

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

- Collaboration with Dr. Santhosh Babu Sukumaran, CSIR-NCL, Pune on charge transfer liquids; Sl. No. 1; National
- Collaboration with Dr. Himansu S. Biswal from NISER Bhubaneswar on studying stability and dynamics of biomolecules (DNA, protein) in various ionic liquids; SI. No. 2; National

- Collaboration with Prof. Nitin Chattopadhyay from Jadavpur University on the microscopic origin of high fluorescence anisotropy for 3HF in water; Sl. No. 3; National
- Collaboration with Dr. Debashree Ghosh from IACS, Kolkata on development and application of Support Vector Regression (SVR) based model of flexible water clusters; Sl. No. 4; National

Outreach program organized / participated

- Mentored the hands-on experiment sessions at the JBNSTS-DST INSPIRE Science Camp during July 22-23, 2019
- Conducted a computational chemistry workshop for the JBNSTS Junior Scholars at IISER Kolkata on 20th June, 2019

Areas of Research

Theoretical and computational biophysical chemistry

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. Phosphorylation code in RhoGDI regulation: Phosphorylation of specific sites of RhoGDI protein can selectively control the release of its binding partner Rac/Rho protein. We have used several microsecond long simulations and free energy calculations using metadynamics to demonstrate how rearrangement of hydrogen bonded network leads to long range control (allosteric) over protein-protein interaction in this system.



2. Development of solvent-free charge transfer liquids: In collaboration with several experimental groups we have explored an efficient and stable charge transfer liquid using a solvent-free liquid dialkoxynaphthalene donor and naphthalenediimide acceptor. It has been observed that irrespective of the donor-acceptor ratio, the charge-transfer liquid exhibited an unprecedented stability and retained characteristic features even at elevated temperatures. The underlying intermolecular interactions leading to efficient CT has been examined by NMR techniques together with theoretical modelling studies.



3. Stability and activity of Cytochrome c in ionic liquids: In this collaborative study, we demonstrate that amino-acid based bio-compatible ionic liquids can enhance the stability of Cytochrome c enzyme while preserving the natural activity.

- 4. Origin of unusually high fluorescence anisotropy (FA) of 3-hydroxyflavone (3-HF) in water: In this collaborative study, using quantum chemical calculations and classical molecular dynamics simulations we elucidate that formation of a solute-solvent cage-like structure is responsible for unusually high FA of 3-HF in water.
- 5. Development and validation of a Support Vector Regression (SVR) based model of flexible water clusters: In this collaborative study, we have performed Monte Carlo simulations on a SVR-based model of flexible water clusters to demonstrate that they have significantly better accuracy than classical force fields, whereas preserving the accuracy of ab initio (quantum chemical) theories.

Plan of Future Work Including Project

- 1. Industry sponsored project from Sarfez Cure India has been initiated. This project is expected to be renewed and extended.
- 2. Effect of various solvents and small molecules on the stability and function of proteins/enzymes
- 3. Energetics and dynamics of various steps in the photoactivation 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.

Any other Relevant Information including social impact of research

1. Industry sponsored project from Sarfez Cure India is expected to generate important know-how regarding controlling hypercholesterolemia. A novel therapeutic approach of tuning the dynamics of disordered loops of the PCSK9 protein would be beneficial towards recycling of LDLR in hepatocytes.



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 (DST Inspire faculty project); Biophysical Characterization of Cancer Exosomes; S. N. Bose National Centre for Basic Sciences, Kolkata
- Brateen Datta (M.Tech thesis project, KIIT University, Bhubaneswar); Biophysical Characterization of Cancer Exosomes; S. N. Bose National Centre for Basic Sciences, Kolkata

Teaching

1. Spring semester; Study of Biomacromolecules; Ph.D. in Chemical Sciences; 8 (credit); Dr. Suman Chakrabarty

Publications

a) In journals

1. Dipanjan Mukherjee, Priya Singh, **Tatini Rakshit**, Theja P Puthiya-Purayil, Praveen Kumar Vemula, Jhimli Sengupta, Ranjan Das, Samir Kumar Pal, *Deciphering the response of asymmetry in the hydrophobic chains of* novel cationic lipids towards biological function, Phys. Chem. Chem. Phys., 22, 1738-1746, 2020

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

1. Quantitative study on single-chromosome elasticity and its relevance to chromosome fragility in cancer; SERB; 3 years (2020-2023); PI

Areas of Research

Cationic liposomes, a type of non-viral vectors, often play the important biological function of delivering nucleic acids during cell transfection. Variations in the molecular architecture of di-alkyl dihydroxy ethyl ammonium chloridebased cationic lipids involving hydrophobic tails have been found to influence their biological function in terms of cell transfection efficiency. For example, liposomes based on a cationic lipid (Lip1814) with asymmetry in the hydrophobic chains were found to display higher transfection efficacy in cultured mammalian cell lines than those comprising of symmetric Lip1818 or asymmetric Lip1810. The effect of variations in the molecular architecture of the cationic lipids on the biological activity of liposomes has been explored here via the photophysical studies of 8-anilino-1-naphthalenesulphonate (ANS) and Nile Red (NR) in three cationic liposomes, namely Lip1810, Lip1814 and Lip1818. Time-resolved fluorescence of ANS revealed reduced hydration at the lipid-water interface and enhanced relaxation dynamics of surface water (lipid headgroup bound water molecules) in Lip1810- and Lip1814-based liposomes in the presence of cholesterol. As the probe ANS failed to be incorporated into the lipid-water interface of Lip1818 due to the significantly high rigidity of these liposomes, no information concerning the extent of hydration of the lipid-water interface or the interfacial water dynamics could be obtained. Time-resolved polarization-gated anisotropy measurements of NR in the presence of cholesterol revealed the rigidity of the cationic liposomes to be increasing in the order of Lip1810 < Lip1814 < Lip1818. In the presence of cholesterol, moderately higher rigidity, reduced membrane hydration and enhanced relaxation dynamics of the interfacial water molecules gave rise to the superior cell transfection efficacy of Lip1814-based cationic liposomes than those of the highly flexible Lip1810 or the highly rigid Lip1818.

Plan of Future Work Including Project

Developing protocols for isolation and fractionation of exosomes from colon and breast cancer cell media and immobilization techniques to visualize them by Atomic Force Microscopy. We have started our single- molecule AFM force spectroscopy experiments to identify different proteins on the exosome surface.





Department of CONDENSED MATTER PHYSICS AND MATERIAL SCIENCES

Department of Condensed Matter Physics and Material Sciences

Kalyan Mandal

Department profile indicators

Table A : Manpower and resources

Number of faculties	17
Number of Post –doctoral research associate (Centre + Project)	15
Number of Ph.D students (including all)	70
Number of other project staff	6
Number of summer students	11
Projects (ongoing)	10

Table B: Research Activities indicators

Number of research papers in Journals	134
Number of Book-chapters/books	2
Number of other publications	17
Number of Ph.D students graduated (submitted + degree awarded)	11
Number of M.Tech/ M.Sc projects	13

Table C: Academic activities and likeage

Number of courses taught by faculties	7	
Number of Visitors (non –associates)	23	
Number of associates	2+3(visiting associates)	
Number of Seminars organized	6	
Number of Conference/Symposia/Advanced Schools organized	14	
Number of talks delivered by members of department in conferences/Symposia	National	40
	International	12

Most important research highlights

- ZrTe₂ was found to be a topological semimetal induced by the metal-chalcogen bond-length.
- For the first time a quantum interference based spin filter was observed with a nonmagnetic single-molecule junction.
- A combination of computational tools was used for prediction and characterization of new magnetic compounds.
- A mechanism was provided to understand shapes of perovskite nanocrystals.

- Development of a new numerical method to solve the quantum many system at finite temperature. This algorithm is known as ED/DMRG algorithm.
- Investigation indicates control of ultrafast spin dynamics, spin-orbitronics and magnonics in magnetic thin films, heterostructures and nanostructures.
- Transmission of a signal in negative time is possible.
- Paper electronic based device for Gas sensors and Photodetectors
- nano-hollow spheres of ferrites served as better microwave absorbers than their solid counterparts.

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Summary of research activities

Professor T. Setti and his group worked on the single crystal growth, physical, and electronic properties studies of various quantum materials, 2D magnetic, and transition metal dichalcogenides during the last academic year. They synthesised the single crystals of $Mn_3Sn_{1-x}Fe_x$, VX_2 (X=S, Se, Te), FeTe, Fe(Ni)₃GeTe2, and Cr(Si)GeTe3 and studied their magnetic, physical, and electronic properties. They also performed systematic ARPES studies on VX_2 , BaZnBi₂ (PRM 3, 024202 (2019)), ZrTe₂, and ZrSe₂ (PRB 101, 165122 (2020)). Their ARPES studies on NiTe₂ and Bi₂Se₃ are accepted for publication in (AIP conference proceedings, in press).

Professor Atindra Nath Pal and his group, in collaboration with Weizmann Institute, showed that spin-polarized currents can be generated in silver-vanadocene-silver single molecule junctions without magnetic components or magnetic fields. In some cases, the measured spin currents approach the limit of ideal ballistic spin transport and their findings paved the way for nanoscale spintronics based on quantum interference. Regarding their ongoing work at SNBNCBS, they focus on the inelastic electron spectroscopy of Cu-H₂-Cu junctions, where they observe the formation of one- dimensional chain of Cu in presence of hydrogen.

Professor Manoranjan Kumar and his group worked on the development of a new numerical method to solve the quantum many-body system at finite temperature. This algorithm is known as ED/DMRG algorithm. This method may help in understanding the low temperature behaviour of many challenging problems related to quantum many body systems. They apply ED/DMRG algorithm to understand spin-peierls transition in CuGeO₃ and other metallo-organic materials (Phys. Rev. B 101, 054411 (2020)) and for the Study of quantum phase diagram of a frustrated spin-1/2 Heisenberg model on a Trellis Ladder (Phys. Rev. B 100, 245118 (2020)).

The group of Professor Priya Mahadevan examined the electronic structure of twisted bilayers of transition metal dichalcogenides. Considering arbitrary angles of rotation, they showed in Phys. Rev. B 101, 045032 (2020) the presence of unusual symmetries that led to certain simplifications in the electronic structure. This allowed for predictions being made without a full-fledged calculation for certain aspects of the electronic structure.

Professor Anjan Barman and his group developed a novel all-optical method to determine spin-mixing conductance and interface transparency for pure spin current generation and transport in ferromagnet/heavy metal heterostructures. He studied strong magnon-magnon coupling, spin-wave nonreciprocity, spin-wave localization and tunnelling and electric field controlled spin-wave generation and propagation. He also studied ultrafast spin dynamics in multi-sublattice Gd-Fe thin films. Professor P. Singha Deo and his collaborators proved that time travel is possible [Transmitting a signal in negative time, P. Singha Deo and U. Satpathi, Results in Physics, **12**, 1506 (2019)]. They also showed some principles by which quantum devices can be stabilized and practically realizable [Current carried by evanescent modes and possible device applications, S. Mukherjee, P. Singha Deo and A.M. Jayannavar, Physica E, **118**, 113933 (2020)].

Research activities of Professor Tanusri Saha Dasgupta and her group focused on understanding the electronic and magnetic behavior at oxide interface, two dimensional ferromagnetism in inorganic and hybrid materails, prediction of new materials by combination of machine learning and first principles calculations, discovery of spin-orbit entangled non-magnetic ground state in S=1 spinel structure, understanding microscopic mechanism of light induced spin state trapping, understanding structural distortions in lonepair active element containing compounds, and revisting cuprate superconductivity.

Professor S. K. Ray and his group studied strong light-matter interactions between resonantly coupled metal plasmons and spin-orbit coupled bright excitons from two dimensional (2D) transition metal dichalcogenides (TMDs), which can produce discrete bright exciton-plasmon polaritons (plexcitons). They also studied the efficacy of MoS_2 nanocrystals for their size tunable properties for optical and photocatalytic applications. Synthesized NPs were found to exhibit size dependent optical properties and excitation dependent fluorescence characteristics in the visible region, which were not observed in bulk or 2D MoS_2 layers.

Professor P. K. Mukhopadhyay and his group worked on Smart Material based fluid and magnetic shape memory materials. In the case of fluids, work was carried in developing a novel rheological material that is a ordinary liquid like material otherwise, but in the face of a very fast moving object, it forms a solid like barrier within 10μ sec. The joint work with prototype testing under 9mm fire, were carried out in collaboration with Combat Battalion of Kolkata Police. The research group of Dr. Barnali Ghosh mainly worked on the development of ultra-sensitive sensor based on paper for hazards gas detection. They were also granted some patents on their work. Her group was also involved on the fabrication of Piezo electric nano generator for battery application and self- powered sensor for pulse rate monitoring.

Dr. Madhuri Mandal worked on the biomedical applications of ferrite nanoparticles, particularly in hyperthermia treatment and imaging. Dr. Anup Ghosh used dimethylformamide as a model amide to account for amide hydrogen bond interactions of protein. To quantify hydrogen bond conformation and the structural change, he monitored the amide I infrared (IR) stretching frequencies while varying the pKa of phenol derivatives. This study can be used as a point of reference for understanding the structural information of proteins, peptides, and nucleosides having hydrogen bond interaction with any drug or ligand molecules.

Professor K. Mandal and his group extensively worked on transition metal oxide nanostructures. They observed that nano-hollow spheres of ferrites served as better microwave absorbers than their solid counterparts. They also developed low-cost magnetocaloric materials with large isothermal magnetic entropy change at around room temperature. Zno- $CoFe_2O_4$ heterostructures developed by them showed higher efficiency for photoelectrochemical water splitting.

Kabyan Jandel.

Kalyan Mandal Head, Department of Condensed Matter Physics and Material Sciences



Anjan Barman

Senior Professor CMPMS abarman@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Sucheta Mondal; Ultrafast Magnetization Dynamics in Ferromagnetic Thin Films, Heterostructures & Nanostructure; Thesis submitted
- 2. Samiran Choudhury; Investigation and Control of Gigahertz Frequency Spin Wave Dynamics in Magnonic Crystals; Awarded
- 3. Avinash Kumar Chaurasiya; Brillouin Light Scattering Studies of Spin Waves in Ferromagnetic/Nonmagnetic Heterostructures; Under progress
- 4. Anulekha De; Spectroscopic Studies of Metallic Nano and Microstructures; Under progress; Prof. Rajib Kumar Mitra (Co-supervisor)
- 5. Sourav Sahoo; Ultrafast Spin Dynamics of 2D and 3D Magnonic Crystals; Under progress
- 6. Surya Narayan Panda; All-Optical Investigation of Spin-Orbit Effects in Ferromagnet/Nonmagnet Heterostructures; Under progress

- Koustuv Dutta; Femto and Picosecond Spin Dynamics of Low Dimensional Magnetic Structures; Under progress
- 8. Amrit Kumar Mondal; Spin Wave Propagation and Localization in Continuous and Confined Magnetic Thin Film; Under progress
- 9. Arundhati Adhikari; Quasistatic and Ultrafast Magnetization Dynamics in Ferromagnetic Nanostructures; Under progress
- Sudip Majumder; Ferromagnetic Resonance of Magnetic Thin films and Nanostructures; Under progress; Prof. Rajib Kumar Mitra (Co-supervisor)
- 11. Pratap Kumar Pal; Spin Dynamics in Ferromagnetic Thin Film and Nanostructures; Under progress
- 12. Sreya Pal; Spin Dynamics in Quantum Materials; Under progress
- 13. Soma Dutta; Ultrafast Magnetization Dynamics in Thin Film Heterostructures; Under progress
- 14. Santanu Pan; Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Heterostructures; Under progress
- 15. Kartik Adhikari; Ferromagnetic Resonance of Patterned Magnetic Nanostructures; Under progress

b) Post-Docs

- 1. Sumona Sinha; Ultrafast Spin Dynamics in Ferromagnet/2D Materials Heterostructures
- 2. Sandeep Agarwal; Magnonics on Flexible Substrate
- 3. Arpan Bhattacharya; Spin-Orbit Effects in Magnonics

c) External Project Students / Summer Training

- 1. Daisy Gogoi; Quasistatic Magnetic Processes in Magnetic Nanostructures; Cotton University
- 2. Kajal Tiwari; Study of Ultrafast Magnetization dynamics in Ferrimagnetic GdFe thin films; NISER Bhubneswar
- 3. Abhilash Mishra; Ultrafast Magnetization Dynamics in $\mathrm{Ni}_{80}\mathrm{Fe}_{20}$ Thin Film; NISER Bhubneswar

Teaching

- 1. Autumn semester; PHY301: Atomic and Molecular Physics; Integrated PhD; 13 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

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- 3. Autumn semester; PHY304: Project Course II; Integrated PhD; 2 students
- 4. Spring semester; PHY401: Project Research III; Integrated PhD; 2 students
- 5. Spring semester; PHY292: Project Course I; Integrated PhD; 1 student

Publications

a) In journals

- K. Adhikari, S. Sahoo, A. K. Mondal, Y. Otani and A. Barman, Large Nonlinear Ferromagnetic Resonance Shift and Strong Magnon-Magnon Coupling in Ni₈₀Fe₂₀ Nanocross Array, Physical Review B 101, 054406 (2020)
- S. Pan, S. Mondal, M. Zelent, R. Szwierz, S. Pal, O. Hellwig, M. Krawczyk, and A. Barman, Edge localization of spin waves in antidot multilayers with perpendicular magnetic anisotropy, Physical Review B 101, 014403 (2020)
- S. Pan, S. Choudhury, J. Sinha, and A. Barman, All-Optical Investigation of Anisotropic Spin Pumping in W/ CoFeB/W Heterostructure, J. Magn. Magn. Mater. 502, 166545 (2020)
- S. Mondal, S. Barman and A. Barman, Magnetic vortex transistor based tri-state buffer switch, J. Magn. Magn. Mater. 502, 166520 (2020)
- N. Porwal, K. Dutta, S. Mondal, S. Choudhury, J. Sinha, A. Barman and P. K. Datta, Observation of spectral narrowing and mode conversion in two-dimensional binary magnonic crystal, J. Magn. Magn. Mater. 501, 166378 (2020)
- B. Rana, S. Choudhury, K. Miura, H. Takahashi, A. Barman and Y. Otani, *Electric field control of spin waves in ultrathin CoFeB films*, Physical Review B 100, 224412 (2019)
- S. N. Panda, S. Mondal, J. Sinha, S. Choudhury and A. Barman, All-optical detection of interfacial spin transparency from spin pumping in β-Ta/CoFeB thin films, Science Advances 5, eaav7200 (2019)
- P. Gruszecki, C. Banerjee, M. Mruczkiewicz, O. Hellwig, A. Barman and M. Krawczyk, The influence of the internal domain wall structure on spin wave band structure in periodic magnetic stripe domain patterns, Solid State Physics 70, 79-132 (2019)
- 9. M. A. Abeed, S. Sahoo, D. Winters, **A. Barman** and S. Bandyopadhyay, *The effect of material defects on*

resonant spin wave modes in a nanomagnet, Scientific Reports 9, 16635 (2019)

- K. Mukherjee, A. Barman, and R. Biswas, Hydration Dynamics in Aqueous Pluronic P123 Solution: Concentration and Temperature Dependence, The Journal of Chemical Physics 151, 184901 (2019)
- E. Tarif, K. Mukherjee, K. Kumbhakar, A. Barman, and R. Biswas, Dynamics at the non-ionic micelle/water interface: Impact of linkage substitution, The Journal of Chemical Physics 151, 154902 (2019)
- D. Winters, M. A. Abeed, S. Sahoo, A. Barman and S. Bandyopadhyay, *Reliability of Magnetoelastic Switching* of Nonideal Nanomagnets with Defects: A Case Study for the Viability of Straintronic Logic and Memory, Physical Review Applied 12, 034010 (2019)
- 13. S. Mondal, A. Talapatra, J. A. Chelvane, J. R. Mohanty and **A. Barman**, *Role of magnetic anisotropy in the ultrafast magnetization dynamics of Gd-Fe thin films with different thicknesses*, Physical Review B 100, 054436 (2019)
- 14. R. A. Gallardo, T. Schneider, A. K. Chaurasiya, A. Oelschlagel, S. S. P. K. Arekapudi, A. Roldan-Molina, R. Hubner, K. Lenz, A. Barman, J. Fassbender, J. Lindner, O. Hellwig, and P. Landeros, *Reconfigurable spin-wave nonreciprocity induced by dipolar interaction in a coupled ferromagnetic bilayer*, Physical Review Applied 12, 034012 (2019)
- S. Mallick, S. Mondal, T. Seki, S. Sahoo, T. Forrest, F. Maccherozzi, A. Barman, K. Takanashi, and S. Bedanta, *Tunability of domain structure and magnonic spectra in antidot arrays of Heusler alloy*, Physical Review Applied 12, 014043 (2019)
- A. De, C. Banerjee, A. K. Chaurasiya, R. Mandal, Y. Otani, R. K. Mitra, and A. Barman, Anisotropic Spin-Wave Dispersion in Two-Dimensional Ni₈₀Fe₂₀ Diatomic Nanodot Array, J. Magn. Magn. Mater. 491,165557 (2019)
- S. Choudhury, S. Pan, S. Barman, Y. Otani, and A. Barman, Anisotropic Spin Waves in Two-Dimensional Triangular Shaped Bi-Component Magnonic Crystal, J. Magn. Magn. Mater. 490, 165484 (2019)
- N. Porwal, A. De, S. Mondal, K. Dutta, S. Choudhury, J. Sinha, A. Barman and P. K. Datta, Observation of angle-dependent mode conversion and mode hopping in 2D annular antidot lattice, Scientific Reports 9, 12138 (2019)
- 19. D. Das Mahanta, S. I. Islam, S. Choudhury, D. Das, R. K. Mitra, and **A. Barman**, *Contrasting hydration dynamics*

in DME and DMSO aqueous solutions: A combined optical pump-probe and GHz-THz dielectric relaxation investigation, J. Mol. Liq. 290, 111194 (2019)

- S. Choudhury, S. Barman, Y. Otani, and A. Barman, Controlled Evolution of Spin Waves in Unconventional Defective Honeycomb Antidot Lattices, J. Magn. Magn. Mater. 489, 165408 (2019)
- A. De, S. Mondal, S. Choudhury, S. Sahoo, S. Majumder, S. Barman, Y. Otani and A. Barman, Shape Dependent High Frequency Spin-Wave Dynamics in Nanoscale Magnonic Crystals, J. Magn. Magn. Mater. 487, 165263 (2019)
- 22. E. Tarif, K. Mukherjee, A. Barman and R. Biswas, Are Water-Xylitol Mixtures Heterogeneous? An Investigation Employing Composition and Temperature Dependent Dielectric Relaxation and Time-Resolved Fluorescence Measurements, J. Chemical Sciences 131, 43 (2019)

b) Conference proceedings / Reports / Monographs / Books

- S. Choudhury, S. Mondal, A. De and A. Barman, Tunable picosecond magnetization dynamics in ferromagnetic nanostructures in 21st century Nanoscience: A Handbook: Exotic Nanostructures and Quantum Systems (Volume Five) (Book), Ed. Klaus Sattler, CRC Press, ISBN 9780815356264 - CAT# K346419 (2020)
- S. Mondal, S. Sahoo, and A. Barman, Precessional Magnetization Dynamics and Spin Waves in 3D Ferromagnetic Nanostructures in Three-Dimensional Magnonics (Book), Ed. G. Gubbiotti, CRC Press, ISBN 9789814800730 - CAT# K426145 (2019)

Talks / Seminars Delivered in reputed conference / institutions

- Fundamentals of Lasers and its Applications, C. K. Majumdar Workshop Jun 4, 2019; S. N. Bose National Centre for Basic Sciences; 75 min
- Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Heterostructures, Contemporary Trends in Optics 2019: From Atoms to Stars; May 23, 2019; IISER Kolkata; 30 min
- Fabrication of Nanoscale Magnonic and Spintronic Devices, Workshop on Nanolithography and Nanofabrication; Jul 9, 2019; S. N. Bose National Centre for Basic Sciences; 30 min
- 4. Ultrafast Spin Dynamics in Ferromagnetic Thin Films and Heterostructures, Magnonics 2019; Jul 31, 2019;

Carovigno, Italy; 30 min

- Interface Engineering in Ferromagnetic Thin Film Heterostructures for Applications in Spintronics, International Conference on Condensed Matter Physics (IEMPHYS 2019); Nov 14, 2019; IEM Kolkata; 45 min
- 6. Investigation and Control of Ultrafast Spin Dynamics in Ferromagnetic Heterostructures and Nanostructures, ICONSAT 2020; Mar 6, 2020; Biswa Bangla Convention Centre, Kolkata; 30 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

Awards, Recognitions

1. Elected Fellow of the Indian Academy of Sciences Bangalore (FASc)

Membership of Learned Societies

- 1. Member of American Physical Society
- 2. Member of IEEE
- 3. Life Member of Material Research Society of India

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

 Center for Nanomagnetics for Energy Efficient Computing, Communications and Data Storage; Indo-US Virtual Networked Centre; 2019 - 2021; PI

Conference / Symposia / Schools organized

- 1. International Conference on Nano Science and Technology: ICONSAT 2020 (Convenor); Mar 5, 2020; Biswa Bangla Convention Centre, Kolkata; 3 days
- International Workshop on Physics of Seminconductor Devices: IWPSD 2019 (Technical co-chair); Dec 17, 2019; Novotel Hotel and Residency, Kolkata; 4 days
- International Conference on Current Trends in Materials Science and Engineering: CTMSE-2019 (Co-Convenor); Jul 18, 2019; S. N. Bose National Centre for Basic Sciences; 3 days

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

- 1. Prof. Supriyo Bandyopadhyay, Virginia Commonwealth University, USA; Sl. No. 9, 12; International
- Prof. O. Hellwig at TU Chemnitz and Helmholtz-Zentrum Dresden-Rossendorf, Germany; Sl. No. 2, 8, 14; International
- 3. Prof. Y. Otani, RIKEN-CEMS, Wako and Univ. of Tokyo, Japan; Sl. No. 1, 6, 16, 17, 20, 21; International
- 4. Prof. K. Takanshi and Dr. T. Seki, Tohoku University, Japan; Sl. No. 15; International
- 5. Prof. M. Krawczyk, AMU, Poznan, Poland; Sl. No. 2, 8; International
- 6. Dr. S. Bedanta, NISER Bhubneswar; Sl. No. 15; National
- 7. Dr. J. R. Mohanty, IIT Hyderabad; Sl. No. 13; National

8. Prof. P. K. Dutta, IIT Kharagpur; Sl. No. 5, 18; National

Areas of Research

Experimental Condensed Matter Physics, Magnetism and Spintronics, Magnonics, Ultrafast spectroscopy

Our research group have made some important contributions in the fields of spintronics, spin-orbitronics and magnonics during last one-year. Some remarkable achievements are listed below.

• We have developed a novel all-optical method to investigate spin pumping in β -Ta/CoFeB thin films. From variation of Gilbert damping with Ta and CoFeB thicknesses, we extract the spin diffusion length of β -Ta and spin-mixing conductance. Consequently, interfacial spin transparency is derived as 0.50 ± 0.03 from the spin Hall magnetoresistance model for the β -Ta/CoFeB interface (Fig. 1). Further control experiment confirms the absence of other interface effects including spin memory loss.



Fig. 1. (a) Schematic of the spin pumping phenomena and the experimental geometry. (b) Extraction of intrinsic Gilbert damping parameter and effective spin-mixing conductance: time-resolved Kerr rotation data for d = 1, 4 and 13 nm. (c) Variation of damping with FM layer thickness linearly fitted by using a spin pumping formalism to extract intrinsic Gilbert damping parameter and effective spin-mixing conductance. (d) Variation of damping parameter with spacer layer thickness, is shown. The dotted line is guide to eye.

- We have further extended this to investigate nonreciprocal spin pumping in W/CoFeB/W heterostructure. A dissimilar enhancement in Gilbert damping is observed when W and CoFeB are interchanged from W/CoFeB to CoFeB/W. In-depth investigation reveals that the precessional trajectory is strongly affected by the induced magnetic anisotropy leading towards the observed non-reciprocal spin pumping. This is clearly demonstrated in W/CoFeB/W trilayer where the spin current generated by spin pumping diffuses more towards W underlayer in comparison to W overlayer. Our findings add new insights in the role of ferromagnet/ nonmagnet interfaces for controlled generation and utilization of pure spin current.
- We have demonstrated that small defects drastically increase the switching error probabilities, which also depends on a critical stress in strained nanomagnets. This could limit the application of straintronic binary switches in Boolean logic and memory, despite their excellent energy efficiency, and restrict them only to non-Boolean (e.g., neuromorphic, stochastic) computing.
- We have achieved microwave-power-driven strong magnon-magnon coupling in Ni₈₀Fe₂₀ nanocross array and large nonlinear FMR shift. These properties are further tunable by internal spin-textures. The tunable coupling strength and nonlinearity by microwave power may lead to hybrid systems for quantum spin-based computation (Fig. 2).

- We have demonstrated electrical control of propagating spin waves in ultrathin ferromagnetic heterostructure using voltage-controlled magnetic anisotropy (VCMA), for highly energy-efficient magnonic devices. We have further developed an on-demand voltage controlled magnonic nanochannel by periodically tailoring VCMA using ITO nanoelectrode arrays, resulting in spin-wave nanochanneling and magnonic bandgap formation.
- We have demonstrated reconfigurable magnon non-reciprocity induced by dipolar interaction in coupled ferromagnetic bilayers. The relative magnetic orientation can be controlled to turn on and off the magnon nonreciprocity, lending their key functionalities in spintronic and magnonic devices.
- We have studied magnetization dynamics of Gd-Fe thin films with different thicknesses over femtosecond to nanosecond timescale. The bias magnetic field dependent precessional frequency revealed the development of out-of-plane anisotropy when the film thickness was increased from 20 to 100 nm. Moreover, the 100-nm-thick film has shown perpendicular standing spin-wave modes along with the uniform Kittel mode and a possible energy transfer between the two, leading to tunable Gilbert damping from 0.02 to 0.15. This shows the potential for applications in miniaturized and fast magnetic storage, magnetic memory, and magnonic devices.



Fig. 2. Strong magnon-magnon coupling and nonlinear FMR shift in $Ni_{80}Fe_{20}$ nanocross array. (a) FMR experimental geometry. (b) SEM image of the nanocross array. (c) Three-dimensional surface plots showing the nonmonotonic variation of FMR peak with magnetic field. (d) Magnon mode anticrossing due to strong magnon-magnon coupling. (e) Determination of cooperativity of strong coupling. (f) Nonlinear FMR peak shift with microwave power.

- We have developed magnetic vortex-based logic and tristate buffer switch for all-magnetic computation.
- We have developed a range of novel magnonic crystal for anisotropic spin-wave propagation for applications in on-chip GHz frequency filters, (de)multiplexers, directional couplers, etc.

Plan of Future Work Including Project

- 1. We will underpin the ultrafast demagnetization mechanism and its correlation with spin-polarization. By varying the alloy composition we will study the variation in spin density of states at Fermi level, spin-flip-scattering rate and demagnetization time. Furthermore, we will study the relationship of Gilbert damping parameter with ultrafast demagnetization time to investigate the effects of inter-band or intra-band scattering mechanism.
- 2. We will investigate the interfacial Dzyaloshinskii-Moriya interaction (iDMI) at the interface of 2D-TMD, MoS2 and ferromagnet from asymmetry in spin-wave dispersion using Brillouin light scattering spectroscopy and its scaling with ferromagnetic layer thickness. We will further study the defect-induced extrinsic spin-orbit coupling at the interface and its correlation with the DMI.
- 3. We will investigate reconfigurable magnonic band structure and bandgap by a bias-field controlled spin texture in chains of connected nanodots. We will study the magnetic field history dependent magnetic phase transition and field-bifurcation leading to the variation in magnonic band structure.
- 4. We will investigate anisotropic magnonic band structure in asymmetric width modulated magnonic waveguide using BLS spectroscopy and plane-wave method.

Based on the observed spin-wave anisotropy, we will develop practical design of frequency dependent logic gates intended for integrated spin-based nanocircuits.

