



SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES



Vol. 12, Issue 1 (2022)

Editorial

New year Greetings from the S. N. Bose Centre, Kolkata!

We are very happy to publish the online version of the Newsletter amid Covid-19 pandemic, thanks to the great efforts made by the Newsletter support staff and members.

We also thank all the contributors, who have sent their articles and made the Newsletter richer. The issue covers some significant academic and non-academic activities in the second half of the previous year. Hope you enjoy it. We wish you all to keep healthy and to have a great year ahead. All the best.



Professor Satyendra Nath Bose

News and Events (Academic)

Colloquium / Named Lectures

Series of talks on “Illustrious Indian Scientists in Pre-independence Era”

1. Prof. Sreerup Raychaudhuri, Tata Institute of Fundamental Research, Mumbai, delivered a lecture on the topic “*The Life and Work of Satyendra Nath Bose*” on 27-08-2021.

2. Prof. B. N. Jagatap, Chairman, Governing Body, S N Bose Centre & CSIR-National Institute of Science Communication and Policy Research, New Delhi, delivered a lecture on the topic “*Acharya Prafulla Chandra Ray : Why his Legacy Relevant Today*” on 21-09-2021.

3. Prof. Gautam Gangopadhyay, Department of Physics, University of Calcutta, delivered a lecture on the topic “*Meghnad Saha : Scientist, Builder, Planner*” on 17-12-2021.



Prof. B. N. Jagatap delivering a lecture at SNBNCBS



Prof. Gautam Gangopadhyay delivering a lecture

Webinar Series on “Quantum Materials and Devices” under VASP

1. Prof. Robert J Cava, Princeton University, USA, delivered a lecture on the topic “*Finding New Materials - a Chemical Perspective*” on 20.09.2021.
2. Prof. Anders W. Sandvik, Boston University, USA, delivered a lecture on the topic “*The enigmatic deconfined quantum critical point*” on 03.11.2021.
3. Prof. Subir Sachdev, Harvard University, USA, delivered a lecture on the topic “*Planckian Metals and Black Holes*” on 10-11-2021.
4. Prof. Rajiv R.P. Singh, University of California, Davis, USA, delivered a lecture on the topic “*Rare Earth Magnetic materials : Platforms for Exotic Spin States and Bose Condensation*” on 22-12-2021.

Webinar Series on “Statistical Mechanics” under VASP

1. Prof. Yariv Kafri, Technion-Israel Institute of Technology, Israel, delivered a lecture on the topic “*The long-ranged influence of disorder on active systems*” on 21-11-2021
2. Prof. Mehran Kardar, Massachusetts Institute of Technology, USA, delivered a lecture on the topic “*Forces from non-equilibrium fluctuations in Active Matter and QED*” on 30-11-2021.

Bose Colloquium

1. Prof. Shobhana Narasimhan, Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, delivered a lecture on the topic “*Designing novel nanomaterials: one atom at a time*” on 20.08.2021.
2. Prof. Mustansir Barma, Tata Institute of Fundamental Research, Hyderabad, delivered a lecture on the topic “*Random Walks in Driven, Arrested and Coded Systems*” on 03.09.2021.
3. Prof. Roop Mallik, Indian Institute of Technology, Bombay, delivered a lecture on the topic “*ON and OFF Controls inside a Cellular Nano-machine*” on 17.09.2021.
4. Prof. Partha P. Majumder, National Science Chair (Scientific Excellence), Government of India, delivered a lecture on the topic “*Genome Diversity in Asia*” on 10.11.2021.



Prof. Partha P. Majumder delivering a lecture

Institute Colloquium

1. Dr. Purna Sharma, Department of Physics, Indian Institute of Science, Bengaluru, delivered a lecture on the topic “*Mechanics of ciliary beating and phototaxis*” on 30.07.2021.
2. Dr. Sarika Maitra Bhattacharyya, Sr. Principal Scientist, Professor, ACSIR CSIR-National Chemical Laboratory, Pune, delivered a lecture on the topic “*Random Walks in Driven, Arrested and Coded Systems*” on 10.09.2021.

