DEPARTMENT OF PHYSICS

Physics Pulse

IIT (ISM) DHANBAD

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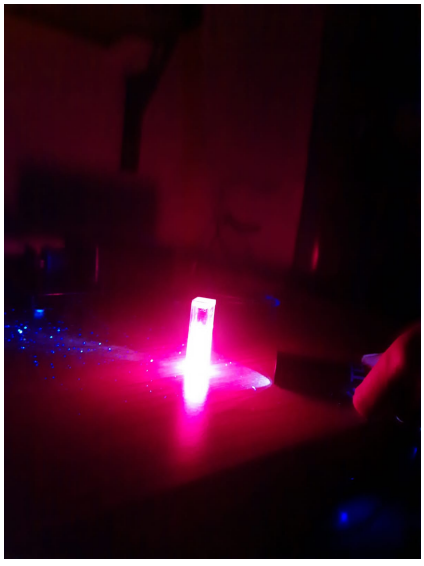
Phytoextract Quantum Dots: A New Hope for OLEDs and High-Performance Optical Devices

By CHINMAY CHIRANJEEB NAYAK, JRF

Quantum dots (QDs) have revolutionized the world of nanotechnology, offering unparalleled optical and electronic properties. Among various QD categories, phytoextract quantum dots, derived from organic precursors such as plant extracts, are emerging as a sustainable alternative for next-generation devices.



Their unique blend of eco-friendliness, cost-effectiveness, and high optical performance positions them as promising candidates for organic light-emitting diodes (OLEDs) and other advanced optical systems.

Phytoextract quantum dots (QDs), synthesized from organic precursors such as plant-derived biomolecules, represent a groundbreaking approach in nanotechnology, offering significant potential for high-performance optoelectronic devices like organic light-emitting diodes (OLEDs). These QDs are formed through green synthesis methods that utilize natural reducing agents and capping molecules, ensuring eco-friendliness and sustainability.

Unlike conventional QDs that rely on heavy metals and toxic solvents, phytoextract QDs exhibit exceptional photophysical properties, including high quantum yield, tunable photoluminescence, and broad absorption spectra, making them ideal for applications demanding precise optical performance.

Their inherent biocompatibility and minimal toxicity further broaden their usability in wearable electronics, bioimaging, and flexible displays. Moreover, the low-cost production process aligns with scalable manufacturing for industrial applications. However, challenges like achieving monodispersity and enhancing stability under operational conditions remain areas of active research.

Phytoextract QDs pave the way for next-generation devices, merging environmental sustainability with cutting-edge technological innovation.

Spotlight

Prof. Manu Kurian joined on 4th December as an Assistant Professor. His research interests include relativistic dissipative magnetohydrodynamics, the physics of Quark-Gluon Plasma, the dynamics of electromagnetic fields generated in relativistic heavy-ion collisions at the LHC and RHIC, and Heavy quark physics.

Read more »

Physics News

ISRO's PSLV-C59 Successfully Launches ESA's PROBA-3 Mission

The Indian Space Research Organisation (ISRO) successfully launched the **Proba-3 mission** on December 5, 2024, at 16:04 IST.

Willow: Redefining the Limits of Quantum

Google's new quantum chip, **Willow**, is revolutionizing computing. Willow completed a benchmark calculation in under five minutes—a task that would take the fastest supercomputer 10 septillion years

Quantum Teleportation Achieved Over Busy Internet Cables!

A team of engineers at the Northwestern University, led by **Prof. Prem Kumar**, have successfully demonstrated quantum teleportation over a 30-kilometer fiber optic cable.

Magnetizing Antiferromagnets with Light

MIT physicists have discovered a new way to magnetize antiferromagnetic materials using terahertz laser light, where they shifted atomic spins to create a durable magnetic state.