5. We will develop extreme sub-wavelength antenna by actuating electromagnetic (EM) antenna with surface acoustic wave (SAW) whose wavelength will be several orders of magnitude smaller than the EM wavelength. The antenna will consist of magnetostrictive nanomagnets deposited on a piezoelectric substrate. By periodically straining the nanomagnets using a SAW, EM waves will emit at the frequency of the SAW.

Any other Relevant Information including social impact of research

- 1. Initiated new and emerging research fields such as magnonics and spin-orbitronics for enabling India to compete at the international level.
- Developed novel research facilities such as Timeresolved Magneto-optical Kerr Effect Microscopy, Microfocused 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

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

Publications

a) In journals

1. Anup Ghosh. Vibrational Coupling on Stepwise Hydrogen Bond Formation of Amide I, J. Phys. Chem. B 2019, 123, 7771–7776

Areas of Research

A. Vibrational Coupling on Stepwise Hydrogen Bond Formation of Amide I

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



B. Surface Directed Disparity in Self Assembled Structures of Small Peptide L-Glutathione on Gold and Silver Nanoparticles

Despite the key roles of L-glutathiones (GSH) in biology and nano-biotechnology, understanding their labile structures and hydrogen bond interactions on nanoparticles has posed a critical challenge to the scientific community. The structural conformation of GSH as a capping layer on gold (AuNP) and silver nanoparticles (AgNP) surfaces are investigated. In this report, we attempt to explore the material-dependent interaction of GSH with the different spherical nanoparticle surfaces by employing FTIR. The infrared signal of amide I of GSH is studied as a function of different material's spherical nanoparticles with comparable size. We revealed the β sheet secondary structure of GSH on AgNPs unlikely random structure on AuNPs even both the nanoparticles are in comparable shape and size, and belong in 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 suppression is perceived by a

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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 capping layer on nanoparticle surfaces as well as surface enhancement of the IR absorption of amide I. We would like to emphasize that molecular selfassembly on the nanoparticle surfaces are definitely of very broad interest for chemists working in nearly any sub-discipline, spanning from the nanoparticle-based medicine to surface-enhanced spectroscopy, to the heterogeneous catalysis, etc.



C. Perturbation of Fermi Resonance on Hydrogen-Bonded >C=O IR Absorption of Small Esters

Based on linear infrared spectroscopy, I have presented an important informative approach for parameterizing spectroscopic maps of ester carbonyl groups against experimental IR absorption spectra. My center of attention is the establishment of the origin of doublet peak

line shape in the infrared spectrum of C=O stretching frequency of small water-soluble esters in protic solvent (water) rather than in aprotic solvent (acetonitrile). But in contrast, comparatively higher molecular weight esters show the singlet peak line shape of carbonyl vibration in neat water. I have established that the doublet peak is due to the fermi resonance of the overtone/combination band with carbonyl vibrational transition of small esters in aqueous solution. I have also spotlighted the picture where fermi resonance does not appear in the infrared spectra of carbonyl stretching mode of mentioned esters in an aprotic solvent, acetonitrile. In the case of comparatively higher molecular weight esters, a single Laurentzian peak appears for C=O stretching in neat water due to the absence of fermi resonance. I have established that the C=O exclusively occupies a doubly hydrogen-bonded conformation in neat water for all of my studied esters, which is in contrast to the conclusions of many previous reports. In combination with DFT calculation and electric field simulations, this spectroscopic map of the C=O vibration of esters has strengthened my arguments. My results will be useful in interpreting the spectra of ester as an infrared probe in a biological environment as well as the chemical environment.





Atindra Nath Pal

Assistant Professor CMPMS atin@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Shubhadip Moulick; Charge and spin transport in hybrid two dimensional nanodevices; Under progress
- 2. Biswajit Pabi; An investigation of mechanical tunability in single molecular junction; Under progress
- 3. Rafiqul Alam; An investigation of transport phenomena in topological materials; Under progress
- 4. Shubhrasish Mukherjee; An investigation of electronic and optical properties in 2D semiconductors and their heterostructures; Under progress; S. K. Ray (Supervisor), Atindra Nath Pal (Co-supervisor)
- 5. Riju Pal; Spintronics with layered materials; 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. Spring semester; PHY 601 Advanced Condensed Matter Physics 2; PhD; 30 students; with 1 (Dr. T. Setti) co-teacher
- 2. Autumn semester; PHY 501- Research Methodology; PhD; 34 students; with 1 (Prof. Rajib Kumar Mitra) coteacher

Publications

a) In journals

1. Atindra Nath Pal, Dongzhe Li, Soumyajit Sarkar, Sudipto Chakrabarti, Ayelet Vilan, Leeor Kronik, Alexander Smogunov & Oren Tal, Nonmagnetic singlemolecule spin-filter based on quantum interference, Nature Communications, 10, 5565 (2019)

Talks / Seminars Delivered in reputed conference / institutions

- nvited talk at the Flatlands and beyond (2019) A meet on 2D materials, Sep 5, 2019; SNBNCBS, Kolkata; 30 minutes
- 2. Invited talk at SPICE-Molecular Electro Opto-spintronics; Oct 16, 2019, University of Mainz, Germany; 30 minutes
- Invited talk in the group of Prof. Michel Calame, EMPA, Switzerland; Oct 23, 2019; EMPA, Switzerland; 60 minutes
- 4. Invited talk at the University of Konstanz, Germany; Oct 24, 2019; University of Konstanz, Germany; 60 minutes
- 5. Invited talk at Spin in Molecular Systems: Experiment, Theory and Application (SiMS2019); Dec 4, 2019; SSCU, IISc, Bangalore; 30 minutes
- 6. Invited talk at IIT Kharagpur, ICFM 2020; Jan 6, 2020 ; IIT Kharagpur; 30 minutes

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 and Ellipsometry under Technical Research Cell
- 4. Member of Project & Patent Cell

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

1. Joint proposal titled "Indo-US Joint Center for Nanomagnetics for Energy Efficient Computing, Communications and Data Storage"; Indo-U.S. Science and Technology Forum (IUSSTF); 3 years; Co-PI

Conference / Symposia / Schools organized

- Flatlands and beyond (2019) A meet on 2D materials September 5-6, 2019; Sep 5, 2019; SNBNCBS, Kolkata; 2 days
- IWPSD 2019, December 17-20, 2019; Dec 17, 2019; Novotel Hotel, Kolkata; 4 days
- 3. International Conference on Nano Science and Technology March 5-7, 2020; Mar 5, 2020; Biswa Bangla Convention Center, Kolkata; 3 days

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

 Prof. Oren Tal, Weizmann Institute of Science, Israel; Nature Communications volume 10, Article number: 5565 (2019); International

Areas of Research

Experimental condensed matter physics

A. Development of the laboratory: In the last one we have created various measurement set up development of the laboratory. These includes, custom made dipstick for temperature dependent transport measurements, one high vacuum set up with in situ molecular evaporation, an high vacuum opto-electronic set up with Arduino based power supply to control light illumination, home

built room temperature mechanically controllable break junction set up to create single molecular junction at room temperature, a low temperature (7K-300K) set up where we can sweep the magnetic field within +/-1T. All these set up are equipped various measurement equipment like lock in amplifiers, sourcemeters, low noise amplifiers. We are also in the process of developing the low frequency noise measurement set up using lock in amplifiers and data high speed data acquisition card.

B. Single molecular transport through mechanically controllable break junction (MCBJ) technique:

A room temperature break junction set up has been developed at the S. N. Bose National center for Basic Science, Kolkata. The set up was characterized by creating a gold wire junction (100 μ m Au wire, 99.999% Alpha Aesar). The photograph of the set up with the details are explained in Fig. 1a. Fig. 1b shows the five breaking traces of gold, which clearly indicate quantized steps, signature of the formation of the atomic point contact. The distance with the piezo voltage was calibrated from by fitting the tunneling current with piezo voltage. Data acquisition and analysis are two important steps for these experiments. Labview based programs were developed to acquire data using a 24 bit DAQ card (PCI 4461, NI instruments). The analysis was performed by custom made MATLAB codes, particularly for histogram and I-V measurements.

Observation of jump-to-contact phenomena in <u>Au-BiPyridine-Au junction</u> (Biswajit Pabi et al., in preparation)

This work focuses on the formation and evolution of the molecular junction in Au-4,4 bipyridine – Au junction at finite temperature. At the ambient condition presence of unknown molecule can be hindrances to the formation of molecular junction. We have chosen 4, 4 bipyridine, which was shown to create stable molecular junction with a conductance $\sim 10^{-3} \,\mathrm{G}_{0}$. Fig. 3a shows the linear and logarithmic histogram of clean Au and Au-molecule-Au junctions. In case of molecular junction, a clear peak at 10-3 G₀ is visible, similar to previous result. One of the important fact lies in the "push" traces, where we find that the molecular junction form at a conductance value of $\sim 10^{-3} \text{ G}_{0}$. Similar analysis was performed for 2,2, pyridine molecule, where we do not find jump-tomolecular contact in the push traces. We are waiting for the molecular dynamics simulation and DFT based calculation for the better understanding of the effect.

<u>Electrical Transport through Cu-H2-Cu junction (Biswajit</u> Pabi and A.N. Pal, in preparation)


Figure 1 (a) Conductance traces of clean Cu and Cu+H2 respectively. (b) Logarithmic conductance histogram for Cu and Cu+H2 junction (c) 2D Conductance-Length density plots for clean Cu and Cu+H2 junctions.

This work was done at 4.2K in liquid helium using a dipstick. First, pure copper wire was broken at low temperature, exhibiting last conductance plateau at $1G_0$, expected for s-metal. Insertion of hydrogen molecule at 4.2K, we observe appearance of conductance values below $1G_0$. Conductance histogram indicates at least 3 conductance peak (Fig. 4b and 4c). We have also studied the IETS measurement to obtain the vibrational energies of the Cu-H2-Cu junction. Initial analysis indicate the formation of one-dimensional chain in this junction. Detail theoretical calculation is required to explain the result.

- C. Fabrication and characterization of low dimensional devices on chip: We have successfully optimized lithographic process to create micron scale devices of 2D materials like graphene or TMDCs. A simple microscope based setup was developed to create 2D layered heterostructure and measure electronic transport of these sensitive devices down to low temperature.
- **D. D. Optoelectronics with all TMDC based hybrid devices:** One of our research direction is all TMDC heterostructures based on the 2D flakes, either prepared by mechanical exfoliation or grown with chemical vapour deposition, and the chemically exfoliated nanoparticles or nanosheets. We have been able to fabricate few layer MoS2 heterostructure and obtain gate dependent transport. In presence of red light ($\lambda \sim 635$ nm) it shows photo response in the I_{SD}-Vg curve (Fig. 6c). We intend to graft WSe2 nanosheets on this device to characterize the photo-response with an intention to create broadband photodetector as discussed above.
- **E.** Low frequency noise measurement set up: We are developing low frequency noise measurement set up to study various physical phenomena. By using suitable amplifier and using a Faraday cage, we are trying to reduce the background noise. We can obtain the thermal noise background with a different resistors. We have also developed the code for data acquisition and analysis with MATLB and Labview for noise measurement. At



Figure 1 (a) Optoelectronic transport measurement set up, (b) I-V characteristics at different gate voltages for a two terminal few layer MoS_2 transistor. Inset shows the device image. (e) I_{DS} -Vbg characteristics in dark and, in presence of red light, showing significant photo response.

present we are optimizing our set up for measuring noise for micro-Ohm samples.

Plan of Future Work Including Project

- 1. Single molecular transport: During the last two 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 could study the inelastic electron spectroscopy in Cu-H2 junction to understand the vibrational modes. Our basic goal is to investigate the relation between the orbital structure and electron transport via electronic transport and inelastic electron tunneling spectroscopy (IETS). We shall focus on following research goals: I. What is the effect of the different metal electrodes (s-metal, p-metal or d-metal in particular) in formation and electronic transport through the molecular junction? II. What would be the effect of the structural asymmetry and the dipole moment of a molecule trapped in a molecular junction, on the junction conductance? Is the vibrational features affected due to the asymmetry and if it possible to detect through IETS? III. Revealing the role molecular orbitals in determining the conduction channels is necessary for deep understanding of electronic transport through molecules and is expected to open a way for better control over electronic transport at the atomic scale.
- Optoelectronics with 2d hybrid: One of our ongoing 2. research direction is to create all TMDC heterostructures based on the 2D flakes for opto-electronics applications, either prepared by mechanical exfoliation or grown with chemical vapour deposition, and the chemically exfoliated nanoparticles or nanosheets. A significant drawback with these 2D layered materials is the low absorption of incident light as a result of the atomic thickness of the active region. This low absorption of incoming light limits the device in terms of both performance and efficiency. A common method used to increase the absorption of incoming light is to incorporate a optically active layer (2D/0D) on top of the active region in the device. As the nanostructures of TMDC semiconductors show different properties from their bulk and layered counter parts, it would be interesting to the study TMDC nanoparticles as well. The bandgap of TMDC (MoS2, WS2) nanoparticles can be changed by changing their particle size, as manifested from absorption, Raman and emission studies. Size tunable band gap and broad absorbance and emission spectrum of nanoparticles covers the visible range that could be exploited in the fabrication of various optoelectronic devices. Therefore, assembling these individual 2D materials (TMDCs) could be very interesting to create a new category of artificial systems with interesting and special physical properties. Such vdW heterostructures are not only fundamentally interesting but also technologically important for novel semiconductor devices. We have already fabricated and

measured the opto-electronic properties MoS2 based FET, and ready to continue further.

- 3. Spintronics with layered magnetic materials: A promising direction for exceptionally efficient and low-power information processing involves manipulations of electronspin rather than its charge at the nanoscale. Due to the presence of weak spin orbit coupling, graphene promises to have long spin coherence length up to $\sim 100 \,\mu$ m, creating a possibility of having a spin-based logic device at room temperature. Moreover, after the successful production of large-scale graphene or by chemical vapor deposition (CVD) based techniques, created a huge prospect for their practical usage. Apart from graphene, there are several magnetic 2d materials have been discovered. We would like to focus on investigating the electronic properties of these new class of materials through electronic and magnetic transport. In addition, we would like to replace the conventional ferromagnetic contacts with these 2d magnet for spin injection. Initially we shall focus on vertical heterostructure based on graphene and FM. As these materials are air sensitive, we shall create a glove box based heterostructure set up for fabricating graphene/ FM heterostructure. After successful device fabrication, electronic and magnetotransport will be studied at various temperature.
- Carbon contacted gate tunable molecular devices: 4. Molecular devices have become an emerging alternative in recent times as molecules can easily be designed and synthesized with new functionalities. Several functionalities have already been demonstrated in molecular tunneling junctions, such as switches, diodes, and transistors. In a molecular scale device quantum effects may dominate the device performance, creating possibilities to explore various quantum phenomena like thermoelectric effects, and quantum interference (QI) effects. It is always challenging to create good electrical contacts to these molecules for stable electronic devices. Moreover, tuning the energy levels by a gate electrode similar to other inorganic devices is always challenging, although, there are few reports where the energy level of a central molecule is tuned by a solid back gate or electrochemical gate to the side of molecular junctions. Here, we intend to design a vertical molecular tunneling transistor with stable operation up to room temperature based on a gate/ graphene/self-assembled monolayer (SAM)/gold crossplane vertical heterostructure. Pattern gold electrode will be created and SAM of functional molecule will be created using a thiol anchoring group. An ionic liquid gate will be used to tune the electronic coupling and the energy levels of the molecules. Graphene, being atomically thin, will not be able to screen the gate electric field and an effective electric field may penetrate into the molecular layer to tunes its energy levels. Initially we shall focus on molecules which manifest switching under external stimuli and quantum inference effects in molecular junctions.



Barnali Ghosh (Saha)

Scientist-F CMPMS barnali@bose.res.in

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; Thesis submitted
- Avisek Maity; Synthesis, Characterization, Physical Property Studies & Applications of Perovskite Halide; Under progress
- 3. Chandan Samanta; Synthesis, Physical Properties And Application Of Metal Oxide Semiconductor Nanostructures And Thin Film; Under progress
- Purushottam Majhi; Structure And Physical Properties Of Strained Metal Oxide Films; Under progress; Prof. A.K.Raychaudhuri (Co-supervisor)
- 5. Snehamoyee Hazra; Investigation on Nanostructured Piezoelectric and Ferroelectric materials; Under progress

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

- 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

- Autumn semester; Integrated Ph.D programme, 3rd, Semester, Methods of Experimental Physics, PHY 391; Integrated PhD; 11 students
- 2. Spring semester; Project Research II (PHY 304); 3rd Semester; Integrated PhD; 2 students

Publications

a) In journals

- 1. Avisek Maity, A. K. Raychaudhuri and **Barnali Ghosh**, High sensitivity NH₃ gas sensor with electrical readout made on paper with perovskite halide as sensor material, Scientific Reports 9:7777, (2019)
- 2. Chandan Samanta, Ankita Ghatak, A K Raychaudhuri and **Barnali Ghosh**, *ZnO/Si nanowires heterojunction array-based nitric Oxide (NO) gas sensor with noiselimited detectivity approaching 10 ppb*, Nanotechnology 30 305501, 2019

b) Conference proceedings / Reports / Monographs / Books

1. Perovskite halide based flexible gas sensor for detection of environmental pollutant at room temperature Cite

as: AIP Conference Proceedings 2115, 030476 (2019); https://doi.org/10.1063/1.5113315 Published Online: 12 July 2019, Avisek Maity, and Barnali Ghosh

 A study on wavelength dependent persistence photoconduction of indium gallium zinc oxide thin film Cite as: AIP Conference Proceedings 2115, 030332 (2019); https://doi.org/10.1063/1.5113171 Published Online: 12 July 2019 Chandan Samanta, and Barnali Ghosh

Talks / Seminars Delivered in reputed conference / institutions

- Invited Speaker and Collaborative research visit in The Joint International Research Laboratory of Information Display and Visualization School of Electronic Science an Engineering, Southeast University, Nanjing, China, April 17-22, 2019, 5 days 17-22 April; Apr 18, 2019; Nanjing, China; 17-22 April, 5 days
- 2. Invited speaker in the third International conference on Advanced Functional Materials (ICAFM 2019) at Thiruvananthapuram, Kerala, India during 9-10 December 2019 organized jointly by Indian Ceramic Society, Kerala Chapter, the Materials Research Society of India, Thiruvananthapuram Chapter and CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram. 9-10 Dec, 2 days. Dec 10, 2019; Thiruvananthapuram, Kerala; 9-10, two days
- Invited speker in the workshop on Nanolithography and Nanofabrication & Raith User meet (India-Nano 2019) during July 9-10, 2019 at S.N.Bose National Centre For Basic Scinces, Kolkata, India, organized by Raith India , Bangalore. 9-10 July, two days; Jul 9, 2019; S.N.Bose National Centre For Basic Sciences, Kolkata; 9-10 July, two days
- Invited speaker and organizing committee member of 24th International conference on Advanced Materials & Nanotechnology" (Advanced Materials -2019), hold during October 21-22, 2019 in Rome, Italy. 21-22 Oct, two days; Oct 21, 2019; Rome, Italy; 21-22, Oct, two days

Administrative duties

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

- 5. Various evaluation committees
- 6. Interview committee

Patents Taken and Process Developed with Details

 "Indian patent has been granted (Grant no: 317234, dated 31/07/2019)" Patent title: "Ammonia gas sensor and a method for manufacturing the same" It is a visual colour change based ammonia sensor: high sensitivity (~ 10ppm), very high selectivity for unheated operation. The sensor material grown on paper and works like a pH paper on disposable basis. Quick and easy method to detect hazardous gases in work places, when the sensor comes in ammonia environment it quickly changes its colour within few seconds and gives visual warning. Proof of concept established, the "Indian patent has been granted (Grant no: 317234, dated 31/07/2019)"; 317234; Granted

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; 06/07/2018- 05/07/2021; PI
- An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide films; SERB- DST; 24/3/2017-23/03/2020; Co-PI
- 3. Technical Research Centre, Centre project, one among other PIs; SERB- DST; 01/01/2016 to 31/ 12/2020; PI

Conference / Symposia / Schools organized

 Organizing committee member, International conference on Nano Science and Technology, ICONSAT 2020, 5-7 March, 2020; Mar 5, 2020; Biswa Bangla convention Centre, Kolkata; 5-7 March, two days

11(

Outreach program organized / participated

- Display of prototypes and poster in the India International Science Festival (IISF 2019), a joint event of Ministry of Science and Technology and Ministry of Earth Sciences, Ministry of Health & Family Welfare organized during November 5th-8th, 2019 at Biswa Bangla Convention Centre and Science City, Kolkata.
- Display of prototypes & poster in the Acharya Satyendranath Basu Smarak Bijnan 'O' Projukti Mela has been scheduled from 16th January to 19th January 2020 at Hedua Park, Kolkata organized by Paschimbanga Vigyan Mancha
- Display of Prototypes and poster in the laboratory at S.N. Bose National Centre For Basic Sciences, Kolkata, on the occasion of National Sciences Day, 28th February, 2020.
- 4. Invited speaker for a Popular lecture at Science City, Kolkata on March 13, 2020, on the occasion of International Women's day for raising awareness against gender bias: 'an interactive session with school students with a women achiever'
- 5. Display of Prototypes and poster in the stall of International Conference, ICONSAT-2020 at Biswa Bangla convention Centre, Kolkata during 5-7 March, 2020

Areas of Research

• Paper electronic based device for gas sensing activity of perovskite halides • Growth and physical property study of perovskite lead halide • Study on paper electronic based Photo detector of perovskite halides • Synchrotron X-ray and Neutron diffraction study in complex oxides. • 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 . Study of Photoresponse and gas sensing property in binary oxide hetero junction systems. • Growth of high performance thin film transistors (TFT) and physical property study

1. Fast response paper based visual color change gas sensor for efficient ammonia detection at room temperature

We show that a cheap, disposable type rapid paper sensor (working at room temperature) can be made

using perovskite halide CH3NH3PbI3 (MAPI) to detect presence of the toxic ammonia gas (NH3) by just color change, where the black colored MAPI film (on the paper) changes to yellow color in presence of a very low concentration of NH₂ gas. The sensor can detect presence of NH₂ gas in open or closed atmosphere down to around 10 ppm with a response time of nearly 10 sec which decreases to few seconds when the concentration exceeds 20 ppm. The easy to fabricate sensor paper being a visual sensor does not need any other extra equipment for its operation. The sensor is not sensitive to moisture with RH upto 90% and does not also respond to gases like Methane (CH₄), Nitrous Oxide (N_2O) , Carbon dioxide (CO_2) etc in the test chamber each up to a concentration of 500 ppm. Conversion/ decomposition of MAPI to PbI2 on exposure to NH3 has been proposed as the mechanism of color change and the mechanism has been established using a collection of techniques like XRD, EDX, UVVisible absorption and Photo Luminescence.

The sensor material grown on paper and works like a pH paper on disposable basis. Quick and easy method to detect hazardous gases in work places, when the sensor comes in ammonia environment it quickly changes its colour within few seconds and gives visual warning.

Proof of concept established, the "Indian patent has been granted (Grant no: : 317234, dated 31/07/2019)". One paper published in : Scientific reports(2018) 8:16851)

2. Paper electronics based High sensitivity NH3 gas sensor (~10ppb) with electrical readout made on paper with perovskite halide as sensor material

We report a cheap, paper electronics based solid state gas sensor to detect NH3 gas selectively with a detection capability of better than 1 ppm. The sensor uses perovskite halide CH₂NH₂PbI₂ (MAPI) as the active sensor material grown on a paper. This paper based sensor works at room temperature. The current through the paper sensor increases by one order on exposure to only 10 ppm NH₂ gas. The calibrated sensitivity is \sim 55% for 1 ppm of NH₂ gas in Nitrogen or Air. The current noise limited resolution estimated to be ~ 10 ppb. This work establishes perovskite halide as a new solid state gas sensing material that can reach sub ppm sensitivity using simple paper electronics. Use of paper and also solution method used to grow the active material makes the sensor cost effective and easy to manufacture. This type of disposable high sensitive paper sensor can be used for detection of NH₂ as a marker in exhaled breathes for non-invasive diagnosis. The sensor formed on the paper, since it supports unheated operation, needs less than few nano watt power for its operation.

Indian Patent filed (patent no: 201831001993), and one paper published in Scientific Reports (2019) 9:7777.



Fig 1: Ammonia sensor material grown on paper has very good sensitivity and selectivity and with noise limited detectivity ~10ppb.



Fig2.ZnO/Si nanowires heterojunction array based nitric Oxide (NO) gas sensor with noise limited detectivity approaching 10 ppb

Plan of Future Work Including Project

1. 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: 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. (Indian patent files, FER report received, 2020)

- 2. Work under Project SERB ref no: EMR-2016/002855 dated 20/3/2017 Synchrotron and Neutron Diffraction study on perovskite oxides
- 3. Work under project SERB ref no: EMR/2017/001990 dated July 2018 Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them: one paper has been published: J. Phys. Chem. C 2019, 123, 2573–2578. Further work is under study
- 4. B) Basic research: i) Physical Property study on Single nanowire based devices ii) Growth to Physical Properties on thin film transistors (TFT) iii) Study of interface physics of complex and binary Oxide thin films and multilayers: iv) Synthesis & optical properties, crystallographic structure microstructural study on Perovskite halide systems

Any other Relevant Information including social impact of research

 One of the activity leader in Technical Research Centre (TRC) project: Main area of work: i) Environment related issue: Making of sensor for Hazardas gas detection ii) Health Care Sector: Technology development for making device for detection of disease 1. Fabrication of Piezo electric nano generator :a) for battery application , (b) self-powered sensor for pulse rate monitoring. Indian Patent has been filed (patent no: 201931015347).

- a) Development of ultra-sensitive sensor for hazards gas detection: Ammonia gas sensor : a) "Visual color change based ammonia gas sensor (<10ppm)for stand alone use for hazards " i) Hazards Gas detection in an open atmosphere down to 10ppm level/based on ammonia gas sensing, patent filed). ii) The technology developed is to be used for Ammonia gas detection without any other peripherals like a pH paper. "Prototype is ready for use which can sense ammonia<10ppm level by visual effect (just by colour change)" (one Indian patent has been granted (Grant no: 317234, dated 31/07/2019)" And one paper published in : Scientific reports(2018) 8:16851)
- 3. 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. Making of prototype is under process, Indian Patent filed (patent no: 201831001993), and one paper published in Scientific Reports (2019) 9:7777.
- 4. Development of Nitric oxide (NO) gas sensor: Fabrication of solid state sensor, detecting NO gas (sensitivity: 500ppm). Exhaled NO can be used as the markers for Asthma and Chronic obstructive pulmonary disease (COPD). Making of prototype is under process. Indian patent filed (patent no: 201731038036) and one paper published in Nanotechnology, 30, 2019, 305501.



Dipanwita Majumdar

Inspire Faculty CMPMS

Teaching

1. Training of micro-Raman setup was given to Didhiti Bhattacharya and Shubhrashish Mukherjee.

Awards/ Recognitions

1. DST Inspire Faculty Award

Areas of Research

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

In pursuit of extra-ordinary two-dimensional materials beyond graphene, enormous attention has been given to TMD materials which led to the emergence of a new era of *flatland* with great potential for a range of applicationsin optoelectronics and sensors. To further potentially extend the functionalities of such materials by modifying them with nanomaterials is of great and widespread interest. The realization of the impact of hybridization is done by a systematic study of structural, optical and vibrational properties of such hybrid systems.

Plan of Future Work Including Project

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



Kalyan Mandal

Senior Professor CMPMS kalyan@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Keshab Karmakar; Oxide semiconductors for energy applications; Thesis submitted
- 2. Mahebub Alam; Multiferroic materials; Thesis submitted
- 3. Indranil Chakraborty; Biomedical applications of transition metal oxide nanostructures; Thesis submitted
- 4. Subrata Ghosh; Magneto caloric effect and materials; Under progress
- 5. Dipika Mandal; High frequency properties of transition metal oxide nanostructures; Under progress
- 6. Dipanjan Maity; Oxide semiconductors for energy applications; Under progress
- 7. Swarnali Hait; Multiferroic materials; Under progress
- 8. Anupam Garai; Ferrite nanostructures; Under progress
- 9. Saheli Samanta; Magnetocaloric effect and materials; Under progress

b) Post-Docs

1. Srabantika Ghose; Multiferroic materials

c) External Project Students / Summer Training

1. Nopu Ongay Bhutia; Na-doped ZnO nanorod photoanode for photoelectrochemical water splitting; Indian Institute of Technology, Kharagpur

Teaching

- 1. Autumn semester; Condensed Matter Physics; Integrated PhD; 13 students; with 1 (Professor Manoranjan Kumar) co-teacher
- 2. Autumn semester; Advanced Experimental Course; Integrated PhD; 13 students; with 4 (Manik Pradhan, Madhuri Mandal, Barnali Ghosh (Saha) and Ramkrishna Das) co-teachers
- 3. Spring semester; Basic Laboratory II; Integrated PhD; with 1 (Pratip Kumar Mukhopadhyay) co-teacher

Publications

a) In journals

- P Saha, R Rakshit, M Alam, K Mandal, Magnetic and Electronic Properties of Zn-doped Fe₃O₄ Hollow Nanospheres, Physical Review Applied 11, 024059 (2019)
- I Chakraborty, U Saha, D Mandal, S Mukherjee, N Joardar, S P S Babu, G. S. Kumar, K. Mandal, Effect of bovine serum albumin on tartrate-modified manganese ferrite nano hollow spheres: spectroscopic and toxicity study, Physical Chemistry Chemical Physics 21, 10726-10737 (2019)
- D Majumder, I Chakraborty, K Mandal, S Roy, Facet-Dependent Photodegradation of Methylene Blue Using Pristine CeO₂ Nanostructures, ACS omega 4, 4243-4251 (2019)
- P. Saha, S. Mukherjee, K. Mandal, Rheological response of magnetic fluid containing Fe₃O₄ nano structures, Journal of magnetism and magnetic material 484, 324-328 (2019)
- P Saha, R Rakshit, K Mandal, Enhanced magnetic properties of Zn doped Fe₃O₄ nano hollow spheres for better bio-medical applications, Journal of Magnetism and Magnetic Materials 475,130-136 (2019)
- 6. D Maity, K Karmakar, **K Mandal**, *N*-*N* type coreshell heterojunction engineering with MoO3 over ZnO nanorod cores for enhanced solar energy harvesting application in a photoelectrochemical cell, Journal of Alloys and Compounds 791, 739-746 (2019)

- D Mandal, A Gorai, **K Mandal**, Electromagnetic wave trapping in NiFe₂O₄ nano-hollow spheres: An efficient microwave absorber, Journal of Magnetism and Magnetic Materials 485, 43-48, (2019)
- D Mandal, M Alam, K Mandal, NiFe₂O₄ nanohollow spheres with improved magnetic and dielectric properties, Physica B: Condensed Matter 554, 51-56 (2019)
- 9. Srabantika Ghose and **Kalyan Mandal**, *Leakage* through the conductive channels appearing at the grain boundaries of multiferroic gallium ferrite, Journal of Physics D: Applied Physics 52, 415001 (2019)
- A Chaudhuri, **K Mandal**, Dynamic magnetic properties of monodisperse CoFe₂O₄ nanoparticles synthesized by a facile solvothermal technique, Physica B: Condensed Matter 575, 311640 (2019)

Talks / Seminars Delivered in reputed conference / institutions

 Magnetism: Bulk to Nano; Jun 1, 2019 in C K Majumder Memorial Summer Workshop- 2019 at S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata; 1 hr 15 min

Administrative duties

- 1. Head of the Department, CMP&MS
- 2. Chairman, Technical Cell
- 3. Chairman, Technical Committee for purchase
- 4. Chairman, Library Committee
- 5. Chairman, Security Committee

Membership of Learned Societies

- 1. Materials Society of India
- 2. Indian Physical Society
- 3. Indian Association of Physics Teachers
- 4. IEEE Magnetics Society
- 5. Indian Non-destructive Society
- 6. Indian Association for the Cultivation of Science

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

1. Study of magneto-structural transitions and magnetocaloric 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

 C. K. Majumdar Memorial Summer Workshop in Physics 2019; May 28, 2019; S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata; 11 days

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

1. Dr. Arka Chaudhuri, Haldia Institute of Technology, Haldia, India; Sl. No. 10; National

Areas of Research

Magnetism and magnetic materials, nanomaterials and energy materials

Giant Room-Temperature Magnetocaloric Effect across Magnetostructural Transition in (MnNiSi), (FeCoGa), Alloys: Magnetic and structural transitions are observed to coincide at around room temperature in transition metal based (MnNiSi)₁ (FeCoGa)_x (x = 0.15 and 0.16) alloys which leads to a coupled first order magnetostructural transition (MST) from paramagnetic hexagonal to ferromagnetic orthorhombic structure and as a result giant magnetocaloric effect is observed in these alloys. With subsequent doping for x= 0.17, MST decouples into two separate transitions, structural and magnetic, though the transitions are realized to couple with enhancing the applied magnetic field. The alloys with x = 0.15, 0.16 and 0.17 are found to exhibit isothermal magnetic entropy change (ΔS_{M}) as large as ~25 Jkg⁻¹K⁻¹ at 323 K, ~31.1 Jkg⁻¹K⁻¹ at 281 K, and \sim 23.8 Jkg⁻¹K⁻¹ at 213 K respectively due to a field change of $\Delta H = 50$ kOe. These low-cost materials may be considered as promising candidates for magnetic refrigeration around room temperature due to their giant magnetocaloric properties with significantly large relative cooling power (RCP = 191.8, 209.6 and 139.2 J/kg respectively for x = 0.15, 0.16,and 0.17 due to $\Delta H = 50$ kOe).

