



# Physics Pulse

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PHYSICS NEWSLETTER\*

## THE QUANTUM KNOT: HOW TOPOLOGY PROTECTS THE FUTURE OF COMPUTING?

By AMINUL HUSSAIN

Imagine it is a lazy Sunday afternoon. You are sitting by the window, enjoying a snack: a hot cup of tea and a crisp medu vada on your plate. Outside, in the backyard, a group of children is kicking a football around. At first glance, these objects have nothing in common.



Figure 1: **Topological Equivalence:** To a topologist, a coffee mug and a medu vada are the same because one can be smoothly deformed into the other. Both define a genus(hole)-1 surface, whereas a football (sphere) is genus-0.[Source: wiki]

But to a topologist—a mathematician who studies properties of shape—the medu vada and the tea cup are fundamentally the same, as one can be reshaped into the other smoothly, without cutting or gluing, because they both share one single hole. However, the cricket ball belongs to a different class altogether; no amount of squashing will give it a hole without tearing the material.

### ARG Grantees

Let us congratulate **Prof. Umakanta Tripathy**, **Prof. Sudeshna Sen**, and **Prof. Sudipto Singha Roy** for receiving project funding from the **Anusandhan National Research Foundation (ANRF)**, New Delhi, India.


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This idea of global properties remains unchanged even when you stretch or bend the details—it is the core concept of topology. Such properties are called *topological invariants* (number of holes for the cup to medu vada transformation example). They do not depend on material, size, or surface roughness, but on the object's overall structure. For a long time, topology seemed like a purely abstract branch of mathematics. Then, physicists discovered something remarkable: quantum matter itself obeys these rules.

This finding changed the field of condensed matter physics and earned David Thouless, Duncan Haldane, and Michael Kosterlitz the **2016 Nobel Prize in Physics** [1]. Their research uncovered phases of matter that defy explanation by the conventional theory of symmetry breaking. In familiar phase transitions—like water freezing into ice—what changes is the local arrangement of molecules. In topological phases, what matters instead is the **global structure** of the quantum wavefunctions describing the system. This paradigm shift began with the discovery of the Kosterlitz-Thouless transition in 1973, which showed that phase transitions could be driven by the unbinding of topological defects (vortices) rather than symmetry breaking [2].

In solids, electrons don't just sit still; they move. This motion is mapped out in a mathematical realm called **momentum space**, which reflects the periodicity of the lattice—much like the repeating pattern of tiles on a temple floor. In most materials, this map is dull and flat. But in topological materials, the electron's quantum state has a **permanent twist**. As you move across momentum space, the wavefunctions "wind" around. One can't undo this quantum knot without changing the material's state, just as you

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**Ms. Sheetal Sharma**, a PhD scholar from the Department of Physics, IIT (ISM) Dhanbad, received the Outstanding Women Researcher Award at the 3rd International Conference on Recent Advances in Nanoscience and Nanotechnology (ICRANN-2025), held at Jawaharlal Nehru University, New Delhi, during December 20–21, 2025. She delivered an oral presentation titled “Synthesis and Fabrication of MXene-based Triboelectric Nanogenerator,” highlighting her work on self-powered energy harvesting devices. The award recognizes her significant contributions to flexible nanogenerator research. She expressed gratitude to her supervisor, Prof. V. K. Singh, and Dr. Manoj Kumar Gupta (CSIR-AMPRI, Bhopal) for their guidance and support.



**Ms. Kalpana Khokhar**, a Ph.D. student working under the supervision of Prof. Soumya Bagchi, has been awarded the Best Poster Award at the DAE Symposium on Nuclear Physics 2025, held at NIT Jalandhar during December 8–12, 2025. The award-winning poster, titled “Study of Isoscalar

Giant Resonances in Highly-Deformed  $^{172}\text{Yb}$ ”, highlights her contribution to nuclear structure studies.