3. Dr. Debashree Ghosh, School of Chemical Sciences, Indian Association for the Cultivation of Science, Kolkata delivered a lecture on the topic “*Quantum chemistry methods to study strongly correlated systems from variational to machine learning approaches*” on 1.10.2021.
4. Prof. B. Ananthanarayan, Centre for High Energy Physics, Indian Institute of Science, Bengaluru delivered a lecture on the topic “*The Life and Scientific Work of Steven Weinberg*” on 12.11.2021.

Scientific Stories

Quantum Materials

Nitesh Kumar

*Department of Condensed Matter Physics and Material Sciences
S N Bose National Centre for Basic Sciences, Kolkata*

If you think the world around you with today's technology is changing with a fast pace then think again. Just think of a future where your laptop can be much faster than the most powerful present-day supercomputers and that too without consuming any significant battery power. Imagine that the energy stored by the renewable sources can be transported anywhere without almost no loss. In the event of a pandemic new drugs and vaccines can be designed in no time. These are only the glimpses of what a class of extraordinary materials dubbed as 'quantum materials' are capable of in real life applications. Quantum mechanics dictates the term in the microscopic level in all matter but the macroscopic properties of most of the materials could be approximated by classical picture. However, quantum materials are unique in the way that quantum picture must be invoked in order to understand their basic properties. Prime example is of graphene where the reduction of one dimension (perpendicular to the layer) to only the monolayer imparts many quantum-mechanical effects observed even at the room temperature. Other important classes of quantum materials are superconductors, topological insulators and semimetals, and quantum spin liquids. In superconductors, extreme correlation of electron wave functions causes complete loss of electrical resistance. This phenomenon is used presently for generating extreme magnetic fields and in future could revolutionize loss-less grid-based electrical transmission. In topological materials, unique topology of the electron wave functions protects electrons from being scattered from any defects present at the surface. Quantum fluctuations the quantum spin liquids stop them to form any conventional magnetic order down to the lowest temperature and spins of the electrons establish long-range entanglement. Topological superconductors and quantum spin liquids are the two main candidates for the realization of super-fast quantum computers.

The research in quantum materials needs a collective

effort because of its sheer importance, complexity, requirement of a variety of cutting edge-experimental and theoretical tools. At S. N. Bose National Centre for Basic Sciences, we have a pool of resources in terms of infrastructure and manpower to undertake exciting research in the field of quantum materials. In the theoretical front, a major activity led by Prof. Tanusri Saha-Dasgupta at our Centre is in the area of quantum materials simulation and prediction, with objectives such as, a) to understand the structure-property relations to predict new functionalities in quantum materials b) accelerated design and discovery of novel quantum materials, via a materials' informatics platform of database-driven high-throughput quantum simulations. Dr. Manoranjan Kumar leads the research in exploring attractive interactions and exotic pairing phases in cold atomic gases and superconductors using state-of-the-art numerical density matrix renormalization group (DMRG) techniques. Prof. Priya Mahadevan leads a group on computational condensed matter. The group works on one of the most recent and most interesting areas of quantum matter i.e., twisted bi-layers of van der Waals compounds. They see for example how with the twist angle (angle between two layers as against the natural order) the band structure and therefore the electronic correlations evolve which can prove fertile playground for exotic quantum phases such as superconductivity and other topological orders.

temperature. Our Centre has acquired infrastructure of performing electrical transport measurements at sub-kelvin temperatures and magnetic field as high as 12 tesla.

The group led by Dr. Atindra Nath Pal focuses on the fabrication of devices based on quantum materials using electron and photolithographic techniques and clean room facility at the Centre. The group studies the optoelectronic properties of transition metal dichalcogenides in the two dimensional limits. Another important area of research of the group is creating atomic or molecular junctions with mechanical break junction techniques to demonstrate quantum conductance of electrons at room temperature. Prof. Anjan Barman leads a group working on spintronics and spin dynamics. Using tools such as time-resolved magneto-optical Kerr microscopy and spectroscopy, terahertz time domain spectroscopy and Brillouin light scattering spectroscopy the group unravels many important effects such as spin waves, interfacial Dzyaloshinskii-Moriya interaction (iDMI) in skyrmionics systems, magnetic vortex and domain wall dynamics among others.