$\rm NiFe_2O_4~Nano-Hollow~Spheres~as~an~Efficient~Microwave~Absorber$

In search of lightweight, broadband and stable microwave absorbing material, here we have presented a morphology dependent study on Nickel Ferrite (NFO). A comparative study of NFO nano-hollow spheres (NFO-NHS) with its nano particles (NPs) and bulk counterpart on permittivity (ε), permeability (μ), Reflection Loss (RL) and Shielding efficiency (SE) has been performed for widely used X-Band (8-12 GHz) on composites filled (25 wt% and thickness of 2 mm) with each sample. Interestingly, NFO nano hollow spheres (NHS) are found to be highly efficient material

towards microwave attenuation. A optimal RL of ~ -59.2 dB is obtained for frequency ~ 11.7 GHz with a band width (W) of ~ (9.18 – 12) GHz with RL < -10 dB (absorption > 90%). Hollow cavity of NHS leads to a lower density (~ 3.9 g/cc) as well as multiple internal reflections in the core of NHS enhances wave absorption. Excellent impedance matching with free space, with proper dielectric and magnetic loss contributes towards maximization of RL for NHS. These properties enhance the potentiality of NFO NHS as an efficient microwave absorbing material applicable in various microwave devices.

Surface Functionalized ${\rm CoFe_2O_4}$ nano-hollow spheres: Novel Properties



Stimuli-responsive controlled release of drugs from metal complex devices has been receiving great attention, as it provides many advantages such as better delivery efficiency and selective binding. Here in, we report the synthesis of biocompatible CoFe_2O_4 NHSs of diameter around 200 nm and emergence of intrinsic multiple fluorescence from blue, green to red on modifying their surface with hydrophilic bio-molecule such as folic acid. The surface engineered NHSs also show excellent drug loading and releasing efficiency in different conditions. Both the surface modified and bare hollow spheres showed excellent catalytic activity towards 4-Nitrophenol reduction.

Plan of Future Work Including Project

- 1. Research on Magnetocaloric materials will be continued.
- Work on ferrites and other transition metal oxide nanostructures will be continued. Their applications in biomedical and microwave communications will be explored.
- 3. Research on photoelectrochemical water splitting will be continued.



Madhuri Mandal Goswami

Visiting Faculty Fellow CMPMS madhuri@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Chaitali Dey; Synthesis and Characterization of Transition Metal Based Magnetic Nanoparticles for Applications in Drug Delivery and Catalysis; Ph.D Awarded; Dr. Madhuri Mandal Goswami, Prof. Ajay Ghosh and Prof. Kalyan Mandal

b) External Project Students / Summer Training

1. Muruganandham Hariram; Synthesis, characterization and functionalization of multifunctional magnetic nanocomposites and their fluorescent properties; S.N.Bose National Centre for Basic Sciences, Kolkata

Teaching

1. PH-391; Practical; 8 students; with Prof. K. Mandal

Publications

a) In journals

1. Arpita Das, Debarati De, Ajay Ghosh, **Madhuri Mandal Goswami**, An innovative cell imaging by *beet root extracted pigment,* Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 230, Article 118037, 2020

- Chaitali Dey, Debarati De, Mahasweta Nandi, Madhuri Mandal Goswami, A high performance recyclable magnetic CuFe₂O₄ nanocatalyst for facile reduction of 4-nitrophenol, Materials Chemistry and Physics, (Elsevier) Volume 242, Article 122237, 2020
- Chaitali Dey, Arpita Das and Madhuri Mandal Goswami, Dopamine Loaded SiO₂ Coated Fe₃O₄MagneticNanoparticles: ANewAnticancerAgent in pH-Dependent Drug Delivery, ChemistrySelect, (Wiley) 4, 12190-12196, 2019

Membership of Learned Societies

1. Magnetic Society of India

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

1. WOS A; DST, India; 3 years; PI

Areas of Research

Synthesis of magnetic materials for hyperthermia therapy, cell imaging, catalysis etc.

We work on synthesis of different magnetic materials especially of ferrites by wet chemical techniques and check their suitability in different application fields such as in drug release by the stimulus responsive technique, cell imaging, hyperthermia therapy, catalysis etc. Structural analysis is done by XRD measurement and morphological analysis by SEM and TEM measurements. FTIR measurement is done to check the surface functioanalization of the magnetic materials for their different use. Frequency dependent AC magnetic measurements and AC magnetic field stimulated drug release event by these particles provide a direction of the promising application of some particles for better cancer treatment in near future. Being porous in structure and magnetic in nature, such materials are also useful in other applications such as in removal of toxic materials, magnetic separation, catalysis etc. Detail mechanisms of cancer cell death are investigated by different techniques such as MTT assay, colony formation assay, anti migratory property, cell apoptosis, reactive oxygen species (ROS) generation, actin cytoskeleton disruption, western blot analysis, mitochondrial membrane disruption investigation etc. Our results convey an important message that some of our materials are able to deliver the cancer drug inside the A549 cancer cell lines and show an anti-cancer effect by inducing apoptosis through activating the cyrochrome-c and caspase dependent apoptotic pathway and iron catalytic ROS generation.

In vitro anti-migratory effect of on A549 cell line is shown in Figure 1. Figure 1(A) is the bidirectional wound healing assay to determine the rate of migration of A549 cells upon treatment with one of our materials in dose (1.5 & 2.5 μ g/ mL) at 0 h and 24 h. (B) is the graphical representation showing percentage of A549 cell migration at 0 h and 24 h on treatment with the magnetic material. Here, the percentage of control cell migration at 24 h has been marked as 100% and the comparison have been made with the control. (C) represent the transwell migration assay images of A549 cells upon treatment with different doses of the material. (D) represent the % of cell migration through transwell migration assay showing the rate of cell migration over the same time period after treatment with the material at the doses (1.5 & 2.5 μ g/mL). (E) is the SEM micrographs of A549 cells showing changes in cell morphology after treatment with our materials at different doses compared to control cell. Arrows indicates the destruction of cell-cell junction, reduction in lammelipodia formation. (F) is the immunofluorescence images of Phalloidin-FITC stained control and properly functionalized magnetic material treated A549 cells. It is done to see the disruption in cytoskeleton of cells. Cell nucleus is counter stained with DAPI. In the magnified images the arrows indicate the intactness and destruction of actin cytoskeleton in the control and treated cells respectively. These results indicate that upon treatment with our materials the cancer cell apoptosis is occurred by inducing ROS, mitochondrial dysfunction and actin cytoskeleton destruction. Hence this method will be applicable for cancer therapy in near future.



It is known that hyperthermia therapy is a type of medical treatment in which especially cancer cells are damaged by exposing the cells to slightly higher temperature than the body temperature. It is known that magnetic particles release heat when they are kept under AC magnetic field and release of heat depends on the magnetic properties of the particles, applied magnetic field and frequency of the AC field. Hence our expectation is that we may change or tune the heat release capacity by these particles by changing different parameters of the particles and a control over them may be achieved with tailor made magnetic particles. But a detailed study is necessary to verify this. We are especially interested to utilize these nanomaterials for magnetic hyperthermia therapy in cancer treatment, hyperthermic drug release, cell imaging etc. in future.

We are planning develop some user friendly kit which will be used in biosensor.

We are trying to work in agricultural fields also. Our aim is to decompose the organic fertilizers in faster rate by using some bacteria for organic cultivation.

Any other Relevant Information including social impact of research

In our country cancer is becoming an epidemic disease. Many people are dying in cancer. In our country many poor people live. Cancer treatment cost is very very high which is difficult to bear even for mediocre people and beyond the expectation for poor people. If our method and the drug can be used in cancer therapy, it will be much cheaper and effective with very low bad side effects.



Manoranjan Kumar

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

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Debasmita Maiti; Frustrated Magnetic Ladders : A DMRG Study; Thesis submitted
- Monalisa Singh Roy; Edge Modes in 1D Chains of Correlated Electrons and Their Junctions; Under progress
- 3. Sk Saniur Rahaman; Quantum Phases in Quasi-One Dimensional Frustrated Spin Systems; Under progress; External student; M Sanjay Kumar (Co-supervisor)
- 4. Koushik Mandal; Theoretical investigation of the properties of correlated fermionic systems in low dimension; Under progress; Ranjan Chaudhury (Supervisor)
- 5. Sudip Kumar Saha; Topology and Thermodynamics in Low-dimensional Systems; Under progress
- Sudipta Pattanayak; Ordering kinetics, steady state and phase transition in active particle systems: Role of noise and boundary; Thesis submitted; M Sanjay Kumar and Shradha Misra(Co-supervisor)

- 7. Manodip Routh; Exotic phases in Bosonic system; Under progress
- 8. Somashree Ghosal; Effect of Non-Hermitian Systems; Under progress
- 9. Monalisa Chatterjee; Topological aspect of Frustrated low dimensional Spin Systems; Under progress
- 10. Jyotirmoy Sau; Topology in Strongly Correlated Systems; Under progress
- 11. Rakesh Das; Coarsing, Steady state and phase transition in Self-propelled particles; Thesis defended

b) Post-Doctoral Research Associates

1. Joy Prakash Das; Strongly correlated 1D systems

c) External Project Students / Summer Training

- 1. Soumyadeep Ghosh; the Ising model and an introduction to the Monte Carlo simulation process; Adamas University
- 2. Pranay B. Sampat; Frustrated classical Heisenberg model on Cubic Lattice and application to ${\rm BiFeO}_3;~{\rm IIT}~{\rm BHU}$

Teaching

- 1. Autumn semester; PHY-302; Integrated PhD; 13 students
- 2. Autumn semester; PHY-503; PhD; 12 students

Publications

a) In journals

- Dayasindhu Dey, Sambunath Das, Manoranjan Kumar, and S. Ramasesha, Magnetization plateaus of spin-1/2 system on a 5/7 skewed ladder, Phys. Rev. B 101, 195110, (2020)
- 2. Sudipta Pattanayak, Jay Prakash Singh, **Manoranjan Kumar**, and Shradha Mishra, *Speed inhomogeneity accelerates the information transfer in polar flock*, Phys. Rev. E 101, 052602, (2020)
- 3. 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)
- A. Valentim, G. A. Bocan, J. D. Fuhr, D. J. García, G. Giri, M. Kumar and S. Ramasesha, A simple scheme for finding magnetic aromatic hydrocarbon molecules, Phys. Chem. Chem. Phys., 22, 5882-5892 (2020)

- 5. Rakesh Das, **Manoranjan Kumar** and Shradha Mishra, Nonquenched rotators ease flocking and memorize it, Phys. Rev. E 101, 012607 (2020)
- Sudip Kumar Saha, Monalisa Singh Roy, Manoranjan Kumar, Zoltán G. Soos, Modeling the spin-Peierls transition of spin-1/2 chains with correlated states: J₁-J₂ model, CuGeO₃ and TTF-CuS₄C₄(CF₃)₄, Phys. Rev. B 101, 054411 (2020)
- Debasmita Maiti, Manoranjan Kumar, Quantum phase diagram of a frustrated spin-1/2 system on a Trellis Ladder, Phys. Rev. B 100, 245118 (2019)
- Debasmita Maiti, Manoranjan Kumar, Melting of ferromagnetic order on a trellis ladder, JMMM 486, 165266 (2019)
- 9. Sudip Kumar Saha, Dayasindhu Dey, **Manoranjan Kumar**, and Zoltán G. Soos, *Hybrid exact diagonalization* and density matrix renormalization group approach to the thermodynamics of one-dimensional quantum models, Phys. Rev. B 99, 195144 (2019)
- Sudipta Pattanayak, Rakesh Das, Manoranjan Kumar, Shradha Mishra, Enhanced dynamics of active Brownian particles in periodic obstacle arrays and corrugated channels, Eur. Phys. J. E 42(5), 62(2019)
- Sudip Kumar Saha, Dayasindhu Dey, Monalisa Singh Roy, Sujit Sarkar, Manoranjan Kumar, Characterization of Majorana-Ising phase transition in a helical liquid system, JMMM 475, 257–263 (2019)
- Arkadeb Pal, Prajyoti Singh, V. K. Gangwar, Surajit Ghosh, P. Prakash, Sudip Kumar Saha, Amitabh Das, Manoranjan Kumar, A. K. Ghosh, and, Sandip Chatterjee, B-site disorder driven multiple-magnetic phases: Griffiths phase, re-entrant cluster glass, and exchange bias in Pr₂CoFeO₆, Appl. Phys. Lett. 114, 252403 (2019)

Talks / Seminars Delivered in reputed conference / institutions

- 1. 2D Electronic Systems in Magnetic Fields; Feb 3, 2020; IISER Kolkata; 2 days
- 2. 2nd Annual Conference on Quantum Condensed Matter; Jul 8, 2019; IISc Bangalore; 3 days
- 3. Spins in Molecular Systems; Dec 2, 2019; IISc Bangalore; 3 days
- 4. Modern Trends in Molecular Magnetism; Nov 27, 2019; IISER Bhopal; 3 days
- 5. International conference on Structure and Dynamics of Molecular and Condensed Matter Systems; Mar 1,

2020; Puri, Odisha (by IISER Kolkata); 4 days

Administrative duties

- 1. JEST Representative
- 2. Library Committee
- 3. Admission Committee
- 4. Computer Service Cell

Conference / Symposia / Schools organized

 Young Investigator Meet On Quantum Condensed Matter Theory (YIMQCMT 2019); Dec 11, 2019; S. N. Bose National Centre for Basic Sciences, Kolkata; 3 days

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

- Zoltán G. Soos, Department of Chemistry, Princeton University, Princeton, New Jersey 08544, USA; Sl. No. 6,9; International
- Sujit Sarkar, Poornaprajna Institute of Scientific Research, 4 Sadashivanagar, Bangalore 560080, India; Sl. No. 11; National
- 3. S. Ramasesha, Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore 560012, India; Sl. No. 4; 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, Indian Institute of Technology (BHU), Varanasi 221005, India; Sl. No. 12; National
- Daniel Julio Garcia, Centro Atómico Bariloche and Instituto Balseiro, CNEA, 8400 Bariloche, Argentina; Sl. No. 4; International
- Shradha Mishra, Department of Physics, Indian Institute of Technology (BHU), Varanasi 221005, India; Sl. No. 2,5,10; 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 the 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 system sizes. To solve these systems we use density matrix renormalization group (DMRG) method, a state-of-the-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 sizes in low dimensions and these low energy spectrum 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. Recently, we have developed a hybrid ED/DMRG approach to study the thermodynamic properties accross the full range of temperature and applied it to shed light on old problems such as spin-Peierls transition in inorganic and organic compounds.

Our group has also recently studied the magnetic spin-1/2 system on a trellis ladder which can be realized in CaV₂O₅ and MgV₂O₅ like systems. We also showed that rung interaction melts the ferromagnetic order in the zigzag ladder. Our group has also studied the localization of partial density of states at the junction of the Y-junction system.

Plan of Future Work Including Project

1. Our future plans for the next couple of years are mostly focused on the study of low temperature behavior of strongly correlated systems. We will use this newly developed ED/DMRG approach to study various models of frustrated magnets and other strongly correlated systems in various geometries, e.g., Y-junctions, Bethe lattice, etc. Our group is also involved in development of efficient DMRG algorithms for two dimensional systems. The study of low temperature behavior of the extended Hubbard model (EHM) Hamiltonians is another area of our research. This model has been extensively used to explain various properties of the material like spontaneous charge density wave (CDW or periodic charge modulations) and bond-order wave phases. The properties at low temperature of these systems are still either unknown or poorly understood. We plan to study the ground state and low temperature properties and the quantum phases of EHM at both half filling and away from half filling using numerical Density matrix renormalization group (DMRG) method and bosonization.



Milan Kumar Sanyal

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Publications

a) In journals

- A. Singh, J.C.T. Lee, K. E. Avila, Y. Chen, S. A. Montoya, E. E. Fullerton, P. Fischer, K.A. Dahmen, S.D. Kevan, M.K. Sanyal and S. Roy, Scaling of domain cascades in stripe and skyrmion phases, Nature Communications 10, 1988 (2019)
- A. Singh, M.K. Mukhopadhyay, M.K. Sanyal, G. Stenning and S. Langridge, Evidence of twodimensional anti-ferromagnetic ordering in rare-earth Langmuir Blodgett films, J. Phys.: Condensed Matter. 31, 495803 (2019)
- A. Bhattacharyya, M.K. Sanyal, U. Mogera, S.J George, S. Dhiman, G.U. Kulkarni and P. Fontaine, Formation of Two-Dimensional Network of Organic Charge-Transfer Complexes at the Air-Water Interface, Langmuir 35, 12630 (2019)
- G. Manna, M.K. Sanyal, A. Sarma, P. Guha, P.V. Satyam, Confinement-induced growth of gold nanocrystals in hybrid hierarchical polymer nanowire, J. Phys. Chem. C. 123, 20649 (2019)

- A. Sarma, A. Dippel, O. Gutowski, M. Etter, M. Lippmann, O. Seeck, G. Manna, M.K. Sanyal, T. Keller, S. Kulkarni, P. Guha, P.V. Satyam and M. Zimmermann, *Electrodeposition of nanowires of a high copper content thiourea precursor of copper sulfide*, RSC Advances 9, 31900 (2019)
- C. De, R. Bag, S. Singh, F. Orlandi, P. Manuel, S. Langridge, M. K. Sanyal, C. N. R. Rao, M. Mostovoy and A. Sundaresan, *Highly tunable magnetic spirals and electric polarization in Gd_{0.5}Dy_{0.5}MnO₃, Phys. Rev. Materials 3, 044401 (2019)*
- A.B. Dey, M.K. Sanyal, D.T. Keane, G.P. Campbell, B.H. Liu, I. Farrer, D.A. Ritchie and M.J. Bedzyk, X-ray atomic mapping of quantum dots, Phys. Rev. Materials 4, 056002 (2020)
- P. Bera, A. Kandar, R. Krishnaswamy, P. Fontaine, M. Impéror-Clerc, B. Pansu, D. Constantin, S. Maiti, M.K. Sanyal, A.K. Sood, Grazing incidence x-ray diffraction studies of lipid-peptide mixed monolayers during shear flow, ACS Omega 5, 14555 (2020)

Areas of Research

1. Two-dimensional magnetism in Langmuir-Blodget film:

In recent years, the ordering of spins in two-dimensions has received considerable attention due to both the fundamental physics interest and for the possible technological applications. Langmuir-Blodgett (LB) films with magnetic ions are ideal systems to study two-dimensional (2D) magnetic ordering as the distances of the magnetic-ions along the out-of-plane and in-plane directions differ by almost an order of magnitude and the effect of the substrate can be neglected. Vortex formation in ferro and anti-ferro 2D magnetic structures are of current interest and LB films are ideal to study this evolving physics. We have shown that 2D magnetic ordering along the in-plane direction of multilayered LB films changes from ferromagnetic to anti-ferromagnetic as the rare-earth magnetic ion is changed from Gadolinium (Gd) to Holmium (Ho). The in-plane magnetization results have shown that Gd based LB films exhibit a temperature dependent saturation moment due to the existence of a vortex structure. The results of the magnetization study have shown that the Ho based LB films exhibit an inplane anti-ferromagnetic ordering and the saturation moment is found to be almost independent of temperature indicating the absence of spin vortex structures. From a $1/\chi$ – T plot the Curie point θ a and the Neel temperature θ_N of the Ho-St LB film were found to be 66 K and 42 K respectively.



2. Confinement-Induced Growth of Gold Nanocrystals:

Understanding and control of early-stage growth of metal nanocrystals have profound effects on the development of nanoscience and have remained an active research subject over the last two decades. Availability of micron- and nano-sized intense X-ray beam, on the other hand, can provide us statistically averaged information regarding evolution of the shape, structure, and connectivity of early nanocrystals even in in situ and in operando conditions. The growth of metal nanocrystals within polymer nanowires deviates from the conventional nucleation-growth process as movements of nucleated metal nanocrystals are hindered due to simultaneous growth of the polymer. We have carried out systematic in-situ small-angle and diffraction measurements simultaneously during growth of goldpolypyrrole composite nanowire within membranes and developed a method to extract the shape and size of gold nanocrystals to understand the growth mechanism. Our results give unique information regarding the early growth processes of nanocrystals as a function of the pore diameter of membranes and concentration of HAuCl4 solution used for the polymerization reaction. We have shown that gold nanocrystals first grow along the [111] direction through contact epitaxy as a cylindrically shaped nanocrystal.



Priya Mahadevan

Senior Professor CMPMS priya@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Joydeep Chatterjee; Electronic structure of lowdimensional materials; Under progress
- 2. Sumanti Patra; Electronic, structural and optical properties of twisted bilayer transition metal dichalcogenides; Under progress
- 3. Prasun Boyal; Electronic and structural properties of two-dimensional materials; Under progress
- 4. Debayan Mondal; Electroc, structural and optical properties of hybrid perovskites; Under progress
- 5. Shivam Mishra; Growth of low-dimensional materials; Under progress
- 6. Krishnendu Patra; Magnetism; Under progress
- 7. Soumyadipta Pal; Understanding martensitic transitions; Thesis submitted; Chhayabrita Biswas (Supervisor)
- 8. Poonam Kumari; Electronic structure of layered materials; Thesis submitted

9. K.P. Aathira; Structural properties of materials; Under progress

b) Post-Docs

1. Priyanka Garg; Catalysis

c) External Project Students / Summer Training

- 1. Surinder Kumar; Magnetism; Central University, Haryana
- 2. Komal Punia; Topological materials; IIT Roorkee

Teaching

1. Spring semester; Advanced Condensed Matter Physics; Integrated PhD; 21 students; with 1 (Ranjan Chaudhuri) co-teacher

Publications

a) In journals

- P Kumari, J Chatterjee, **P Mahadevan**, Engineering spin-valley physics in bilayers of MoSe₂, Phys. Rev. B 101, 045432 (2020)
- A Rahaman, M Chakraborty, T Paramanik, RK Maurya, S Mahana, R Bindu, D Topwal, **P Mahadevan**, D Choudhury, *Tetramer orbital ordering and lattice chirality in MnTi₂O_a*, Phys. Rev. B 100, 115162 (2019)
- Lucheng Peng, Sumit Kumar Dutta, Debayan Mondal, Biswajit Hudait, Sanjib Shyamal, Renguo Xie, Priya Mahadevan, Narayan Pradhan, Arm growth and facet modulation in Perovskite Nanocrystals, J. Amer. Chem. Soc., 141, 16160 (2019)
- Shashank Kumar Ojha, Sujay Ray, Tanmoy Das, S Middey, Sagar Sarkar, **Priya Mahadevan**, Zhen Wang, Yimei Zhu, Xiaoran Liu, M Kareev, Jak Chakhalian, Anomalous electron transport in epitaxial NdNiO₃ films, Phys. Rev. B 99, 235153 (2019)

Talks / Seminars Delivered in reputed conference / institutions

- 1. DPS Seminar at IISER Mohali; Feb 26, 2020; DPS Seminar at IISER Mohali; 2 days
- 2. SSCU Alumni meet; Dec 13, 2019; IISc, Bengaluru; 2 days
- 3. National Conference on Electron Spectroscopy; Nov 27, 2019; S.N.Bose centre; 3 days
- 4. Flatlands and beyond (2019); Sep 5, 2019; S.N. Bose centre; 2 days

- 5. International workshop on advances in 2d materials; Jul 22, 2019; IISER Trivandrum; 2 days
- 2nd annual conference on Quantum Condensed Matter; Jul 8, 2019; IISc Bengaluru; 3 days
- 7. Seminar at NISER Bhubaneswar; Jul 5, 2019; NISER, Bhubaneshwar; 1 day
- 8. Seminar at HRI Prayagraj; May 6, 2019; HRI, Prayagraj; 1 day
- 9. Seminar at CKM Memorial Summer Workshop in Physics; May 30, 2019; S.N.Bose centre; 1 day
- 10. Nano India (2019); Apr 26, 2019; MG University, Kottayam; 2 days

Administrative duties

- 1. Associate Dean (Academic Programme)
- 2. Chairperson, Computer Advisory Cell
- 3. Expert committee member of various DST/SERB committees

Membership of Learned Societies

1. American Physical Society

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

- 1. Electronic, structural and optical properties of semiconductor nanoplatelets; DST Nanomission; 3 years; PI
- 2. Twistronics with transition metal dichalcogenides; SERB; 5 years; PI

Conference / Symposia / Schools organized

1. Flatlands and beyond 2019; Sep 5, 2019; SN Bose centre; 2 days

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

- 1. Collaboration with IIT KGP to understand the unusual tetramer orbital ordering found in $MnTi_2O_4$, Sl. No. 2, National
- Collaboration with IACS on understanding the growth of certain facets in perovskite nanocrystals; Sl. No. 3; National

3. Collaboration with Srimanta Middey (IISc) and Jak Chakhalian (USA) on nickelates; Sl. No. 4; International

Outreach program organized / participated

1. C.K. Majumdar memorial summer workshop in Physics

Areas of Research

Electronic structure of materials, Growth of nanomaterials

Spin-orbit interactions lead to a large spin-splitting of the valence band maximum at K in MoSe, monolayer. However, on stacking a second layer of $MoSe_{2}$ in the same manner as found in the bulk, one finds that there is no net spin splitting. This has been attributed to the presence of inversion symmetry in the structures. An obvious route to making the bilayers useful for exploring the coupled spin and valley physics is through breaking inversion symmetry. We examined this by rotating the top layer by an angle theta with respect to the lower layer. We find that for some angles of rotation, the spin splitting vanishes, even though there is no inversion symmetry in these structures. In Phys. Rev. B 101, 045032 (2020), bilayers of MoSe, with those rotation angles which lead to smallish unit cells, were studied. The valence band maximum of these rotated bilayers was found to be at K of the supercell. Contrary to our speculation, the spin splitting of the valence band maximum did not emerge for the slightest angle of rotation from the configuration where we had inversion symmetry. It was observed that for certain angles of rotation, which were otherwise arbitrary, there is a net spin-splitting of the valence band maximum whereas for other angles this net spin-splitting vanishes. Our results suggest that there is an alternate mechanism at work which can lead to a vanishing spin splitting at arbitrary angles of rotation. This is operational even when there is no inversion symmetry in the lattice, indicating a distinct origin. Additionally we find that for every angle of rotation theta that we find a spin splitting, there is no spin splitting for 60-theta. As the choice of rotation angles was arbitrary, this relation emerges from the hexagonal symmetry of the lattice. Further, it is shown that a knowledge of the angles made by the supercell lattice vectors with the primitive cell ones can be used to determine the presence or absence of spin splitting. This allows us to examine the result even for sizes beyond those that can be probed within ab-initio calculations.

While most synthesised nanocrystals of the halide perovskites were cubic in shape, in a recent study that appeared in JACS 141 161160 (2019), we have explained the experimental observation of being able to change the shape of the nanocrystals. The energy of each facet has been calculated under different experimental conditions, corresponding to excess or deficient anions. It has been shown how one can stabilize all 26 facets associated with the cubo-octahedron

under certain conditions, while at others one stabilizes only the cubic facets.

Another aspect that was investigated was the presence of orbital ordering. Usually orbital ordering modulations are seen over two lattice sites. A recent study on a spinel $(MnTi_2O_4)$ revealed that one had the modulation over 4 lattice sites. A picture involving primarily strain as well as exchange interaction strengths was derived from the ab-initio results. This appeared in Phys. Rev. B 100, 115162 (2019).

Plan of Future Work Including Project

1. Our earlier work on bilayers of transition metal dichalcogenides had examined unit cells that were not too large so that the calculations were not too computationally intensive. In the future we would like to examine different aspects of the small angle rotation angle limit which has shown interesting phenomena such

as the presence of flat bands, successive semiconductormetal-semiconductor transitions, superconductivity etc. The unrotated limit as well as the constituent layers are examples of uncorrelated materials. It is therefore of interest to understand how these apparently uncorrelated materials become a playground of strong correlation physics. Another aspect that has emerged from our earlier calculations has been the symmetry that the hexagonal lattice imposes on the spin splittings in the transition metal dichalcogenides. This makes the twist angle equal to thirty degrees a special point and we would like to examine the structure and the electronic structure in the vicinity of this point. Our earlier work has explained the stabilization of certain facets of perovskite nanocrystals under certain experimental conditions. In future we would like to explore how to exploit the stabilization of certain facets in modifying the functionality of materials.



Prosenjit Singha Deo

Professor CMPMS deo@bose.res.in

Publications

a) In journals

1. S. Mukherjee, **P. Singha Deo** and A.M. Jayannavar, *Current carried by evanescent modes and possible device application*, Physica E, 118 113933 (2020)

Talks / Seminars Delivered in reputed conference / institutions

1. Can we understand time through scattering in low dimensions; Jul 22, 2019; Melbourne, Australia; 2 days

Areas of Research

Mesoscopic transport and thermodynamics

In one of our works we were studying if time travel is possible using quantum principles and we have successfully proved that it is possible. In another work we studied if magnetization due to evanescent modes can be used to build stable quantum devices. And here too we found the shortcomings due to instability of quantum devices to small perturbations can be successfully overcome.