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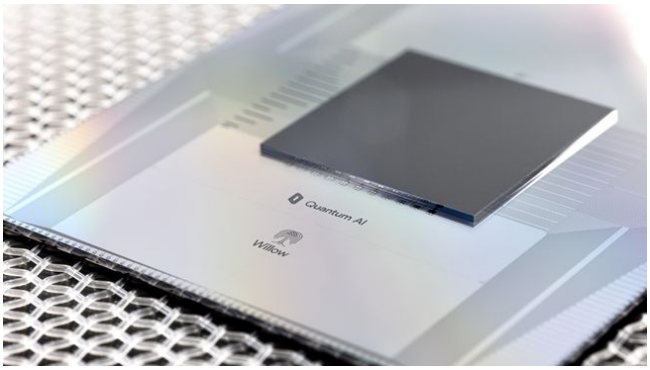
Physics News

ISRO's PSLV-C59 Successfully Launches ESA's PROBA-3 Mission

The Indian Space Research Organisation (ISRO) successfully launched the Proba-3 mission on December 5, 2024, at 16:04 IST from the Satish Dhawan Space Centre, Sriharikota. The PSLV-C59 rocket placed the Proba-3 spacecraft into a highly elliptical orbit. Developed by the European Space Agency (ESA), Proba-3 is an In-Orbit Demonstration (IOD) mission showcasing advanced formation flying technology. It comprises two spacecraft—the Coronagraph Spacecraft (CSC) and the Occulter Spacecraft (OSC)—launched in a stacked configuration. Proba-3 aims to achieve precision formation flying, enabling artificial solar eclipses for unprecedented observations of the Sun's corona, typically hidden by its intense brightness.

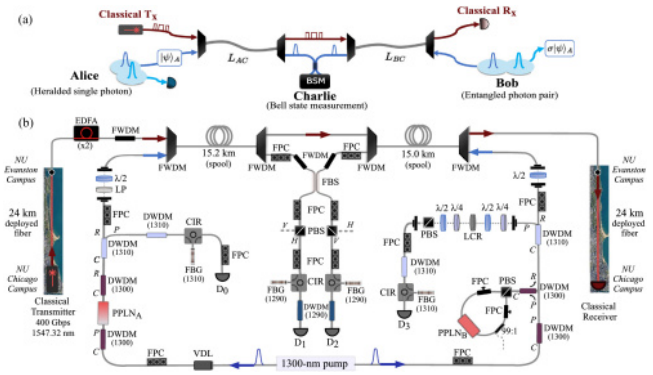
Willow: Redefining the Limits of Quantum

Google's new quantum chip, Willow, is revolutionizing computing. Traditional computers use bits, which are either "0" or "1", while quantum computers use qubits, capable of being "0", "1", or both simultaneously, thanks to quantum physics. Unlike classical systems, where increased size leads to more errors, Willow reduces errors as it scales up. Its speed is groundbreaking. Willow completed a benchmark calculation in under five minutes—a task that would take the fastest supercomputer 10 septillion years, far surpassing the Universe's age. This breakthrough marks a monumental step forward in the potential of quantum computing.



Quantum Teleportation Achieved Over Busy Internet Cables!

Northwestern University engineers, led by Professor Prem Kumar, have made a remarkable breakthrough in quantum communication. They successfully demonstrated quantum teleportation over a 30-kilometer fiber optic cable. Quantum teleportation allows the transfer of quantum information, such as a particle's state, using the principles of quantum entanglement. The team overcame the challenge of transmitting fragile quantum signals alongside millions of classical data particles in the same fiber without interference. By identifying wavelengths to minimize scattering and employing noise-reducing filters, they ensured smooth coexistence with regular high-speed internet traffic. This ground-breaking experiment shows that quantum teleportation can coexist with modern communication networks.



Magnetizing Antiferromagnets with Light

MIT physicists have discovered a new way to magnetize antiferromagnetic materials using terahertz light. By aligning the laser's trillion-times-per-second oscillations with the material's atomic vibrations, they shifted atomic spins to create a durable magnetic state.

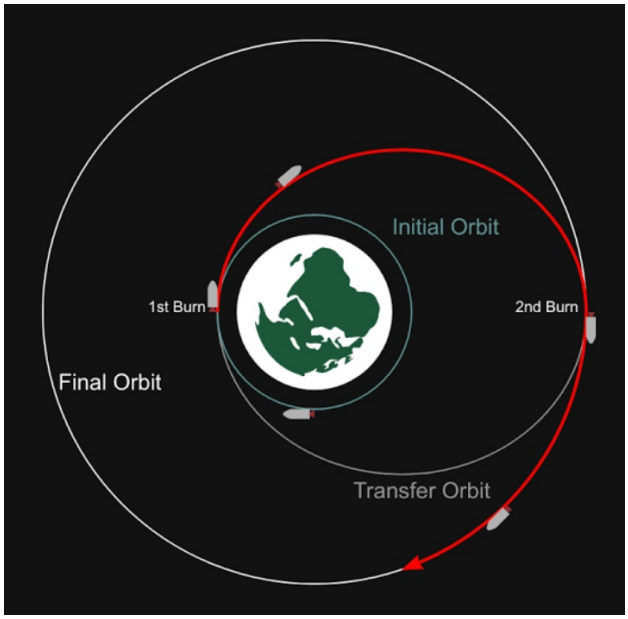
Antiferromagnets are promising for advanced data storage, enabling robust, compact memory chips resistant to stray magnetic fields. Memory chip could be made from antiferromagnetic material! A certain configuration of spin orientations