RS Ophiuchi: the recurrent nova that erupted again in August 2021

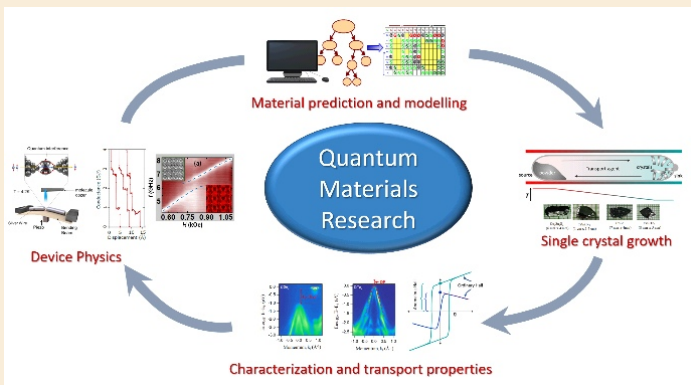
Ramkrishna Das

*Department of Astrophysics & Cosmology,
S N Bose National Centre for Basic Sciences, Kolkata*



Figure 1: Artist view of a nova system where a white dwarf (left) accumulates hydrogen-rich gas from its companion star. The material spirals down to the white dwarf surface and forms an accretion disk around the dwarf. The bottom layer is compressed and ignites in a thermonuclear blast. Image credit: ESO

More than half of the stars that we observe in the sky belong to binary or multiple star systems. Spectacular explosions keep occurring in few of the binary star systems. **RS Ophiuchi** (RS Oph) is such a stellar system located in the constellation "Ophiuchus", approximately 5,000 light-years away from the earth. The speciality of this system is that one of the stars is a tiny, compact and super-dense white dwarf (WD), while



One of the most important aspects of the research in quantum materials is the growth of high-quality single crystals. Dr. Thirupathaiah Setti leads the research on bulk single crystal growth and their characterization by spectroscopic and transport measurements. The group takes advantage of beamline facilities around the world for performing angle resolved photoemission spectroscopy (ARPES) in order to understand the electronic properties of topological insulators and semimetals. The group of Dr. Nitesh Kumar grows single crystals of various magnetic and nonmagnetic topological semimetals using chemical vapor transport and perform electrical and thermal transport measurements at low temperature and up to very high magnetic fields. A major focus is on the establishing ways to obtain large intrinsic anomalous Hall effect at room

the other component is a large red giant star. These two stars are orbiting each other and complete one rotation in about 454 days. The white dwarf orbits close to the red giant, accumulates hydrogen-rich mass from its companion giant star and forms an accretion disc around itself (Figure 1) where it gets compressed and heated by the dwarf's powerful gravity. When the bottommost layer of this disc reaches a temperature around 10 million degrees Celsius, it ignites the hydrogen fusion reactions in a brilliant thermonuclear flash that blows all the accumulated gas into space at a tremendous speed of few thousands of kilometres a second. Such explosions in binary star systems are called "Novae" which means "new stars".

In the past, RS Oph was observed to erupt in 1898, 1933, 1958, 1967, 1985 and 2006 (a further two eruptions, in 1907 and 1945, have been inferred from archival data.) with an average recurrence period of about 20 years (Figure 2). Novae, which show such multiple explosions observed in a human life time are called "Recurrent Novae".

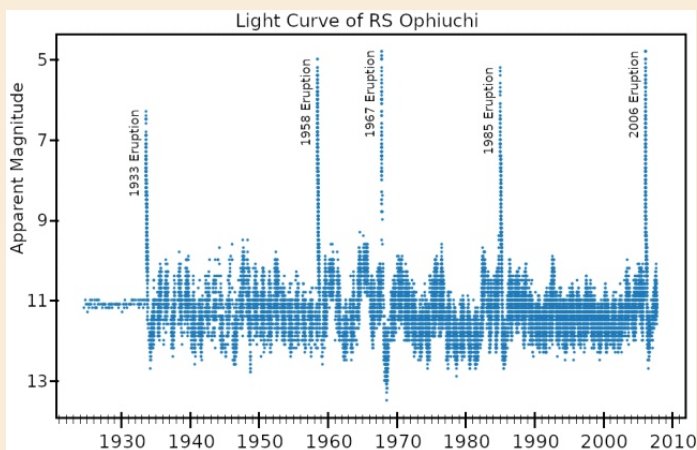


Figure 2: Previously observed outbursts of RS Oph (using AAVSO data). The brightness increases (magnitude decreases) during the outbursts. The average recurrence time is about 20 years.