Samit Kumar Ray

Senior Professor & Director CMPMS samit@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

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

b) Post-Docs

1. Arka Dey; Photovoltaic devices

Publications

a) In journals

 R.K. Chowdhury, P. K. Datta, S. N. B. Bhaktha, and S. K. Ray, Ultrafast Investigation of Individual Bright Exciton–Plasmon Polaritons in Size-Tunable Metal–WS₂ Hybrid Nanostructures, Advanced Optical Materials, 8, 1901645 (2020)

- Md S. Hassan, P. Basera, S. Bera, M. Mittal, S. K. Ray, S. Bhattacharya, S. Sapra, Enhanced Photocurrent Owing to Shuttling of Charge Carriers across 4-Aminothiophenol-Functionalized MoSe₂-CsPbBr₃ Nanohybrids, ACS Applied Materials & Interfaces 12, 7317-7325 (2020)
- M. Banik, P. Chakrabarty, A. Das, S. K. Ray and R. Mukherjee, Colloidal Transfer Printing–Mediated Fabrication of Zinc Oxide Nanorods for Self - Cleaning Applications, Advanced Materials Interfaces 6 (9), 1900063 (2019)
- 4. S. Singh , A. K Katiyar, A. Sarkar, P. K. Shihabudeen, A. R.Chaudhuri, D. K. Goswami and S. K Ray, Superior optical ($\lambda \sim 1550$ nm) emission and detection characteristics of Ge microdisks grown on virtual Si0.5Ge0.5/Si substrates using molecular beam epitaxy, Nanotechnology, 31, 115206 (2020)
- S. Dey , S. Santra, P. K. Guha and S. K. Ray, Liquid Exfoliated NiO Nanosheets for Trace Level Detection of Acetone Vapors, IEEE Transactions on Electron Devices, 66, 3568 (2019)
- T. K. Sinha, J. Lee, J. K. Kim, S. K. Ray and B. Paul, Rapid growth of fully-inorganic flexible Ca_xCoO₂ thin films from a ligand free aqueous precursor ink for thermoelectric applications, Chem. Commun., 55, 7784 (2019)
- S. Pal, S.Mukherjee, M. Nand, H. Srivastava, C. Mukherjee, S. N. Jha, S. K.Ray, Si compatible MoO₃/ MoS₂ core-shell quantum dots for wavelength tunable photodetection in wide visible range, Applied Surface Science, 502, 144196 (2020)
- D. Bhattacharya, S. Mukherjee, R. K. Mitra and S. K Ray, Size-dependent optical properties of MoS₂ nanoparticles and their photo-catalytic applications, Nanotechnology, 31, 145701 (2020)
- N. Gogurla, R. K. Chowdhury, S. Bhattacharya, P. K. Datta, and S. K. Ray, Plasmon charge transfer dynamics in layered Au–ZnO nanocomposites, J. Appl. Phys. 127, 053105 (2020)
- 10. SS Sarkar, S Mukherjee, RK Khatri, **SK Ray**, Solution-processed MoS_2 quantum dot/GaAs vertical heterostructure based self-powered photodetectors with superior detectivity, Nanotechnology 31, 135203 (2020)
- S. Mukherjee, S. Jana, T. K. Sinha, S. Das, and S. K. Ray, Infrared tunable, two colour-band photodetectors on flexible platforms using 0D/2D PbS–MoS₂ hybrids, Nanoscale Advances., 1, 3279 (2019)

- R. Maiti, S. Mukherjee, T. Dey and S. K. Ray, Solution Processed Highly Responsive UV Photodetectors from Carbon Nanodot/Silicon Heterojunctions, ACS Appl. Nano Mater., 2, 3971–3976 (2019)
- S. Bayan, N. Gogurla, A. Ghorai, and S. K. Ray, Förster Resonance Energy Transfer Mediated Charge Separation in Plasmonic 2D/1D Hybrid Heterojunctions of Ag-C₃N₄/ZnO for Enhanced Photodetection, ACS Appl. Nano Mater., 2, 3848–3856 (2019)
- A. Ghorai, A. Midya and S. K. Ray, Surfactant-Induced Anion Exchange and Morphological Evolution for Composition-Controlled Caesium Lead Halide Perovskites with Tunable Optical Properties, ACS Omega, 4, 12948 (2019)
- A. Sarkar , S. Mukherjee, A. K. Das and S. K. Ray, Photoresponse characteristics of MoS₂ QDs/ Si nanocone heterojunctions utilizing geometry controlled light trapping mechanism in black Si, Nanotechnology 30, 485202 (2019)
- P. Chakrabarty, M. Banik, N. Gogurla, S. Santra, S. K. Ray and R. Mukherjee, Light Trapping-Mediated Room-Temperature Gas Sensing by Ordered ZnO Nano Structures Decorated with Plasmonic Au Nanoparticles, ACS Omega, 4, 12071 (2019)
- A. Gupta, R. K.Chowdhury, S. K. Ray and S. K. Srivastava, Selective photoresponse of plasmonic silver nanoparticle decorated Bi₂Se₃ nanosheets, Nanotechnology 30, 435204 (2019)
- A. Mondal, S. Pal, A. Sarkar, T. S. Bhattacharya, S. Pal, A. Singha, S.K. Ray, P. Kumar, D. Kanjilal, D. Jana, Raman investigation of N - implanted ZnO: Defects, disorder and recovery, J Raman Spectrosc., 50, 1926 (2019)
- S. K Najmul Islam, N. Gogurla, D. Giri, S. K.Ray and S. K.Patra, Highly emissive fluorene and thiophene based π-conjugated A-alt-Bcopolymers: Synthesis, characterization and electroluminescence properties, Journal of Luminescence, 208, 509 (2019)
- P. Rani, A. Ghorai, S. Roy, D. K Goswami, A. Midya and S. K. Ray, Mesoporous O-TiO₂ nanocomposites for flexible solid-state supercapacitor applications, Mater. Res. Express 6 (2019) 125546

b) Conference proceedings / Reports / Monographs / Books

 R. K Chowdhury, S. Nandy, S. Bhattacharya, M. Karmakar, S.B.N. Bhaktha, P. K. Dutta, A. Taraphder, S. K Ray, "Ultrafast transient evolution of excitons and biexcitons in layered WS2 at room temperature", EMRS 2019, Nice, France, May 27-31, 2019.

- S. Singh, V. Dhyani, J. Wellington, D. K Goswami, S. Das, S. K Ray, "Ge Quantum Dots Decorated Si Nanowire Transistor for Infrared Photodetectors", - 10th International Conference on Materials for Advanced Technologies, Singapore, 23-28 June 2019
- P. Chakrabarty, M. Banik, N. Gogurla, S. K. Ray, and R. Mukherjee, "Piezo-phototronic Enhanced Self-biased UV Photodetection in Light Trapping Ordered ZnO 1D nanorod/PEDOT:PSS Schottky Diodes", EMRS 2019, Nice, France, May 27-31, 2019
- A. Sarkar, A. K Katiyar, S. Singh, A. K. Das and S. K. Ray, "Efficient White Light Emission and Extraction from CdS/Black Si Nano-conical Heterojunction Arrays", IWPSD 2019, Kolkata, India, 17-20 December 2019.
- S. Mahato, A. Ghorai, M. Modak and S. K Ray, "Allinorganic highly air stable single-crystalline b-CsPbI3 nanorods for inverted perovskite solar cells", ICONSAT 2020, Kolkata, 5 - 7 March 2020
- R. K Chowdhury, S. Bhaktha BN, S.K Ray, "Ultrafast observation of bright exciton-plasmon polaritons in metal-2d semiconductor hybrids", ICONSAT 2020, Kolkata, March 5-7, 2020.
- T. Dey, A. Ghorai, S. Das and S. K. Ray, "Solution Processed Graphene Quantum Dots as Excellent Downconverters for Silicon based Heterojunction Photodetector", IWPSD 2019, Kolkata, 17-20 December 2019.
- S. Singh, D. K. Goswami, S. K. Ray, "Core-shell heterojunction of Si nanocones and CZTS nanocrystals for optoelectronic devices", International Conference on Nano Science and Technology, Kolkata, 5-7 March 2020.
- S. Pal, S. Bayan, D. K. Goswami, S. K. Ray, "Selfbiased photoresponsivity of 2D SnO nanosheets based broadband photodetector utilizing piezo-phototronic effect", IWPSD 2019, Kolkata, 17-20 December. 2019.
- S. Jana, S. Mukherjee, A.Ghorai, S B. N. Bhaktha and S. K. Ray, "Broadband Photodetector Utilizing Tunable Optical Properties of Black Phosphorus Nanoparticles" IWPSD 2019, Kolkata, 17-20 December 2019.
- S. Das, T.Dey, S. Das and S. K. Ray, "Solution processed graphene nanoribbon/Si heterojunction for photovoltaics application", ICONSAT 2020 Kolkata, 5-7 March, 2020
- S. Bose, S. Mukherjee, S. Jana, S. K. Srivastava and S. K. Ray, "Transition Metal (Mo, W) Disulphide based van der Waals Heterostructures for Wideband Optical Devices", ICONSAT 2020, Kolkata, 5th March - 7th March, 2020

Talks / Seminars Delivered in reputed conference / institutions

- Excitements with group-IV semiconductor heterostructures for strain and bandgap engineered devices, 31st AGM MRSI & 2nd Materials Conclave Kolkata; Feb 13, 2020; CGCRI Kolkata
- 2. Semiconductor Nanostructures for Electronic & Photonic Devices, Synthesis, Intl. Conf. on Synthesis, Characterization and Application of Nanomaterials; Nov 2, 2019; Novotel, Kolkata
- Light Matter Interactions in Plasmonic Hybrid WS2 Layers, Flatlands and Beyond (2019); Sep 6, 2019; S N Bose Centre
- 4. Nanofabrication and Semiconductor Nanodevices, India Nano Workshop on Nanolithography and Nanofabrication, Kolkata; Jul 9, 2019; S N Bose Centre
- Towards Next Generation Flexible Electronic and Photonic Devices, CTMSE - 2019 Jul 19, 2019; S N Bose Centre, Kolkata
- 2D Transition Metal Dichalcogenides/Si Heterostructures for Photonic Devices - 10th Intl. Conference on Materials for Advanced Technologies, Singapore; Jun 26, 2019 Singapore
- Heterostructures based on 2D Materials Versatile Platforms for Si Photonics - NanoIndia 2019; Apr 26, 2019; MGU, Kottayam

Administrative duties

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

Awards, Recognitions, if any

2. MRSI-ICSC Materials Science Senior Award for the year 2020

Conference / Symposia / Schools organized, if any

- XXth International Workshop on The Physics of Semiconductor Devices - Chairman Dec 16, 2019;Novotel Hotel, Kolkata; 16th - 20th, December 2019
- International Conference on Nanoscience and Technology (ICONSAT 2020) Mar 5, 2020; Biswa bangla Convention Centre, Kolkata; 5th - 7th March, 2020

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

- 1. IIT Kharagpur; Sl. No. 1, 3-5, 8-20; National
- 2. IIT Delhi; Sl. No. 1, 3-5, 8-20; National
- 3. Gyeongsang National University, South Korea & Linkoping University, Sweden; Sl. No. 6; International
- 4. RRCAT, Indore; Sl. No.7; National
- 5. Solid State Physics Laboratory, Delhi; Sl. No. 10; National
- 6. Bose Institute & Calcutta University; Sl. No. 18; National

Outreach program organized / participated

- "Small is Beautiful !! Lessons from Nature", North East Students Conclave, India International Science Festival, Kolkata, 8th November 2019
- "Surfaces & Heterostructures to Quantum Technology", C.K. Majumdar Memorial Summer Workshop 6th June, 2019

Areas of Research

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

(a) Bright Exciton-Plasmon Polaritons in Size-Tunable Metal-WS, Hybrid Nanostructures

We have studied strong light-matter interactions between resonantly coupled metal plasmons and spinorbit coupled bright excitons from two dimensional (2D) transition metal dichalcogenides (TMDs), which can produce discrete bright exciton-plasmon polaritons (plexcitons). Here, both the bright plexcitons are identified discretely at room temperature and their ultrafast temporal dynamics in size-tunable Au-WS, hybrid nanostructures are investigated using helicity-controlled а femtosecond pump-probe spectroscopy technique. The zero detuning between both the bright excitons and plasmons is achieved at \sim 7.0 ps, matches with the stable plexciton formation time. The Rabi-splitting energy is as high as $\sim 250 \text{ meV}$ for both the plexcitons [Fig.1], validating the strongcoupling conditions of polariton formation. Realization of these novel bright exciton-plasmon interactions in the metal-TMDs platform is, therefore, interesting for both fundamental understanding and their possible futuristic applications in quantum photonics operating at room temperature.



Figure 1. (a) Schematic representation of plexciton for two-state model. The exciton (yellow sphere) and plasmon (green sphere) are coupled together through a hypothetical spring (black dashed line). (b) An artistic representation of two-state model for the exciton-plasmon coupling in AuNI-WS₂ hybrid nanostructures. (c, d) Typical transient anti-crossing behavior of the hybridized energy branches (E_{+} and E_{-}) for individual bright exciton-plasmon polaritons, X_{A}^{0} -P and X_{B}^{0} -P.

(b) Size dependent optical and photocatalytic properties of MoS₂ nanocrystals

We studied the efficacy of MoS_2 nanocrystals for their size tunable properties for optical and photocatalytic applications. Synthesized NPs are found to exhibit size dependent optical properties and excitation dependent fluorescence characteristics in the visible region [Fig.2], which are not observed in bulk or 2D MoS_2 layers. Charge carrier emission dynamics of different sized MoS_2 NPs yield two time components - one in the order of several hundreds of ps, which arises due to the radiative recombination of charge carriers, while the other one is of the order of a few ns, which emanates from the defect states of MoS_2 NPs. The average time constants are found to decrease with increase in particle size and a non-linear increase in the relative quantum yield of the NPs is observed, as the size decreases below the Bohr radius. A noticeable photocatalytic activity of the synthesized MoS_2 NPs under visible light illumination for the degradation of Brilliant Green dye is also demonstrated for the first time and the effect of size variation of NPs in the dye degradation process is reported.

Any other Relevant Information including social impact of research

- 1. Development of new materials for energy devices
- 2. Development of low cost sensors for chemical & environment monitoring



Figure 2. (a) Excitation dependent fluorescent spectrum of ~ 17 nm MoS₂ NPs. (b) Variation in emission peak position with excitation wavelength. (c) Variation of the relative quantum yield with particle size.



Tanusri Saha Dasgupta

Senior Professor CMPMS tanusri@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Anita Halder; Electronic Structure of Double Perovskites; Thesis submitted.
- 2. Shreya Das; Magnetism in Oxides; Under progress.
- 3. Edwine Tandong (Jointly with J Chakraborti);Classical and Quantum Study of Materials under Confinement; Under progress.
- 4. Samir Rom; Electronic Structure of Complex Materials; Under progress.
- 5. Shiladitya Karmakar; Low dimensional Systems; Under progress.

b) Post-Docs

1. Dipayan Sen; Hybrid compounds, 2D magnetism

Teaching

1. Spring semester; Advanced Condensed Matter Physics; PhD; 10 students; Yes with Thirupathaiah Setti (co-teachers)

Publications

a) In journals

- 1. E Tendong, **T Saha-Dasgupta**, J Chakrabarti, Dynamics of Water Trapped in Transition metal oxide-Graphene Nano-confinement, Journal of Physics: Condensed Matter, 32, 325101 (March, 2020)
- 2. A Paul, A Mukherjee, I Dasgupta, **T Saha-Dasgupta**, Interplay between breathing and polar instabilities in transition metal perovskites with active A-sites, Physical Review Research 2, 013333 (2020)
- 3. S Karmakar, D Ghosh, **T Saha-Dasgupta**, *Light-induced excited spin-state trapping in spin crossover model system*, International Journal of Quantum Chemistry 120 (6), e26122 (2020)
- P Aich, S Das, C Meneghini, I Schiesaro, T Saha-Dasgupta, S Ray, *Re-examining the nature of ordering* in CaMnO₂: The role of Mn-O covalency in the local structure, Physica B: Condensed Matter 581, 411837 (2020)
- EPavarini, IDasgupta, TSaha-Dasgupta, OKAndersen, Comment on "Apical Charge Flux-Modulated In-Plane Transport Properties of Cuprate Superconductors", Physical Review Letters 124 (10), 109701 (2020)
- 6. **T Saha-Dasgupta**, Double perovskites with 3d and 4d/5d transition metals: compounds with promises, Materials Research Express 7, 014003 (2020)
- 7. P Biswas, A Adhikari, U Pal, P Singh, M Das, **T Saha-Dasgupta**,Sudeshna Shyam Choudhury, Ranjan Das, 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 (2020)
- D Nafday, D Sen, N Kaushal, A Mukherjee, **T Saha-Dasgupta**, 2D ferromagnetism in layered inorganicorganic hybrid perovskites, Physical Review Research (Rapid) 1, 032034 (2019)
- S Das, D Nafday, **T Saha-Dasgupta**, A Paramekanti, NiRh₂O₄ : A spin-orbit entangled diamond-lattice paramagnet, Physical Review B (Rapid) 100, 140408 (2019)

- 10. H Banerjee, O Janson, K Held, **T Saha-Dasgupta**, Electronic and magnetic state of LaMnO₃ epitaxially strained on SrTiO₃: Effect of local correlation and nonlocal exchange, Physical Review B 100, 115143 (2019)
- A Halder, A Ghosh, **T Saha-Dasgupta**, Machine-learningassisted prediction of magnetic double perovskites, Physical Review Materials 3, 084418 (2019)
- A Koshelev, E Zvereva, L Shvanskaya, O Volkova, M Abdel-Hafiez, Andrey Gippius, Sergey Zhurenko, Alexey Tkachev, Dmitry Chareev, Norbert Büttgen, Martina Schaedler, Asif Iqbal, Badiur Rahaman, **Tanusri Saha-Dasgupta**, Alexander Vasiliev, Short-Range and Long-Range Order in AFM–FM Exchange Coupled Compound LiCu₂(VO₄)(OH)₂, The Journal of Physical Chemistry C 123 (29), 17933 (2019)
- A Halder, P Sanyal, **T Saha-Dasgupta**, Magnetism in cation-disordered 3d-4d/5d double perovskites, Physical Review B (Rapid) 99, 020402 (2019)
- A Paul, A Mukherjee, I Dasgupta, A Paramekanti, T Saha-Dasgupta, Hybridization-Switching Induced Mott Transition in ABO₃ Perovskites, Physical review letters 122, 016404 (2019)

b) Conference proceedings / Reports / Monographs / Books

- 1. Machine-learning Assisted Prediction of Magnetic Double Perovskites T Saha-Dasgupta, A Halder, A Ghosh Bulletin of the American Physical Society (2020)
- 2. Non trivial deformation structures in confined elastic membrane under stretching D Das, J Horbach, S Sengupta, T Saha-Dasgupta Bulletin of the American Physical Society (2020)
- 3. Electronic and magnetic state of LaMnO₃/SrTiO₃ heterostructures: Effect of local correlation and nonlocal exchange H Banerjee, O Janson, K Held, T Saha-Dasgupta, M Aichhorn Bulletin of the American Physical Society (2020)

Talks / Seminars Delivered in reputed conference / institutions

- Advances in Electron Spectroscopy Experiment and Theory (AESET 2019) Apr 17, 2019; Dresden, Germany; 4 days
- 2. 2nd Conference on Quantum Condensed Matter (Q-Mat2019); Jul 8, 2019; IISc, Bangalore; 3 days
- JEMS 2019: Electronic structure and strongly correlated electron systems including superconductivity; Aug 26, 2019; Uppsala, Sweden; 5 days

- 4. EASTMAG-2019; Sep 8, 2019; Ekatrinburg, Russia; 5 days
- 5. Topological Quantum Matter; Sep 26, 2019; KITP, Santa Barbara, USA; 30 days
- 6. National Conference on Electronic Structure (NCES 2019); Nov 27, 2019; SNBNCBS, Kolkata; 3 days
- 7. National symposium on rare earths (STAR2019); Dec 5, 2019; BARC, Mumbai; 3 days
- 8. Winter School; Dec 2, 2019; JNCASR, Bangalore; 4 days
- 9. Current Trends in Functional Materials" (CTFM-2020); Jan 15, 2020; NIT, Surathkal; 3 days
- 10. ICONSAT 2019; Mar 5, 2020; Kolkata; 3 days

Awards, Recognitions

1. Elected fellow of The World Academy of Sciences (TWAS)

Membership of Learned Societies

1. American Physical Society

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

- 1. Thematic Unit on Computational Materials Science; DST, Nanomission; Until 2020; PI
- 2. Technical Research Center; DST, Nanomission; Until 2020; Co-PI

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

- 1. J. Chakrabarti, SNBNCBS; ICONSAT 2019; National
- 2. I. Dasgupta, IACS; Sl. No. 2, 5, 14; National
- 3. A. Mukherjee, NISER; Sl. No. 2, 8, 14; National
- 4. D. Ghosh, IACS; Sl. No. 3; National
- 5. S. Ray, IACS; Sl. No. 4; National
- 6. O.K. Andersen, Max-Planck Institute, Stuttgart, Germany; Sl. No. 2, 5, 14; International
- 7. Samir Pal, SNBNCBS; Sl. No. 7; National
- 8. Arun Paramekanti, Univ of Toronto; Sl. No. 9, 14; International

- 9. Karsten Held, TU, Vienna; Sl. No. 10; International
- 10. Alexandre Vasiliev, Moscow State Univ; Sl. No. 12; International

Outreach program organized / participated

 Delivered talk at Women Scientists' & Entrepreneurs' Conclave in session "Women Leaders and Achievers for RISEN India" at IISF, October 2019

Areas of Research

Computational Condensed Matter Physics; Materials Physics; Electronic Structure

NiRh2O4: A spin-orbit entangled diamond-lattice paramagnet

Shreya Das, Dhani Nafday, Tanusri Saha-Dasgupta, and Arun Paramekanti

Phys. Rev. B 100, 140408(R), 2019

Motivated by the interest in topological quantum paramagnets in candidate spin-1 magnets, we investigate the diamondlattice compound NiRh2O4 using *ab initio* theory and model Hamiltonian approaches. Our density functional study, taking into account the unquenched orbital degrees of freedom, shows stabilization of S=1, L=1 state. A single-site model Hamiltonian incorporating the large tetragonal distortion is shown to give rise to a spin-orbit entangled nonmagnetic ground state, largely accounting for the entropy, magnetic susceptibility, and inelastic neutron scattering results.



Figure: The various magnetic exchange paths in NiRh₂O₄

Machine-learning-assisted prediction of magnetic double perovskites

Anita Halder, Aishwaryo Ghosh, and Tanusri Saha Dasgupta

Phys. Rev. Materials 3, 084418 (2019)

In the present work, we use a combination of computational tools: a machine-learning technique for screening of stable candidates, an evolutionary algorithm for crystal structure determination, and first-principles calculations for characterization of electronic and magnetic properties to make predictions on magnetic double perovskites, which are yet to be synthesized.

Plan of Future Work Including Project

- 1. Rare-earth magnets
- 2. 2D Magnetism
- 3. Topological Quantum Materials
- 4. Quantum Spin Liquids



Figure: The steps adapted for screening of stable double perovskites, following the machine-learning algorithm.



Thirupathaiah Setti

Assistant Professor CMPMS setti@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Indrani Kar; Transition metal dichalcogenides; Under progress
- 2. Susmita Changdar; Topological semimetals; Under progress
- 3. Achintya Low; Quantum Spin Liquids; Under progress
- 4. Sayan Routh; Topological Superconductors; Under progress
- 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

c) External Project Students / Summer Training

1. Mohammad Mudasir Khan; Synthesis and Structural Characterization of Bismuth Palladium Oxide (Bi₂PdO₄); Baba Ghulam Shah Badshah University

Teaching

1. Spring semester; Advanced Condensed Matter Physics-PHY601; PhD; 14 students; with 1 (Prof. Tanusri Saha-DasGupta) co-teacher

Publications

a) In journals

1. I. Kar, Joydeep Chatterjee, Luminita Harnagea, Y. Kushnirenko, A. V. Fedorov, Deepika Shrivastava, B. Büchner, P. Mahadevan, **S. Thirupathaiah**, Metalchalcogen bond-length induced electronic phase transition from semiconductor to topological semimetal in ZrX_2 (X = Se and Te), Phys. Rev. B 101, 165122, 2020

Talks / Seminars Delivered in reputed conference / institutions

- 1. Metal-Chalcogen Bond-Length Induced Electronic Phase Transition in ZrX_2 (X = Se & Te) and ARPES Studies on TaTe₂; Sep 6, 2019; SNBNCBS; 6-7, Sept, 2019
- Advances in Electron Spectroscopy Experiment and Theory; Apr 15, 2019 Max Planck Institute for Chemical Physics of Solids, Germany; 14th-17th, April 2019
- Angle Resolved Photoemission Spectroscopy (ARPES): Theory & Technique; Feb 10, 2020; IIT Tirupati; 10th Feb 2020

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

1. Inspire Faculty Fellowship; DST; 5 years; PI

Conference / Symposia / Schools organized

- National Conference on Electronic Structure (NCES-2019); Nov 27, 2019 SNBNCBS; 27th-29th November, 2019
- International Conference on Nano Science and Technology (ICONSAT 2020); Mar 5, 2020; Biswa Bangla Convention Centre, New Town, Kolkata; 5th-7th March, 2020

- 1. IISER Pune; Sl. No. 1; National
- 2. SNBNCBS; Sl. No. 1; National
- 3. IFW Dresden; Sl. No. 1; International

Areas of Research

Synthesis, physical properties, and electronic structure studies of quantum materials

- 1. Single Crystal Growth and Characterization of the Quantum Materials: Various single crystals of quantum materials have been grown at our lab. We then studied the physical and electronic properties of as grown single crystals.
- 2. Electronic Structure Studies of FeSi: A Chiral Topological System: Most recent observation of

topological Fermi arcs on the surface of manyfold degenerate B20 systems. CoSi and RhSi, have attracted enormous research interests. Although an 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. See the data in Figs. 2 and 3.



Fig.1: (a) Single crystals of various quantum materials. (b) Transport and magnetic properties of Mn_{3-x}Fe_xSn. (c) ARPES studies of VTe₂.





Fig. 2 In-plane electronic band structure of FeSi. (a) and (b) are Fermi surface maps in $k_x - k_y$ plane measured using photon energy $h\nu$ =130 eV and 90 eV, respectively. (c) Energy distribution map along the $\Gamma - M$ high symmetry line overlapped with DFT bulk band structure calculations including SOC. (d) Energy distribution map along the $\Gamma - X$ high symmetry line overlapped with DFT band structure calculations including SOC. (e) DFT calculated band structure without SOC. (f) DFT calculated band structure with SOC.

3. Metalchalcogen bond-length induced electronic phase transition from semiconductor to topological semimetal in ZrX2 (X = Se and Te): Using angle resolved photoemission spectroscopy (ARPES) and density functional theory (DFT) calculations we studied the low-energy electronic structure of bulk ZrTe₂. ARPES studies on ZrTe₂ 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 ZrTe₂ to a semimetal. The DFT calculations further suggest a band inversion between Te p and

Fig. 3 Band structure calculated for a (001) oriented FeSi slab of thickness 88.96Å. (a) Energy-momentum plot showing surface states (red colored) overlapped with the bulk band structure. Surface state Fermi map taken at E_F (b), $E_F+0.1eV$ (c), and $E_F+0.55eV$ (d).

Zr *d* states at the Γ point, hinting at the non-trivial band topology in ZrTe₂. Thus, our studies for the first time unambiguously demonstrate that ZrTe₂ is a topological semimetal. Also, a comparative band structure study is done on ZrSe₂ which shows a semiconducting nature of the electronic structure with an indirect band gap of 0.9 eV between $\Gamma(A)$ 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 ZrSe₂ to ZrTe₂. See the data shown in Fig.4.



Fig. 4 Out-of-plane (k_z) electronic structure of ZrTe₂. (a) k_z Fermi surface map measured using *p*-polarized light in the ΓMAL plane. (b) EDM taken along the $\Gamma - A$ high symmetry line. (c) Photon energy dependent EDC curves extracted from (b). (d) Photon energy dependent MDC curves extracted from (a). (e) EDMs taken from Γ and A high symmetry points. (f) Energy-momentum plot from the calculations along the $\Gamma - A$ high symmetry line. (g) k_z Fermi surface map measured using *p*-polarized light in the MKHL plane. (h) EDM taken along the M - L high symmetry line. (i) Photon energy dependent EDC curves extracted from (b). (i) Photon energy dependent MDC curves extracted from (g). (k) EDMs taken from M and L high symmetry points. (l) Energy-momentum plot from the calculations along the M - L high symmetry line. In (b) and (h) the DFT band structure along $\Gamma - A$ and M - L is overlapped on the ARPES data by shifting the calculated Fermi level 0.3 eV towards lower binding energy. Note that since the band renormalization effects are not consider, only a qualitative agreement is found between theory and experiment.

Plan of Future Work Including Project

 Our main research interests are synthesising the new quantum materials such as multifold fermionic and skyrmionic systems which have direct application in the quantum computations. Therefore, our future studies involve the discovery and investigation of various exotic quantum materials in this direction.



Department of THEORETICAL SCIENCES

Department of Theoretical Sciences

Makhtedar Sanjay Kumar Department profile indicators

Table A : Manpower and resources

Number of faculties	11
Number of Post –doctoral research associate (centre+project)	5
Number of Ph.D students	21
Number of other project staff	0
Number of summer students	4
Projects (ongoing)	3

Table B: Research Activities indicators

Number of research papers in Journals	33
Number of Book-chapters/books	0
Number of other publications	2
Number of Ph.D students graduated (submitted+degree awarded)	16
Number of M.Tech/M.Sc projects	9

Table C: Academic activities and likeage

Number of courses taught by faculties	8	
Number of Visitors (non –associates)	5	
Number of associates	1 + 2 (visiting associate)	
Number of Seminars organized	12	
Number of Conference/Symposia/Advanced Schools organized	1	
Number of talks delivered by members of department in conferences/Symposia	National	4
	International	2

Most important research highlights

- Quantization of constrained field theories near the horizon of a black hole
- Dynamics of fermions on curved spacetime
- Anisotropic Bianchi type-I cosmological model at late times, taking into account quantum gravitational corrections
- Generalised temperature gives the Hawking temperature in the infra-red limit and leads to a generalised thermodynamics like law
- Meissner like effect in holographic superconductors in

the presence of Dirac-Born-Infeld electrodynamics

- A new action for a nonrelativistic free particle coupled to background gravity
- Non-relativistic reduction of spinors, new currents and their algebra
- Additivity and density fluctuations in Vicsek-like models of self-propelled particles
- Interplay between surface and bending energy helps membrane protrusion formation
- Dynamics of coupled modes for sliding particles on a fluctuating landscape
- Role of ergodicity in Quantum Spin Glass Phase on Quantum Annealing
- Non-holonomic deformations of the nonlinear Schroedinger equation
- Jacobi-Maupertuis type variational principle leads to null geodesics as well as timelike geodesics
- Generalized quantum discord based on Sharma-Mittal entropy
- Entanglement negativity as a universal non-Markovianity witness

Summary of research activities

- Quantization of constrained field theories near the horizon of a black hole has been studied. It has been demonstrated that ghost states could be consistently eliminated, i.e., it is possible to quantize the theory outside the horizon.
- The effect of spacetime torsion on the dynamics of fermions in curved backgrounds has been studied. How this provides a new mechanism of neutrino oscillations has been pointed out.
- Anisotropic Bianchi type-I cosmological model at late times, taking into account quantum gravitational corrections in the formalism of the exact renormalization group flow of the effective average action for gravity has been studied.
- A generalised temperature has been defined that gives the Hawking temperature in the infra-red limit and leads to a generalised thermodynamics like law.
- The Meissner like effect in holographic superconductors in the presence of Dirac-Born-Infeld electrodynamics has been investigated.
- A new action is given for a nonrelativistic free particle coupled to background gravity. Both lagrangian and Hamiltonian formulations reveal that the equation of motion is a geodesic in the curved background.
- Non-relativistic reduction of the Dirac lagrangian is performed. Appropriate reduction on the spinors leads to new currents and their properties have been investigated.

- Large deviation probabilities in the paradigmatic Vicseklike models of self-propelled particles with alignment interactions have been studied. Results provide an evidence of the existence of an equilibrium-like chemical potential, which governs the coarse-grained density fluctuations in these nonequilibrium models.
- In a system of growing actin filaments pushing against a flexible membrane, it has been shown that as a result of interplay between surface energy and bending energy of the membrane, interesting protrusions may develop which causes non-monotonicities in the force-velocity curve of the system.
- In a coupled driven system of sliding particles on a fluctuating energy landscape several different universality classes using the formalism of nonlinear fluctuating hydrodynamics have been characterized. Detailed numerical simulations demonstrate how presence of strong finite size effects can overshadow analytical predictions from the hydrodynamic theory.
- The question of ergodicity in Quantum Spin Glass Phase and its role in Quantum Annealing has been investigated.
- Comparative study of the non-holonomic deformation of the nonlinear Schroedinger equation, uniquely obtained from both the Lax pair and Kupershmidt's bi-Hamiltonian approaches, and the quasi-integrable deformation of the same system, is performed.
- It has been shown that not only null geodesics, but also time like geodesics are governed by a Jacobi-Maupertuis type variational principle and a Randers-Finsler metric for which explicit formulae are given.
- Results of Berry and Shukla on a fundamental new dynamics concerning forces (accelerations) depending only on position, i.e. without velocity-dependent dissipation, have been extended to nonlinear curl forces, where the nonlinearity is with respect to the coordinate dependence of the forces.
- A generalization of quantum discord has been presented using a generalized definition of von-Neumann entropy, viz. Sharma-Mittal entropy.
- It is shown that by monitoring directly the entanglement behavior of a system in a tripartite setting it is possible to witness all invertible non-Markovian dynamics, as well as all (also non-invertible) qubit evolutions.