(for example up-down) in a given domain would represent bit "0." A different configuration (down-up) would mean "1"", allowing binary representation. This innovation could lead to energy-efficient chips capable of processing more data in less space.

Hohmann transfer in space docking

By TANISHA SHUKLA, M.SC. PHYSICS, 1ST YEAR

In astronautics, the Hohmann transfer orbit is an orbital maneuver used to transfer a spacecraft between two orbits of different altitudes around a central body. For example, a Hohmann transfer could be used to raise a satellite's orbit from low Earth orbit to geostationary orbit.



In the idealized case, the initial and target orbits are both circular and coplanar. The maneuver is accomplished by placing the craft into an elliptical transfer orbit that is tangential to both the initial and target orbits. The maneuver uses two impulsive engine burns: the first establishes the transfer orbit, and the second adjusts the orbit to match the target. The Hohmann maneuver often uses the lowest possible amount of impulse (which consumes a proportional amount of delta-v, and hence propellant) to accomplish the transfer, but requires a relatively longer travel time than higher-impulse transfers.

In some cases where one orbit is much larger than the other, a bi-elliptic transfer can use even less impulse, at the cost of even greater travel time. The maneuver was named after Walter Hohmann, the German scientist.

When used for traveling between celestial bodies, a Hohmann transfer orbit requires that the starting and destination points be at particular locations in their orbits relative to each other. Space missions using a Hohmann transfer must wait for this required alignment to occur, which opens a launch window. For a mission between Earth and Mars, for example, these launch windows occur every 26 months.

International Visits

Prof. Esha Kundu visited the Australian National University (ANU) at the invitation of her collaborator **Prof. Lilia Ferrario**, the director of the Mathematical Science Institute at ANU, to work on and commence future collaborative research projects. During this month-long academic visit, Prof.Kundu initiated a new collaborative research project to investigate the origin of Fast Radio Bursts in very dense astrophysical systems containing older populations like black holes, neutron stars, and white dwarfs. Besides, her investigation of radio emissions from new sets of explosions of white dwarfs in three-dimensional, currently being performed by Prof. Ferrario's group at ANU, resulted in interesting outcomes. Consequently, this led them to initiate another collaborative project involving the study of the optical emissions from these explosions to understand the progenitor of thermonuclear explosions, which is very poorly understood to date. Overall, it was a remarkable and productive visit that strengthened Prof. Kundu's collaboration with Prof. Ferrario and further advanced their joint research. Prof. Kundu also thanks the Indian Institute of Technology (Indian School of Mines), Dhanbad, for making this month-long academic visit to ANU feasible!

New Staff Member

Mr. Purushottam Kumar Paul, joined the Department as a Junior Technician on 26 December 2024. Before joining the Physics department he was working at the Mechanical Engineering department since Aug 2021. He has completed Diploma in Mechanical Engineering. He will take care of the B.Tech Engineering Physics and B.Tech Common laboratories. Please join us in giving, Purushottam a warm welcome to the department!

A Hohmann transfer orbit also determines a fixed time required to travel between the starting and destination points; for an Earth-Mars journey this travel time is about 9 months. When transfer is performed between orbits close to celestial bodies with significant gravitation, much less delta-v is usually required, as the Oberth effect may be employed for the burns.

They are also often used for these situations, but low-energy transfers which take into account the thrust limitations of real engines, and take advantage of the gravity wells of both planets can be more fuel efficient.

International Visits

Prof. R Thangavel visited Khalifa University, Abu Dhabi to attend the International Conference - I2DM 2024. The Innovative & Industrial 2D/Advanced Materials Summit & Expo (I2DM2024), hosted by Khalifa University,

Abu Dhabi during Nov 24-28, 2024, brings together researchers, industry leaders, and policymakers to explore breakthroughs in advanced materials. At the forefront of these materials are graphene and two-dimensional materials (2DMs), which are reshaping industries ranging from electronics to energy and healthcare.