So far, scientists have confirmed ten Recurrent Novae in our galaxy, RS Oph being one of them. During the explosion about 10^{45} ergs of energy (brightness of about 10^5 Suns) is released, the system brightens up by a huge factor and become visible from a large distance. Measurements from observed data of RS Oph show that the outburst causes ejection of mass $\sim 10^{23}$ Kg, at a speed of ~ 2000 - 4000 km per second. Studies indicate that the WD mass of RS Oph is close the Chandrasekhar limit of 1.4 solar mass which is the maximum mass of a stable WD. And, the WD in the RS Oph system is possibly increasing too due to accumulation of a percentage of accreted matter on its surface. Consequently, the mass of the WD may gradually reach the limiting value of 1.4 solar mass. As the mass of a WD cannot be more than the limiting value of 1.4 times solar mass, it will possibly

collapse and give birth of a Type Ia supernova (a category of supernovae which does not show any emission of hydrogen lines in their spectra) if the mass of the WD exceeds the limit. Scientists have observed many such Type Ia supernovae, but they are not sure about their origin. This is very important to know it as understanding of the origin of such supernovae is related to the more accurate determination of distances in the universe. Thus, if RS Oph finally explodes as a supernova, scientist will finally get the answer of the question "how does a Type Ia supernova form?" This has made RS Oph an object of immense significance to the astrophysicists.



Figure 3: In this photo taken with a CCD camera on August 9, 2021, RS Oph shines brightly at around 5.0 magnitude. Image credit: Ernesto Guido, Marco Rocchetto & Adriano Valvasori/telescope.live.

The well-known recurrent nova RS Ophiuchi (RS Oph) has exploded recently on 8 August 2021 again. Irish amateur astronomer Keith Geary was the first to report this surprise outburst of RS Oph. He captured photos of it glaring at optical magnitude of 5.0 with his camera and confirmed it. Within a few days the star became very bright (maximum magnitude ~ 4.5) and became visible with naked eye for a few days (Figure 3). Scientists from different parts of the world have started observing the 2021 outbursts at different wavelength regions, e.g., X-ray, Ultra-Violet, Optical, Infrared and Radio, using the ground based as well as the space-based telescope. The scientists at S N Bose Centre have also been studying the object in details to understand its properties. Already, they analysed the observed data of the previous outbursts and showed how the physical and chemical parameters of the RS Oph system changed with time in the past years. The results got published in the leading research journals like the Monthly Notice of the Royal Astronomical Society, the Astrophysical Journal etc. This time, also, they are working in collaboration with the national and international astronomers and trying to learn more about this interesting star.

Ph.D. Awarded/Submitted

Ph.D. degree awarded

1. **Shaili Sett**, Thesis title: Investigation of Electronic and Thermal Transport and Opto-Electronic Properties of Single Germanium Nanowires. Supervisor: Arup K Raychaudhuri
2. **Keshab Karmakar**, Thesis title: Oxide Semiconductors for Energy Applications. Supervisor: Kalyan Mandal
3. **Suraka Bhattacharjee**, Thesis title: Study of Generalized Spin And Charge Stiffness Constants of Doped Quantum Anti-Ferromagnets on Low Dimensional Lattices Based on T-J-Like Models. Supervisor: Ranjan Chaudhury
4. **Sanchi Maithani**, Thesis title: Evanescent Wave and Cavity Enhanced Absorption Spectroscopy for Trace Molecule Sensing using Diode and Quantum Cascade Lasers. Supervisor: Manik Pradhan
5. **Tuhin Kumar Maji**, Thesis title: Spectroscopic and Computational Studies on Functionalized Nanohybrids for Potential Manifold Applications. Supervisor: Samir Kumar Pal
6. **Dipika Mandal**, Thesis title: Magnetic, Dielectric and Microwave Absorption Properties of Transition Metal based Ferrite Nanostructures. Supervisor: Kalyan Mandal
7. **Subrata Ghosh**, Thesis title: Large Magnetocaloric Effect in Low-Cost Transition Metal Based Alloys for Magnetic Refrigeration. Supervisor: Kalyan Mandal
8. **Debabrata Ghorai**, Thesis title: Aspects of Gauge/Gravity Duality and it's Applications. Supervisors: Sunandan Gangopadhyay & Biswajit Chakraborty
9. **Juriti Rajbangshi**, Thesis title: Investigations of Multi-Component Mixtures and Complex Systems with Longer-ranged Interactions. Supervisor: Ranjit Biswas
10. **Soumendra Singh**, Thesis title: Development of Spectroscopic Techniques for Potential Environmental and Biomedical Applications. Supervisor: Samir Kumar Pal
11. **Arka Chatterjee**, Thesis title: Studies on Light Harvesting Mechanism at Near Infrared Region of Solar Radiation for Potential Application in Photovoltaics and Photocatalysis. Supervisor: Samir Kumar Pal