Makhtedar Sanjay Kumar Head, Department of Theoretical Sciences



Amitabha Lahiri

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Karan Savio Fernandes; Field theories on curved spacetimes with boundaries; Awarded
- 2. Ambalika Biswas; Aspects of two Higgs doublet models; Awarded
- Pratik Tarafdar; Accreting black hole systems as classical analogue gravity models; Thesis submitted; T. K. Das, HRI (Co-supervisor)
- 4. Subhasish Chakrabarty; Field theoretic approach to gravity; Thesis submitted
- 5. Shantonu Mukherjee; Some applications of quantum field theory to superconductivity and superfluidity; Under progress

b) External Project Students / Summer Training

1. Samya Roychowdhury; Dirac equation and its form in orthogonal coordinates; IISER Kolkata

Teaching

- 1. Autumn semester; Mathematical Methods; (Phy 102) Integrated PhD; 12 students
- 2. Spring semester, Advanced Mathematical Methods (PHY 406), IPhD and PhD (3 students credit, several non-credit).

Publications

a) In journals

- 1. K. Fernandes and **A. Lahiri**, Hamiltonian BRST formalism for gauge fields on black hole spacetimes, Phys. Rev. D99, 085004, 2019
- 2. S. Chakrabarty and **A. Lahiri**, Geometrical contribution to neutrino mass matrix, Eur. Phys. J. C79, 697, 2019
- 3. R. Mandal, S. Gangopadhyay and **A. Lahiri**, Cosmology of Bianchi type-I metric using renormalization group approach for quantum gravity, Class. Quant. Grav. 37, 065012, 2020

b) Conference proceedings / Reports / Monographs / Books

 A. Lahiri, Review of "New spherically symmetric solutions admitting a wormhole throat in Eddingtoninspired Born-Infeld gravity" Mathematical Reviews, MR 3897559 (2019)

Administrative duties

1. Chairman, Grievance redressal committee, SNBNCBS

Conference / Symposia / Schools organized

1. Pressing for Progress IPA National Conference Towards Gender Equity in Physics; Sep 18, 2019; University of Hyderabad; 3 days

Areas of Research

Quantum Field Theory, Gravitation, Mathematical Physics

I studied, with a student, the procedure of quantization of constrained field theories near the horizon of a black hole. This is different from the usual treatment, as the horizon does not allow information to flow out of it, but is not a physical boundary. As a result the `boundary conditions' on fields at the horizon are somewhat tricky. A careful analysis showed that the picture that emerges for Maxwell theory is

equivalent to the membrane paradigm of black holes. We then studied the BRST structure of this field theory and found that the ghost states could be consistently eliminated, i.e., it was possible to quantize the theory outside the horizon.

I also studied, with a student, the dynamics of fermions on curved spacetime. This requires an auxiliary field called contorsion which is fully determined by the axial current density of fermions, resulting in quartic interactions involving all known fermions. We proposed that left and right handed components of fermions couple to contorsion with different strengths, then all fermions gain an effective mass when propagating through fermionic matter. This manifests as an observable effect on neutrino oscillations, which can now take place without requiring fields beyond the Standard Model even if neutrinos are massless in vacuum.

With a colleague and a student, I studied quantum gravity in an effective field theory formulation called asymptotically safe gravity. It is so called because it is based on the idea that there is an effective quantum field theory of gravity which includes higher order terms in the curvature and for which the beta function vanishes at a finite energy, making the theory perturbatively sensible at high energies. We considered the cosmology of a homogeneous anisotropic Bianchi I universe, in particular its behaviour at late times, taking into account the quantum gravity corrections. We showed that radiation and most matter drives the universe into the FLRW form at late times, while dust and stiff matter allows for a Kasner type solution, with both expanding and contracting directions.

Plan of Future Work Including Project

1. Quantum Field Theory: I plan to investigate interactions between vortex strings and electrons, which can arise in type II superconductors with unpaired electrons. Such systems appear in certain models of high temperature superconductors, but are also interesting as an exercise in nonperturbative quantum field theory. Using path integral methods and a technique called dualization, I plan to find an effective field theory of the interactions of the vortex strings and from there calculate the effective potential of electrons and strings.

- 2. Quantum Gravity: I plan to investigate, with my collaborators, quantum gravity in the effective field theory (renormalization group flow) approach, in particular its role in cosmology. I plan to look at the role of matter in evolution of the Friedmann-Le Maitre-Robertson-Walker universe under RG-flow, as well as calculate the rate of entropy generation through these quantum gravity effects.
- 3. Particle physics: Previously I had shown with a student that the existence of gravity causes a special kind of interaction between fermionic currents, which is too small to detect in usual experiments but should have observable physical consequences for fermions passing through matter or in matter at high densities, even when the background gravitational field is not otherwise strong. I plan to follow up on this and related ideas with calculations pertaining to different models and systems in particle physics and gravitation.

Any other Relevant Information including social impact of research

- Social impact of research: Like all research in basic 1. science, my work will add to what we know about the universe and the theories that describe it and its constituents. It will help answer questions like how to quantize fields near black holes, i.e. how particles are created and annihilated in this region and how they interact with one another and with the gravitational field. It will answer how neutrinos and other fermions behave in gravitational fields, in curved spacetime in general, and in presence of matter, leading to new questions about evolution of stars and the universe. My work will also answer questions regarding how quantum theories of gravity affect our understanding of the early universe. During the course of my research, many students are trained who in turn will train more students in future and carry forward scientific research in the country.
- 2. The annual return on immovable property for the preceding calendar year was completed within the date prescribed by the Centre, which was 30th April for this year.



Bikas K. Chakrabarti

Honorary Professor (Emeritus) Theoretical Sciences bikask.chakrabarti@saha.ac.in

Publications

a) In journals

- 1. Sudip Mukherjee and **Bikas K Chakrabarti**, On the Question of Ergodicity in Quantum Spin Glass Phase and its role in Quantum Annealing, Journal of the Physical Society of Japan, Vol. 88, art. 061004 (2019)
- 2. Abhik Basu and **Bikas K Chakrabarti**, *Hydrodynamic* descriptions for surface roughness in fracture front propagation, Philosophical Transactions of the Royal Society A, vol.377, art. 20170387 (2019)
- Soumyajyoti Biswas, Lucas Goehring and Bikas K Chakrabarti, Statistical physics of fracture and earthquakes, Philosophical Transactions of the Royal Society A, vol. 377, art. 20180202 (2019)



Biswajit Chakraborty

Senior Professor

Theoretical Sciences

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Partha Nandi; Noncommutative Quantum systems; Under progress
- 2. Sayan Pal; Noncommutative Quantum systems; Under progress
- 3. Anwesha Chakraborty; Noncommutative Quantum systems; Under progress
- Debabrata Ghorai; Holographic Superconductivity; Under progress; Biswajit Chakraborty (Co-supervisor), Sunandan Gangopadhyay (Supervisor)

b) Post-Docs

1. Dr. Kumar Das; Inflationary Cosmology

c) External Project Students / Summer Training

1. Saptarshi Biswas; Berry phase with phase space noncommutativity; Indian Institute of Science Education and Research, Kolkata

Teaching

1. Spring semester; Electromagnetic Theory; Integrated PhD; 12 students

Publications

a) Independent Publication of Students /Post-Docs

- 1. Sayan Kumar Pal and Partha Nandi, *Effect of dynamical noncommutativity on the limiting mass of white dwarfs*, Physics Letters B, 797, 134859, 2019
- 2. Ravikant Verma and Partha Nandi, *Effect of non*commutativity of space-time on thermodynamics of photon gas, Gen. Rel. Grav. 51, 143, 2019

Administrative duties

He has been holding the position of Dean (Academic Programme) for quite a few years now. Besides, he is a member of the following committees

(i) ARPAC (ii) SAC (iii) SCREC (iv) Admission committee

Areas of Research

Quantum Field Theory, Noncommutative Geometry

The main problems I worked on during this period can be summarized as follows:

(i) The problem of formulating a Lorentzian version of Noncommutative geometry is pending for a long time. The original formulation, due to Alain Connes, was given using Euclidean signature and used subsequently to provide a completely new paradigm for the Standard model in Particle Physics. However, the corresponding spectral triples were the so-called ``Almost commutative spaces", which means the 4-dimensional space was taken to be the usual commutative Euclidean manifold. But in order to capture any aspect(s) of quantum gravity, one requires the model 4-dimensional space too become noncommutative in nature. It is therefore a very important to ask whether one can indeed consider such a complete noncommutative theory, where the underlying signature is also of Lorentzian type. But for that we need to first check whether an appropriate spectral triple for Lorentzian signature can indeed be constructed, so that one can recover the expected metric structure of such spaces from its axiomatic setup. Indeed, it is only recently that people have started investing their efforts to come up with a consistent axiomatic formulation for the Lorentzian spectral triple. Using a recent such construction due to Franco et.al. we computed the spectral distance between a pair of timelike separated `events', given by pure states associated

with pure density matrices in (1+1)D Moyal plane. The computation was carried out using Hilbert-Schmidt operatorial formulation and the un-normalised Fock-Bargmann coherent states. We found that expected results are obtained with no associated noncommutative deformation.

- (ii) We have computed Berry's geometrical phase shift in a planar oscillator lying in the Moyal plane, where we have also the momentum space noncommutativity, apart from the spatial ones. By introducing a novel form of Bopp shift, we could show, using Heisenberg picture, that the system acquires a geometrical phase by traversing a closed loop in the parameter space, where the mass and frequency parameters are taken to be slowly varying periodic function of time. We show how time-reversal symmetry breaking plays a vital role here in getting a non-vanishing phase shift.
- (iii) We have shown how the noncommutativity can be a source of entanglement in the Moyal plane. This work is under progress.
- (iv) We are investigating how one can construct a gauge theory in the framework of almost commutative geometry a la Connes et.al., by taking the extra space to be the fuzzy sphere and using Watamura's Dirac operator. This work is also under progress.

Plan of Future Work Including Project

1. As mentioned above, we have initiated a programme for constructing suitable gauge theories, taking fuzzy sphere as the extra space in the framework of almost commutative gauge theory a la Connes et.al. This is expected to yield an SU(2) gauge theory, apart from the chiral gauge theory, as the Watamura's Dirac operator admits chiral zero modes. This is expected to pave the way for comparing with the usual Kaluza-Klein theory, if the corresponding extra space is taken to be standard round sphere S^2 , which is a differentiable manifold and is known to admit no chiral fermions. Further since, our computation so far were restricted to the lowest spin 1/2 fuzzy sphere, it would be interesting to construct such a theory for arbitrary spin j theory and take the limit j tending to infinity. This should then have some points of contact with commutative round sphere case in Kaluza-Klein case.

2. If noncommutative nature of the so-called quantum/ fuzzy space-time, has really anything to do with quantum gravity, it should then definitely show up in the expression of entropy for a truly noncommutative system, as entropy is the main link between macro and micro structures of a thermodynamical system. We have initiated such a computation already and have obtained some encouraging results. We therefore intend to keep working on this during the next few months.

Any other Relevant Information including social impact of research

1. Areas of my research interest is of completely theoretical and mathematical in nature and so it is difficult to see immediate social impact of such an endeavor. But, as history has shown us time and again and showing till today, that all such purely abstract works invariably finds its application in some or other technology development within a few decades. There are several such examples, that one can cite like cryptography coming from Number theory in pure Mathematics, GPS used in cell phones, for example, came out of General Theory of Relativity, developed by Albert Einstein in a purely quest driven research.



Makhtedar Sanjay Kumar

Associate Professor Theoretical Sciences

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Saniur Rahman; Aspects of quantum many body systems; Under progress; Manoranjan Kumar (Supervisor), M. Sanjay Kumar (Co-supervisor)
- 2. S. Adarsh; Quantum Information in Many-Body Quantum Systems; Under progress; Sanjay Kumar (Supervisor), Manoranjan Kumar (Co-supervisor)
- 3. 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; Aspects of Spin Squeezing and Entanglement in Optical Systems

Teaching

1. Spring semester; Optical Physics; Integrated PhD; 4 students

Administrative duties

- 1. Member, Admissions Committee & Admissions Coordinator
- 2. Head, Dept of Theoretical Sciences
- 3. Member, SCRE Committee
- 4. Member, APMP Committee
- 5. Chairperson, Medical Committee

Areas of Research

QUANTUM OPTICS AND QUANTUM INFORMATION

USE OF GEOMETRIC PHASES IN IMPLEMENTATION OF QUANTUM GATES

Implementation of a holonomic 3-qubit gate using Rydberg atoms in a microwave cavity Holonomic (i.e., based on geometric phase) quantum gates have been studied extensively in recent years because they are relatively more immune to environmental effects than normal gates. There have been several physical implementations of such gates. for example, using coupled cavity arrays, ion traps, etc. A particular implementation relevant for our work is one with Rydberg atoms in a single one-mode microwave cavity. Earlier works in the literature have proposed schemes for designing holonomic 2-qubit gates using this system. However the known schemes don't straight-forwardly extend to the 3-qubit case. Our work is focussed on designing a 3-gubit gate with Rydberg atoms in a single cavity. Our scheme involves seending two species (i.e., with different level structures) of Rydberg atoms in a two-mode cavity. The computational basis is formed by the four collective ground states of the two species of atoms that interact with each other via the common cavity modes. For specific values of the gate parameters, we show how the Toffoli gate can be realized.

Plan of Future Work Including Project

- Two further works that have formed part of the thesis of Soumyakanti Bose will be expanded upon. (i) A scheme for spatially redistributing two-mode entanglement generated at a point by using a two-dimensional array of beam splitters. (ii) Some aspects nonclassicality of singlemode non-Gaussian states. We have identified states that show interesting properties as regards the coexistence or otherwise of quadrature squeezing on the one hand and sub-Poissonian statistics on the other. This matter needs further investigation.
- 2. Work with the external student Prosenjit Maity (RKM, Narendrapur): Further studies of geometric phase in quantum information.



Manu Mathur

Professor Theoretical Sciences manu@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Atul Rathor; Duality Transformations in SU(N) Lattice Gauge Theories; Under progress

Teaching

1. Spring semester; Quantum Mechanics II; Integrated PhD; 12 students

Areas of Research

Lattice Gauge Theory, Mathematical Physics

1. Resolution of SU(3) Outer Multiplicity Problem:

We resolve the SU(3) group representation outer multiplicity problem by defining all possible SU(3) XSU(3) invariant operators in terms of SU(3) Schwinger bosons. We show that these elementary invariant operators form SO(4,2) algebra. Further, they enable us to construct a family of operators whose eigenvalues uniquely identify all repeating representations present in the reduction of the direct product of two SU(3) irreducible representations.

2. Duality and Disorder Operator in SU(N) Lattice Gauge Theory:

We construct the most general disorder operator for SU(N) (N=2, 3) lattice gauge theory in (2+1) dimension by exploiting exact SU(N) duality transformations. The new order-disorder algebra is derived and discussed. The SU(N) t'Hooft disorder operator is obtained as a special limit of our result. In this limit, we also recover the Wilson-t'Hooft order disorder algebra. These techniques can be easily generalized to construct disorder operators for higher SU(N) lattice gauge theories.

Plan of Future Work Including Project

1. Generalisation of SU(N) Lattice Gauge Theory Duality Transformations to (3+1) dimension. 2. Construction of dual Wilson loop operator in (3+1) dimension



Partha Guha

Senior Professor

Theoretical Sciences

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Ankan Pandey; Mathematical Physics, Nonlinear Dynamics, Integrable Systems; Under progress
- 2. Souma Mazumdar; Information Geometry and Game Theory; Under progress

b) Post-Docs

1. Supriyo Dutta;Generalized entropy, generalized thermostatistics and quantum information

c) External Project Students / Summer Training

1. Archisman Saha; Regularization and dynamics of N-body problems; Visva Bharati

Publications

a) In journals

1. Ogul Esen, **Partha Guha**, On the quest for generalized Hamiltonian descriptions of 3D-flows generated by the curl of a vector potential, Int. J. Geom. Methods Mod. Phys. 17 (2020), no. 3, 2050042

- Partha Guha, Generalized Emden-Fowler equations in noncentral curl forces and first integrals, Acta Mech. 231 (2020), no. 2, 815-825
- 3. Kumar Abhinav, **Partha Guha**, Indranil Mukherjee, Analysis and comparative study of non-holonomic and quasi-integrable deformations of the nonlinear Schrödinger equation, Nonlinear Dynamics 99 (2) (2020) 1179-1194
- Indranil Mukherjee, Partha Guha, A study of nonholonomic deformations of nonlocal integrable systems belonging to the nonlinear Schrödinger family, Nelineinaya Dinamika (Russian Journal of Nonlinear Dynamics), 15 (2019), no. 3, 293-307
- 5. A. Ghose Choudhury, **Partha Guha**, Branched Hamiltonians and time translation symmetry breaking in equations of the Liénard type, Modern Phys. Lett. A 34 (2019), no. 32, 1950263
- 6. A. Ghose-Choudhury, **Partha Guha**, Hamiltonian description of nonlinear curl forces from cofactor systems, Acta Mech. 230 (2019), no. 6, 2267-2277
- Souma Mazumdar, Supriyo Dutta, Partha Guha, Sharma-Mittal quantum discord, Quantum Inf. Process. 18 (2019), no. 6, Paper No. 169, 26 pp.
- 8. **Partha Guha**, A. Ghose-Choudhury, Nonlocal transformations of the generalized Liénard type equations and dissipative Ermakov-Milne-Pinney systems, Int. J. Geom. Methods Mod. Phys. 16 (2019), no. 7, 1950107, 18 pp.
- Partha Guha, Indranil Mukherjee, Hierarchies and Hamiltonian structures of the Nonlinear Schrödinger family using geometric and spectral techniques, Discrete & Continuous Dynamical Systems - B, 2019, 24 (4): 1677-1695
- Sumanto Chanda, G. W. Gibbons, Partha Guha, Paolo Maraner, Marcus C. Werner, Jacobi-Maupertuis Randers-Finsler metric for curved spaces and the gravitational magnetoelectric effect, J. Math. Phys. 60 (2019), no. 12, 122501

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

- 1. Ogul Esen, Department of Mathematics, Gebze Technical University, Turkey; Sl. No. 5; International
- 2. Anindya Ghose-Choudhury, Diamond harbour women university, West Bengal; Sl. No. 5,6,8; National
- 3. Gary Gibbons DAMTP, Cambridge, UK; Sl. No. 10; International

- 4. Indranil Mukherjee, Maulana Abul Kalam Azad University of Technology, West Bengal; Sl. No. 3,4,9; National
- 5. Kumar Abhinav, The Institute for Fundamental Study, Naresuan University, Thailand; Sl. No. 5; International

Areas of Research

Mathematical Physics, Nonlinear Dynamics, Integrable Systems

Project 1 (Integrable PDEs): The non-holonomic deformation of the nonlinear Schroedinger equation, uniquely obtained from both the Lax pair and Kupershmidt's bi-Hamiltonian (Kupershmidt in Phys Lett A 372:2634, 2008) approaches, is compared with the quasi-integrable deformation of the same system (Ferreira et al. in JHEP 2012:103, 2012). It is found that these two deformations can locally coincide only when the phase of the corresponding solution is discontinuous in space, following a definite phasemodulus coupling of the non-holonomic inhomogeneity function. In our second project we have studied the nonholonomic deformations of non-local integrable systems belonging to the Nonlinear Schroedinger family are studied using the Bi-Hamiltonian formalism as well as the Lax pair method. We have also explored the Adler-Kostant-Symes theory and its connection to Tu's method.

Project 2 (Jacobi-Maupertuis type variational principle): It has been shown that not only null geodesics, but also timelike geodesics are governed by a Jacobi-Maupertuis type variational principle and a Randers-Finsler metric for which we give explicit formulae. The cases of the Taub-NUT and Kerr spacetimes are discussed in detail. Finally we show how our Jacobi-Maupertuis Randers-Finsler metric may be expressed in terms of the effective medium describing the behaviour of Maxwell's equations in the curved spacetime. In particular, we demonstrate in very concrete terms how the magnetolectric susceptibility enters the Jacobi-Maupertuis-Randers-Finsler function.

Project 3 (Curl forces): Recently, Berry and Shukla presented (J Phys A 45:305201, 2012; J Phys A 46:422001, 2013; Proc R Soc A 471:20150002, 2015) a fundamental new dynamics concerning forces (accelerations) depending only on position, i.e. without velocity-dependent dissipation. We have extended their results to nonlinear curl forces, where the nonlinearity is with respect to the coordinate dependence of the forces, and study the Hamiltonians for homogeneous quadratic and cubic cases presenting the conditions for existence of Hamiltonian curl forces. In particular, we have examined the existence and expressions of the Hamiltonian curl forces for planar systems when the accelerations are given by general (both homogeneous and inhomogeneous) second-order and homogeneous cubic polynomials. Noncentral force is an exemplary example of curl force and in general this is not an integrable system. In a second paper study a different reduction in the noncentral force compared to Berry and Shukla, which leads to the generalized Emden–Fowler (GEF) equation. This equation can be mapped to the Thomas-Fermi equation. In a closely related project Hamiltonian analysis of three-dimensional advection flow of incompressible nature has been studied, here we have assumed that dynamics is generated by the curl of a vector potential.

Project 4 (Quantum discord): We have demonstrated a generalization of quantum discord using a generalized definition of von-Neumann entropy, which is Sharma-Mittal entropy; and the new definition of discord is called Sharma-Mittal quantum discord. Its analytic expressions are worked out for two qubit quantum states as well as Werner, isotropic, and pointer states as special cases. The $R\{é\}$ nyi, Tsallis, and von-Neumann entropy based quantum discords can be expressed as limiting cases for of Sharma-Mittal quantum discord. We also numerically compare all these discords and entanglement negativity.



Punyabrata Pradhan

Associate Professor Theoretical Sciences

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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; Interacting exclusion processes in the presence of moving defects; Under progress; Sakuntala Chatterjee (Deepshikha Das)
- 5. Subhadip Chakraborti; Studies of fluctuations in systems of self-propelled particles; Awarded

b) Post-Docs

1. Shubhashis Rana; Interacting particles in a periodically moving potential

Teaching

- 1. Autumn semester; PHY 304; Integrated PhD; 1 student
- 2. Spring semester; PHY 401; Integrated PhD; 1 student

Publications

a) In journals

1. Subhadip Chakraborti and **Punyabrata Pradhan**, Additivity and density fluctuations in Vicsek-like models of self-propelled particles, Physical Review E, 99, 052604, 2019

Talks / Seminars Delivered in reputed conference / institutions

1. Invited for talk in an international conference on "Fluctuations in nonequilibrium systems: Theory and Applications". Title of the talk: "Hydrodynamics, superfluidity and giant number fluctuations in a model of self-propelled particles" (the talk was delivered by Subhadip Chakraborti on my behalf due to Covid-19 pandemic related travel restriction); Mar 12, 2020; International Centre for Theoretical Sciences (ICTS), Bengaluru; March 9 - 13, 2020

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 selfpropelled particles; Science and Engineering Research Board (SERB, DST); 3 years; PI

Areas of Research

Nonequilibrium statistical physics: Large-deviation properties and fluctuation-response relation in driven systems

My research primarily revolves around the problem of static and dynamic characterization of driven systems in terms of hydrodynamic (large-scale) and large-deviation properties of various observables in the systems, such as coarse-grained density and current. In the past year, we have studied density fluctuations in self-propelled particles, also called active matter. To this end, we have specifically considered active matter with alignment interactions, namely the paradigmatic Vicsek-like models, which could describe flocking of birds. swarming of insects, and fish schools, etc. By using an additivity property and the related fluctuation-response relation, we have computed logarithm of the large-deviation probabilities of subsystem particle-number (or, in other words, coarse-grained density) in Vicsek-like models, while the systems are in the disordered fluid phase with vanishing macroscopic velocity. The large-deviation probabilities, computed within the theory of additivity, agree remarkably well with that obtained from microscopic simulations of the model systems. Our results provide a strong evidence of the existence of an equilibrium-like chemical potential, which governs the density fluctuations in the Vicsek-like models with alignment interactions. Comparison of the particle-number fluctuations among several other self-propelled particle systems, which do not have any alignment interactions, but have only steric repulsion among particles, indeed suggests a common mechanism through which the particlenumber fluctuations arise in such systems. To understand the fluctuation properties of self-propelled particles better, recently we have proposed a class of active lattice gases, consisting of hardcore particles having a variable-range hopping mechanism, and calculated transport coefficients - the bulk-diffusion coefficient and the conductivity, which govern the time evolution of coarse-grained density field

(submitted in September, 2019; presently in press). Our analytical results suggest that the "giant" particle-number fluctuations in self-propelled particles, which have generated a significant interest in the past couple of decades, could be intimately connected to the coherent transport, arising due to the huge mobility of particles and characterized by diverging conductivity in the systems.

Plan of Future Work Including Project

- 1. Studies of transport properties in active matter systems
- Studies of transport properties in mass aggregation processes
- 3. Studies of hydrodynamics in sandpiles
- 4. Studies of transport in interacting exclusion processes in the presence of moving defects

Any other Relevant Information including social impact of research

1. Development of manpower and knowledge base in higher-education sector in terms of teaching and training of students



Rabin Banerjee

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Arpan Krishna Mitra; Field theory aspects of fluid dynamics; Submitted
- 2. Shirsendu Dey; some aspects of anomalous hydrodynamics; Thesis submitted (External candidate)

b) External Project Students / Summer Training

1. Sagar Maity; Symplectic techniques and Dirac's realization of de Sitter algebra ; SNBNCBS

Teaching

1. 2nd semester; Classical dynamics; IPh.D; 12 students; Full course

Publications

a) In journals

- 1. **Rabin Banerjee** and Pradip Mukherjee, A new action for nonrelativistic particle in curved background, Physics Letters B797, 134834, 2019
- Debabrata Ghorai, Sunandan Gangopadhyay, Rabin Banerjee, Meissner effect in holographic superconductors with Dirac-Born-Infeld electrodynamics, Modern Physics Letters A, 35, 2050020, 2020

3. Rabin Banerjee and Debashis Chatterjee, Non-relativistic reduction of spinors, new currents and their algebra, Nuclear Physics B954, 114994, 2020

Talks / Seminars Delivered in reputed conference / institutions

1. S.N. Bose and Evolution of Quantum Mechanics; August 2019; Presidency University; 1 hour

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

1. Joint publ. Barasat Govt. College (1), Bijoygarh College(3), West Bengal; Sl. No. 1 & 3; National

Areas of Research

Nonrelativistic gravity, Quantum field theory

We have given a new action for a nonrelativistic (NR) free particle coupled to background gravity. A covariant expression is found where the coupling is provided by the Newton Cartan structures. Both lagrangian and Hamiltonian formulations reveal that the equation of motion is a geodesic in the curved background. The Schroedinger equation for this model is derived which outlines a path to its quantisation.

The analysis is extended to the spinning particle model. We first derive an action for the free particle with spin half in a flat background. This model is then written in a curved background where covariant couplings are once again found which are effected by the Newton Cartan structures. The equation of motion shows that there is a deviation from the equation of geodesy which is a consequence of the existence of spin.

Starting from the Dirac lagrangian, a NR reduction was performed that led to the Pauli-Schroedinger theory, i.e. Schroedinger theory for a spin half case. Appropriate reduction was done for the corresponding spinors. Because of the nonabelian nature of the symmetry transformations, new currents were obtained. Their conservation laws were studied.

The Meissner effect in holographic superconductors with Dirac Born Infeld electrodynamics was investigated using analytical and numerical techniques.

Plan of Future Work Including Project

I would like to extend the analysis done for the particle case to strings. Writing an action for nonrelativistic strings has been a topic of continual interest. In recent times it has been used in discussions of nonrelativistic holography or AdS/CFT correspondence. A suitable limiting prescription has to be developed that yields the string action starting from the well known relativistic expressions, either the Nambu-Goto form or the Polyakov form. This action has to be written in a curved background using our method of Galilean gauge theory. Once this is achieved we hope to obtain new results in this area of research.



Sakuntala Chatterjee

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

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Subrata Dev; Bacterial chemotaxis in presence of signaling noise; Awarded
- 2. Raj Kumar Sadhu; Force genetation by biofilaments; Thesis submitted
- 3. Shauri Chakraborty; Coupled driven systems; Thesis submitted
- 4. Shobhan Dev Mandal; Bacterial motility in complex environment; Under progress
- 5. Deepsikha Das; Periodically driven many-particle systems; Under progress; Punyabrata Pradhan, SNBNCBS (Co-supervisor)

Teaching

1. Autumn semester; Quantum Mechanics 1; Integrated PhD; 12 students

Publications

a) In journals

- 1. Shauri Chakraborty, **Sakuntala Chatterjee** and Mustansir Barma, Dynamics of coupled modes for sliding particles on a fluctuating landscape, Physical Review E 100, 042117, 2019
- 2. Raj Kumar Sadhu and **Sakuntala Chatterjee**, Interplay between surface and bending energy helps membrane protrusion formation, Physical Review E Rapid Comm 100, 020401(R), 2019

Talks / Seminars Delivered in reputed conference / institutions

- 1. Talk title: "Effect of extra-cellular and intraEffect of extracellular and intra-cellular environment on chemotactic performance of an E.coli cell", Conference: Statistical Physics of Complex Systems; May 7, 2019; Nordita, Stockholm; 5 days
- Talk title: Effect of extra-cellular and intraEffect of extracellular and intra-cellular environment on chemotactic performance of an E.coli cell"; Nov 11, 2019; NISER Bhubaneswar; 1 day

Administrative duties

1. TPSC co-ordinator, also served in many internal committees of the centre

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

- 1. Study of E.coli chemotaxis at the single cell level: a statistical physics approach; SERB DST; Feb 2017-Feb 2020; PI
- Theorerical investigation of run-and-tumble motion in a noisy environment DST SERB (under Matrics scheme); Feb 2020 - Feb 2023; PI

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

1. Collaboration with Mustansir Barma from TIFR-Hyd; Sl. No. 1; National

Outreach program organized / participated

 Gave an outreach talk at Barrackpore Rastraguru Surendranath College during the UGC-CPE Funded National Level Seminar on Interdisciplinary Studies in Physics: An Exploration into Biophysics, on 22nd Jan 2020

Areas of Research

Nonequilibrium statistical physics, biological systems

Interplay between surface and bending energy helps membrane protrusion formation

Actin filaments polymerize and push against the cell membrane to create protrusions. This process plays an important part in cell motility and therefore is being investigated in a large number of recent theoretical and experimental studies. We consider a one-dimensional elastic membrane, which is pushed by growing filaments. The filaments tend to grow by creating local protrusions in the membrane and this process has surface and bending energy costs. Although it is expected that with increasing surface tension and bending rigidity, it should become more difficult to create a protrusion, we find that for a fixed bending rigidity, as the surface tension increases, protrusions are more easily formed. This effect also gives rise to non-trivial dependence of membrane velocity on the surface tension, characterized by a dip and a peak. We explain this unusual phenomenon by studying in detail the interplay of the surface and the bending energy and show that this interplay is responsible for a qualitative shape change of the memrane which gives rise to the above effect.

Dynamics of coupled modes for sliding particles on a fluctuating landscape

The recently developed formalism of nonlinear fluctuating hydrodynamics (NLFH) has been instrumental in unraveling many new dynamical universality classes in coupled driven systems with multiple conserved quantities. In principle, this formalism requires knowledge of the exact expression of locally conserved current in terms of local density of the conserved components. However, for most nonequilibrium systems an exact expression is not available and it is important to know what happens to the predictions of NLFH in these cases. We address this question for the first time here in a system with coupled time evolution of sliding particles on a fluctuating energy landscape. In the disordered phase this system shows short-ranged correlations, this system shows short-ranged correlations, the exact form of which is not known, and so the exact expression for current cannot be obtained. We use approximate expressions based on meanfield theory and corrections to it, to test the prediction of NLFH using numerical simulations. In this process we also discover important finite size effects and show how they affect the predictions of NLFH. We find that our system is rich enough to show a large variety of universality classes. From our analytics and simulations we have been able to find parameter values which lead to diffusive, Kardar-Parisi-Zhang (KPZ), 5/3 Lévy and modified KPZ universality classes. Interestingly, the scaling function in the modified KPZ case turns out to be close to the Prähofer-Spohn function which is known to describe usual KPZ scaling. Our analytics also predict the golden mean and the 3/2 Lévy universality classes within our model but our simulations could not verify this, perhaps due to strong finite size effects.

