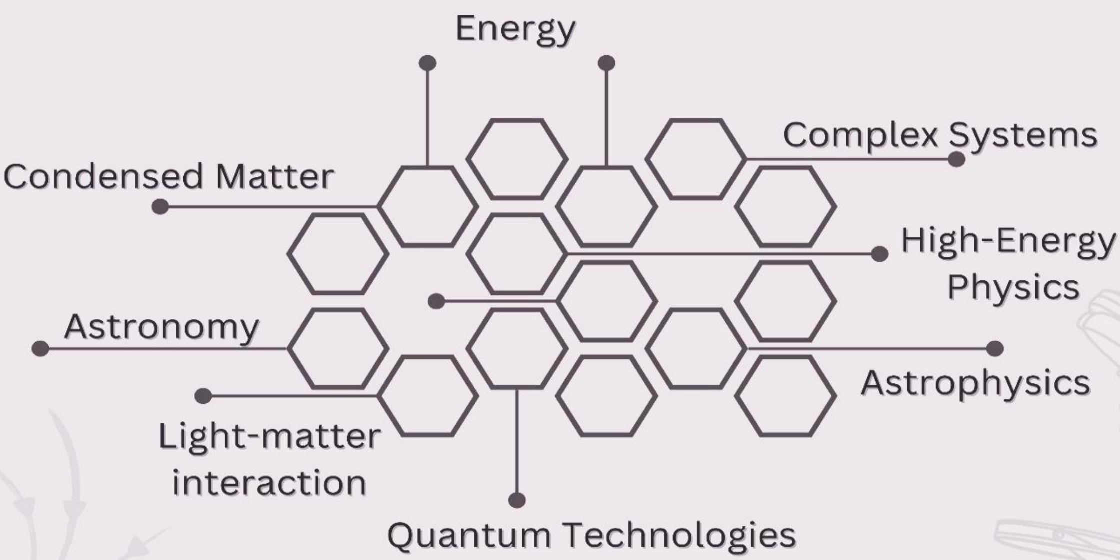
IISER THIRUVANANTHAPURAM

IISER
THIRUVANANTHAPURAM

Frontier Symposium in Physics 2025

FS PHY-2025



January 17th-19th, 2025

Organised by:

School of Physics , IISER TVM

About FS-PHY 2025

FS-PHY 2025 is annual series of scientific meetings organized by the School of Physics, IISER Thiruvananthapuram, Kerala, India, and serves as a platform for the examination and dissemination of current and emerging research in Physics and interdisciplinary areas. Scientists and researchers from almost all sub-domains of Physical Science converge at this event to exchange innovative ideas, engage in broader impact programming, network with friends and colleagues, and contribute to the advancement of Physics.

PATRON

Prof. J. N. Moorthy,

Director, IISER Thiruvananthapuram

Frontier Symposium in Physics (FS-PHY 2025) Program Schedule

Day 1: Friday, 17-01-2025

Lec. No.	Time	Session Description
	11:30 - 14:00	**Registration**
	14:30	Inaugural Address by **Prof. J. N. Moorthy** The Director, IISER Thiruvananthapuram
		Session 1: Chair: Prof. Ramesh C. Nath
1	14:50 - 15:15	**Prof. Soumitro Banerjee,** IISER Kolkata Is our Sun going through a bifurcation?
	15:15 - 15:30	Tea break
		Special Session
	15:30-16:30	Professor M. V. George Memorial Endowment Lecture by **Prof. George K. Thomas**, IISER Thiruvananthapuram Exploring Light-Matter Interactions at the Nanoscale
		Session 2: Chair: Dr. Nitin Yadav
2	16:45 - 17:10	**Prof. Arun Kumar Pati,** TCG CREST Kolkata Quantum Speed limit and Quantum Battery
3	17:10 - 17:35	**Prof. P. Ramadevi,** IIT Bombay Knots, links, three-manifolds from Chern-Simons Field theory.
4	17:35 - 18:00	**Prof. Ranjith Padinhateeri,** IIT Bombay Physics of DNA folding and fate of living cells
	18:00 - 19:00	**Poster Session + Tea**

Day 2: Saturday, 18-01-2025

Lec. No.	Time	Session Description
		Session 3: Chair: Dr. D. V. Senthilkumar
5	9:00 - 9:25	**Prof. Gagan Mohanty,** TIFR Bombay Stories from the energy frontier
6	9:25 - 9:50	**Prof. Shankar Kumar Selvaraja,** IISc Bangalore Photonic Integrated Circuits a Platform for Connectivity, Computing and Sensing
7	9:50 - 10:15	**Prof. Rajesh Ganapathy,** JNCASR Bangalore Unveiling the hidden structural order in dense liquids and glasses
8	10:15 - 10:40	**Prof. Anil Shaji,** IISER Thiruvananthapuram Unravelling why mixed state quantum computation works
	10:40 - 11:10	Tea break
		Session 4: Chair: Prof. Joy Mitra
9	11:10 - 11:35	**Prof. Bivas Saha,** JNCASR Bangalore Polaritons for Near-UV-to-Far-Infrared Nanophotonics

10	11:35 - 12:00	**Prof. Karthik V. Raman,** TIFR Hyderabad In-Plane Anisotropy of Magnetic Textures Revealed by Planar Hall Effect
11	12:00 - 12:25	**Prof. Anandmayee Tej,** IIST Thiruvananthapuram Probing Planetary Atmospheres
	12:25 - 13:30	Lunch
	13:30 - 14:30	**Poster Session**
Session 5: Chair: Dr. Suraj S. Hegde		
12	14:30 - 14:55	**Prof. Rajesh V Nair,** IIT Ropar Exploring the emission properties of quantum emitters in diamond
13	14:55 - 15:20	**Prof. Parinda Vasa,** IIT Bombay Emitters in proximity of plasmonic nano-cavity
14	15:20 - 15:45	**Prof. Sunil Nair,** IISER Pune When magnons drag electrons: the phenomena of interfacial magnon drag
	15:45 - 16:15	Tea break
Session 6: Chair: Dr. Souvik Paul		
15	16:15 - 16:40	**Prof. Dibyendu Nandi,** IISER Kolkata Influence of Stellar Magnetism on Planetary Environments and Habitability
16	16:40 - 17:05	**Prof. Amal Medhi,** IISER Thiruvananthapuram Convolutional restricted Boltzmann machine correlated variational wave function for the Hubbard model
17	17:05 - 17:30	**Prof. Subhro Bhattacharjee,** ICTS Bangalore Variational wave-function for correlated metals
	17:35 - 19:00	**Poster Session + Tea**

Day 3: Sunday, 19-01-2025		
Session 7: Chair: Dr. Shabnam Iyyani		
18	9:00 - 9:25	**Prof. Madhu Thalakulam,** IISER Thiruvananthapuram Macroscopic manifestation of backaction due to quantum tunnelling of electrons
19	9:25 - 9:50	**Prof. Dipankar Banerjee,** IIST Thiruvananthapuram Variability of our nearest star the sun as studied from Aditya L1 observatory
20	9:50 - 10:15	**Prof. Pallavi Bhat,** ICTS Bangalore Magnetic reconnection and particle acceleration
21	10:15 - 10:40	**Prof. Ranjit Kumar Nanda B,** IIT Madras The new kid in the magnetic Horizon and the name is altermagnetism: What is the story so far?
	10:40 - 11:10	Tea break
Session 8: Chair: Dr. Tuhin Maity		
22	11:10 - 11:35	**Prof. Rajeev Kini,** IISER Thiruvananthapuram THz phonon amplification via the Cerenkov mechanism in an acoustic cavity
	11:35 - 12:30	**Flash Talk**
	12:30 - 13:00	**Awards and Concluding Session**

TABLE OF CONTENTS

INVITED TALKS

Title of the talk

Stellar mid-life crisis: Is our Sun going through a bifurcation?