**Mr. Ashutosh Yadav** presented his research work titled “The Critical Role of DFT Functionals in Low-Energy Electron–Nitric Oxide Scattering” and received the Best Oral Presentation Award at the International Conference on Atomic, Molecular, Nano and Optical Physics with Applications (IAMNOP-2025), held at Jawaharlal Nehru University (JNU), New Delhi, from 17 to 19 December 2025.



**Mr. Tanuj Datta** won the Best Poster Award for his poster presentation titled “Multi-wavelength Investigation of low-mass X-ray binaries as plausible engines of FRB20200120E”, at the conference Young Astronomer’s Meet (YAM) 2025-II, which was hosted by Indian Institute of Technology (Banaras Hindu University), Varanasi between December 5th to 7th, 2025. Tanuj sincerely thanks his Ph.D. supervisor Prof. Esha Kundu, for her guidance and constant support throughout this work.



## Physics in History

- **1 January 1801:** Giuseppe Piazzi discovered the dwarf planet Ceres, the largest object in the Asteroid Belt, marking a major milestone in planetary astronomy.
- **7 January 1610:** Galileo Galilei observed the four largest moons of Jupiter—Io, Europa, Ganymede, and Callisto—providing strong evidence against the geocentric model and transforming observational astronomy.
- **10 January 1946:** The U.S. Army Signal Corps successfully reflected radar signals off the Moon under Project Diana, marking the birth of planetary radar astronomy and demonstrating the feasibility of space communication.
- **30 January 1964:** NASA launched Ranger 6 as part of its early lunar exploration program. The spacecraft was designed to transmit high-resolution images of the Moon before impact.
- **31 January 1862:** Alvan Graham Clark, while testing a new 18.5-inch refractor telescope, discovered Sirius B—the faint companion of Sirius—becoming the first known white dwarf star.



Glimpses from the Physics exhibition stall on Day 6. **The Chairman, Board of Governors, Prof. Prem Vrat**, and **the Director, Prof. Sukumar Mishra**, visited the Physics stall and appreciated the exhibits showcased by the department.

## Research Talk



We were delighted to host **Prof. Gniewomir Sarbicki** from Nicolaus Copernicus University for his seminar titled “Entanglement Detection via Randomized Measurements” at the Department of Physics, IIT (ISM) Dhanbad. The session featured engaging discussions and insightful exchanges, and we thank all participants for contributing to its success.

## Events Organized

### Centenary Week Celebration

As the **Indian Institute of Technology (Indian School of Mines), Dhanbad marked its 100th year**, the Department of Physics proudly showcased a series of interactive scientific demonstrations at the Centenary Scientific Exhibition. Faculty members and students collaboratively presented innovative models and live experiments highlighting ongoing research, hands-on learning, and the spirit of scientific curiosity within the department.

The exhibition stall witnessed enthusiastic participation, even including visits from school students whose curiosity and excitement added vibrant energy to the event. Their keen interest and thoughtful questions were truly inspiring and reaffirmed the importance of science outreach.

As we celebrate this historic milestone, we remain committed to advancing scientific excellence, fostering innovation, and nurturing the next generation of scientific minds.

## Physics News

### Can AI Simplify Quantum Field Simulations?

Artificial intelligence has led to a major advancement in computational physics by optimizing how quantum field theories are simulated on computers. Traditionally, researchers face huge computational challenges when mapping these theories onto a discrete four-dimensional lattice for numerical simulation. A team from TU Wien and collaborators designed a custom neural network that respects physical laws to find



“fixed-point” lattice formulations. These formulations preserve key properties across different grid scales, allowing even coarse grids to yield accurate results. This breakthrough shows significantly more efficient simulations of complex particle interactions and early-universe physics! The work was published in Physical Review Letters.