Plan of Future Work Including Project

- 1. Investigation of various different sources of signaling noise in bacterial chemotaxis and how these noise affect the cell behavior
- 2. Study of periodically driven system in presence of particles with finite range interaction



Subhrangshu Sekhar Manna

Emeritus Professor Theoretical Sciences manna@bose.res.in

Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

1. Chandreyee Roy; Statistical Physics of Fiber Bundle models; Awarded

Publications

a) In journals

 Chandreyee Roy and S. S. Manna, Brittle to quasibrittle transition in a compound fiber bundle, Phys. Rev. E 100, 012107 (2019)

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

- A. I have a research collaboration with Prof. Robert Ziff of Department of Chemical Engg., University of Michigan, USA. The paper is titled as: "Bond percolation between k separated points on a square lattice". The paper has been accepted in Phys. Rev. E, but will be published in 2020-21 Academic year; International
- B. A team of four scientists namely, S. S. Manna, Ronald Dickman, Peter Grassberger, Attilio Stella are editing a special volume of FRONTIERS, titled: "Self-Organized

Criticality, Three Decades Later" that is expected to be published in 2020-21; International

Areas of Research

Percolation Phenomena, Self-organized Criticality, Material Breakdown

We consider a percolation process in which k widely separated points simultaneously connect together (k > 1), or a single point at the center of a system connects to the boundary (k = 1).

These processes yield new thresholds p_{ck} defined as the average value of p at which the desired connections first occur. These thresholds are not sharp as the distribution of values of p_{ck} remains broad in the limit of $L \rightarrow \infty$. We study \bar{p}_{ck} for bond percolation on the square lattice, and find that \bar{p}_{ck} are above the normal percolation threshold $\bar{p}_c = 1/2$ and represent specific supercritical states.

The p_{ck} can be related to integrals over powers of the function $P_{\infty}(p)$ which gives the probability a point is connected to the infinite cluster; we find numerically from both direct simulations and from measurements of $P_{\infty}(p)$ on $L \times L$ systems that for $L \rightarrow \infty$, $\bar{p}_{c1} = 0.51761(3)$, $\bar{p}_{c2} = 0.53220(3)$, $\bar{p}_{c3} = 0.54458(3)$, and $\bar{p}_{c4} = 0.55530(3)$. The percolation thresholds p_{ck} remain the same, even when k points are randomly selected within the lattice. We show that the finite-size corrections scale as L^{-1/ν_k} where $\nu_k = \nu/(k\beta + 1)$, with $\beta = 5/36$ and $\nu = 4/3$ being the ordinary percolation critical exponents, so that $\nu_1 = 48/41$, $\nu_2 = 24/23$, $\nu_3 = 16/17$, $\nu_4 = 6/7$, etc. We also study three-point correlations in the system.





Sunandan Gangopadhyay

Associate Professor

Theoretical Sciences

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Guidance of Students/Post-Docs/ Scientists

a) Ph.D. Students

- 1. Debabrata Ghorai; Holographic superconductors; Under progress; 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. Swarup Saha; Gravitational waves in noncommutative space framework; Awarded; Anirban Saha (Co-supervisor)
- 5. Rituparna Mandal; Renormalization group approach to quantum gravity; Under progress
- 6. Neeraj Kumar; Black hole thermodynamics and phase transitions; Under progress
- 7. Anish Das; Black hole shadow; Under progress

8. Manjari Dutta; Noncommutative quantum mechanics; Under progress

b) Post-Docs

1. Dharmesh Jain; String theory

Teaching

- 1. Autumn semester; Advanced Quantum Mechanics and applications (PHY303); Integrated PhD; 13 students; with 1 (Archan Majumdar) co-teacher
- 2. Spring semester; Advanced Quantum Field Theory; Integrated PhD; 7 students

Publications

a) In journals

- 1. **Sunandan Gangopadhyay**, Sukanta Bhattacharyya, Path integral action of a particle with the generalized uncertainty principle and correspondence with noncommutativity, Physical Review D, 99, 104010, 2019
- 2. Debabrata Ghorai, **Sunandan Gangopadhyay**, Rabin Banerjee, *Meissner effect in holographic superconductors with Dirac-Born-Infeld electrodynamics*, Modern Physics Letters A, 35, 2050020, 2020
- 3. Suchetana Pal, Saumya Ghosh, **Sunandan Gangopadhyay**, Meissner like effect in holographic superconductors with back reaction, Annals of Physics 414, 168078, 2020
- 4. Sourav Kara, Rohit Mishra, **Sunandan Gangopadhyay**, Holographic subregion complexity of boosted black brane and Fisher information, Physical Review D 100, 026006, 2019
- 5. Ashis Saha, **Sunandan Gangopadhyay**, Jyoti Prasad Saha, *Holographic entanglement entropy and generalized entanglement temperature*, Physical Review D 100, 106008, 2019
- 6. Neeraj Kumar, Sukanta Bhattacharyya, **Sunandan Gangopadhyay**, *Phase transitions in Born-Infeld AdS black holes in D-dimensions*, General Relativity and Gravitation, 52, 20, 2020
- 7. Rituparna Mandal, **Sunandan Gangopadhyay**, Amitabha Lahiri, Cosmology of Bianchi type-I metric using renormalization group approach for quantum gravity, Classical and Quantum Gravity, 37, 065012, 2020

- 8. Ashis Saha, Sourav Karar, **Sunandan Gangopadhyay**, Bulk geometry from entanglement entropy of CFT, European Physical Journal Plus, 135, 132, 2020
- 9. Arnab Mukherjee, **Sunandan Gangopadhyay**, Manjari Dutta, *Photon velocity, power spectrum in Unruh effect with modified dispersion relation*, Europhysics Letters, 129, 30002, 2020
- Ankur Srivastav, Debabrata Ghorai, Sunandan Gangopadhyay, p-wave holographic superconductors with massive vector condensate in Born-Infeld electrodynamics, European Physical Journal C, 80, 219, 2020
- Diganta Parai, Debabrata Ghorai, Sunandan Gangopadhyay, Effect of magnetic field on holographic insulator/superconductor phase transition in higher dimensional Gauss-Bonnet gravity, European Physical Journal C, 80, 232, 2020
- 12. Anish Das, Ashis Saha, **Sunandan Gangopadhyay**, Shadow of charged black holes in Gauss-Bonnet gravity, European Physical Journal C, 80, 180, 2020

b) Conference proceedings / Reports / Monographs / Books

 Sunandan Gangopadhyay, Sukanta Bhattacharyya, Anirban Saha, "Signatures of noncommutativity in bar detectors of gravitational waves", Ukrainian Journal of Physics, 64, 1029, 2019

Talks / Seminars Delivered in reputed conference / institutions

- 1. Talk given in XI Bolyai-Gauss-Lobachevsky (BGL-2019) Conference on Non-Euclidean, Non-Commutative Geometry and Quantum held at the Bogolyubov Institute for Theoretical Physics, Kyiv; May 19, 2019; Kyiv, Ukraine; 5 days Conference
- Talk given in Institute of Mathematical Sciences, Chennai; Feb 27, 2020; Talk given in Institute of Mathematical Sciences, Chennai; 2 days

Membership of Learned Societies

1. Associate of Inter University Centre for Astronomy and Astrophysics (IUCAA) Pune from 2011-till date

Areas of Research

Applications of gauge/gravity correspondence, quantum cosmology

I have been involved in studying the flow of holographic entanglement entropy using the gauge/gravity duality. The main observation was that a generalised temperature could be defined which gives the Hawking temperature in the infra-red limit and leads to a generalised thermodynamics like law. I have also computed the holographic subregion complexity for boosted black brane for a strip like subsystem. This has been computed for a subsystem chosen along and perpendicular to the boost direction. We observe that there is an asymmetry in the result due to the boost parameter which can be attributed to the asymmetry in the holographic entanglement entropy. The Fisher information metric and the fidelity susceptibility have also been computed using bulk dual prescriptions. It is observed that the two metrics computed holographically are not related for both the pure black brane as well as the boosted black brane. This is one of the main findings in this research work and the holographic results have been compared with the results available in the quantum information literature where it is known that the two distances are related to each other in general. Apart from this I have also investigated the Meissner like effect in holographic superconductors in the presence of Dirac-Born-Infeld electrodynamics. The so called matching method has been applied to obtain the critical magnetic field and critical temperature. I have also studied the effect of Born-Infeld electrodynamics in holographic p-wave superconductors with massive vector condensation. The model is analysed in the probe limit using a variational method known as the Stürm-Liouville eigenvalue approach. In the area of cosmology, I have looked at the Wheeler-DeWitt quantization for Bianchi type I anisotropic cosmological model in the presence of a scalar field minimally coupled to the Einstein-Hilbert gravity theory. The cosmological (perfect) fluid is taken to construct the matter sector of the model whose dynamics plays the role of time. After obtaining the Wheeler–DeWitt equation from the Hamiltonian formalism, the self-adjointness relations are defined properly. Doing that, we proceed to get a solution for the Wheeler-DeWitt equation and construct a wellbehaved wave function for the universe. The wave packet is next constructed from a superposition of the functions with different energy eigenvalues together with a suitable weight factor which renders the norm of the wave packet finite. It is then concluded that the Big-Bang singularity can be removed in the context of quantum cosmology. I have also studied the anisotropic Bianchi type-I cosmological model at late times, taking into account quantum gravitational corrections in the formalism of the exact renormalization group flow of the effective average action for gravity. We derive the cosmological evolution equations by including the scale dependence of Newton's constant and cosmological constant. Using these, the scale factors have been obtained in different directions. We show that the scale factors

eventually evolve into FLRW universe for known matter like radiation. However, for dust and stiff matter the universe need not evolve to the FLRW cosmology in general, but can also show Kasner type behaviour.

Plan of Future Work Including Project

 I would like to carry my research work in the area of holographic complexity, holographic QCD, holographic superconductors. I would also like to investigate in the area of cosmology using the renormalisation group approach to quantum gravity. In holographic QCD, I would like to follow a `bottom-up' AdS/QCD approach to holographically probe the dynamics of a moving qq⁻ pair inside a strongly coupled plasma at the boundary.

Any other Relevant Information including social impact of research

1. The societal impact of my research would be the following: 1. The research carried out by me will produce Ph.D. students who shall become the torch bearers of tomorrow. 2. The research in theoretical physics would help the society to understand the fundamental ways in which nature works and may also help in future to develop newer technologies. 3. It is important that research needs to be done in the fundamental areas that would make way for modern technology. This is in pursuit of this that my research is focused.



Swapan Rana

Assistant Professor Theoretical Sciences swapan.rana@bose.res.in

Publications

a) In Journals

 Jan Kołodyński, Swapan Rana, and Alexander Streltsov, Entanglement negativity as a universal non-Markovianity witness, Phys. Rev. A 101, 020303(R) (2020)

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

 Jan Kolodynski and Alexander Streltsov, Centre for Quantum Optical Technologies, Centre of New Technologies, University of Warsaw, Banacha 2c, 02-097 Warsaw, Poland; Jan Kołodyński, Swapan Rana, and Alexander Streltsov, "Entanglement negativity as a universal non-Markovianity witness", Phys. Rev. A 101, 020303(R) (2020); International

Areas of research

Quantum Information

- **Quantum resource theories:** characterization, quantification, manipulation, and application (otherwise limitation) of quantum resources -- especially that of entanglement and coherence.
- **Quantum channels:** positive and completely positive maps, structure and representation of channels.
- **Mathematical Physics:** operator theory, functional analysis, information theory.





FACILITIES

Kards

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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 16100 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 Audiovisual 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. 2019-20

- 1. Approximately 300 new books and some new journals have been added in the library collection during the above mentioned financial year.
- 2. Library has developed an institutional digital repository with multiple way search facility. It is enriched with pre-published version of the published research papers of the S.N. Bose Centre. In this financial year retrospective papers for the years 2018 have been uploaded in the repository.
- 3. In the Financial Year 2019-20, the Fiction Section has been enriched by procuring 45 books of classic literature, novel, short story, biography and books of general interests.
- 4. 32 Hindi books are added in the Library collection the mentioned financial year.
- 5. Plagiarism detection services to research papers and thesis.

Saumen Adhikari Librarian – cum – Information Officer



ENGINEERING SECTION (Infrastructure Development, Maintenance & Housekeeping and Support Services)

A. CIVIL:

(i) Construction of Additional two floors at the Basundhara Building for Translational Research Facility :

It was decided to construct Two additional floors on the existing 4 storied Basundhara Building to be earmarked exclusively for TRC. Accordingly, construction of these

two floors commenced from April 2019 and as on date, about 65% work has been completed. Once completed, a total floor area of about 20000 sft will be available for the Translational Research Facility under TRC. This dedicated premises will house 20 modules with all the necessary infrastructure of adequate Power supply, Airconditioning, Fire fighting and Lift facility.



VRF AC Works





Fire Detection System



Fire Protection system

(ii) Construction of Laboratory Buildings :

Construction additional work space of about 6500 Sqft,

to facilitate advanced research works, including Airconditioning and Electrical works has been completed and is being used for various Lab work of TRC.



External view of TRC Lab



View of Lab Room





Interior of TRC Lab Building



Interior of functional new TRC Labs

(iii) Renovation of External Surfaces of Main Building and other areas of SNBNCBS by taking out existing stone slabs and surface finish work

The external surface of the building was cladded with Dholpur stone which started caving in resulting

safety hazard to Centre's occupants and also profuse leakages observed. The remedy demanded removal of the claddings, through plastering etc. to get rid of the associated problems and adorn the building surface with modish painting portraying aesthetic look.



Construction Phase



Exterior Painting Main Building



Exterior Painting Bhagirathi Building



Inside Courtyard view

Illumination effect after painting

(iv) Carpeting of existing bituminous road along with raising road in front of pump house and construction of a new road from main gate to Laboratory II at SNBNCBS. The existing bituminous road inside the Centre is deteriorated due to normal wear and tear which has been repaired by bituminous premix layer. A new approach road also has been laid from Main Gate to Lab II. The work is completed in all respect and in use.



New Road Constructed From Main Gate to Lab II



In front of Bhagirathi Building

Carpeting to Road Surface

West Gate

(v) Interior Decoration of VIP Dining Hall at Basundhara Building.

This proposal is for setting up a VIP Dining Hall in Ground Floor of Basundhara Building with state of

art facilities like fixtures and furniture, luminaries and varying colour shading for dining arrangements of dignitaries on special occasions and sponsored programme hold in the Centre. The work is completed in all respect and Hall is commissioned.

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(vi) Refurbishing and Painting of Rooms & Corridors of Bhagirathi at Ground, First & Second Floor.

The Guest House rooms were to be face lifted by painting work, renovating flooring etc. in order to accommodate the external guests to the extent possible during conferences in the Centre economising hotel expenses.

The work is completed and guests were provided lodgings during ICCFM, IWPSD and other conferences.



Internal renovation with new flooring



Corridor painting

(vii) Renovation of PCCP Lab and Chemistry Lab at Ground Floor of Main Building.

To accommodate spectroscopy related equipments, the major renovation work carried out.



(viii) In view of 125 yrs of celebration S.N.Bose Birth Aniversary, the proposal to face lift common areas of Main Building was taken up and completed.



Ground & 1st Floor

(ix) Furnishing Offices, Hostels, Staff Quarters and Laboratories: According to the demand of different faculties and other officials, different types of cubicles sometimes in modular shape suitable to their office spaces are provided, furniture, table & chairs are procured.



PDRA Sitting Arrangement

- (x) In addition to the above, the Engineering Section has to look after day to day upkeep, sweeping and cleaning Service for the Main Building, the Hostel Buildings, Guest House, Director's Bunglow, Sub-station and ESQ Building
- (xi) The Centre has around 3.5 Km of Water pipeline network of various sizes spread all over the Campus and also in the buildings, is maintained.
- (xii) There is also a vast network of sewerage and storm water drainage line of an approximate length of about 3 Km with numerous Gulley pits, Yard gulley, Manholes etc which are being maintained and kept congestionfree round the year.
- (xiii) The Centre has about 27 nos. of overhead PVC water tanks over roof of various buildings which gets water supply from the RCC Overhead Water Tank (Capacity 1,60,000 It.) all of which are maintained and regularly cleaned and water samples are periodically tested to ensure hygiene for the users. There is also an Ironremoval plant of 35,000 litre/hr. capacity efficiently operated and maintained to supply Iron-free potable water for the entire Campus.



Different Shades of Horticulture

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

B) Estate Management Activities:

Making allotment of hostel rooms and office spaces, maintaining all the records of the allotment of the offices, hostels, Guest Houses, proper co-ordination during allotment and surrender of office/living areas by new entrants and outgoing students/PDRAs.

C) Electrical Work:

(i) Electrical Installation work of two nos. Laboratory Buildings:

The entire electrical works including laying of power cable (above 1.0 KM length) of different sizes, installation of outdoor feeder pillar and indoor panels along with state of the art illumination system have been completed in both the Laboratory Buildings for Research facilities at the Centre.



Lab-1 Main Electrical Panel



- Lab-2 Main Electrical Panel
- (ii) Installation of VRF Air-conditioning machines for the two nos. Laboratory Buildings:

The entire VRF Air-Conditioning system is of a capacity of around 156 Ton, which has been completed in both the Laboratory Buildings to provide proper cooling

- effect to the Scientific Instruments for Research facilities at the Centre.
- (iii) Maintenance and up keeping of Solar Water Heating System to a Capacity of 2500 Litre per Day roof top of the students hostel.



Lab-1 VRF Air Conditioning Machines







Another 500 LPD Capacity Solar Water Heating System



Additional 2 Nos. 500 LPD Capacities Solar Water Heating System

- (iv) Electrical Facilities for "RF" Induction Furnace: Electrical power supply work along with Supply, Installation, Testing & Commissioning of new Electrical Panel Boards and laying of suitable rating of Power cable was completed, keeping in mind future expansion and probable additional power demand at required places.
- (v) New electrical installation works for various Laboratories as and when required at the Centre were carried out.
- (vi) 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.

- (vii) 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.
- (viii) The Centre has 04 nos. of 08 passenger Lifts which are also looked after by the Engineering Section.

- (ix) Water and Fire Pumps: There are 02 Nos. of 12.5 H.P. Submersible Motor Pump sets (Bore well Type), 04 Nos. of Centrifugal Pumps, 02 Nos. of 3.0 H.P. Submersible Domestic water pumps, 01 No. 3.0 H.P. & 01 No. 5.0 H.P. Mono Block pumps for supplying water to the garden area. Besides those, there are Fire Pump and Diesel driven pumps each of capacity 75.0 H.P. along with a Jockey Pump of rating 5.0 H.P. for Fire Fighting of Krishnachura Hostel Building and Basundhara Building which are regularly maintained. In addition to that there is an Iron Removal Plant at Pump House, the operation and maintenance for that IR plant is looked after by the Engineering Section.
- (x) Water Purifiers: Centre has 22 Nos. of purifier machines for providing pure drinking water throughout the Campus which are maintained and serviced periodically for availability of pure drinking water on regular basis.

Major Construction under foray:

The proposal of "Construction of G+6 storied Building for SNBNCBS in JD Block, Sector-III, Kolkata –700106" will be implemented by Central Public Works Department(CPWD), a premier Central Government Department in charge of public works carrying out the job in totality i.e. project

inception to completion. CPWD has consented to take up the work including drawing, designing and construction and supervision of the project. This project is important and formulated in-line with the strategy and role of Science and Technology (S&T) sector.

With the continuous progress of various projects and mandates within the Centre, the requirement for additional infrastructures has become very crucial for the further growth of the Centre and participation in mission mode projects.

The proposed building is G+ 6 storied structures and its total built up area is building 10400 sqm and shall be constructed at an estimated cost of Rs 64.07Crores. This building will house High Tech Research Laboratories in place of existing make shift arranged laboratories, dry as well as wet Labs, supercomputing facilities, additional teaching and innovation laboratories, large and multiple class rooms for offering additional courses etc. The proposed building also include an auditorium with car parking facility of 300 person to hold frequent seminars and colloquiums, functions which are being attended by dignitaries from all across the world. The building structure will also house various departments under the administrative purview.

The Detailed Project Report along with preliminary cost estimate has been submitted to DST for the Approval.

Amitalha Haldan

(Amitabha Haldar) Executive Engineer


COMPUTER SERVICES CELL

Sanjoy Choudhury Scientist – D

Publications

a) Conference proceedings / Reports / Monographs / Books

1. Nurul Amin Choudhury, Soumen Moulik, Sanjoy Choudhury "Cloud-based Real-time and Remote Human Activity Recognition System using Wearable Sensors" Accepted for International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan), 2020

Administrative duties

The nature of work has two distinct regions: 1. Administrative nature: 70% of works handling Central Computational facilities under Computer Services Cell as Scientist I/C of the Cell including all kinds of technical support regarding the organization of all National and International Conferences. 2. Academic nature: 30% of the work research activities, individual and along with Collaborative. 3.Internal Committee Members : Computer Center in-charge, members of CSC-Working Group (CSC-WG), CSC -Advisory Committee, members of internal E-procurement Committee, Nodal officer of Central Public Procurement Portal, Govt. of India, member of Procurement of New Laptop/Desktop Committee, members of Procurement of New Generation Firewall Technical Committee, members of Procurement of Video Conferencing facility Committee, members of Fire-Safety Technical Committee, members of Student Advisory Committee(SAC), Development and Implementation of Asset Tracking Application Committee. 4.Nodal Officer Central Public Procurement Portal, Govt. of India. 5. Nodal Officer GeM. Govt Portal Govt. of India.

Membership of Learned Societies

- 1. Computer Society of India Life Membership
- 2. IEEE- Life Membership
- Member of Indian Registry for Internet Names and Numbers (IRINN)

Areas of Research

Edge/Fog Comoputing, Cloud Cpmputing, IoT and machine learning

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: Successfully completed Ph.D. Course works as well as Comprehensive Exam on February 2020 from National Institute of Technology (NIT), Meghalaya.

2. 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 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 aboveproposed 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.

Plan of Future Work Including Project

 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.

Any other Relevant Information including social impact of research

1. 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.

The Computer Services Cell (CSC) is equipped with most modern and advanced infrastructure to provide a distributed computing environment to cater to the computing and networking needs of the inmates of the institute. The centre has a state of art Computer Network along with blade server and HPC infrastructure. The Computer Centre is providing Electronics class facility to scholars as part of their academic curriculum. It has a wide range of specialized licensed software mined in the software vault of the institute intranet for easy use of researchers. Frequently the centre organizes training programs on specialized software by specialized trainer for students, researchers and staffs. The computer centre also has many dedicated logical servers such as HPC, Mail server, Backup server, Intranet server, Webserver, Authentication server, Blog server, Antivirus server, etc. which provide dedicated resources to different applications.. The Computer Services Cell Advisory Committee (CSC-AC) governs the cell and the Computer Services Cell Working Group Committee (CSC-WG) carries out required services. CSC In-charge (Mr. Sanjoy Choudhury), Jr. Computer Engineers (Mr. Abhijit Ghosh, Mr. Sagar S. De, Ms. Deblina Mukherjee and Ms. Somasree Mal) and Jr. Assistant (Mr. Bijay Pramanik) had supported all day-to-day activities associated to the cell.

Centre's Computing Facilities are all facilities related to numerical and symbolic computations and communications and network access such as, but not limited to, e-mail and Internet access.CSC provides these to facilitate the research, education and administrative efforts of its members and staff. To this end the Computer Centre (CC) provides support in networking and information resources for its computing community. The Computer Centre undertakes security and monitoring measures to preserve the integrity and performance of its networking and computing resources.

The Computer Centre is solely responsible for keeping the Information and Communication Technology & Computation related facilities available to each and every member of the Centre.

These facilities are constantly upgraded to meet the evolving standards of Centre. The Centre is also engaged in designing and facilitates the NKN Project with NIC. National Knowledge Network (NKN) project is aimed at establishing a strong and robust internal Indian network which will be capable of providing secure and reliable connectivity. Using NKN, all vibrant institutions with vision and passion will be able to transcend space and time limitations in accessing information and knowledge and derive the associated benefits for themselves and for the society towards ushering in a knowledge revolution in the country. NKN is intended to connect all the knowledge and research institutions in the country using high bandwidth / low latency network.

At the end of the academic year 2018-19, there were more than 900 users including faculty members, administrative staffs, PDRAs, and students. The Centre is backboned with a fibre optic based internal network capable to support up to 1Gbps. Internet facility had been pulled up to support up to 1Gbps access supported by NKN and an 15Mbps line by Sify Technologies Pvt. Ltd. as a backup. Web, Intranet server configuration had been extended. Wi-Fi support had been extended for better coverage. Desktops, Printers, UPSes, Xerox machines and other Network devices had been maintained regularly. Activities such as updation of website, tenders, and jobs, web-based General Notice Board (where the Centre's general, official, academic, seminar and placement related notices are posted regularly) are followed regularly. CSC facilited Centre by developing new web applications, taking care of email facility, online admission. CSC also looks after other centre computational facilities including Serial Computing Clusters and Parallel Computing Clusters built by Super Micro. Project Clusters as well as CRAY supercomputer **TUE-CMS** project are also maintained by the cell. New super computer (TRC CRAY) has been installed as a part of **Technical Research Centre (TRC)**. As a part of the Centre's vision towards Academic/Scientific society, CSC allows external users (Academic/Research) to use center's computational facilities.

Summary of central computational facilities

Machine Name	Processor Core	Storage	User
Photon	84	-	55
Phonon	84	-	27
UNANST	480	12 TB	25
UNANST	96	12 TB	30
AMRU1	360	6 TB	31
AMRU2	48	-	27

Summary of project sponsored computational facilities

Machine Name	Processor Core	Storage	User
ATHENA	320	-	12
CRAY	7808	255	50
TRC CRAY	960	120	30



SC-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 (2019-20):

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

SNBNCBS is the **top 31** in the List of Top Supercomputers in India as of January 2020, Cray XE6/XC50 cluster, Massively Parallel Cray Supercomputing Facility with **75 TF** Theoretical Peak Performance.

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

Range of research: 4 Basic science research seeks to understand how nature works. This research includes

modelling and simulation of physical, chemical, and biological processes, and high-energy physics. This research focuses primarily on Basic Sciences and related challenges.

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

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

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

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

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.
- 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.
- 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.
- 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.
- 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 Est ate Office Complaints had been introduced.
- 16. Hall booking application had been developed for reliable and sophisticated use with new feature.
- 17. Initiated and completed the development and implementation of almost all the system backup (Administration, Intranet, Web server, Mail server, Admission Server, Software Server) for any unusual accidental breakdown..
- 18. GeM, Govt. of Indian e-marketplace has been implemented for day to day purchasing of common goods and services.
- 19. Govt. of India Central Public Procurement Portal (CPPP) E-Procurement Portal has been implemented for the transparency of every new procurement through Centre.
- 20. Initiate Computational Training/Workshop for the Scientists and Researchers for the better way of utilizing Central Computational Resources.
- 21. Enable the Centre Website for social networking site for publishing the Centre's novel and innovative research ideas and day-to-day broad discussions with the academic and research communities of the entire world.
- 22. LAN infrastructures has been upgraded to capable for higher bandwidth, Network racks had been rearranged for better arrangement and maintenance concern.
- 23. CSC configured Linux based new personal firewall, gateway for the centre.
- 24. Web applications such as New Admission Portal, Online Annual Appraisal application for Academic members, Radhachura booking, Guesthouse Billing, Visitor pass, Asset Manager, Online Confreg had been developed and deployed in the intranet server.
- 25. New Admission application has been modified to fulfil 2019 admission criteria.

- 26. BCRC blog has been created & upgraded.
- 27. Guesthouse Wi-Fi has been re-established after building repair. Entire guest house is now covered by enterprise class Wi-Fi equipment to provide internet facilities.
- 28. Old 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. Implemented Complete Office Automation (ERP) Implementation (under Process)

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
- Solution 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. The cell also keeps track of the manpower under projects. It also coordinates with the committee(s) constituted by the Authority for evaluating proposals to be filed for grant of patent and also takes care of the administrative matters during the filing of patents under the instruction of the inventor(s).