Prof. Soumitro Banerjee
IISER Kolkata

Abstract: Astronomers have noticed that old stars of masses comparable to that of our Sun rotate slower and have reduced magnetic activity than younger stars. A mechanism of magnetic braking of stars is well known, but it is a very slow process. Observational data indicate that there must be another mechanism that becomes active around the middle of a star's life, which renders the magnetic braking mechanism ineffective. There are indications that our Sun, at the age of 4.6 billion years, is now undergoing that 'stellar mid-life crisis' because the 11-year solar activity cycle is exhibiting intermittent cycles of dormancy. Using a stochastic delay differential equation model of the mean magnetic field generation process in stars, we show that the phenomenon is caused by the existence of two attractors. As the sun ages, the system can come close to a saddle-node bifurcation point, where the periodic orbit representing the normal magnetic activity coexists with an equilibrium point representing a magnetically dormant state. When the two attractors are sufficiently close to each other, the system noise can intermittently knock the state from the periodic orbit to the equilibrium point and vice versa. These two solutions are possibly involved in the observed bimodal distribution of magnetic cycles in the Sun. On that basis, we argue that the Sun is right now undergoing a bifurcation that will eventually lead to the transition from a magnetically active to an inactive state.

Title of the talk

Quantum Speed Limit and Quantum Battery

Prof. Arun K Pati

CQuERE, TCG CREST, KOLKATA

Abstract: Quantum speed limits (QSL) set fundamental bounds on how fast quantum state and observable can evolve in time. I will discuss QSL for states and observables. I will also discuss a stronger version of the observable speed limit and show that the previously obtained bound is a special case of the new bound. The stronger quantum speed limit for the state also follows from the stronger quantum speed limit for observables (SQSLO). I will discuss how to apply the SQSLO in the context of interacting qubits in a quantum battery. This reveals that the time required to charge the battery can be exactly predicted using the new bound and SQSLO is actually tight. Our findings can have important applications in other areas such as quantum thermodynamics, predicting the time rate of quantum correlation growth, and quantum technology in general.

Title of the talk

Knots, links, three-manifolds from Chern-Simons field theory

Prof. P. Ramadevi
IIT Bombay

Abstract: Knots are closed curves embedded in three-dimensional space. Firstly, I will present the historical information motivating the study of knots. I will also provide an overview of interdisciplinary and intradisciplinary areas connecting knot theory. Then, I will focus on Chern-Simons theory and the invariants for knots, links and three-manifolds.

Title of the talk

Physics of DNA folding and fate of living cells

Prof. Ranjith Padinhateeri
IIT Bombay

Abstract: DNA serves as the blueprint of life, containing the genetic instructions that define every aspect of an organism. Interestingly, despite every cell in our body carrying the exact same genetic code, cells such as skin, brain, and muscle cells exhibit vastly different behaviors and functions. This remarkable diversity arises from how DNA is folded and organized in space and time within each cell, as well as its micro and macro states. In this talk, we will explore the physics underlying DNA folding and organization, and how these dynamic states influence cellular fate and function.

Title of the talk

Stories from the energy frontier

Prof. Gagan Mohanty
TIFR Bombay

Abstract: We present the latest results of the CMS experiment at the Large Hadron Collider, the most expensive scientific instrument ever built to address fundamental questions at the most elementary level. Before closing, we provide the near-future plan of the experiment, highlighting India's role in this multi-billion-dollar enterprise.

Title of the talk

Photonic Integrated Circuits a Platform for Connectivity, Computing and Sensing

Prof. Shankar Kumar Selvaraja
IISc Bangalore

Abstract: Integrated photonics, particularly silicon-based photonic circuits, has revolutionized optical signal processing in communication, sensing, and computing. By leveraging scalable and flexible fabrication technology, monolithic and heterogeneous integration has addressed the inherent limitations of silicon photonics. In this talk, I will present our exploration of passive silicon photonic technology developed at IISc for applications in communication, RF signal processing, and sensing. The integration of electro-optic and phase-change materials is pivotal in extending the functionality and application space of traditional silicon photonic platforms. We will discuss strategies for realizing energy-efficient neuromorphic photonic circuits. While telecom wavelengths dominate photonic integrated circuit (PIC) developments, shorter wavelengths hold immense potential for applications in spectroscopy and biosensing. I will provide compelling reasons for developing circuits operating at these wavelengths, alongside demonstrations of circuits with integrated wavelength-division multiplexing (WDM) and on-chip detectors. Additionally, photonic circuits offer exciting opportunities for enhancing signal transduction. By integrating photonics with micro-mechanics, we have demonstrated state-of-the-art displacement detection down to the picometer scale. While photonic circuits promise numerous disruptive technologies, scalable and reliable fabrication remains essential. All the demonstrations in this talk are based on indigenous processes and materials developed at the Indian Institute of Science, Bangalore.

Title of the talk

Unveiling the hidden structural order in dense liquids and glasses

Prof. Rajesh Ganapathy
JNCASR, Bangalore

Abstract: The textbook approach for quantifying the structure of liquids entails calculating the pair-correlation function—the average particle density in spherical shells of different radii centered on a given particle. Since the spherical averaging washes out any angular structural correlations that may be present, this method finds that liquids are structurally uninteresting beyond a particle diameter or so. Here, using a recently developed technique that explicitly seeks out these angular correlations, we show that bidisperse colloidal liquids have a highly nontrivial structure extending well beyond nearest-neighbor distances. Our single particle-resolved imaging studies show that this intermediate-range structural order grows as the particle number density increases, i.e., on supercooling, and dictates the relaxation dynamics of the liquid.