### NASA's Webb reveals more about Dark Matter's Influence on Universe

On January 26, NASA scientists published the most expansive and high-resolution dark matter map to date, using data from the James Webb Space Telescope. This map is twice as big as any previous generation. While dark matter neither emits or absorbs light, it does interact through gravity, which is what the map visualises here. The findings reinforce the theory that dark matter was crucial in creating the current universe. By clumping together shortly after the Big Bang, dark matter's gravity also clumped regular matter, accelerating the birth of stars and galaxies. This early formation was crucial for the development of planets and complex elements. Hence, this map provides stronger evidence that without dark matter, we might not have the elements in our galaxy that allowed life to appear.

## Academic Visits



**Prof. Rajendra Prasad Giri** (IIT (ISM) Dhanbad), together

with **Prof. Takahiro Maruyama** (Meijo University, Nagoya, Japan), successfully secured a highly prestigious and competitive exchange program funded by the Japan Science and Technology Agency (JST). Under this programme, **Prof. Rajendra Prasad Giri** along with his Ph.D. scholars **Mr. Preyash Kumar Bal** and **Ms. Suprita Paul** visited Meijo University, Nagoya, Japan, from November 17 to December 7, 2025. A memorable highlight of the visit was their meeting with **Prof. Sumio Iijima**, the discoverer of single-walled carbon nanotubes (SWCNTs). During the 21-day research stay, the team carried out synthesis and characterization of SWCNTs aimed at biomedical applications.



**Prof. Umakanta Tripathy** visited the Saha Institute of Nuclear Physics (SINP), Kolkata, to deliver an invited talk at the FCS XVI Conference.



**Dr. Tusharkanti Dey** attended the QMEC 2025 Conference, held at IISER Bhopal during December 21–24, 2025, where he delivered an invited talk titled “Frustration driven unconventional magnetism in the triple perovskite  $\text{Ba}_3\text{MnTa}_2\text{O}_9$ .” His Ph.D. student, **Mr. Romario Mondal**, also participated in the conference and presented a poster titled “Frustration driven unconventional magnetism in  $\text{Ba}_3\text{MnTa}_2\text{O}_9$ .”



**Prof. Binata Panda** participated in the Indian String Meeting (ISM) 2025, held during December 9-14, 2025, and jointly hosted by the National Institute of Science Education and Research (NISER), Jatni, and IIT Bhubaneswar.



She delivered an invited talk titled “Logarithmic Corrections to Near-Extremal Kerr-Newman Black Holes,” presenting recent research findings at this international conference, which brought together researchers in string theory, quantum gravity, and related areas.



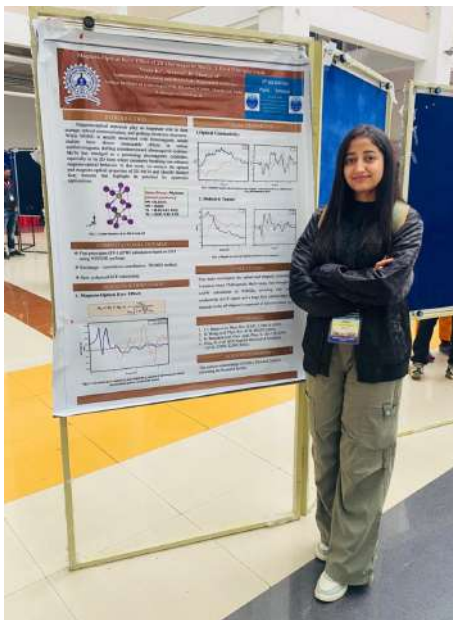
**Prof. Avijit Misra** delivered an invited talk titled “Estimating Dipole-Dipole Interaction and Localization in Atomic Networks” at the Quantum Crossroads: Workshop on Materials, Computation, Communications and Information, held during 21–24 January 2026. The workshop was organized by the Department of Physics and Nanotechnology, SRMIST, Kattankulathur, in association with IIT Madras. The event brought together leading condensed matter and quantum physicists, fostering vibrant discussions across both theoretical and experimental frontiers.