Ph.D. thesis submitted

1. **Joydeep Chatterjee**, Thesis title: The Electronic and Structural Properties of Semiconductor Heterostructures. Supervisor: Priya Mahadevan
2. **Subhamita Sengupta**, Investigation of Temperature

- and Frequency Dependent Electrical Transport Phenomena at The Interface of Bilayered Ferromagnetic Ferroelectric Thin Films and Related Issues. Supervisor: Arup K Raychaudhuri
3. **Partha Nandi**, Thesis title: Some Aspects of Quantum Mechanics and Quantum Field Theory on Quantum Space-Time. Supervisor: Biswajit Chakraborty
4. **Sayan Kumar Pal**, Thesis title: On Some Theories on Quantum Space-Time and Matter and their Plausible Implications. Supervisor: Biswajit Chakraborty
5. **Sk Imadul Islam**, Thesis title: Studies on Ultrafast Dynamics and Spectroscopic Investigations on Fluorescent Probes in Bimolecular and Biomimetic Recognition. Supervisor: Rajib Kumar Mitra
6. **Sudip Kumar Saha**, Thesis title: Thermodynamics of Low-Dimensional Interacting Quantum Systems: A Hybrid Exact Diagonalization and Density Matrix Renormalization Group Study. Supervisor: Manoranjan Kumar
7. **Ananda Gopal Maity**, Thesis title: Study of Various Quantum Information Theoretic Resources and Their Applications. Supervisor: Archan S Majumdar
8. **Prantik Nandi**, Thesis title: Spectral and Temporal Properties of Super-Massive Black Holes in Light of Two Component Advective Flows. Supervisor: Sandip K Chakrabarti
9. **Shreya Das**, Thesis title: First Principles Study on Novel and Functional Materials. Supervisor: Tanusri Saha Dasgupta
10. **Sourav Sahoo**, Thesis title: Spin Dynamics in 2D and 3D Confined Magnetic Structure and Thin Film Heterostructures. Supervisor: Anjan Barman
11. **Arnab Samanta**, Thesis title: Synthesis and Characterization of Nanoscale Alloys and Metal Oxides for Potential Application in Catalysis. Supervisor: Samir Kumar Pal and Subhrajana
12. **Shashank Gupta**, Thesis title: Certification and Preservation of Quantum Correlations. Supervisor: Archan S Majumdar
13. **Sumanti Patra**, Thesis title: Electronic, Structural and Optical Properties of Transition Metal Dichalcogenides Heterostructures. Supervisor: Priya Mahadevan
14. **Kartik Adhikari**, Thesis title: Spin Dynamics in Ferromagnetic Nanostructures. Supervisor: Anjan Barman
15. **Sasthi Charan Mandal**, Thesis title: Microscopic Studies on Biomolecular Complexes. Supervisor: Jaydeb Chakrabarti
16. **Dipanjan Maity**, Thesis title: Solar Energy Harvesting in a Photoelectrochemical Cell:

Development of Photoanodes Based on Earth Abundant Materials. Supervisor: Kalyan Mandal

17. **Akash Das**, Thesis title: Investigation of Optical Beam Shifts for Two-Dimensional (2D) Materials . Supervisor: Manik Pradhan
18. **Priyanka Saha**, Thesis title: Improvement in Rheological Response of Transition Metal Oxide Based Magnetic Fluids . Supervisor: Kalyan Mandal
19. **Saikat Pal**, Thesis title: Some Studies on The Effects of Crowding Agents on The Structure, Functionality and Activity of Biomolecules. Supervisor: Rajib Kumar Mitra
20. **Rahul Bandyopadhyay**, Thesis title: Multiwavelength Studies of Planetary Novae. Supervisor: Ramkrishna Das.