Title of the talk

Unravelling why mixed state quantum computation works

Prof. Anil Shaji
IISER-Thiruvananthapuram

Abstract: Resources that allow quantum computers working with pure states to perform certain computational tasks exponentially faster than classical computers are well established. Quantum entanglement that grows unboundedly with system size is required for endowing pure state quantum computers with exponential speedups. No analogous result is known for quantum computers operating on mixed states even though mixed state quantum computers can also give exponential speedups for certain computational problems. A summary of the efforts over the past two decades on identifying the quantum resources that are key for mixed state quantum computing is presented. Recent results on viewing mixed state computation as information processing on part of a larger pure state are also discussed.

Title of the talk

Polaritons for Near-UV-to-Far-Infrared Nanophotonics

Prof. Bivas Saha
Jawaharlal Nehru Centre for Advanced Scientific Research

Abstract: Polaritons, the hybrid quasiparticles of photons and electric or magnetic dipoles (plasmons, polar phonon modes, excitons, etc.), have attracted significant interest in numerous nano-photonic applications. Due to their sub-diffraction mode confinement and field enhancement, plasmon- and phonon-polaritons are researched extensively to overcome the fundamental resistance-capacitance delay in electronics and the diffraction limit in photonic devices. However, applications of polaritons in practical devices are limited primarily due to the significant optical losses arising from the scattering of the free electrons and optical phonon modes. Therefore, materials exhibiting low-loss and high-quality plasmon and phonon-polaritons in the ultraviolet (UV)-visible and infrared (IR) spectral range are in great demand. Titanium nitride, an archetypal refractory transition metal nitride, has been studied extensively as an alternative plasmonic material to gold for visible spectral range applications. However, as the epsilon-near-zero wavelength of TiN cannot be varied readily, there is a pressing demand to develop new polaritonic materials that lead to strong light-matter interactions in near-UV to far-IR spectral range. In this talk, we will present low-loss and high-quality plasmon and phonon-polariton resonances in epitaxial transition metal nitrides and group III-nitride semiconductors spanning from the near-UV to far-IR spectral ranges. Epitaxial HfN heterostructures are developed as an alternative plasmonic material to silver for near-UV applications, such as solar mirrors. Similarly, with tuneable carrier concentration, polar semiconducting ScN thin films are designed to exhibit IR plasmon-polaritons with low optical loss and high propagation lengths. Polar phonon modes of ScN and GaN are

further utilized to achieve surface phonon-polaritons and Reststrahlen band nanophotonics.Additionally, the optical properties of the nitride heterostructures are tuned by accessing their trans dimensional regime, designing hyperbolic metamaterials, Ferrell-Berreman mode engineering, and activating surface-polaritons with nanostructure formation. Our recent findings also show an electron confinement-induced plasmonic breakdown in epitaxial ultrathin nitride metals that originate due to the strong Coulomb interaction among electrons. Our work elucidates that nitride thin films and heterostructures are excellent hosts for polaritonic resonances for a wide array of near-UV to far-IR spectral range applications.

References:

1. P. Das, S. Rudra, D. Rao, S. Banerjee, A. I. K. Pillai, M. Garbrecht, A. Boltasseva, I. V. Bondarev, V. M. Shalaev and B. Saha, “Electron Confinement-Induced Plasmonic Breakdown in Metals”, Science Advances 10, eadr2596(2024).
2. D. Mukhopadhyay, D. Rao, R. S. Rawat, A. I. K. Pillai, M. Garbrecht, B. Saha, “Flexible Near-Infrared Plasmon-Polaritons in Epitaxial Scandium Nitride Enabled by van der Waals Heteroepitaxy” Nano Letters, 24, 45, 14493–14499 (2024).
3. K. C. Maurya, D. Rao, S. Acharya, P. Rao, A. I. K. Pillai, S. K. Selvaraja, M. Garbrecht and B. Saha, “Polar Semiconducting Scandium Nitride as an Infrared Plasmon and Phonon-Polaritonic Material” Nano Letters, 22, 13, 5182-5190 (2022).
4. K. C. Maurya, A. Chatterjee, S. M. Shivaprasad and B. Saha, “Morphology-Controlled Reststrahlen Band and Infrared Plasmon Polariton in GaN Nanostructures” Nano Letters, 22, 23, 9606–9613 (2022).

Title of the talk

In-Plane Anisotropy of Magnetic Textures Revealed by Planar Hall Effect

Prof. Karthik V. Raman
TIFR Hyderabad

Abstract: The investigation of magnetic textures with non-coplanar ordering in bulk chiral magnets and thin-film heterostructures is a focal point in condensed matter physics due to the rich physical phenomena associated with topologically non-trivial states and low-energy excitations. Challenges arise in visually capturing the anisotropy of these textures, including the well-studied skyrmions. A prudent approach involves the examination of magnetotransport through the study of topological Hall effect. However, in our work, we utilized a less-explored planar Hall measurement configuration to examine the spin-canted state of a Heisenberg ferromagnetic insulator Europium sulfide (EuS) in $Bi_2(Se,Te)_3$/EuS bilayer devices. Our observation of planar Hall anisotropy, substantiated by theoretical investigations, thus far provides evidence for the existence of an unconventional magnetic phase in interfacial EuS, such as the elongated skyrmions, opening up promising new avenues in the development of next-generation topological spintronic devices.

References:

1. Phys. Rev. B 110, 125133, 2024
2. Phys. Rev. B 110, 134433, 2024

Title of the talk

Probing Planetary Atmospheres

Prof. Anandmayee Tej
Indian Institute of Space Science and Technology, Trivandrum

Abstract: Stellar occultations have proven to be a very powerful technique to study solar system objects. A plethora of discoveries like detecting tenuous atmospheres and ring systems are well documented in literature. In this talk, I will discuss this powerful yet simple technique and present interesting results on Pluto's and Triton's atmosphere from recent observations. Going beyond the solar system, more than 5000 exoplanets have now been detected, displaying extreme diversities in their macroscopic properties. While detections are being beamed down, the gear has shifted to probe the atmospheres of these planets as well. This would lead to a paradigm shift in our understanding and classification of planetary systems and shed crucial light on their formation and evolution. Towards the later part of my talk, I will give a brief overview on, ExoWorlds, a proposed mission to probe exoplanetary atmospheres through transit spectroscopy.

Title of the talk

Exploring the emission properties of quantum emitters in diamond

Prof. Rajesh V Nair
IIT Ropar

Abstract: Quantum emitters (QEs) are pivotal in developing cutting-edge quantum technologies, including quantum computing, imaging, and sensing. The building blocks of quantum technologies require exceptional properties of QEs, such as brightness, stable photoluminescence (PL), optical addressability, and coherent manipulation. The NV centers in diamonds have emerged as promising QE with stable emission dynamics, long spin coherence time, and reproducibility even at room temperature, making NV ideal for single-photon sources. However, its interaction with light is typically weak; high lifetime and broad phonon sidebands (PSB) limit its practical use. The metal-insulator-metal cavity can cope with this issue by coupling NV with them. We experimentally analyse the optical properties and investigate the effect of coupling strength on the emission and lifetime dynamics of the coupled NVs. The cavity-coupled NVs show a high decay rate and PL enhancement along with high tunability of cavity, thus offering a platform to couple a variety of QEs.