**Prof. Sudipto Singha Roy** and **Prof. Avijit Misra** delivered invited talks at conference “Quantum Foundations, Technologies and Applications” QFTA2025, held at IISER Mohali during December 04-08, 2025. The conference witnessed one of the highest participation in the country in the area of quantum technologies, bringing together leading researchers from both theoretical and experimental domains.

**Prof. Ritwik Mondal** delivered an invited talk at the Spintronics and Magnonics Symposium (SMS 3), held at IIT Hyderabad, where he presented recent work on “Spin Inertia as a Source of Topological Magnons.” The talk highlighted inertial effects in spin dynamics as a novel route to realizing topological magnonic phases and led to engaging discussions with theorists and experimentalists working on spintronics and magnon-based information processing. The work is in collaboration with Prof. Dr. Alexander Mook from University of Münster, Germany and Prof. Dr. Levenete Rozsa from Budapest, Hungary. **Mr. Subhadip Ghosh** from Ultrafast Terahertz Spintronics Group has worked on this.







**Ms. Nidhi Khare** and **Ms. Alveera**, a PhD research scholar and a master's student respectively, attended the 69th DAE SSPS 2025 held at IIT Roorkee and organized by Department of Atomic Energy, Bhabha Atomic Research Center, Mumbai. There they got opportunity to present their work in poster presentation session, under the title "Structural, Morphological and Optical properties of beta Gallium Oxide nanorods by Facile Hydrothermal Methods" and "Magneto-Optical Kerr Effect of 2D Altermagnetic MnTe: A First-Principles Study"

respectively. They sincerely acknowledge their PhD supervisor and master's thesis guide Prof. R Thangavel for guiding and encouraging their participation in this symposium.



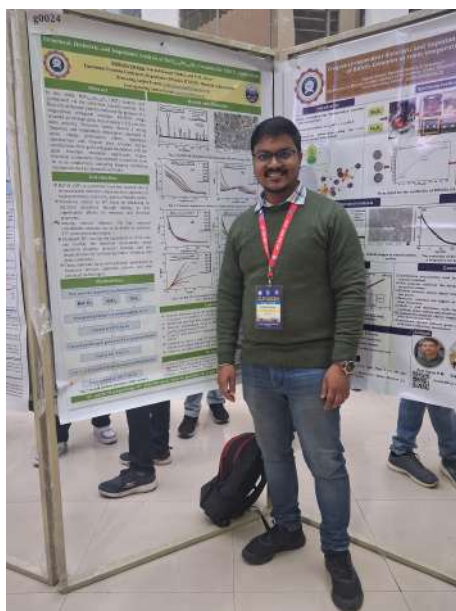
**Mr. Ashes Modak** attended Indian Strings Meeting (ISM) 2025 held at the Indian Institute of Technology (IIT) Bhubaneswar and the National Institute of Science Education and Research (NISER), Bhubaneswar, during 9-14 Dec, 2025.

He also attended the 20th Asian Winter School on Strings, Particles and Cosmology, organized by IISER Bhopal.



**Mr. Soumyo Kheto** participated at the International Conference on Atomic, Molecular, Nano and Optical Physics with Applications (IAMNOP-2025), held at Jawaharlal Nehru University (JNU), New Delhi, from 17 to 19 December 2025,

and presented his research work titled “Irradiation-driven fragmentation of  $W(CO)_6$ : Analysis of scaling dependencies in IDMD simulation.” This work deepens our understanding of radiation-driven chemistry and opens avenues for predictive modeling of nanostructure growth, offering direct relevance to nanofabrication, materials science, and radiation biology.