Did our Universe collide with another? The Eridanus Supervoid

By SHIVANI PANDEY, M.SC. PHYSICS, 2ND YEAR

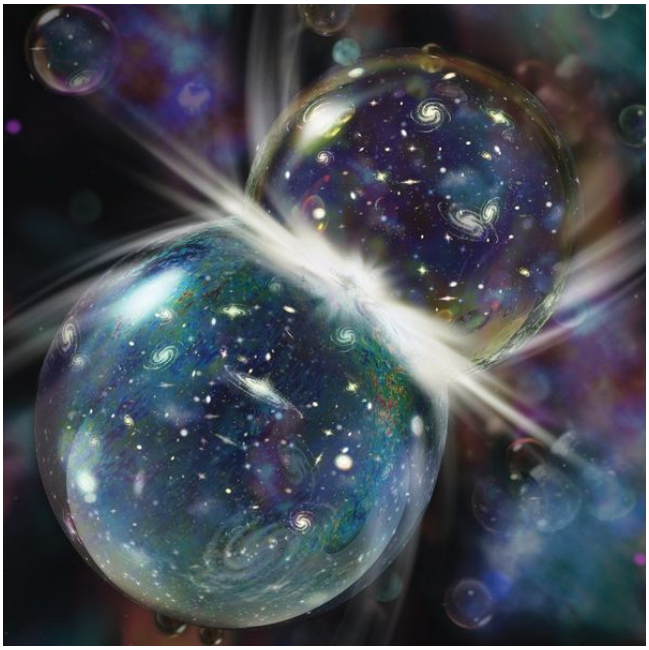
Discovered in the direction of the constellation Eridanus, this vast region of space spans roughly 1 billion light years in diameter and is astonishingly empty of galaxies and normal baryonic matter.

The Universe is a large-scale cosmic web of clusters of galaxies having "*matter and gas*" sticking on the filaments of the cosmic dark web as a fly sticks to the web of spiders. The vast empty space between these filaments is called void. While most voids are relatively small, the Eridanus Supervoid is an exceptionally large and low-density region.

In addition to being low density, 20 – 30 % lower than the normal matter density, the supervoid is also related to the Cold Spot, a region of space that is about 70 microkelvins cooler than its surroundings. As photons passing through this region lose a significant amount of energy, the CMB radiation coming through seems cooler than the rest and we get a cold anomaly.

Some of the rational explanations which are used by the astrophysicists are that the supervoid is just a statistical anomaly. Though rare, statistically something like this cannot be ruled out and can very well exist. Some say that the void could be a relic of quantum fluctuations in the early Universe, which seeded areas of higher and lower density in the cosmic web whereas some say it is a supervoid inside another supervoid. Eridanus may itself contain smaller voids nested within it, further amplifying its emptiness. But the most interesting possibility is that the supervoid is a remnant of a collision between our Universe and another universe. Such a collision could disrupt the distribution of matter and leave an imprint in the CMB.

The multiverse hypothesis suggests that our Universe is one of the countless “pocket universes” that formed during cosmic inflation. Occasionally, these universes might interact, especially during the inflationary period when they were in close proximity. The collision would cause disturbances in the energy fields driving inflation, leading to ripples in the density and temperature of matter and radiation in each. These disturbances could propagate through space, leaving scars or anomalies in the CMB and potentially cause supervoids.

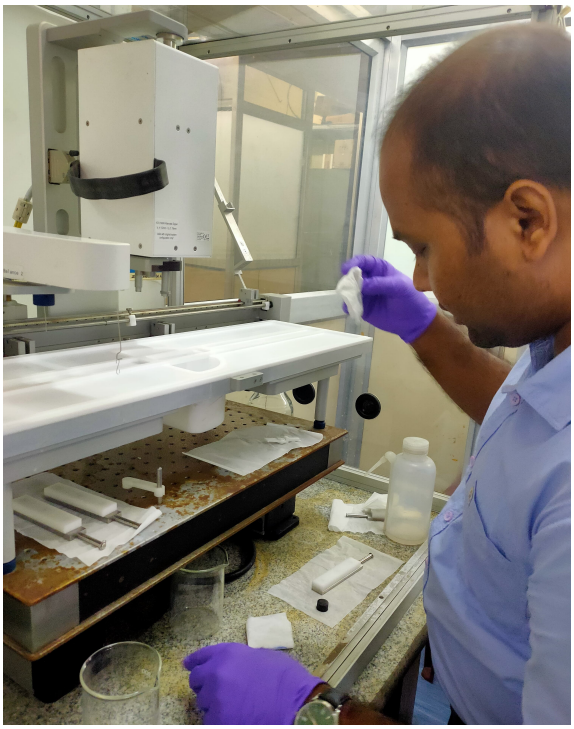


While this idea is speculative, it has been explored in theoretical physics and cosmology as a potential signature of the multiverse, the existence of which is a monumental task to