Title of the talk

Emitters in proximity of plasmonic nano-cavity

Prof. Parinda Vasa
Department of Physics, IIT Bombay

Abstract: Spontaneous emission (SE) is the most fundamental light-matter interaction. Controlling the SE decay rate is appealing for fundamental as well as applied research. According to Fermi's golden rule, the SE decay rate is proportional to local density of states in proximity of the emitter. Here, we have investigated the optical resonances supported by ~15 nm wide and semi-infinite in length nano-slit antenna in silver films. We studied modification of the SE decay rate of CdSe/ZnS quantum dots (QDs) in proximity of nano-slit antenna.

Title of the talk

When magnons drag electrons: the phenomena of interfacial magnon drag

Prof. Sunil Nair
IISER Pune

Abstract: The thermal Hall effect owing to magnons - the quanta of collective spin wave excitations- offers an indirect probe of the magnonic band structure. We demonstrate that a measurement geometry comprising of a heavy non-magnetic metal deposited on top of a ferromagnet could be used to measure the magnon Hall effect. Using a measurement geometry typically used in the past for spin-caloritronic measurements, we identify a voltage that arises as a consequence of the dragging force which surface magnons of a pyrochlore ferromagnet impart on the conduction electrons of the adjacent metal layer. Besides offering a new means of measuring the magnon Hall effect, this also suggests that surface magnons could potentially be interrogated using electrical means.

Title of the talk

Influence of Stellar Magnetism on Planetary Environments and Habitability

Prof. Dibyendu Nandi
IISER Kolkata

Abstract: The magnetic activity of stars such as the Sun has a profound influence on planetary space environments. This is mediated via variable stellar radiation, energetic particle fluxes, and magnetized plasma storms. The resultant space weather impacts our space-reliant technologies on the one hand, and on the other, this dynamic environment influence planetary habitability. Drawing upon our research, I shall present the physical basis and consequences of this beautiful relationship we share with our star.

Title of the talk

Convolutional restricted Boltzmann machine correlated variational wave function for the Hubbard model

Prof. Amal Medhi
IISER-Thiruvananthapuram

Abstract: The neural-network quantum states (NQS) wave functions have recently been shown to be highly accurate in representing the ground states of several quantum many-body systems. These wave functions constructed based on artificial neural networks have a large number of variational degrees of freedom and are highly unbiased. The NQS wave functions offer the possibility of removing the main drawback of biased results in the otherwise powerful variational method to study many-body physics. Though there have been several studies of NQS wave functions for bosonic systems, their applications to fermionic systems have been few. The main reason has been the failure of NQS wave functions to capture the complicated sign structure of fermionic wave functions. In this talk, I will present our recent work (Phys Rev B 110, 125125 (2024)) on a novel convolutional restricted Boltzmann machine (CRBM) correlated variational wave function for the two-dimensional (2D) fermionic Hubbard model. The wave function is shown to be highly accurate. It outperforms some of the best known Jastrow-type variational wave functions in terms of energy. Moreover, the number of variational parameters in the wave function does not grow automatically with the system size and is computationally much more efficient compared to other neural network wave functions. I will present the detailed results for the half-filled 2D Hubbard model obtained by using this wave function.

Title of the talk

Variational wave-function for correlated metals

Prof. Subhro Bhattacharjee
ICTS Bangalore

Abstract: Correlated metals are a set of least understood electronic phases inspite of their ubiquity. This is partly due to the breakdown of the basic control of quantum field theories-- the absence of low energy quasiparticles and presence of massive many-body entanglement. In this talk, we explore a complementary route by asking : Are there prototypical many-body wave functions that captures the basic phenomenology of the unconventional ground state of correlated metals ? We shall show that a set of candidate wave-function exists which involves superposing "Fermi surfaces".

Title of the talk

Macroscopic manifestation of backaction due to quantum tunnelling of electrons

Prof. Madhu Thalakulam
IISER-Thiruvananthapuram

Abstract: Inherent randomness and the resulting stochastic behavior of fundamental particles, manifested as the quantum noise, put a lower bound on measurement imprecision in the quantum measurement process. In addition, the quantum noise imparts decoherence and dephasing on the system being measured, referred to as the measurement back-action. While microscopic effects of back-action have been observed, macroscopic evidence is a rarity. Here we report a macroscopic display of the back-action of an ultra-sensitive quantum point contact (QPC) electrical amplifier whose transport is defined by the quantum tunnelling of electrons. The QPC amplifier, realized on GaAs/AlGaAs heterostructures, coupled to a planar superconducting resonator, operates at a frequency of in the shot-noise-limited regime. Being realized on a piezoelectric platform, there exists positive feedback between the electrical and mechanical degrees of freedom. Piezoelectrically active vibrational modes are excited by the shot noise, and these mechanical modes in turn induce polarization charges across the QPC, enhancing tunneling and modulating the shot-noise spectra. While the excitation of the vibrational modes is a display of the macroscopic effects of measurement back-action, the amplitudes of the noise peaks allow us to calibrate the displacement sensitivity of the QPC-resonator systems, which is in the range, making it an excellent sensor for ultra-sensitive and fast strain or displacement detection.

Title of the talk

Variability of our nearest star the sun as studied from Aditya L1 observatory

Prof. Dipankar Banerjee
Indian Institute of Space Science and Technology, Trivandrum

Abstract: We have been studying the variability of the sun from Kodaikanal Observatory (KSO) over a century now. We have archived more than 100 years of solar images in three different wavelengths namely white light, Ca K and H-alpha. In this talk I will give examples of solar observations from different Indian facilities from ground based facilities. Then I will demonstrate how the space era has changed our understanding of our nearest star the sun. We have launched our own space observatory, Aditya L1 , which is the first observatory class solar mission from the Indian Space Research organization, launched in 2nd September 2023. The L1 insertion took place on 6th January 2024. With a combination of four remote sensing and 3 in situ instruments covering multi-wavelength it provides a unique opportunity to have joint observations with other co temporal missions. Early results from Aditya will provide an indication how with joint campaign it can lead to improved understanding of the variability of our nearest star the sun.

Title of the talk

Magnetic reconnection and particle acceleration

Prof. Pallavi Bhat
ICTS Bangalore

Abstract: Magnetic reconnection is a fundamental process in astrophysical plasmas, crucial for understanding high-energy phenomena such as solar flares, geomagnetic storms, particle acceleration in jets, pulsar winds, and potentially even galaxy clusters. While much of the research on reconnection has focused on two dimensional models, our group at ICTS has explored its three-dimensional aspects, which I will discuss. Further, we propose that fast reconnection in dynamo-driven magnetic field configurations can efficiently accelerate particles, offering insights into the origin of nonthermal emission in galaxy clusters. I will present this model and our related findings..