**Mr. Subhasis Sarangi** participated in the 69th DAE Solid State Physics Symposium, held at IIT Roorkee from 19–23 December 2025, organized by Bhabha Atomic Research Centre (BARC), Mumbai, India and sponsored by Board of Research in Nuclear Sciences (BRNS), Department of Atomic Energy, Government of India. During the symposium, he presented his research work entitled “Structural, Dielectric, and Impedance Analysis of  $BaTi_{0.95}Sn_{0.05}O_3$  Ceramics for MLCC Applications.” The event brought together researchers and academicians from across the country and abroad, fostering insightful discussions on recent advances in solid-state physics. The symposium provided a valuable opportunity to exchange ideas and receive expert feedback on dielectric materials. Overall, the experience contributed significantly to his academic and research development.

**Mr. Rajdeep Sarkar**, a first-year Ph.D. student working under the supervision of Prof. Esha Kundu, attended the workshop series “Frontier Topics in Astronomy, Astrophysics and Space Science” held at the Indian Centre for Space Physics (ICSP), Kolkata, from December 6–8, 2025. He participated in sessions on optical astronomy data analysis and modeling of stellar and supermassive black holes, gaining hands-on experience with key astronomical software tools.



**Mr. Tanuj Datta**, a second-year Ph.D. scholar, was selected to attend the fully funded 18th Radio Astronomy Winter School (RAWS 2025), organized by IUCAA and NCRA–TIFR from December 9–19, 2025. The program included lectures, hands-on data analysis, and a visit to the Giant Metrewave Radio Telescope (GMRT), concluding with a successful group project presentation.



**Mr. Saurabh Kumar Mishra** attended the 69th DAE Solid State Physics Symposium at IIT Roorkee to present his paper, “Dielectric, Impedance, and Electrical Conductivity Analysis of BZT Electroceramics.” His study focused on BZT ceramics synthesized via solid-state reaction, which confirmed a single-phase tetragonal structure. The material exhibited a high dielectric constant and remarkably low energy loss, with a Curie temperature of 120 °C. Combined with high impedance and low conductivity, these findings demonstrate that BZT is an excellent candidate for high-performance capacitors and memory devices due to its superior charge retention and efficiency.





**Dr. Aditya Singh** contributed to ST4 2025. Student Talks on Trending Topics in Theory is a discussion meeting on theoretical physics organized by and aimed at advanced graduate students and postdoctoral fellows working in India and abroad. The meeting is similar in spirit to the Modave Summer School on Mathematical Physics, held annually in Belgium. It aims to provide an interactive environment for students and postdocs working in areas such as quantum field theory, general relativity, string theory, and related topics in mathematical and theoretical condensed matter physics.

**Mr. Ashutosh Kumar** presented his research paper titled “An Ultrawideband Meta-Absorber for UAV-Based Mining Applications in Q, E, and W Bands” at the ELEXCOM 2025 International Conference, demonstrating a lightweight PTFE-based microwave absorber operating from 50–110 GHz with over 90% absorption efficiency and strong angular and polarization robustness.

**Mr. Vrukshala Varshik Nath** completed a summer internship at the Variable Energy Cyclotron Centre (VECC) in Kolkata. Working in the Theoretical Physics Division under the supervision of Dr. Jajati K. Nayak, his research focused on particle production in relativistic heavy-ion collisions, a key area in high-energy physics.

- **Prof. Umakanta Tripathy** has also received an ARG project funding as the **Co-Principal Investigator** of a research project titled “**Tunable Fluorescent Organic Nanoparticles Based on a Single Benzene-Based Fluorophore for Enhanced Emission, White Light Generation, and Bioimaging**”. The project, led by **Dr. Soumit Chatterjee** from IIT (ISM), Dhanbad, has been sanctioned with a total grant of approximately **INR 87 lakhs** and involves the acquisition of advanced experimental equipment.
- We are pleased to announce that **Prof. Sudeshna Sen** has received an ARG project funding from the **Anusandhan National Research Foundation (ANRF), New Delhi, India** as a **Co-Principal Investigator** for the research project titled “**Strong Correlation, Entanglement, and Complexity in Topological and Flat Band Systems: A GPU-Accelerated Quest**”. The project focuses on advanced algorithmic development and GPU-based high-performance computing, aligned with national priorities under the **National Quantum Mission**.