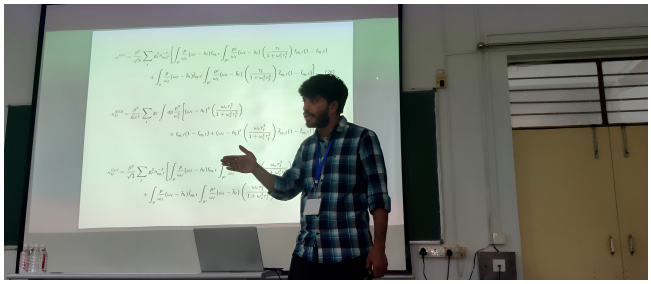
prove otherwise. If true, it would revolutionize our understanding of reality, suggesting that our Universe is just one of many in a vast and complex multiversal framework.

National Visits

Prof. Rajendra P Giri and his research scholars **Preyash Kumar Bal** & **Suprita Paul**, visited SINP, Kolkata to perform Langmuir monolayer isotherm measurements in Prof. Mrinmay K. Mukhopadhyay's lab at the SPMS Division, SINP, Kolkata.



Anowar Shaikh visited Banaras Hindu University to attend XXVI DAE-BRNS High Energy Physics Symposium 2024 held during 19 - 23 Dec 2024.

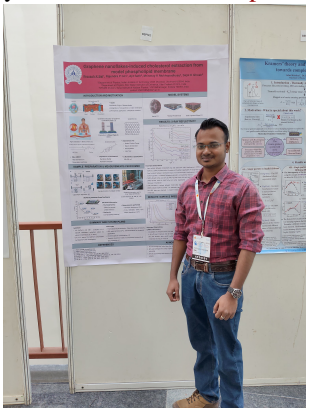


Prof. Ram Bilash Choudhary visited IIT Patna during 8-11 Dec 2024 to attend the "Asia-Pacific Conference on Condensed Matter Physics 2024 (AC2MP2024)." as an invited speaker.

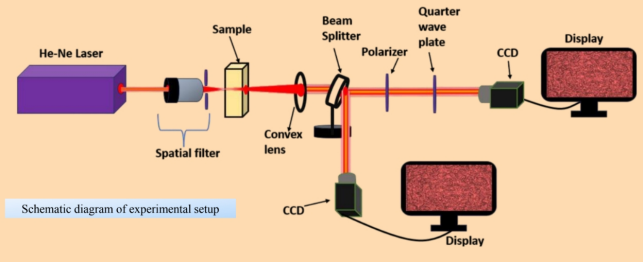
Prof. Tusharkanti Dey visited IIT Patna during 8-11 Dec 2024 to attend the Asia-Pacific Conference on Condensed Matter Physics 2024 (AC2MP2024). He delivered an invited talk titled "***Frustrated magnetism in 3d and 5d-based triple perovskite materials***."

Ashes Modak visited IIT Ropar to perform research work.

Preyesh Kumar Bal visited IIT Hyderabad to attend CompFlu-2024: Soft Matter & Beyond held during 16 - 18 Dec 2024. CompFlu-2024 was organized by IIT Hyderabad and Indian Society of Rheology with the theme 'Soft Matter & Beyond'. Since 2002, the Complex Fluids (CompFlu) meeting is serving as a key scientific gathering for India's dynamic, vibrant, and ever-growing soft matter research community, bringing together academia and industry across various science and engineering disciplines. Preyesh presented a poster titled "***Graphene nanoflakes-induced cholesterol extraction from model phospholipid membrane***".