Title of the talk

The new kid in the magnetic Horizon and the name is altermagnetism: What is the story so far?

Prof. Ranjit Kumar Nanda B
IIT Madras

Abstract: In recent times, there is a buzzword and it is altermagnetism. While some are claiming it as a new collinear magnetic quantum state, the others are claiming it to be just old wine in the new bottle. In the first part of the talk, we will distinguish the altermagnetism from the conventional ferromagnetism and antiferromagnetism. Through a brief literature survey, we will highlight how the group theoretical analysis is a successful tool in designing a binary selection rule to identify probably altermagnetic materials. In the second part of the talk, by examining the strongly correlated electron system, NiS, we will explore the deterministic role of chemical bonding in developing a quantitative description of altermagnetism. References: Deterministic role of chemical bonding in the formation of altermagnetism: Reflection from correlated electron system NiS, Arijit Mandal, Arindom Das, and B. R. K. Nanda, arXiv: 2501.00453

Title of the talk

THz phonon amplification via the Cerenkov mechanism in an acoustic cavity

Prof. Rajeev Kini
IISER-Thiruvananthapuram

Abstract: Phonon engineering using semiconductor superlattices has emerged as a promising technique for manipulating thermal/electronic properties. Phonons, the quantized vibrations in solid materials, are crucial in determining materials' electronic, thermal, and mechanical properties. Like the quantization of electronic levels by quantum confinement, phonon energy levels can also be discretized in a phonon cavity. An innovative concept was formulated to explore phonon interactions. A unique structure was designed with a GaAs-AlAs double quantum well (QW) embedded in a high-Q value (Q ~ 10 4) acoustic cavity. This structure also integrates a generator superlattice to generate the required phonon frequency. The GaAs-AlAs QW serves to confine electrons, and by the applied external electric field, the drift velocity of the confined electrons can be made to exceed the speed of sound. The cavity phonon can induce the transition of electrons in the QW with the emission and absorption of longitudinal acoustic phonons. It has been proposed that strong electron-phonon coupling can be achieved between the electrons and the cavity phonon mode. When the electron drift velocity exceeds the speed of sound, it leads to the amplification of the phonon mode by a process analogous to the Cerenkov process. Two-color pump-probe studies were performed to investigate phonon dynamics. The results obtained showed amplification of the cavity phonon mode upon applying the bias across the device. High gain (≈ 10 5 cm - 1) was obtained with modest powers (≈ 40 mW). The realization of a phonon laser promises significant advancements in studying nanoscale mechanical systems and applications in quantum computing.

POSTER ABSTRACTS

Magnetic properties of the double trillium lattice antiferromagnet $KBaCr_2(PO_4)_3$

Ratnamay Kolay

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Trillium lattices formed by corner-shared triangular units are the platform for magnetic frustration in three dimensions. Herein, we report structural and magnetic properties of the Cr-based (S = 3/2) double trillium lattice material KBaCr2(PO4)3 studied by x-ray diffraction, dc and ac magnetization, heat capacity, thermal conductivity, and 31P nuclear magnetic resonance (NMR) measurements complemented by density-functional band-structure calculations. Magnetization, heat capacity, and 31P NMR measurements reveal the magnetictransition at TN1 ~ 12.5 K in zero field followed by another transition (TN2) at low temperatures in weak applied fields. The 31P spin-lattice relaxation rate in the ordered state follows the T^3 behavior indicative of the twomagnon Raman process. The spin lattice of KBaCr2(PO4)3 comprises two crystallographically nonequivalent ferromagnetic sublattices that are coupled antiferromagnetically, thus eliminating frustration in this trillium network and leading to weak ferromagnetism in the vicinity of TN1.

Exploring TeV scale Vector Leptoquarks as Solutions to Magnetic Dipole Moment Anomalies

Soumyadip Kundu

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: This study investigates TeV-scale vector leptoquarks (vLQs) and their contributions to the magnetic dipole moments of charged leptons. Significant parameter space for these LQs is excluded using current LHC data. Among vLQs only U_1 and V_2 can account for the observed positive shift in $(a_\mu^{\rm exp} - a_\mu^{\rm SM})$ through a lepton chirality-flipping contribution with $\mathcal{O}(1)$ LQ-quark-lepton coupling($\Delta a_\mu = (2.49 \pm 0.48)\times 10^{-9}$). These LQs can also fit the electron dipole moment and atomic parity violation measurements.

Design of (Y,RE)BCO single grain Superconductors with Nano-defects to sustain flux pinning to high fields at 77 K

BOGGALA VENKATESULU REDDY

UNIVERSITY OF HYDERABAD

Abstract: Single grain superconductors are free from grain boundaries that act as weak-links with lower current capacity limiting the applications. High Tc superconductors (HTS) exhibit large flux creep that leads to failure of superconductivity at irreversibility field that is much lower than upper critical field Bc2 of the material. To suppress the flux creep and improve the sustenance of critical current densities (Jc,) to high fields, defects of the size of coherence length (a few nm) are introduced in sufficient density to pin the flux lines enough to overcome the Lorentz force up to high fields. Varieties of methods used to generate nano-defects include substitution at lattice sites, addition of nano-particles, structural defects caused by stress field due to lattice mismatch, Columnar defects created by heavy-ion irradiation, etc. The magnetic field at which pinning is effective depends on the defect-size or spacing. This work presents the effect of adding nano-particles of WO3, BaCeO3 and 20 mol% of mixed rare earth (Nd,Sm,Gd) in place of Y in YBa2Cu3Oy single grain superconductors [1] synthesized by Two-step Seeded Infiltration and Growth Process (TSIGP). The results reveal factors that control Jc(B) and flux pinning density Fp(B) up to 9 T field at 77 K. Analysis of Fp(B) in terms of scaling laws throws light on the δk and δl pinning mechanisms that are operative in different temperature and field regimes. Outcome of this work is of significance for HTS to realize applications.

Reference :

1. Venkatesulu Reddy Boggala[1] , Pawan Kumar Verma[1] , Poly Rose[1] , Seshu Bai Vummethala[1] ,Devendra K Namburi[2] and Thankappan Pillai Rajasekharan[3] Net-shaping (Y,NSG)BCO composite superconductor into cylindrical geometry with enhanced flux pinning up to 9T at 77K, Phys. Scr. 100 (2025) 015914 https://doi.org/10.1088/1402-4896/ad941e

AI assisted Design and Fabrication of Chemical Sensor array for VOCs Detection

Shivam Singh[1], Sajana S[1], Poornima[2], Sreelekha Gajje[3], Chandranath Adak[3], Rajendra Shukla[4], Vinayak Kamble*[1]

[1]School of Physics, IISER Thiruvananthapuram, India.
[2]Dept. of CSE, Indian Institute of Technology (IIT), Patna, India.
[3]Dept. of CSE, Indian Institute of Information Technology (IIIT), Lucknow, India.
[4]MESA+ Institute of Nanotechnology, University of Twente, Netherlands.