This project is a collaborative effort with Prof. Rudranil Basu, Prof. Arnab Paul, and Prof. Gargi Prabhu from BITS Pilani K K Birla Goa Campus. We look forward to a fruitful and impactful research outcome in the months and years ahead.

- We are also pleased to announce that **Prof. Sudipto Singha Roy** has received approval for an ARG project funding from the **Anusandhan National Research Foundation (ANRF), New Delhi, India** as a **Co-Principal Investigator** for the research project titled “**Engineering Quantum Networks for Scalable Quantum Technology**”. The project focuses on developing noise-aware and scalable quantum network architectures, integrating theoretical and simulation tools with near-term experimental platforms, and aligns strongly with objectives of the **National Quantum Mission**.

Our heartiest congratulations to all the grantees for their grand success.

## ARG Grants awarded

- We are delighted to announce that **Prof. Umakanta Tripathy** has received an ARG project funding from the **Anusandhan National Research Foundation (ANRF), New Delhi, India** for the research project titled “**Introducing a novel optical device to study protein aggregation in real time for disease diagnosis**”. The project has been sanctioned with a total grant of approximately **INR 72 lakhs** and involves the procurement of a **picosecond pulsed laser** as the major experimental equipment.

## Research Publications

1. **Jeetendra Kumar Tiwari**, Ankita Tiwari, Arpit Gaur, **Sujeet Kumar**, **P.M. Sarun**, Origin of Griffiths phase and long-range ordering in three-dimensional  $\text{Nd}_{0.8}\text{Sr}_{0.2}\text{MnO}$  manganite perovskite, **Journal of Alloys and Compounds**.
2. **Soubhik Bhattacharyya** and **P M Sarun**, A first-principles study on the electronic structure of  $\text{BaSbO}_3$  and electron-phonon coupling in K-doped superconducting antimonate, **Physical Chemistry Chemical Physics**.

3. **Sathi Chatterjee and Asit Kumar Kar**, Role of surface capping and photophysical interaction FRET on UV-light driven photocatalytic performance of PVP capped ZnO nanosheets, *Journal of Physics and Chemistry of Solids*.
4. **Esha Kundu**, Radio Supernovae, *Universe*.
5. Zi-Jian Lang, **Sudeshna Sen**, Pak Ki Henry Tsang, Kristjan Haule, Vladimir Dobrosavljević, and Wei Ku, Relevance of long-range screening in Mott transition examined via a hydrogen lattice, *Physical Review B*.
6. **Vishakha Zimba, Meghana N., Jhasaketan Nayak**, Enhancing the room temperature ethanol gas sensing properties of MoS<sub>2</sub> nanospheres by compositing with WO<sub>3</sub> nanorods, *Sensors and Actuators A: Physical*.

## *Physics Job Openings*

1. **Systems Engineer – Semiconductor Fab Equipment (Applied Materials, Bengaluru)**  
Seeking Master's/PhD in Electrical Engineering, Mechatronics, or Engineering Physics with 8+ years of R&D

experience. Requires expertise in electro-optics, control systems, and signal/image processing (Python/Matlab); exposure to SEM, motion systems, or algorithms desirable. Includes short-term training in Israel and up to 20% international travel.

[For Details & Application](#)

2. **Materials Failure Analysis Engineer – Apple (Bengaluru)**

Master's with 5+ years' experience in materials characterization required. Role involves hands-on failure analysis using SEM/FIB/EBSD, root cause investigation, reporting, and cross-functional collaboration.

[For Details & Application](#)

3. **Process Engineer – Simulation and Modeling (Applied Materials)**

Design and optimize OLED/semiconductor processes; develop models for vacuum evaporation and thin-film optics. Requires strong physics fundamentals, modeling skills, and programming (MATLAB/Python/VBA).

[For Details & Application](#)

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