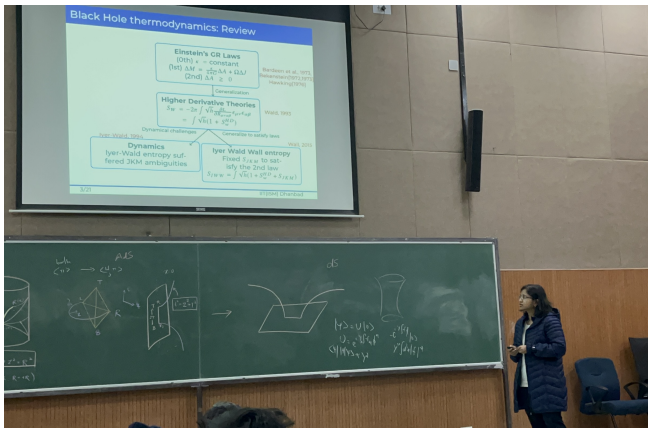
Aditya Shankar Shahane presented a poster titled "***Advancing Food Quality Control: Polarization and Laser Imaging in Honey Adulteration Detection***" at the International Conference on Materials & Applied Science for Society (MASS 2024) held during 30 - 31 Dec 2024 at Anand Niketan College of Science, Arts and Commerce. Other authors of the poster are Hemraj Bhai Patel, Anuradha Sinha, and Prof. Anil Kumar Nirala. (mass2024.in). [Further Reading]



Aminul Hussain visited IIT Guwahati to attend QMAT 2024 held during 20 - 23 Dec 2024. QMAT2024 is a national conference for the Quantum Condensed Matter Community in India. Aminul presented a poster on his research on topological insulators.

Prof. Sudipto Singha Roy, **Prasant Mallik** and **Arkaprava Sil** visited IISER, Kolkata to attend Conference on 100 Years of Quantum Mechanics held from 18 to 21 December 2024. Prasant presented a poster on ***"Clifford Induced Area-Law in Quantum Many-Body Systems"***, and Arkaprava presented a poster on ***"Quantum Game of Life - A Quantum Information Perspective"***.

Alokananda Kar visited IIT Ropar, Punjab to attend National Strings Meeting 2024 held during 09 - 14 Dec 2024. National Strings Meeting (NSM) is a biennial conference where the participants working in string theory, quantum field theory, and related areas from Indian institutes/universities attend and present their work. Alokananda gave a talk titled "***Gauge covariance of entropy current in higher derivative theories of gravity***".



Student Visit Abroad

Romario Mondal visited the ISIS Neutron and Muon Source at STFC Rutherford Appleton Laboratory, UK to perform neutron powder diffraction experiment at the WISH spectrometer during 9-10 Dec 2024. The goal of the experiment was to investigate the ground state spin configuration in a newly synthesized triple perovskite material. ISIS is one of the world's premier international research facilities, where beamtime allocations are highly prized and in great demand. The Facility Access Panels (FAP) peer review all beamtime proposals and select those with the highest scientific merit. Romario also received ISIS-Indian Partnership funding for this visit.

Enhancement of room temperature sensitivity and reduction of baseline drift in WO_3/g-C_3N_4 nanocomposite based volatile organic compound gas sensors

By MEGHANA N, SRF

Detection of volatile organic compounds (VOCs) at room temperature is a key area of interest in environmental monitoring, indoor air quality assessment, industrial safety, and human health monitoring. Currently, VOC gas sensing at room temperature is challenging, mainly because most VOCs are nonreactive and appear in low concentrations.

Generally, Metal oxide semiconductors such as SnO_2, ZnO, In_2O_3, Ga_2O_3, CuO, Fe_2O_3, and WO_3 and their composites can be efficient gas sensors at elevated temperatures but room temperature gas sensors are still scarce. Room temperature gas sensing with metal oxide semiconductors has several shortcomings such as low response, poor stability, long response and recovery time, and baseline resistance drift error.

In our work, we effectively synthesized various composites of metal oxide semiconductors WO_3 with organic materials such as g-C_3N_4 by varying weight percentages. Among 50%WO_3/50%g-C_3N_4 (w/w) nanocomposite showed 91 % response to 1272 ppm ethanol gas with the limit of detection for ethanol gas being 106 ppm. The innovation points of this work include enhanced sensitivity, very small baseline drift, and stable room temperature operation of WO_3/g-C_3N_4

nanocomposite-based ethanol gas sensors. Enhanced ethanol sensing properties of WO_3/g-C_3N_4 nanocomposite at room temperature invite its possible application in commercial volatile organic compound gas sensors in the future.