Abstract: Semiconducting Metal Oxides (SMO) are the most common materials used in gas sensor technology. It works on the variation of surface electrical conductance in a gaseous environment. Medium to wide-bandgap oxide semiconductors is an excellent choice for gas sensing material due to intrinsic donors/acceptors in the bandgap. It has been demonstrated that high-power consumption can be reduced by designing nanostructure-based chemical sensors with ultra-small device footprints to achieve room-temperature operations. By designing a sensor array, this study investigates the low selectivity of SMO by using multivariate data analysis tools. Here the pattern of each gas-sensitive oxide layer is recorded and analyzed using a statistical analysis method, for example, Principal Component Analysis (PCA) and Artificial Neural Network (ANN) algorithms. The extensive data set shall be screened using Machine learning methods to evaluate the best oxide candidates and their simultaneous sensor characterization undertaken upon fabrication. The outcomes are processed using traditional PCA algorithms integrated with machine learning techniques [2] (including NN) to select desired gas per the end-use application. This can help to detect gases like volatile organic compounds [1] (ethanol, acetone, etc.), humidity, ammonia, NOx, etc. Therefore, the same sensor array could be used to detect various gases for applications like monitoring body vitals, detecting air pollutants, defence-related applications, etc.

Reference :

1. Khatib, M. and Haick, H., 2022. Sensors for volatile organic compounds. ACS nano, 16(5), pp.7080-7115.
2. McAlpine, M.C., Ahmad, H., Wang, D. and Heath, J.R., 2007. Highly ordered nanowire arrays on plastic substrates for ultrasensitive flexible chemical sensors. Nature materials, 6(5), pp.379-384.

TITANIUM-SUBOXIDE THIN FILM STACK AS SPECTRALLY SELECTIVE SOLAR ABSORBER COATINGS

Ann Eliza Joseph

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Solar energy is a clean, renewable, and affordable source of power that can reduce our environmental impact and dependence on fossil fuels. Concentrated Solar Power (CSP) is a growing technology with large sun-tracking reflective surfaces to concentrate and direct solar radiation to an absorber of a small surface area. The spectrally Selective Solar Absorber (SSA) coatings are used to achieve high photothermal efficiency. Here, we fabricated titanium-suboxide thin film stacks for photo-thermal application using the DC/RF magnetron co-sputtering thin film deposition technique, followed by annealing at different temperatures. The sample annealed (vacuum) at 5000C has achieved a high solar absorptance value of 0.894 and a low thermal emittance value of 0.11. Further characterizations revealed that the annealed thin film contained magneli phases as well as other forms of titanium oxide. These findings suggest that titanium suboxide thin films are best suited for efficient SSA coatings in CSP applications.

Energy transfers in internal gravity wave turbulence

Nishant N. Uchale

International Centre for Theoretical Sciences, TIFR

Abstract: In general, climate models do not consider the impact of wave interactions in the kinetic energy budget of oceans. Observational studies have revealed that internal gravity waves dominate over balanced flow over a broad range of spatio-temporal scales in certain wave-dominant oceanic regions. The energy flow pathways in this particular regime are not well understood. Hence, our study aims to understand the energy transfer pathways in ocean turbulence especially in the internal wave continuum. To do so, we time-integrated the non-hydrostatic Boussenisq equations in a forced wave-dominant regime for different Rossby number (Ro) cases. We found that the energy transfer becomes more localized, occurring at progressively smaller scales with increasing Ro number. Additionally, our analysis revealed that most of the energy flux in the system is contributed by low flux values and low divergence regions. Conversely, the high flux values contribute minimally to the overall energy flux.

$CsPbBr_3$-P_3HT in-situ Hybrid-Heterojunction for Self-Powered Photodetection and Optical Communication

Sandaap Sathyanarayana

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Fabrication of type II or staggered semiconductor heterojunctions is well established technique to design photovoltaic devices. As per the nature of the competent material used, heterojunctions are classified into inorganic, organic and inorganic-organic hybrid heterojunctions. Solution process is one of the cost-effective methods to design these kinds of heterojunctions. But when it comes to the utilization of single crystals of competent material for the heterojunction formation, the yield of functional devices per fabrication is quite challenging task. Here, we report a strategic development of device architectures to improve the yield percentage of inorganic-organic heterojunction photodetectors. We have implemented in-situ growth of single crystal all-inorganic CsPbBr3 perovskite over the photolithography patterned organic polymer semiconductor Poly(3-hexylthiophene) (P3HT). The optimized design architecture improved the yield percentage from 5 to 38. Fabricated devices showed superior performance with open circuit voltage of 0.7 V and short circuit current of 25 nA when illuminated with a light of wavelength 532 nm at 403 nW power. Ultra-low dark current of 10 fA at room temperature, empowers the devices to have large linear dynamic range (LDR) of 164.52 dB and high signal to noise ratio (SNR) of 319.27 dB for 532 nm wavelength in self-power mode. Further to realize the capability of the photodetector in advance applications, we demonstrated a light intensity to electrical frequency converter circuitry by embedding our photodetector as a light dependent resistor. Hence, the proposed device architecture proved not only the improvement in the yield but also the extreme performance of the devices as it is functionalized with the in-situ heterojunction formation between competent semiconductors.

Triggering Exothermic Water Dissociation in Alkaline Medium via Foreign Atom Incorporation on Inert Copper

Bhargav Rajbongshi

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: The alkaline hydrogen evolution reaction (HER) is crucial for sustainable energy production and industrial applications like water electrolysis and ammonia synthesis. It enables cost-effective hydrogen generation with non-precious metal catalysts, supporting the green energy transition. However, sluggish kinetics, low catalyst activity, and stability issues under alkaline conditions remain major challenges. Advancing catalyst design is essential to improve the electro-catalytic activity via acceleration of the water dissociation step, making hydrogen a viable clean energy carrier. Herein, we demonstrated an approach to trigger exothermic water dissociation via the implantation of foreign elements in a catalytically inactive copper lattice. The electrodeposited catalyst not only showed enhanced behavior but also mimicked the benchmark Pt/C catalyst. The electrochemical characterizations, density functional theory calculations, and in-situ Raman measurements were carried out, which disclosed that in the modified copper catalyst surface, water molecules dissociate exothermally owing to the faster hydrogen bond breaking among adjacent water molecules.

Partial charges on the ions reveal bonding in MgZn2 type compounds as evidenced from Electron Localization Function (ELF).