News and Events (Administrative)

- 1) One Hindi Workshop held on 22.09.2021; Topic: “*Karyalayen Hindi ka Vyakaranik Swarup*”; Speaker: Shri L.K.Singh, Hindi Teacher, Rajbhasha Bibhag, Hindi Shikshashan Yojana, Nizam Palace, Kolkata.
- 2) One Hindi Workshop held on 27.09.2021; Topic: “*Computer Technique ke madhyam se rajbhasha hindi me sahaj karya v hindi mein typing*”; Speaker: Shri Narayan Shaw, Chief Editor, Rajbhasha Sankay, Power Grid Corporation of India Limited, Kolkata.
- 3) An invited talk on “*Independent India@75 Self Reliance with Integrity*” was delivered by Dr. Preeti Mahto, Chief Vigilance Officer, Vigilance Department, Kolkata Port Trust as part of the celebration of Vigilance Awareness Week, 2021 on 9th November, 2021 at Silver Jubilee Hall of the Centre.
- 4) Shri Sunil Kumar, Joint Secretary and Head AI Division, Department of Science and Technology, Govt. of India, New Delhi visited the Centre and its facilities on 22.11.2021 viz., Computer Services Cell, Laboratories, Bose Archive etc. Prof. Tanusri Saha Dasgupta, Director of the Centre elaborated him about different facilities of the Centre.



- 5) The Inspection Meeting of Second Sub-Committee of Parliament on Official Language was held on 23.11.2021 at The Oberoi Grand, Kolkata. The

Centre updated the Committee regarding its achievements in implementing official language (Hindi) as per Section 3(3) of the Official Languages Act, 1963. The Committee, after going through the report, gave its recommendations.



- 6) The Centre celebrated the Constitution Day on 26th November, 2021 through a pledge taking ceremony held at Silver Jubilee Hall of the S N Bose Centre in commemoration of the celebration of 75th year of Independence of the country as '*Azadi ka Amrit Mahotsav*'.



- 7) One Hindi Workshop held on 23.12.2021; Topic: “*Karyalayen Patrachar mein hindi ka sahaj Prayog*”; Speaker: Shri Sunil Kumar Loka, Deputy Director, Rajbhasha Bibhag, Hindi Shikshashan Yojana (East), Nizam Palace, Kolkata.

Awareness Programme on “The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013”

The Centre organized one day awareness programme in Silver Jubilee Hall on 9th December, 2021 to commemorate the 8th anniversary of notification of the landmark legislation. The awareness programme was held both in online and offline (maintaining COVID19 restrictions) mode. Approx. 100 nos. of students, faculty and staff members from the Centre as well as from outside participated in the programme. Prof. Tanusri Saha-Dasgupta, Senior Professor and Director, SNBNCBS delivered the welcome address. The following experts delivered talk on the occasion:

1. Dr. Suchetana Chatterjee, Presiding Officer, Internal Complaints Committee, S N Bose Centre and Assistant Professor, Presidency University, Kolkata

talked on *“Diversity and Inclusivity in Physics: The Road Forward”*

2. Dr. M. P. Chengappa, Assistant Professor (Law), The West Bengal National University of Juridical Sciences, Kolkata, talked on *“Protection against Sexual Harassment at the workplace: A constitutional Perspective”*
3. Prof. Jayasri Das Sarma, Member, Internal Complaints Committee, S N Bose Centre and Professor, Indian Institute of Science Education and Research, Kolkata, delivered talk on *“Preventing and Responding to Sexual Harassment by implementing Harassment Act in Higher Education Institutions”*



The lecture session was followed by question and answer session and discussion from the audience.



Blooming rhododendrons on the way to Tonglu (10130 ft), a peak in the Singalila Range, Himalayas, located near India and Nepal border. Photograph by Gurudas Ghosh

Editorial Board:

Saumen Adhikari, Jaydeb Chakrabarti, Sanjoy Choudhury, Ramkrishna Das, Gurudas Ghosh, Manoranjan Kumar, Rajib Kumar Mitra, Punyabrata Pradhan

For any comments, suggestions and input, please mail to: punyabrata.pradhan@bose.res.in

Published by:



S N Bose National Centre for Basic Sciences
Block-JD, Sector-III, Salt Lake,
Kolkata - 700 106