Physics in History

- The New Year of 1801 was definitely worth celebrating since **Giuseppe Piazzi** discovered Ceres, the first and largest object found in the asteroid belt.
- Celebrations are in order since it's the birthday month of **Satyendra Nath Bose** (1, Jan 1894), The physicist behind the word Boson, but his academic work lies far beyond just work around subatomic particles, and we encourage you to read about him.
- On January 7, 1927, **Clinton Davisson** and **Lester Germer** first demonstrated the wave nature of electrons for which in 1937 Davisson shared the Nobel prize with George Paget Thomson, if Thomson rings some bells it is because G.P Thomson is the son of J.J Thomson who got Nobel prize for his discovery of the electron, the first subatomic particle. The only family benefited the most from the dual nature of electrons.
- On the same date a few centuries ago, on 7 Jan 1610, **Galileo Galilei** discovered four of Jupiter's largest moons using his improved telescope.
- In January 1928, **Paul Dirac** gave an equation to unify quantum mechanics and special relativity, hence beginning the quest to find the grand unified theory.

Spotlight

Prof. Manu Kurian graduated with a Master's degree in Physics from Calicut University, Kerala, in 2015. He earned his Ph.D. from the Indian Institute of Technology Gandhinagar in 2021 under the supervision of Professor Vinod Chandra.

Following his Ph.D., Prof. Kurian served as an Institute Postdoctoral Fellow at IIT Gandhinagar from November 2020 to January 2022. He then pursued a postdoctoral position at McGill University, Canada, from February 2022 to April 2023 under the guidance of Professor Charles Gale. This position was supported by the Excellence Scholarship Program for Foreign Students (PBEEE) from the Fonds de Recherche du Québec – Nature et Technologies (FRQNT).

Subsequently, he was appointed as a RIKEN Special Postdoctoral Researcher (SPDR) Fellow at Brookhaven National Laboratory, New York, United States, from May 2023 until he joined our department. During his Ph.D., Prof. Kurian focused on the thermodynamic and transport properties of strongly interacting nuclear matter, specifically the Quark-Gluon Plasma, under the influence of strong electromagnetic fields. His doctoral research was recognized with the Gold Medal for Outstanding Research. During his postdoctoral studies, he explored various aspects of the hydrodynamical evolution of Quark-Gluon Plasma created in heavy-ion collisions and investigated charm quark energy loss in strongly interacting nuclear matter.

Prof. Kurian's current research interests include relativistic dissipative magnetohydrodynamics, the physics of Quark-Gluon Plasma, the dynamics of electromagnetic fields generated in relativistic heavy-ion collisions at the LHC and RHIC, heavy quark physics, and other related topics.

Workshop Organized

Twenty-four (24) days residential Faculty Induction Program on various teaching and learning ecosystems in higher education institutions was organized by **Prof R Thangavel**, Convenor and **Prof. P. M. Sarun**, Co-convenor, during 02-14 December 2024 and 03-18 January 2025 under the aegis of Madan Mohan Malaviya Teachers Training Programme, UGC, New Delhi.

Six days Online Faculty Development Program on ***Crystal Growth, Semiconductor Processing and Manufacturing Technologies*** was organized by **Prof R Thangavel**, Convenor and **Prof Manodipan Sahoo**, Co-convenor, Department of ECE, during 16-21 December 2024. The FDP was sponsored by AICTE Training and Learning (ATAL) Academy, New Delhi.

Physics Openings

1. **Postdoctoral Opportunity in Quantum Information and Control Technologies**: The School of Applied Mathematics (MIEM, HSE University), Moscow, Russia, is inviting applications for 2024 Postdoctoral Fellowships in Quantum Information and Quantum Control. The position offers an opportunity to work in a dynamic research environment and contribute to innovative studies at the intersection of stochastic analysis, mathematics, and their applications.

Research Publications

1. Meghana N, Vishakha Zimba, and Jhasaketan Nayak, Enhancement of room temperature sensitivity and reduction of baseline drift in WO_3/g-C_3N_4 nanocomposite based volatile organic compound gas sensors, Ceramics International
2. Deenbandhu Sharma, and S K Sharma, Influence of Sn^{2+} doping to improve the charge transport and light-emitting properties of $CsPbCl_3$ perovskites, Journal of Physics: Condensed Matter
3. Anupam Kumar, and Chi-Hang Lam and Cho-Tung Yip, *et. al.*, Direct manipulation of diffusion in colloidal glasses via controlled generation of quasi-particle-like defects, Physical Review E