Akhil T

University of Hyderabad

Abstract: The nature of bonding in crystalline solids can be clarified by knowing partial charges on their atoms. Charges on atoms cannot be measured directly in intermetallic solids; DFT- based QTAIM technique estimates partial charges (δ) on atoms. In the present work, 117 Laves phase compounds of MgZn2 type crystal structure are investigated and the partial charges (Q) on the ions in the compounds are derived from internal radii of ions, following the Spherical-Ion picture in Atom pair bond (APB) model reported recently [1]. The charge values obtained by APB and QTAIM are compared. Radii changes of atoms on alloying and the charge transfer direction are visualized by Electron Localization Function (ELF) [2], using the DFT-based CASTEP software in typical compounds of MgZn2 type. The results confirm the basic conclusions from the APB and suggest that modifications are required in DFT to obtain partial charges consistent with ELF and radii changes.

Reference :

1. T. Rajasekharan, V. Seshu Bai, Nature of the bond in intermetallic compounds, Phys. Scr. 99 085918 (2024). https://doi.org/10.1088/1402-4896/ad59d9.
2. A. Savin, R. Nesper, S. Wengert, T.F. Fässler, ELF: The electron localization function, Angewandte Chemie 36 1808–1832 (1997). https://doi.org/10.1002/anie.199718081.

Single-shot Distinguishability and Anti-distinguishability of Quantum Measurements

Sneha Suresh

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: We consider four distinct scenarios for distinguishing (and anti-distinguishing) quantum measurements – (i) probing single systems and without access to the post-measurement states, (ii) probing entangled systems and without access to the post-measurement states, (iii) probing single systems with access to the post-measurement states, and (iv) probing entangled systems with access to the post-measurement states. For any set of measurements, distinguishability (and anti-distinguishability) in scenario (i) is always less than or equal to in any other scenario, while it reaches its highest possible value in scenario (iv). We establish that the relations form a strict hierarchy, and there is no hierarchical relation between scenarios (ii) and (iii).

Switchable polarisation in a single unit cell of BaTiO3

Manisha Bansal

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: The electric polarisation suppresses below the critical thickness of a ferroelectric material due to the surface bound charges. The existence of critical thickness hampers the growth of low-power compact ferroelectric memories. Here, we demonstrate bulk-like ferroelectricity down to 1 unit cell of BTO in epitaxially grown LSMO-BTO superlattices. However, bilayer of LSMO-BTO becomes paraelectric below 5 u.c. as previously reported. Second harmonic generation and piezo response microscopy illustrate breaking of inversion symmetry and switchable polarisation. Reciprocal space mapping techniques confirm the strain evolution in the superlattices. With DFT calculations, we prove that the interface charges in tandem with lattice strain can be a source of functionality precluding the need of conducting electrodes. We finally extend our model to different systems such as LMO-BTO and LSMO-STO, thereby sustaining FE phase in paraelectric STO and BTO indicating the possible absence of critical thickness in perovskites, enabling ultralow-dimension future ferroelectric memory devices.

Current Compliance dependent Gradual/Digital modes and ION/IOFF ratio in Sputter deposited Al/Hf0.5Zr0.5O2/Pt thin film based RRAM devices

Kifayat Hussain Mir

Vellore Institute of Technology, Vellore, Tamilnadu

Abstract: This study explores the resistive switching (RS) properties of amorphous $Hf_{0.5}Zr_{0.5}O_2$ (HZO) thin films in Al/HZO/Pt/Si stacks, fabricated via single-target sputtering of $Hf_{0.5}Zr_{0.5}O_2$. While many studies focus on enhancing ferroelectric properties to improve HZO-based FeRAM, only a few address the RS behavior. The amorphous HZO exhibits low leakage current (~10-6 A/cm²) and a high current ratio (ION/IOFF) of up to 106, highlighting its suitability for non-volatile resistive random-access memory (RRAM) applications. The RS behavior, driven by oxygen vacancies, is enabled without requiring high thermal budgets, making the devices energy-efficient. Structural analysis confirms the stabilization of the orthorhombic phase at 550 °C, while XPS verifies the chemical composition. The ferroelectric resistive switching is linked to a polarization-modulated trap-assisted tunneling mechanism, combining ferroelectricity and semi-conductivity. This work demonstrates a simple fabrication process for amorphous HZO-based thin films and emphasizes their potential for next-generation RRAM devices with high ION/IOFF ratios and low power consumption.

Exploring Neuromorphic Functionality in Cs2AgBiBr6 Through Defect Engeneering

Jnanaprakash Dash

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Nowadays, the brain-inspired synaptic behavior of analog memristor devices has gained a huge paradigm in the field of neuromorphic computing. Lead-based perovskite is already well established in the field of memristor devices but lead halide–based perovskites pose environmental hazards. So, to mitigate this problem, the research is focused on the development of lead-free double perovskite. Despite these efforts, double perovskites have not yet reached the efficiency and stability levels in comparison to lead-based perovskites. Here, we have synthesized lead-free double perovskite Cs2AgBiBr6 (CABB) by utilizing single crystals grown through the inverse temperature crystallization method to improve the quality of the thin film which results in the better performance of the memristor device. Pin hole-free thin film of CABB is characterized by scanning electron microscope and atomic force microscope. CABB thin film is sandwiched between ITO and Au electrode, which represents vertical device architecture. Systematic electrical I-V characterization of our memristor device shows a stable bipolar Analog resistive switching. Further, the device shows neuromorphic functionalities which was confirmed by recording the potentiation and depression of the conducting states of the device. Ion migration and filament formation at the defect site in CABB thin film are mainly the reason for the resistive switching property, supported by the Electrochemical impedance spectroscopy and theoretical fitting results. Several neuromorphic functionalities of the device were further explored by conducting PPF, EPSC. Overall, by using this solvothermal method for single crystal growth, memristor device performance is improved.

ExpMagnetic Crossover and Quantum-Spin Liquid Behaviour in Epitaxial $TbInO_3$ Thin Film

Riya Pathak

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: "Quantum spin liquids (QSLs) are fascinating materials that offer novel quantum states with potential for Quantum Technology. The $TbInO_3$ (TIO) system, a hexagonal perovskite QSL,exhibits unique magnetic properties. We successfully fabricated epitaxial TIO thin films on MgO (100) substrates via Pulsed Laser Deposition.X-ray diffraction and Ramanspectroscopy confirm the epitaxial growth and hexagonal phase respectively. X-ray photoelectron spectroscopy reveals minimal disorder in the films, with a consistent chemical composition, oxidation states, and oxygen vacancies. Temperature-dependent susceptibility(χ-T) measurements for both polycrystalline and thin film samples show no magnetic ordering down to 0.4 mK, supporting QSL behaviour. Curie-Weiss fitting of χ-T plots and Husimi Antasz fitting of reduced susceptibility plot reveal a Curie-Weiss crossover,characteristic of QSLs. Isothermal magnetization curves, fitted with the Brillouin function, show deviations at low temperatures, indicating strong antiferromagnetic correlations, a key QSL feature. These findings highlight the potential of TIO for quantum technologyapplications."