The members of the Project and Patent Cell during the year 2019-20:

- Prof. Samir Kumar Pal, Convenor
- Dr. Atindra Nath Pal
- Prof. Gautam Gangopadhyay
- Dr. Soumen Mondal
- Mr. Debashish Bhattacharjee, Deputy Registrar (Administration)

- Mr. Shiladitya Chatterjee, Deputy Registrar (Finance)
- Mr. Rupam Porel, O.A. Representative from office of Dean(F)
- Ms. Chandrakana Chatterjee, O.A. Representative from office of Students and Academic Section

The following table summarizes the details of the externally funded projects in the Centre, for the last five years:

Year	No. of Projects	Amount Received (Rs.)
2015-2016	38	4,71,50,347=00
2016-2017	16-2017 35 4,05,49,788	
2017-2018	32	3,04,37,606=00
2018-2019	31	4,62,15,993=00
2019-2020	27	4,15,59,908=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 2019-20

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
"J.C. Bose Fellowship"	Prof. A.K. Raychaudhuri	DST SR/S2/JCB- 17/2006	1-7-2006 to 30-6-2011 2fnd Phase: 1-7-2011 to 30-6-2016 3 rd Phase Up to 29-2-2020	40,00,000 68,00,000 in 2 nd phase 68,75,000 in 3 rd phase	Ended on 31-08- 2019
"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	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/-	
DBT/SKP/13-14/126-2 – "Nanogels: Biophysical characterization and Potential Biomedical Applications in Drug Delivery"	Prof. S.K. Pal	DBT BT/PR11534/ NNT/28/766/2014	4-5-2016 to 3-5-2019	16,53,600/-	

Project Title	PI / Co – PI	Funding Agency Duration of the Project To		Total Sanctioned	Remarks
DST/SJ/14-15/142 – "Solution phase conversion of Nanoscale Metals into Intermetallics: Efficient Catalysts for Chemoselective Organic Transformations"	Dr. Subhra Jana	DST SR/NM/NS- 18/2014	06-06-2016 to 05-06- 2019	52,56,800/-	
DST/SC/16-17/170 – (SERB) – "Study of E.Coli Chemotaxis at the single cell level: A Statistical Physics Approach"	Dr. Sakuntala Chatterjee	DST (SERB) EMR/2016/001663	27-02-2017 to 26-02- 2020	18,00,144/-	
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	2,12,86,400/-	
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	SERB 17-6-2017 to 16-6-2020		
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	30,39,600/-	
DST(RFBR)/TSD/16- 17/176 – "Topological phase transitions in quasi-two- dimensional magnets"	Prof. Tanusri Saha Dasgupta	DST INT/RUS/ RFBR/P-274	11-8-2017 to 10-8-2019	23,68,400/-	
SERB (DST)/SJ/16-17/180 – SERB Women Excellence Award - "Low Temperature Synthesis of Multi Metallic Inorganic Nanostructures for Catalysis and Chemical Sensing"	Dr. Subhra Jana	DST (SERB) SB/WEA-08/2016	30-03-2017 to 29-3-2020	18,00,000/-	
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	44,48,969/-	
DST (SERB-NPDF)/SR/17- 18/195 – "Interacting particles in a periodically moving external potential"	Dr. Shubhashis Rana	SERB (NPDF) PDF/2017/002896	1-9-2017 to 31-8-2019	Fellowship: 55,000/- per month (13,20,000/-) Research Grant: 2,00,000/- per annum Overheads: 1,00,000/- per annum	Ended on 12-04- 2019 ***

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
DST (SERB-NPDF)/ SS/17-18/196 – "Ultrafast Magnetization Dynamics: Use of 2D Layered Material as Non-magnetic Underlayer in Ferromagnetic / Non- magnetic Bilayer System"	Dr. Sumona Sinha	SERB (NPDF) PDF/2017/000519	24-10-2017 to 23-10- 2019	Fellowship: 55,000/- per month (13,20,000/-) Research Grant: 2,00,000/- per annum Overheads: 1,00,000/- per annum	Ended on 31-07- 2019
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/-	
DST (WOS-A)/MR/18-19/208 – "Theoretical Studies on Silicon Version of Metathesis Reactions for Searching New Efficient Synthetic Routes to Prepare Advanced Silicon Materials"	Dr. Mausumi Ray	DST (WOS-A) SR/WOS-A/PM- 81/2017	T (WOS-A) WOS-A/PM- 81/2017 13-09-2018 to 12-09- 2021 2021		Ended on 26-04- 2019
SERB (DST – NPDF)/SB/18- 19/217 – "Dynamics and Thermodynamics of Qubits in Spin Environments"	Dr. Samyadeb Bhattacharya	SERB (NPDF) PDF/2017/001333	30-10-2017 to 29-10- 2019	Fellowship: 55,000/- per month (13,20,000/-) Research Grant: 2,00,000/- per annum Overheads: 1,00,000/- per annum	Ended on 16-08- 2019
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	18,67,244/- (Received during 2019-20)	
DST (WOS-A)/MR/18-19/208 – "Theoretical Studies on Silicon Version of Metathesis Reactions for Searching New Efficient Synthetic Routes to Prepare Advanced Silicon Materials"	Dr. Mausumi Ray	DST (WOS-A) SR/WOS-A/PM- 81/2017	13-09-2018 to 12-09- 2021	29,95,500/-	Ended on 26-04- 2019
SERB (DST – NPDF)/SB/18- 19/217 – "Dynamics and Thermodynamics of Qubits in Spin Environments"	Dr. Samyadeb Bhattacharya	SERB (NPDF) PDF/2017/001333	30-10-2017 to 29-10- 2019	Fellowship: 55,000/- per month (13,20,000/-) Research Grant: 2,00,000/- per annum Overheads: 1,00,000/- per annum	Ended on 16-08- 2019

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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/-	
"Quantum Information Technologies with Photonic Devices"	Prof. Archan S. Majumdar	DST DST/ICPS/QuST/ Theme-1/2019	24-04-2019 to 23-04- 2022	17,00,000/- (Capital) 97,14,000/- (General)	

Project Title	PI / Co – PI	Funding Agency	Duration of the Project	Total Sanctioned	Remarks
"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	From 19-06-2019	8,24,032/-	
"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	5,00,000/- (Received during 2019-20)	
"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/2019/000970	06-02-2020 to 05-02- 2023	26,56,800/-	
"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	2,20,000/- (Received during 2019-20)	
"Fluctuation and Transport in the Models of Self Propelled Particles"	Dr. Punyabrata Pradhan	SERB MTR/2019/000386	21-02-2020 to 20-02- 2023	2,20,000/- (Received during 2019-20)	
"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/-	
"Twistronics with Transition Metal Dichalcogenides"	Prof. Priya Mahadevan	SERB IPA/2020/000021	30-03-2020 to 29-03- 2025	1,56,82,000/- (Received during 2019-20)	

*** Apart from this, the Centre has also received the TRC project during January 2016.

Details the list of Postdocs, Scientists, DST INSPIRE Faculty, etc. under projects for the Year 2019-20

SI.	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. Sumona Sinha	National Post Doctoral Fellow	Ultrafast Magnetization Dynamics: Use of 2D Layered Material as Non-magnetic Underlayer in Ferromagnetic/ Non-magnetic Bilayer System	Self	24.10.2017	Resigned on 31.07.2019
3	Dr. Shubhashis Rana	National Post Doctoral Fellow	Interacting particles in a periodically moving external potential	Self	01.09.2017	Resigned on 12.04.2019
4	Dr. Samyadeb Bhattacharyya	National Post Doctoral Fellow	Dynamics and Thermodynamics of qubits in spin environments	Self	30.10.2017	Resigned on 16.08.2019
5	Dr. Mausumi Ray Women Scientist Theoretical studies on silicon version of metathesis reactions for searching new efficient synthetic routes to prepare advanced silicon materials		Self	10.10.2018	Resigned on 26.04.2019	
6	Ms. Shauri Chakrabarti	rti Research Associate – I Thematic Unit of Excellence on Computational Materials Science		Prof. Tanusri Saha- Dasgupta	02.09.2019	Resigned on 30.10.2019
7	Ms. Anita Research Associate – I Thematic Unit of Excellence on Computational Materials Science		Prof. Tanusri Saha- Dasgupta	03.09.2019	31.08.2020	
8	Dr. Amit Kumawat	Research Associate – I (Adhoc)	Tuning electrostatistics and dynamics of the flexible areas of PCSK9 protein towards controlling interactions with LDLR: A computational approach	Dr. Suman Chakrabarty	16.09.2019	15.03.2020
9	Mr. Basant Roondhe	Research Associate – I (Adhoc)	Thematic Unit of Excellence on Computational Materials Science	Prof. Tanusri Saha- Dasgupta	03.02.2020	02.08.2020
10	Dr. Manik DST INSPIRE Faculty Quantum nonlocality and its implications for device independent technology		Self	18.04.2018	Resigned on 14.02.2020	
11	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
12	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
13	Dr. Dipanwita Majumdar	Quadruplex Ita DST INSPIRE Faculty Optical and Electronic Properties of Metal Nanoparticles Decorated Transition Metal Dichalcogenides and Their Applications		Self	03.01.2019	16.04.2022

List of Students Under Project (2019-20)

SL	NAME OF THE STUDENT	CURRENT DESIGNATION	PROJECT INSTRUCTOR	DEPT.	NAME OF THE PROJECT	JOINED ON	APPOINTMENT TENURE	DURATION OF THE PROJECT	APPOINTED UPTO	RESIGNED ON
1	Sudipta Chatterjee	Project - JRF	Arup K Raychaudhuri, Barnali Ghosh (Saha)	CMPMS	An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide flims (SERB)	27.11.2017	23.03.2020	23.03.2020	23.03.2020	
2	Anirban Goswami	Project - JRF	Arup K Raychaudhuri, Barnali Ghosh (Saha)	CMPMS	An investigation on certain emerging aspects of Metal-Insulator Transition in thin oxide flims (SERB)	11.12.2017	23.03.2020	23.03.2020	23.03.2020	
3	Sourav Kanthal	Project - JRF	Anjan Barman, Sudipta Bandyopadhyay, CU, Tanusri Saha Dasgupta (Coordinator)	CMPMS	Topological phase transition in quasi two- dimensional magnets	06.04.2018	25.07.2019	10.08.2019	25.07.2019	
4	Saikat Mitra	Project - JRF	Barnali Ghosh (Saha) & Manik Pradhan	CMPMS	Understanding 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	05.07.2021	
5	Aathira K. P.	Project-JRF (Ad-hoc)	Priya Mahadevan	CMPMS	Electronic, structural and optical properties of semiconductor nanoplatelets	17.09.2019	6 Months	27.12.2021	16.03.2020	
6	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	31.08.2020	31.08.2020	
7	A. Darshana Yazhini	Project Assistant (Ad-hoc)	Anup Ghosh	CMPMS	Ultrafast 2D-IR Spectroscopy on the Structural Dynamics of DNA/G Quadruplex	17.09.2019	31.12.2019	31.12.2023	31.12.2019	
8	Suranjana Chakrabarty	Project Assistant (Ad-hoc)	Anup Ghosh	CMPMS	Ultrafast 2D-IR Spectroscopy on the Structural Dynamics of DNA/G Quadruplex	20.09.2019	31.12.2019	31.12.2023	31.12.2019	
			Dept Total		8					

SL	NAME OF THE STUDENT	CURRENT DESIGNATION	PROJECT INSTRUCTOR	DEPT.	NAME OF THE PROJECT	JOINED ON	APPOINTMENT TENURE	DURATION OF THE PROJECT	APPOINTED UPTO	RESIGNED ON
1	Arnab Samanta	Project - JRF	Subhra Jana	CBMS	Solution Phase Conversion of Nanoscale Metals into Intermetallics: Efficient Catalysts for Chemoselective Organic Transformations	20.09.2016	Initially for One Year + Continued after evaluation	05.06.2019	02.06.2019	Tenure Completed
2	Suman Mondal	Project Assistant	Tatini Rakshit	CBMS	Biophysical Characterization of Extracellular Vesicle (Evs) using Single Molecule Detection (SMD) Methods: A Potential Non-invasive Diagnostic Tool	15.03.2019	6 Months	12.08.2023	14.09.2019	31.07.2019
3	Debashish Paul	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	22.08.2019	6 Months Extended	12.08.2023	31.08.2020	
			Dept Total		3					
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					
1	Raj Kumar Sadhu	Project - SRF	Sakuntala Chatterjee	TS	Study of E.coli Chemotaxis at the single cell level: a statistical physics approach	08.04.2019	6 Months	26.02.2020	07.10.2019	31.08.2019
			Dept Total		1					
			Total		14					

Patents Granted / Applied during 2019-20

Patents Granted:

Patent No.: 312640
 Application No.: 964/KOL/2011
 Date of Filing: 20/07/2011

 Date of Grant: 10/05/2019
 Method and System of Enhanced Degradation of Bilirubin Involving Zinc Oxide (Zno) Nanoparticles

- Patent No.: 317234 Application No.: 201731000270 Date of Filing: 03/01/2017
 Date of Grant: 31/07/2019 AMMONIA GAS SENSOR AND A METHOD FOR MANUFACTURING THE SAME (TRC)
- 3. No.: 322384 Application No.: 963/KOL/2011 Date of Filing: 20/07/2011 Date of Grant: 04/10/2019 SODIUM BIS (2-ETHYLHEXYL) SULFOSUCCINATE (AOT) BASED DRUG DELIVERY SYSTEM
- 4. Patent No.: 323954 Application No.: 1267/KOL/2014 Date of Filing: 04/12/2014
 Date of Grant: 30/10/2019 CITRATE FUNCTIONALIZED MN₃0₄NANO-PARTICLE BASED SUSTAINABLE THERAPEUTIC CATALYTIC AGENT FORHYPERBILIRUBINEMIA

Patents Applied:

A Method to Grow Single Crystalline Sharp Nano Needles of Piezoelectric Materials (Dr. Barnali Ghosh Saha & others) (TRC) Patent Application No: 201931015347 dated 16/04/2019

A Non Invasive Screening System for Neonatal Hyperbilirubinemia (Prof. S. K. Pal & others) Application No.: 201831029718 dated 07-08-2018 PCT Application filed on 3rd May, 2019 through e-PCT route PCT Application Number: PCT/IN2019/050355 (TRC)

A spark spectrometry based point of care portable device for simultaneous detection of Na+, Li+ and K+ concentration in body fluid (Prof. S. K. Pal & others) (TRC) Patent Application No: 201931026410 dated 02/07/2019

A Spectroscopy based Fluoride Sensor for Drinking Water (Prof. S. K. Pal & others) (TRC) Patent Application No: 201931028219 dated 13/07/2019

A Spectroscopy-based Optical Device for estimation of milk quality (Dr. Soumen Mondal and Prof. Samir Kumar Pal) (TRC) Patent Application No: 201931028306 dated 15/07/2019

A Chromogenic Nanocomposite-based Optical Device Cap Nano Scope for detection and quantification of CO_2 (Prof. S. K. Pal & others) (TRC) Patent Application No: 202031001325 dated 11/01/2020

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 lowcost 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 :

Dr. Soumen Mondal (Nodal Officer since January 2020); 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:

- Non-contact Optial Device Clinical Diagnostics of Anaemia, Jaundice and Oxygen Deficiency (AJO Device)
- Digital Camera Based Spectrometry for the Development of Point-of-Care Anaemia Detection on Ultra-low Volume Whole Blood Sample
- Development of Spectroscopy Based Fluoride Sensor in Drinking Water (FeFlu)
- Development of Optical Emission Spectroscopy (OES) based Sensor for Minimally-invasive Detection of Essential Electrolytes in Human Body (NaLiK)
- A non-invasive breath analysis based detection of Peptic Ulcer disease, nonulcerous dyspepsia and helicobacter pyroli infection
- Development of Flexible paper-based highly sensitive sensor for ammonia gas detection by visual effects.
- Prototype development for spectroscopic based detection of adulteration in Milk (MIL-Q-WAY)
- Fabrication of High Surface Area Silica Nanoflowers for CO₂ Capture and Detection of COPD.
- Piezo-electric Nano generator.
- Enzyme Catalysed Bio-degradation of Xenobiotic Compounds: Treatment of Industrial Effluents.
- Development of light operated microactuator using photomechanical actuation of specific alloys.
- Development of sensors and optoelectronic devices using ultrathin layered materials and organic molecules.
- Calorimeter for biochemical and small volume analyzer to be used as an attachment of a microscope: Hand held portable thermal analyzer
- Use of silver nanoparticles to enhance the antifungal properties of natural fiber like Jute.
- Prediction of new magnetic double perovskites and Machine-learning assisted designing of new rare earth based permanent magnets..
- Rare-Earth-Elements (REE) Extraction
- Computation-based understanding and prediction of technologically important materials.

B. Transfer of Technology (TOT) to an Industry under TRC :

Sl No.	Technology Transfer	Industry Partner
1.	Non-invasive Quantitative Estimation of Bilirubin in Blood	M/s. EzeRx Health Tech Private Limited
2.	Non-invasive detection of Oxygen deficiency in blood	M/s. EzeRx Health Tech Private Limited

C. Number of Patents (submitted during 01.04.2019 – 31.03.2020) :

SI.	Title	Inventors	Country	File No.	Status
1.	A Method to Grow Single Crystalline Sharp Nano Needles of Piezoelectric Materials	Barnali Ghosh, A. K. Raychaudhuri, Ankita Ghatak, Snehamoyee Hazra	INDIA	201931015347	Filed on 16/04/2019
2.	A Non Invasive Screening System for Neonatal Hyperbilirubinemia	Samir Kumar Pal & others	INDIA	201831029718 PCT/IN2019/050355	Filed on 07/08/2018 PCT Application filed on 3/05/2019 through e-PCT route
3.	A Spark Spectrometry based point of care portable device for simultaneous detection of Na+, Li+ and K+ concentration in body fluid	Samir Kumar Pal & others	INDIA	201931026410	Filed on 02/07/2019
4.	A Spectroscopy Based Fluoride Sensor for Drinking Water	Samir Kumar Pal and others	INDIA	201931028219	Filed on 13/07/2019
5.	A Spectroscopy-based Optical Device for estimation of milk quality	Soumen Mondal & Samir Kumar Pal	INDIA	201931028306	Filed on 15/07/2019
6.	A Chromogenic Nanocomposite-based Optical Device CapNanoScope for detection and quantification of \rm{CO}_2	Subhra Jana, Samir Kumar Pal and others	INDIA	202031001325	Filed on 11/01/2020

D. A few sample Prototypes developed under the TRC Project :



E. List of consultancy projects/Industrial Partners under TRC:

S. No	Particulars of Industrial Partner	Name of the Translational project/ technology	Specific role in Development / commercialization etc.	
1	EzRex Health Tech Pvt. Ltd.	A low-cost non-contact AJO device	Taker of the technology for commercialization	
2	Sarfez Cure India	Study the effect of additives on decomposition kinetics of hydrates	Industrial collaboration initiated	
3	Dundee University, Scttoland and and EzRex Health Tech Pvt. Ltd (Consultancy project jointly)	A screening device (Spec-U-Lesion) for the detection of bladder cancer using spectroscopic techniques	Consultancy project jointly	

F. Knowledge Based Services at TRC:

The TRC offers knowledge based services in a number of highly sophisticated instrumentation, ranging from several spectroscopic to microscopic instruments. For more information, please visit our web site -: http://newweb.bose.res. in/departments/TRC

G. Participation in Outreach Program

SI.	Outreach Program	Date
1.	Two-day conference at MN Saha Auditorium, CGCRI Kolkata: Science Communication, Popularisation & Extension in Bengali: The Road Ahead Organized by Vigyan Prasar	26 – 27 th April, 2019
2.	"Technology Outreach as an Enabler for Inclusive & Sustainable Development – Tech for Seva" at IIT Delhi	10 -12 th August, 2019
3.	"7th Indian National Exhibition-Cum-Fair 2019" at Kolkata	25 - 29th September, 2019
4.	"India International Science Festival (IISF) 2019" at Science City, Kolkata.	5 – 8 th November, 2019
5.	"Acharya Satyendranath Basu Smarak Bijnan 'O' Projukti Mela" at Hedua Park, Kolkata	16 -19 th January, 2020
6.	"Bigyan 'O' Sanskritik Mela 2020" at Kolkata	23-26 th January,2020
7.	"Interaction Session with Dr. Kingshuk Poddar – Director and CEO at AIC-AMTZ, MediValley " at Technical Research Centre of S N Bose National Centre for Basic Sciences	25 th January, 2020
8.	"National Science Day" at S. N. Bose National Centre for Basic Sciences	28 th February, 2020
9.	"International Conference on Nano Science and Technology" at Biswa Bangla Convention Centre"	5 – 7 th March, 2020



Prototypes demonstration and technical presentation arranged at TRC stall in the ICONSAT-2020, held during 5 - 7 March, 2020, with visit of several dignitaries including Prof. Ashutosh Sharma, Secretary of DST, Prof. Samit Ray, Director, SNBNCBS, Prof. Ajay Sood, Prof. Dipankar Das Sharma.



Prototypes of TRC demonstrated at National Science Day held at SNBNCBS on $28^{\rm th}$ February, 2020

Prototypes of TRC demonstrated at Indian International Science Festival (IISF) held at Kolkata during $5-8^{\rm th}$ November 2019

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Soumen Mondal Nodal Officer Technical Research Centre

Technical Cell

In SNBNCBS, all the common experimental facilities were brought under one umbrella and "Technical Cell" was established in the year of 2008 to maintain the central experimental facilities of SNBNCBS which can be availed by any researcher from our Centre as well as from other institutions / laboratories. The details of the available experimental facilities and the terms and conditions for using these facilities are mentioned in the website : https://newweb.bose.res.in/facilities/TechnicalCell/. The activities of Technical Cell during April 2019 - March 2020 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 Facilities
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 (FESEM) 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 77 students of our centre used the above experimental facilities extensively for their Ph.D. thesis work. 23 students completed their M.Sc. / M.Tech. Project work and 20 students did their summer project performing extensive work in technical cell. About 83 external users used our Technical cell facilities for their research work during the period of report.

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 2019 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.

VI. Utilization of equpment

- (b) The North East Students' Conclave as a part of IISF 2019 was organized by the Centre at Biswa Bangla Convention Centre, Hall No. 3 during 7th-8th November, 2019. Nearly 180 school students from 08 different NE states of the Country visited the facilities of Technical Cell a part of this event.
- (c) National Science Day was celebrated on 28th February 2020 at the Centre. About 100 college students participated the day long programme and visited the central facilities of our Technical Cell.

V. Major maintenance and up-gradation:

SI. No.	Name of Instrument	Major repair and up-gradation
1.	FESEM	PM combined DSGS/HT. F/G, FEG RETIP
2.	PLD	Installed the new 16 bit energy monitor, mechanical part/ beam splitter & plash for terminal.
3.	FLUOROLOG	Installation of Xenon Lamp
4.	UV SPECTROMETERE	Installation of D2 Lamp
5.	XPERT PRO	Gonio Motor PW3050/(Qty-2) Poscon 2 Board (Qty-2)

ITEM	USAGE (time & hour)	UP TIME%	DOWN TIME %	No. OF EXTERNAL USERS
PLD	114	25%	75%	NILL
FESEM	1200	85%	15%	23
XPERT PRO	800	60%	40%	7
MINI XRD	345	90%	10%	4
TG/DTA	612	93%	7%	20
AFM	702	85%	15%	6
VSM	1182	85%	15%	12
DSC	505	80%	20%	11
HRTEM	1271	70%	30%	13

VII. Revenu Generation

Some revenue was generated from the external users for using the facilities of Technical Cell.

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Kalyan Mandal (Chairman, Technical Cell)

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 and meetings etc with

separate dining facilities. The Medical Cell of the Centre also functions from the guest house. The Centre's modern cafeteria with a state-of-the 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 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. Various academic and research organizations also use the guest house for accommodating their visitors from abroad. During the year 2019-20, the Guest House accommodated a number of dignitaries from within the country and abroad, who visited Kolkata for participating in two very important International Conferences (IWPSD-2019 & ICONSAT-2020) hosted by the Centre during December 2019 and March 2020 respectively. This was in addition to the Guest House accommodating various guests visiting the Centre for official work and also guests from other organizations. The guest house has been providing satisfactory service and warm hospitality to all the guests staying in it.

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RECREATIONAL AND CULTURAL PROGRAMMES

Throughout the year, the Centre organized number of cultural events involving participation of all staff and students of the Centre.

- On the occasions of the 71st Republic Day on 26th January 2020 and 73rd Independence Day on 15th August 2019, the Director hoisted the national flag in the premises of the Centre. On both the occasions, national anthem was sung by students and staff present and parade was performed by the Centre's security personnel. Small replicas of national flags were distributed amongst the members present in the gathering and snacks and sweets were distributed.
- On 1st January 2020, the Centre celebrated 127th Birth Anniversary of Prof. Satyendra Nath Bose with the following events:
 - Garlanding the bust of Satyendra Nath Bose.
 - Opening of the New Bose Archive.
 - Lecture by Professor Debashis Mukherjee on "Emergence of Modern Science in Colonial India: the German Connection".
 - 24th S.N.Bose Memorial Lecture delivered by Professor Supriyo Datta on "Mesoscopic Physics: A New Perspective on Transport".
- 'Muktangan' organised the following events:-
 - "Rabindrajayanti" with an in-house cultural programme on 9th May 2019;
 - "International Day of Yoga" on 21st June 2019 featuring an Interactive Yoga Session conducted by Ms. Chandni Kumari, Yoga Instructor & Therapist where the staff and students participated enthusiastically. A Slogan & Article Writing Competition was also organised among the staff and students of the Centre with the focus on highlighting

the potential health benefits of adopting Yoga in day to day lifestyle in which Mr. Amit Roy, Technical Assistant (Library) was adjudged the winner in the Article Writing Competition;

- An Intra-Institute Table Tennis Tournament was organised (both Singles & Doubles) on $10^{\rm th}$ and $11^{\rm th}$ April 2019;
- Fresher's Welcome 2019 was organised on 12th September 2019;
- An Intra-Institute Football Tournament 2020 was organised on 8th and 9th January 2020 and Intra-Institute Cricket Tournament 2020 was organised on 8th and 9th February 2020. Both the events were a grand success;
- An Intra-Institute Carrom Tournament 2020 was organised (both Singles & Doubles) on 26th and 27th February 2020 followed by Intra-Institute Badminton Tournament 2020 on 28th and 29th February 2020.
- ۲ On the occasion of 'BOSE FEST 2020' held during 24th January 2020 – 25th January 2020, Family Day was celebrated in the evening of 24th January 2020. The Performing Arts Group of 'Muktangan' organised an in-house cultural programme on that day comprising of individual and group performances comprising of singing, recitation and a dance drama. The programmes were attended by friends and family members of staff and students and were huge success. The In-house Bose Fest programme was followed by a gala dinner attended by friends and family members of the staff and students of the Centre. On the evening of 25th January 2020, Baul Rock Fusion Band 'Bolepur Bluez' entertained the audience with their popular numbers. Art & Photography Fest were held successfully along with Oral & Poster presentations by the students.

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Shohini Majumder Registrar





PUBLICATIONS

List of Journal Publications 2019-2020

Department of Astrophysics and Cosmology

- C. Jebaratnam, D. Das, S. Kanjilal, R. Srikanth, D. Sarkar, I. Chattopadhyay, A. S. Majumdar, Superunsteerability as a quantifiable resource for random access codes assisted by Bell-diagonal states, Phys. Rev. A 100, 012344 (2019)
- T. Guha, B. Bhattacharya, D. Das, S. S. Bhattacharya, A. Mukherjee, A. Roy, K. Mukherjee, N. Ganguly, A. S. Majumdar, Environmental effects on nonlocal correlations, Quanta 8, 57 (2019)
- A. Sarkar, K. R. Nayak, A. S. Majumdar, Stochastic gravitational wave background from accreting primordial black hole binaries during early inspiral stage, Phys, Rev D 100, 103514 (2019)
- Z. Bian, A. S. Majumdar, C. Jebaratnam, K. Wang, L. Xiao, X. Zhan, Y. Zhang, P. Xue, Experimental demonstration of one-sided device-independent selftesting for any pure two-qubit entangled state, Phys. Rev. A 101, 020301 (R) (2020)
- M. Banik, S. Saha, T. Guha, S. Agrawal, S. S. Bhattacharya, A. Roy, A. S. Majumdar, Constraining the state space in any physical theory with the principle of information symmetry, Phys. Rev. A 100, 060101 (R) (2019)
- S. Rout, A. G. Maity, A. Mukherjee, S Halder, and M. Banik, Genuinely nonlocal product bases: Classification and entanglement-assisted discrimination, Phys. Rev. A 100, 032321 (2019)
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- 230. **Rabin Banerjee** and Pradip Mukherjee, A new action for nonrelativistic particle in curved background, Physics Letters B797, 134834, 2019
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- 233. Raj Kumar Sadhu and **Sakuntala Chatterjee**, Interplay between surface and bending energy helps membrane protrusion formation, Physical Review E Rapid Comm 100, 020401(R), 2019
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- 242. Ashis Saha, **Sunandan Gangopadhyay**, Jyoti Prasad Saha, Holographic entanglement entropy and generalized entanglement temperature, Physical Review D 100, 106008, 2019
- 243. Neeraj Kumar, Sukanta Bhattacharyya, **Sunandan Gangopadhyay**, *Phase transitions in Born-Infeld AdS black holes in D-dimensions*, General Relativity and Gravitation, 52, 20, 2020
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- 249. Anish Das, Ashis Saha, **Sunandan Gangopadhyay**, Shadow of charged black holes in Gauss-Bonnet gravity, European Physical Journal C, 80, 180, 2020
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- 252. Jan Kołodyński, **Swapan Rana**, and Alexander Streltsov, Entanglement negativity as a universal non-Markovianity witness, Phys. Rev. A 101, 020303(R) (2020)

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- 259. A. De, C. Banerjee, A.K. Chaurasiya, R. Mandal, Y. Otani, **R.K. Mitra** and **A. Barman**, Anisotropic spinwave dispersion in two-dimensional Ni₈₀Fe₂₀ diatomic nanodot array, J. Mag. Mag. Mat. 491, 165557, 2019
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- 22. T. Dey, A. Ghorai, S. Das and S. K. Ray, "Solution Processed Graphene Quantum Dots as Excellent Downconverters for Silicon based Heterojunction Photodetector", IWPSD 2019, Kolkata, 17-20 December 2019.
- S. Singh, D. K. Goswami, S. K. Ray, "Core-shell heterojunction of Si nanocones and CZTS nanocrystals for optoelectronic devices", International Conference on Nano Science and Technology, Kolkata, 5-7 March 2020.

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Total number of Other Publications : 32

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IMPACT FACTOR FOR PUBLICATIONS IN THE FINANCIAL YEAR 2019-20

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
1	ACS Applied Materials & Interfaces	8.758	2	17.516
2	ACS Applied Nano Materials		4	0
3	ACS Omega	2.87	8	22.96
4	ACS Sustainable Chemistry & Engineering	7.632	3	22.896
5	Acta Mech	2.102	2	4.204
6	Advanced Materials Interfaces	4.948	1	4.948
7	Advanced Optical Materials	8.286	1	8.286
8	Advances in Space Research	2.177	2	4.354
9	AIP Advances	1.337	1	1.337
10	Analytical Chemistry	6.785	2	13.57
11	Annals of physics	2.083	1	2.083
12	APL Materials	3.819	1	3.819
13	Applied Catalysis A: General	5.006	1	5.006
14	Appl. Phys. Lett	3.597	1	3.597
15	Applied Surface Science	6.182	2	12.364
16	Astronomical Journal	5.838	1	5.838
17	Astrophysical Journal	5.745	3	17.235
18	Biomaterials Science	6.183	1	6.183
19	Biomolecular Concepts	1.011	1	1.011
20	Biophysical Chemistry	1.995	1	1.995
21	Biopolymers	2.248	1	2.248
22	Chem. Commun	5.996	2	11.992
23	Chemical Engineering Journal	10.652	2	21.304
24	Chemical Engineering Science	3.871	1	3.871
25	Chem. Eur. J.	4.857	1	4.857
26	Chemical Physics	1.771	2	3.542
27	Chemistry Letters	1.485	1	1.485
28	ChemistrySelect	1.811	1	1.811
29	CHEMCATCHEM	4.853	1	4.853
30	ChemMedChem	3.124	1	3.124
31	Classical and Quantum Gravity	3.071	1	3.071
32	Comm. Monlin. Sci. Numer. Simul	4.115	1	4.115

SI No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
33	Computational Biology and Chemistry	1.85	1	1.85
34	Computational Materials Science	2.863	1	2.863
35	Cryst. Growth Des.	4.089	3	12.267
36	Dalton Trans	4.174	1	4.174
37	Discrete & Continuous Dynamical Systems - B	1.27	1	1.27
38	Energy	6.082	1	6.082
39	European Physical Journal C	4.389	4	17.556
40	European Physical Journal E	1.812	1	1.812
41	European Physical Journal Plus	3.228	1	3.228
42	Europhysics Letters	1.958	1	1.958
43	Fluctuation and Noise Letters	0.988	1	0.988
44	General Relativity and Gravitation	2.03	2	4.06
45	IEEE J. Biomed. Health Informatics	4.217	1	4.217
46	IEEE Sensors Journal	3.076	1	3.076
47	IEEE Transactions on Electron Devices	2.62	1	2.62
48	International Journal of Biological Macromolecules	5.162	1	5.162
49	International Journal of Geometric Methods in Modern Physics	1.287	2	2.574
50	International J. Pharmaceutics	4.845	1	4.845
51	International Journal of Quantum Chemistry	1.747	1	1.747
52	Ionics	2.394	1	2.394
53	Journal of Alloys and Compounds	4.65	2	9.3
54	J. Amer. Chem. Soc	14.612	1	14.612
55	Journal of Analytical Atomic Spectrometry	3.498	1	3.498
56	Journal of Applied Physics	2.286	4	9.144
57	Journal of Biomolecular structure and Dynamics	3.31	1	3.31
58	Journal of Chemical Physics	2.991	3	8.973
59	Journal of Chemical Sciences	1.406	1	1.406
60	Journal of Dairy Science	3.333	1	3.333
61	Journal of Electronic Materials	1.774	1	1.774
62	Journal of Luminescence	3.28	3	9.84
63	Journal of Magnetism and Magnetic Materials	2.717	13	35.321
64	Journal of Mathematical Physics	1.317	1	1.317
65	Journal of Molecular Liquids	5.065	3	15.195
66	Journal of Molecular Spectroscopy	1.229	1	1.229
67	Journal of Nanoparticle Research	2.132	1	2.132

SI No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
68	Journal of Photochemistry and Photobiology A: Chemistry	3.306	1	3.306
69	Journal of Physical Chemistry A	2.6	2	5.2
70	Journal of Physical Chemistry B	2.857	7	19.999
71	Journal of Physical Chemistry C	4.189	2	8.378
72	Journal of the Physical Society of Japan	1.485	1	1.485
73	Journal of Physics D: Applied Physics	3.169	1	3.169
74	Journal of Physics: Condensed Matter	2.707	5	13.535
75	J Raman Spectrosc	2	1	2
76	J. Stat, Mech. Theo. Expt.	2.215	1	2.215
77	Langmuir	3.557	2	7.114
78	Materials Chemistry and Physics	3.408	2	6.816
79	Materials Research Bulletin	4.019	1	4.019
80	Materials Research Express	1.929	4	7.716
81	Modern Physics Letters A	1.391	3	4.173
82	Monthly Notices of the Royal Astronomical Society	5.356	6	32.136
83	Nanoscale Advances	3.119	1	3.119
84	Nanotechnology	3.551	6	21.306
85	Nature Communications	11.878	2	23.756
86	Nelineinaya Dinamika	0.623	1	0.623
87	New Journal of Chemistry	3.288	4	13.152
88	Nonlinear Dynamics	4.867	1	4.867
89	Nuclear Physics B	2.817	1	2.817
90	Optics Express	3.669	1	3.669
91	Physica A: Statistical Mechanics and its Applications	2.924	2	5.848
92	Physica B	1.902	3	5.706
93	Physica E	3.57	1	3.57
94	Physica Scripta	1.985	1	1.985
95	Physica Status Solidi B: Basic Solid State Physics	2.291	1	2.291
96	Physical Chemistry Chemical Physics	3.43	6	20.58
97	Physical Review A	2.777	8	22.216
98	Physical Review Applied	4.194	4	16.776
99	Physical Review B	3.575	16	57.2
100	Physical Review D	4.833	6	28.998
101	Physical Review E	2.296	7	16.072
102	Physical Review Letters	8.385	2	16.77

Sl No.	Name of Journal	Journal Impact Factor	No. of Papers Published	Total of Impact Factor in the Journal
103	Physical Review Materials	3.337	3	10.011
104	Physical Review Research	1.811	2	3.622
105	Physics Letters B	4.384	2	8.768
106	PLOS ONE	2.74	1	2.74
107	PNAS	9.412	1	9.412
108	Quanta	0.67	1	0.67
109	Quantum	7.286	1	7.286
110	Quantum Information Processing	2.419	3	7.257
111	RSC Advances	3.119	4	12.476
112	Science Advances	13.116	1	13.116
113	Scientific Reports (Nature Publishing Group)	3.998	4	15.992
114	Semiconductor Science and Technology	2.361	2	4.722
115	Soft Matter	3.14	2	6.28
116	Solar Energy Materials and Solar Cells	6.984	1	6.984
117	Solid State Physics	2.434	1	2.434
118	Solid State Sciences	2.434	1	2.434
119	Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy	3.232	2	6.464
	TOTAL	440.928	263	943.852



A Comparative Study between the Impact Factor of Journals and the Number of Papers Published in those Journals

Impact Factor of Journals

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+ +>

RESEARCH PUBLICATION STATUS

Citation Report (On 5th June, 2020)

Time span = All years. Database = SCI-EXPANDED, CPCI-S, CPCI-SSH, CCR-EXPANDED, IC.

Total Publications 3,374 Analyze



Sum of Times Cited per Year



No. of Publications	:	3374
Sum of the Times Cited	:	42570
Sum of Times Cited without self-citations	:	33799
Citing Articles	:	27681
Citing Articles without self-citations	:	25325
Average Citations per Item	:	12.62
h-index	:	75

Total no. of Papers published	Total no. of Citation received	Citations per paper	Citation per year*	h-index	
3374	42570	42570 / 3374= 12.62	42570 / 33 =1290	75	
* Year of establishment of the Centre is 1986. Citations received from 1988 to $2020 = 33$ 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

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BUDGET SUMMARY 2019-2020

SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 106

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the year 2019-2020.

			(Figure in Lakhs)
	Actuals 2018-2019	Budget Estimate 2019-2020	Revised Estimate 2019-2020
Plan	3877.65	4601.13	4161.71
TOTAL	3877.65	4601.13	4161.71

Plan

Sl no.	Sanction Letter No.	Dated	Amount (Rs.)
1	AI/SNB/SAL/003/2019/1	29/04/2019	23741000.00
2	AI/SNB/GEN/003/2019/1	13/05/2019	23288000.00
3	AI/SNB/CAP/003/2019/1	07/05/2019	10663000.00
4	AI/SNB/CAP/003/2019/2	28/06/2019	7109000.00
5	AI/SNB/GEN/003/2019/2	29/06/2019	15103000.00
6	AI/SNB/SAL/003/2019/2	28/06/2019	8360000.00
7	AI/SNB/SAL/003/2019/3	02/09/2019	72948000.00
8	AI/SNB/GEN/003/2019/3	29/09/2019	61469000.00
9	AI/SNB/CAP/003/2019/3	29/09/2019	35218000.00
10	AI/SNB/GEN/003/2019/4	30/12/2019	19971000.00
11	AI/SNB/SAL/003/2019/4	30/12/2019	21010000.00
12	AI/SNB/CAP/003/2019/4	30/12/2019	10598000.00
13	AI/SNB/SAL/003/2019/5	11/02/2019	14006000.00
14	AI/SNB/CAP/003/2019/5	28/02/2020	7065000.00
15	AI/SNB/GEN/003/2019/5	28/02/2020	13315000.00
	TOTAL (PLA	N)	Rs. 343864000.00

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, 2020, 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.Credit of Rs 11,66,145 in Union Bank of India not responded by Centre-Refer note no 2.2.4 of Schedule-25

2.26AS statement of Traces could not be opened and therefore T.D.S receivable and income relating thereto could not be ascertained and accounted for.

3.T.D.S liability as per Traces of Rs 1,36,569 not 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) Difference between guest house income as per account and guest house record of Rs 2,51,510 is not accounted pending reconciliation. Refer to note no-2.2.5 of schedule-25.

C) Bank interest on S.B & Fixed deposit account refundable to DST-Rs1,93,54,120.Refer to schedule-7.

This amount relates to interest earned for the FY-2019-20-Refer to note 2.2.6 of schedule-25

Responsibilities of Management and Those Charged with Governance for the Financial Statements

The management of the Centre is responsible for the preparation of the financial statements in accordance with the rules of the Centre and for such internal control as the management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the entity's financial reporting process.

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

 Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by 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 Mookherjee Biswas & Pathak, Chartered Accountants FRN: 301138E

(S P Mukherjee) Partner M. No. 010807 UDIN: 20010807AAAABC9324

 Place:
 Kolkata

 Date:
 05-09-2020

BLOCK JD, SECTOR-III, SALT LAKE, KOLKATA - 700 106

BALANCE SHEET AS AT 31 ST MARCH 2020 Am						
FUNDS AND LIABILITIES	Schedule	Current Year	Previous Year			
Capital / Corpus Fund	1	1053452329.61	1036922087.13			
Reserves And Surplus	2	-				
Earmarked/Endowment Funds	3	511608573.70	523723174.73			
Secured Loans And Borrowings	4					
Unsecured Loans And Borrowings	5					
Deferred Credit Liabilities	6					
Current Liabilities And Provisions	7	75093543.31	80433185.31			
TOTAL		1640154446.62	1641078447.17			
ASSETS						
Fixed Assets	8	676825377.77	684029447.36			
Investments-From Earmarked/Endowment Funds	9	171008898.00	172387641.38			
Investments - Others	10	476771951.00	595324963.00			
Current Assets, Loans, Advances Etc.	11	315548219.85	189336395.43			
Miscellaneous Expenditure						
(to the extent not written off or adjusted)						
TOTAL		1640154446.62	1641078447.17			
Significant Accounting Policies	24					
Contingent Liabilities And Notes On Accounts	25					

As Per our report of even date

Date: 05.09.2020 **Place:** Kolkata

For Mookherjee Biswas & Pathak

Chartered Accountants FRN: 301138E

(S P Mukerjee)

Partner Membership no:010807

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

INCOME AND EXPENDITURE ACCOUNT

FOR THE YEAR ENDED 31ST MARCH 2020

FOR THE YEAR ENDED 31 ST MARCH 2020			Amount (Rs.)
	Schedule	Current Year	Previous Year
INCOME			
Income from Sales/Services	12	10503233.00	7382797.00
Grants/Subsidies	13	273211000.00	313188000.00
Fees/Subscriptions(Student Admission & Semester Fees)	14	404,500.00	
Income from Investments (Income on Investment)	15		
from earmarked/endowment Funds transferred to Funds)			
Income from Technology Transfer & Contract Project	16	1,050,000.00	1200000.00
Interest on loan(HBA etc.) to employees	17	223164.00	25375118.00
Other Income	18	510272.80	461888.20
Increase/(decrease) in stock of finished goods and	19		
works-in-progress			
TOTAL (A)		285902169.80	347607803.20
EXPENDITURE			
Establishment Expenses	20	163779626.00	139814819.00
Other Administrative Expenses etc.	21	156376092.38	175463456.13
Expenditure on Grants, Subsidies etc.	22		
Bank interest adjustable (refunded to DST shown separately in schedule 7			25094860.00
TOTAL (B)		320155718.38	340373135.13
Balance being excess of Income over Expenditure(A-B)		(34253548.58)	7234668.07
Prior period adjustments (Credit)		3082522.65	1244535.74
Transfer to/from Capital Fund			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO			
CORPUS/CAPITAL FUND		-31171025.93	8479203.81
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

As Per our report of even date Date: 05.09.2020 Place: Kolkata

For Mookherjee Biswas & Pathak

Chartered Accountants FRN: 301138E

(S P Mukerjee)

Partner Membership no:010807

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BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

RECEIPTS AND PAYMENTS ACCOUNTS For the year ended 31st March 2020

					Amount (Rs.)
RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			I. Expenses :		
a) Cash in hand	32161.00	25681.00	a) Establishment Expenses	179124691.00	170295699.00
b) Bank Balances :			b) Administrative Expenses	128941810.43	139190830.07
I. In current accounts(Schd 11A)	67299391.44	17173847.86	c) Maintenance	51584815.00	48265361.00
ii. In deposit accounts			II. Payments made against funds for		
Schedule - 10	595324963.00	624873415.00	various Projects		
Schedule - 11A	26326381.00	35689927.00			
iii. Savings accounts (Schd 11A)	60880054.85	21980563.01	III. Investments and deposits made		
iv. Remittance-in-Transit			a) Out of Earmarked/Endowment		22603185.00
II. Grants Received			b) CPWD Deposit and NBCC Deposit		
a) From Government of India			c) Bank Gurantee & LC A/C	140671099.94	3024500.00
-For the year	502623969.00	592441737.00	d) Out of Own Fund	510195994.00	38911998.00
-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	124173335.00	144238520.00
To be shown separately)			b) Expenditure on Capital Work- in-Progress	2839156.00	8,029,954.00
			V. Refund of Interest		
III. Interest Received			a) To the Government of India	33917073.00	
a) On Bank deposits	9829482.00	9956510.00	b) To the State Government		
			c) To other providers of funds		
IV. Other Income	4160210.00	5399232.00	VI. Finance Charges (Interest)		
V Amount Borrowed			VII. Other Payments	48233320.94	80470326.67
VI. Any other receipts	21600624.36	16081330.16	VIII. Closing Balances		
			a) Cash in hand	40650.00	32161.00
VII. Amount transferred from Current Account/	459685273.94	1222485.00	b) Bank Balances :		
Savings Account to Deposit Account.			I. In current accounts(Schd	50204316.87	67299391.44
			11A)		
			ii. In deposit accounts		
VIII. Amount transferred from Deposit Account	223432733.00	80048597.00	Schedule - 10	476771951.00	595324963.00
to Savings Account & Currect Account.			Schedule - 11A	163055800.94	26326381.00
			iii. Savings accounts(Schd.11A)	61441229.47	60880054.85
			iv. Remittance-in-Transit		
	1971195243.59	1404893325.03		1971195243.59	1404893325.03

Per our report of even date Date: 05.09.2020 Place: Kolkata For Mookerjee Biswas & Pathok Chartered Accountants FRN: 301138E

> (S P Mukerjee) Partner Membership no: 010807

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALA	NCE SHEET AS	AT 31.03.2020		Amount (Rs.)
	Cur	rent Year	Previ	ous Year
SCHEDULE 1 -CAPITAL FUND:				
Balance as at the beginning of the year	1060635560.63		1048440173.65	
Add:Interest earned on FD and savings bank(adjustable) for last year			16126971.00	
Add : Contributions towards Corpus/ Capital Fund	70653000.00		35914000.00	
Less:Depreciation for the year	46665205.09		72038261.33	
Add : Surplus during the year	-31171025.93		8479203.81	
		1053452329.61		1036922087.13
BALANCE AS AT THE YEAR - END		1053452329.61		1036922087.13
	`	×	`	``
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		-		-

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

							Amount (Rs.)
		FUNI	D-WISE BREAK	UP			TOTAL
	Technical Research Centre	Project Fund	Retirement Benefits Fund	Staff Medical Fund	Corpus Fund	Current Year	Prev. Year
SCHEDULE 3 - EARMARKED/ ENDOWMENT FUNDS							
a) Opening balance of the funds	328089220.62	82259671.73	91588814.00	6785315.00	15000153.38	523723174.73	477094566.55
b) Additions to the Funds							
I) Donations/grants/ Contributions	100000000.00	60829615.00	3302635.00	706036.00	1324015.00	166162301.00	254778097.00
ii) Income from investments made on	14026045.00	2861683.00	7965195.00	516998.00	913068.62	26282989.62	24729880.00
account of funds							
iii) Other additions -Provision during the year	-						
TOTAL (a + b)	442115265.62	145950969.73	102856644.00	8008349.00	17237237.00	716168465.35	756602543.55
c) Utilisation/Expenditure towards							
objectives of funds							
i) Capital Expenditure							
Fixed Assets	103689442.00	5,249,359.54					132439469.00
Others							
Total							
ii) Revenue Expenditure							
Salaries, Stipen and	18008168.00	26,103,071.00					36753788.00
allowances etc.							
Rent							
Other Administrative							
expenses							
Other Payments	12849480.68	8,104,099.43	213730.00	516998.00	0.00	21684308.11	45310037.82
iii) Adjustment (Interest)							
Interest Refunded to DST	29754458.00	71085.00	0.00	0.00	0.00	29825543.00	18376074.00
TOTAL (c)	164301548.68	39527614.97	213730.00	516998.00	0.00	51509851.11	232879368.82
NET BALANCE AS AT THE YEAR-END (a+b-c)	277813716.94	106423354.76	102642914.00	7491351.00	17237237.00	511608573.70	523723174.73
	277813716.94	106423354.76	102642914.00	7491351.00	17237237.00	664658614.24	523723174.73

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2020

			A	mount (Rs.)
	Currer	nt Year	Previo	us 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

Amount (Rs.)

	Current	Year	Previou	ıs 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

	Curre	nt Year	Previo	ous Year
SCHEDULE 6 - DEFERRED CREDIT LIABIILTIES:				
a) Acceptances secured by hypothecation of capital equipment and other assets				
b) Others				
TOTAL	Nil	Nil	Nil	Nil

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

		Amount (Rs.)
	Current Year	Previous Year
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS		
A. CURRENT LIABILITIES		
1. Acceptances		
2. Sundry Creditors:		
a) For Capital expenditure	9620879.00	3424270.00
b) Others - Revenue expend.(including TRC)	13354778.00	26528648.00
3. Othert Liabilities	10760441.88	5108903.88
4. Deposit from Contractors (including Project & TRC)	11271865.00	10831285.00
5. Deposit from Students	1858500.00	1714500.00
6. Deposit from Contractual Employees	1705199.00	1819148.00
7.Provident Fund Account (Payable)	1042076.00	472.00
8.Project Overhead Fund	6125684.43	5911098.43
9.Interest earned on fixed deposit and savings bank (adjustable)	19354120.00	25094860.00
TOTAL (A)	75093543.31	80433185.31
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)	75093543.31	80433185.31

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

ASSETS
FIXED
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CHEDULE 8

SCHEDULE 8 - FIXED	ASSETS									Amount (Rs.)
		GROS	S BLOCK				DEPRECIAT	NOI	N	T BLOCK
DESCRIPTION	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	Adjus ment , 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			10950654.60				0.00	10950654.60	10950654.60
2. BUILDINGS:										
a) On Leasehold Land	437288443.86	9683580.00		446972023.86	59687158.30	6925694.50		66612852.80	380359171.06	377601285.56
b) On Freehold Land										
c) Ownership Flats/Premises										
d) Superstructures on Land										
not belonging to the entity										
3. PLANT MACHIENRY & EQUIPMENT	483624999.22	12270493.00	2851730.00	493043762.22	393208257.66	33129894.03	2709143.50	423629008.19	69414754.03	90416741.56
4. VEHICLES	1042199.00			1042199.00	374272.56	85640.84		459913.40	582285.60	667926.44
5. FURNITURE, FIXTURES	41100181.22	632839.00		41733020.22	30881532.29	2723474.38		33605006.67	8128013.55	10218648.93
6. OFFICE EQUIPMENT	5990798.29	165106.00		6155904.29	4346142.84	738419.11		5084561.95	1071342.34	1644655.45
7. COMPUTER & LAN INSTALLATION	76016866.44	9288474.00		85305340.44	67550784.78	2064655.80		69615440.58	15689899.86	8466081.66
8. ELECTRIC INSTALLATIONS	11699040.00			11699040.00	6539470.18	997426.43		7536896.61	4162143.39	5159569.82
9. LIBRARY BOOKS	239167668.11	11909574.00		251077242.11	69586478.05			69586478.05	181490764.06	169581190.06
10. TUBEWELLS & W.SUPPLY										T
11. OTHER FIXED ASSETS	84225.55			84225.55	80014.27			80014.27	4211.28	4211.28
TOTAL OF CURRENT YEAR	1306965076.29	43950066.00	2851730.00	1348063412.29	632254110.93	46665205.09	2709143.50	676210172.52	671853239.77	674710965.36
PREVIOUS YEAR	1261937437.29	45027639.00		1306965076.29	560215849.60	72038261.33		632254110.93	674710965.36	701721587.69
B. CAPITAL WORK IN PROGRESS	9318482.00	5203711.00	9550055.00	4972138.00					4972138.00	9318482.00
TOTAL $(A + B)$	1316283558.29	49153777.00	12401785.00	1353035550.29	632254110.93	46665205.09	2709143.50	676210172.52	676825377.77	684029447.36

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

		Amount (Rs)
	Current Year	Previous Year
SCHEDULE 9 - INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS		
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Project Fund Investment	48491523.00	53848010.00
7. Retirement Benefit Fund Investment	104608149.00	101905864.00
8. Staff Medical Fund Investment	6275397.00	5777995.00
9.Corpus Fund Investment (Project)	11633829.00	10855772.38
TOTAL	171008898.00	172387641.38

	Current Year	Previous Year
SCHEDULE 10 - INVESTMENTS - OTHERS		
1. In Government Securities		
2. Other approved Securities		
3. Shares		
4. Debentures and Bonds		
5. Subsidiaries and Joint Ventures		
6. Others - Fixed Deposit with Indian Overseas Bank (including Project overhead investment)	217757716.00	142053297.00
Fixed Deposit with Union Bank of India	115725835.00	158850194.00
7.TRC Fund Investment	143288400.00	294421472.00
TOTAL	476771951.00	595324963.00

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

				Amount (Rs.)	
	Currer	t Year Previo		us Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.					
A. CURRENT ASSETS:					
1. Inventories:					
a) Stores and Spares		32969.57		66894.14	
2) Cash balances in hand		40650.00		32161.00	
3) Bank Balances:					
a) With Scheduled Banks:					
On Current Accoutns:					
Indian Overseas Bank (CA-08930200000220)	5851734.83		52224297.82		
Indian Overseas Bank (CA-08930200000273)	24960392.69		12308994.46		
Union Bank of India (CA-460901010034252)	19392189.35	50204316.87	2766099.16	67299391.44	
On Deposit Accounts for LC&BG:					
Indian Overseas Bank (CA-08930200000220)	44145695.00		11840183.00		
Indian Overseas Bank (SB-089301000018596 TRC)	118910105.94		10544518.00		
Indian Overseas Bank (CA-08930200000273 PROJECT)		163055800.94	3941680.00	26326381.00	
On Savings Accounts:					
Indian Overseas Bank(SB-089301000010662 UNAST)	3426009.30		1030917.00		
Indian Overseas Bank(SB-089301000012029 SYNC.)	768078.30		741833.30		
Indian Overseas Bank(SB-089301000011479 NANO TECH)	544634.00		526040.00		
Union Bank of India (SB-460901110050013)	8047146.37		7987205.93		
Axis Bank (SB-775010100024408)	7023124.00		26975822.00		
Axis Bank (SB-775010100017860)	1742.00		1682.00		
Union Bank of India(SB-460902010097273 TRC)	8901589.80		8545271.80		
Indian Overseas Bank (SB- 089301000018598 TRC)	8923516.10		15071282.82	60880054.85	
HDFC Bank (SB-6771192)	5000.00				
Indian Overseas Bank-(SB-089302000019902)	23800389.60	61441229.47			
5. Remittance - in - Transit					
6. Post Office-Savings Accounts					
TOTAL (A)		274774966.85		154604882.43	

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

				Amount (Rs.)
	C	urrent Year	Pre	evious Year
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.(Contd.)				
B. LOANS, ADVACNES AND OTHER ASSETS				
1. Loans:				
a) Staff including HBA ,Vehicle &PC Advance(includes Project A/c)	2051063.00	2051063.00		1724551.00
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account - Bridge & Roof and CPWD Deposit Account	438840.00		438840.00	
b) GST payment			0.00	
c) Others	305430.00		315650.00	
d) Contractors & Suppliers	5375275.00	6119545.00	4407461.00	5161951.00
3. Income Accrued:				
a) On Investments from Earmarked/Endowment Funds(Including Project & TRC)	26453690.00		16620322.00	
b) On investmetns - Others	5885337.00		10476071.00	
c) Income tax (TDS) Refundable	175000.00	32514027.00	70000.00	27166393.00
4.Sundry Debtors - Ezerex Health Tech Pvt.Ltd				590,000.00
5. Security Deposit		88618.00		88618
TOTAL (B)		40773253.00		34731513.00
TOTAL (A + B)		315548219.85		189336395.43

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2020

		Amount (Rs.)
	Current Year	Previous Year
SCHEDULE 12 - INCOME FROM SALES/SERVICES		
1) Income from Sales		
a) Sale of Finished Goods		
b) Sale of Raw Material		
c) Sale of Scraps		3225.00
2) Income from Services		
a) Guest House Rent	2346620.00	2006500.00
b) Hostel Charges (Recovery of HRA)	5515540.00	3117813.00
c) Equipment Utilisation Fees	570800.00	404803.00
d) Hostel Maintenance Fees	1508452.00	1345221.00
e) Project Overhead	433783.00	437960.00
f) Income from BSNL	113038.00	33275.00
g) Seminer Hall Rent	15000.00	20000.00
h) Dining Hall Rent	0.00	0.00
i) Course Fees	0.00	14000.00
TOTAL	10503233.00	7382797.00

	Current Year	Previous Year
SCHEDULE 13 - GRANTS/SUBSIDIES (Irrevocable Grants & Subsidies Received)		
1) Central Government	273211000.00	313188000.00
2) State Government(s)		
3) Government Agencies		
4) Institutions/Welfare Bodies		
5) International Organsations		
6) Others		
TOTAL	273211000.00	313188000.00

	Current Year	Previous Year
SCHEDULE 14 - FEES/SUBSCRIPTIONS		
1) Student Admission Fee	94500.00	
2) Annual Fees/Subscriptions		
3) Student Semester Fee	310000.00	
4) Consultancy Fees		
5) Others		
TOTAL	404500.00	Nil

Note: Accounting Policies towards each item are to be disclosed

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2020

Amount (Rs.)

SCHEDULE 15 - INCOME FROM INVESTMENTS	Investment from Earmarked Fund		Invest	ment - Others
(Income on Invest. From Earmarked/Endowment Funds transferred to Funds)	Current Year	Previous Year	Currnet Year	Previous Year
1) Interest				
a) On Govt. Securities				
b) Other Bonds/Debentures				
2) Dividends:				
a) On Shares				
b) On Mutual Fund Securities				
3) Rents				
4) Others				
TOTAL	Nil	Nil	Nil	Nil
TRANSFERRED TO EARMARKED/ ENDOWMENT FUNDS	Nil	Nil	Nil	Nil

	Current Year	Previous year
SCHEDULE 16 - INCOME FROM TECHNOLOGY TRANSFER & CONTRACT PROJECT		
1. Income from Technology Transfer	1050000.00	700000.00
2. Income from Contract Project		500000.00
3. Others		0.00
TOTAL	1050000.00	1200000.00

	Current Year	Previous year
SCHEDULE 17 - INTEREST EARNED		
1) On Term Deposits:		
a) With Scheduled Banks	0.00	24931853.00
b) With Institutions		
c) Others		
2) On Savings Accounts:		
a) With Scheduled Banks	0.00	163007.00
b) Post Office Savings Accounts		
c) Others		
3) On Loans:		
a) Employees/Staff (Interest on HBA etc.)	223164.00	280258.00
b) Others		
4) Interest on Debtors and Other Receivables		
TOTAL	223164.00	25375118.00

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2020

		Amount (Rs.)
	Current Year	Previous Year
SCHEDULE 18 - OTHER INCOME		
1) Profit on Sale/disposal of Assets:		
a) Owned assets		
b) Assets acquired out of grants, or received free of cost		
2) Export Incentives realized		
3) Fees for Miscellaneous Services		
4) Miscellaneous Income	510272.80	461888.20
TOTAL	510272.80	461888.20

	Current Year	Previous Year
SCHEDULE 19 - INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS		
a) Closing stock		
Finished Goods		
Work-in-progress		
b) Less: Opening Stock		
Finished Goods		
Work-in-progress		
NET INCREASE/(DECREASE) [a-b]	Nil	Nil

	Current Year	Previous Year
SCHEDULE 20 - ESTABLISHMENT EXPENSES		
a) Salaries and Wages	99862201.00	104155290.00
b) Other Allowances and Bonus	0.00	0.00
c) Contribution to Provident Fund	3759139.00	4038424.00
d) Contribution to Retirement Benefits Fund	3146563.00	3474832.00
e) Staff Welfare Expenses (Medical)	2397859.00	2455554.00
f) Contribution to NPS	3265073.00	2826205.00
g) Others (LTC, Leave Encashment on LTC, Re-imbursement of Tuition Fees etc.)	2650877.00	3695126.00
h)Fellowships(Phd. Students & Post Doc. Fellows)	48697914.00	36190204.00
TOTAL	163779626.00	156835635.00

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SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2020

		Amount (Rs.)
	Current Year	Previous Year
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.		
a) Extended Visitors Programme.(Including Seminars & Workshops)	4038786.80	13141359.00
b) Meeting Expenses	968718.00	1062167.00
c) Library General Expenses	98582.00	128870.00
d) Electricity and Power	37260989.00	36197454.00
e) Laboratory Expenses	12037347.00	11182577.55
f) Insurance	17007.00	85608.00
g) Repairs and Maintenance	67322811.57	57024227.43
h) TPSC Programme	662217.00	1073815.00
i) Parliamentary Committee Meeting Exps	0.00	1352225.00
j) Vehicles Hire Charges	2117535.00	2457104.00
k) Postage, Telephone and Communication Charges	886278.00	1298219.00
l) Printing and Stationary	895500.00	1193841.00
m) Travelling and Conveyance Expenses	2743821.00	2709889.00
n) Contingency to Faculty	12966.00	337390.00
o) Auditors' Remuneration	48200.00	47200.00
p) Bank Charges	692888.92	683178.67
q) Professional Charges (Legal Charges)	386319.00	864047.00
r) Staff Training & Welfare	204651.00	162282.00
s) Patent & Trademark	171202.00	332,050.00
t) Integrated Ph.D.	5334145.00	5769368.00
u) Hindi Programme	64196.00	80424.00
v) Advertisement and Publicity	458003.00	732417.00
w) Others	1100004.09	557894.48
x) Municipal Tax	146968.00	141388.00
y) Bose Archive Expenses	6300.00	658257.00
z) Contract Services	18700657.00	19169388.00
TOTAL	156376092.38	158442640.13

BLOCK-JD, SECTOR III, SALT LAKE CITY, KOLKATA 700 106

SCHEDULES FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31.03.2020

		Amount (Rs.)
	Current Year	Previous Year
SCHEDULE 22 - EXPENDITURE ON GRANTS, SUBSIDIES ETC.		
a) Grants given to Institutions/Organisations		
b) Subsidies given to Institutions/Organisations		
TOTAL	Nil	Nil

	Current Year	Previous Year
SCHEDULE 23 - INTEREST		
a) On Fixed Loans		
b) On Other Loans (including Bank Charges)		
c) others		
TOTAL	Nil	Nil

BLOCK-JD, SECTOR-III, SALT LAKE, KOLKATA-700 106

SCHEDULE 24

SIGNIFICANT ACCOUNTING POLICIES

1. ACCOUNTING CONVENTION

The financial statements are prepared on the basis of historical cost convention, unless otherwise stated and on the accrual method of accounting. Interest on interest bearing loans/advances granted to the staff and Guest House Rent are accounted on cash basis. Interest on Fixed deposit on lien against LC/BG is accounted on Cash basis.

2. INVENTORY VALUATION

2.1 Stores and Spares (including machinery spares) are valued at cost.

3. INVESTMENTS

3.1 Investments are valued at cost.

4. FIXED ASSETS

- 4.1 Fixed assets are stated at cost of acquisition inclusive of inward freight, duties and taxes and incidental and direct expenses related to acquisition, as well as customs duty & clearing charges on imported equipment are also capitalized.
- 4.2 Fixed Assets received by way of non-monetary grants (other than towards the Capital Fund), are capitalized at value stated / agreed by corresponding credit to Capital Fund. Incomplete work is shown as Capital-Work- in Progress to be capitalized on completion.
- 4.3 Library Books are accounted for on receipt basis and Journals are accounted for on payment basis.
- 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

6. FOREIGN CURRENCY TRANSACTIONS

6.1 Transactions denominated in foreign currency are accounted at the exchange rate prevailing at the date of transaction.

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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– Rs. 1, 77,52,725.94 (Previous year Rs.1,58,26,381.00) against 100% margin money. Interest earned on such deposit is accounted on cash basis.
 - Bills discounted with banks Rs. Nil (Previous year Rs. Nil).
- 1.3 Disputed demands in respect of:

Income-tax Rs. Nil (Previous year Rs. Nil)

Sales-tax Rs. Nil (Previous year Rs. Nil)

1.4 In respect of claims from parties for non-execution of orders, but contested by the Centre – Rs.Nil (Previous year Rs.Nil).

NOTES ON ACCOUNTS

2.1.1 Capital Commitments:

Estimated value of contracts remaining to be executed on capital account (renovation of external surface of Main Building) and not provided for Rs. 7,89,063.30 (Previous year Rs. 2,12,56,839/-).

- 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, 2019 was Rs. 93,18,482/- addition during the year is Rs.52,03,711/-, totaling to Rs.1,45,22,193/- an amount of Rs.95,50,055/- has been capitalized, leaving balance of Rs.49,72,138/- which has been carried forward.

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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	<u>Amount</u>	<u>Remarks</u>
Amrtya Sarkar	Rs. 63000/-	Unadjusted since 2012-13
Venkata Kamalakar	Rs. 70000/-	Unadjusted since 2008-09

- 2.2.4 Rs.11,66,145/- was credited through NEFT in Union Bank of India not adjusted during the Financial Year due to non availability of required information from the bank.
- 2.2.5 Difference of Rs.2,51,510/-in Guest House Income as Per Accounts and Guest House Records will be accounted after reconciliation.
- 2.2.6. Amount payable to DST –Rs.1,93,54,120/-- relates to Interest Earned on SB & Fixed.Deposits during the Financial Year 2019-20

2.3 Taxation

In view of there being no taxable income under Income-tax Act 1961, no provision for Income tax has been considered necessary.

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2.4 Foreign Currency Transactions

(i) Value of Imports Calculated on C.I.F basis :

	(Amount in Rs.)
<u>Current Year</u>	<u>Previous Year</u>
5,87,56,981/-	6,57,34,323 /-
13,83,430 /-	25,29,487 /-
	<u>Current Year</u> 5,87,56,981/- 13,83,430 /-

- (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: Net of TDS Rs.42,49,240/-
 - Bank Charges

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(iii) <u>Earnings:</u>

Value of Exports on FOB basis: Nil

2.5 Corresponding figures for the previous year have been re-grouped/re-arranged, wherever necessary.

Kolkata Dated: 05.09.2020





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