Linear and Nonlinear Optical Properties of Nanostructured CdSe Thin Films

Dr.Sajid Babu.N

School of Energy Materials, Mahatma Gandhi University, Kottayam, Kerala

Abstract: In recent years, there has been rapid development in the field of semiconductor thin films owing to their wide range of applications. As an important member of the II–VI group of binary compounds, cadmium selenide (CdSe) with a band gap of 1.7 eV is of interest because of its photoelectronic and electrical properties for applications in high efficiency thin film transistors, solar cells, photo electrochemical cells, photoconductors, etc. In this work, we present the linear and nonlinear optical properties of nanostructured CdSe thin films. Nanostructured CdSe thin films were deposited on glass substrates at a relatively high pressure at room temperature using a vacuum coating unit. GIXRD and AFM were used to study the crystallinity, crystal structure and surface morphology of the samples. The linear optical properties of the samples were investigated using UV–visible absorption spectroscopy. The nonlinear absorption of the samples was measured by Z-scan technique using nanosecond laser radiation of wavelength 532 nm.

Complex topological spin structures in transition-metal ultrathin films

Mathews Benny

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Topologically protected nanoscale swirling spin structures, such as skyrmions, are envisioned as the building blocks of next-generation spintronic devices. Skyrmions appear as metastable quasi-particles on a spin polarized background in bulk and 2D materials, which are suitable for applications. In this study, using atomistic spin dynamics simulations based on a spin Hamiltonian completely parameterized from density functional theory, we predict that the topologically protected skyrmion-like complex spin structures can be stabilized on a noncollinear background in hcp-Rh/Co/Re(0001) ultrathin film with an external magnetic field and in fcc-Pd/Co/Re(0001) ultrathin film at zero magnetic field. Our analysis reveals that one of the higher-order exchange interactions play a crucial role in stabilizing these spin structures. The calculated energy barriers indicate that these complex structures can be observed in experiment.*equal contribution"

2D WS_2 as third component and transport layer in organic solar cells: Insights on the performance and charge carrier dynamics

Anjana K N

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: "Two-dimensional layered materials, owing to their excellent transport characteristics and high tunability in structure, offer an exceptional platform for the fabrication of semitransparent flexible photovoltaic devices. Among the 2D materials, transition metal dichalcogenides (TMDCs) are significant because of their favourable solution processibility and strong photochemical stability. TMDC nanosheets and their hybrids, used as transport and interface modification layers, can effectively enhance the operational stability and performance of organic solar cells (OSCs) [1]. In this study, liquid phase exfoliated WS2 nanosheets are incorporated as a third component in the bulk of the active layer, as transport layer, and at the interface of the transport and active layers. Performance and stability of the devices with 2D WS2 incorporated at various sites of the OSCs are evaluated and compared, and the mechanism for the performance is elucidated from various characterization techniques like impedance and capacitance spectroscopies and transient measurements.

Reference:

1. Lin, Y., et al., 17% efficient organic solar cells based on liquid exfoliated WS_2 as a replacement for PEDOT: PSS. Advanced Materials, 2019. 31(46): p. 1902965.

MALTA2 Characterization

Fathima C

IISER Mohali

Abstract: The MALTA sensor is an advanced monolithic pixel detector created to withstand the rigorous conditions of high-energy physics experiments like those at the Large Hadron Collider (LHC). Unlike conventional pixel sensors that rely on separate readout electronics, MALTA combines the sensor and readout circuitry on a single silicon wafer. This integrated monolithic design increases compactness, enhances resolution, and makes the sensor highly efficient in speed and radiation resistance. Extensive electrical testing has been undertaken to fine-tune these sensors before they are implemented in actual detectors. The findings from the electrical characterization and DAC analysis of the sensor, performed using the setup at IIT Madras, will be presented.

Device Modification for High-Efficiency Methylammonium-free Wide-bandgap Perovskite Solar Cells

Prithwish Kumar Bhunia

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Wide-bandgap perovskite solar cells are vital for tandem applications but face challenges like rapid crystallization, non-uniform films, and VOC losses due to non-radiative recombination. Pb(SCN)2 improves film crystallization but generates excess PbI2, harming performance. A post-treatment with mixed PEAI and MAI solutions efficiently converts residual PbI2 into quasi-2D perovskites, reducing VOC losses and enhancing charge extraction compared to PEAI alone, which forms 2D perovskite. This approach improves film quality and device performance, achieving 19.34% efficiency. Encapsulated cells retained over 90% of their efficiency after 200 hours under 1-sun illumination, demonstrating enhanced stability in ambient conditions.

Superconducting Diode Effect in Van der Waals Josephson Junctions

Annu Anns Sunny

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: A lot of attention has been drawn to the recently discovered superconducting diode effect (SDE), also known as the rectification of supercurrents, from a theoretical standpoint as well as in terms of novel device applications in superconducting electronics, superconducting spintronics, and quantum information and communication technology. To put in simple words, the diode effect in superconductors occurs when the critical current Ic depends on the current sweep direction. When both inversion and time-reversal symmetries are broken, Ic can be nonreciprocal. Van der Waals materials (Two-dimensional materials(2D)) with high crystal quality and tunable transition temperatures can be a promising candidate for superconducting Josephson Junction devices, which possess broken inversion and time reversal symmetries.Van der Waals heterostructure, which consists of Niobium Diselenide $NbSe_2$, a superconducting Transition Metal Dichalcogenide (TMDC material) which has a transition temperature of T□7K, can be an excellent device that demonstrates superconducting diode effect. In this work, $NbSe_2$ Josephson junction is fabricated by micromechanical exfoliation of layered $NbSe_2$ flakes and vertically stacking them by dry transfer technique on prepatterned Cr-Au metalized probes and followed by etching to control the junction area. An $NbSe_2$ flake with an odd number of layers can be a reason for broken inversion symmetry, and the application of an in-plane magnetic field can break the time-reversal symmetry of the Josephson junction. From the Current-voltage characteristics and magnetotransport measurements at temperatures lower than the critical temperature, I□+ ≠ |I□-| at a definite in-plane magnetic field where I□+ is the critical current in the forward directions and I□- is the critical current in backward directions. Second harmonic resistance measurements and half-wave rectification using square waves at different magnetic fields are also carried out to confirm the superconducting diode effect. Our study demonstrates that low-dimensional crystalline superconductors like $NbSe_2$ are promising systems to realize the effects like superconducting diode effect and, consequently, valuable for additional device applications.

On the role of strain and defect engineering with respect to temperature triggered resistance switching in PLD grown epitaxial VO_2-based thin films on (0006) Al_2O_3

Aditya Kamat

Indian Institute of Technology Kanpur

Abstract: Vanadium Dioxide (VO_2), an Insulator-to-Metal Transition (IMT) material has garnered significant research interest due to its potential applications in radiative coolers, optical memories, and optical switches. VO_2 exhibits MIT near 68°C, thereby requiring tuneable transition temperatures (Tc) in VO_2 thin films for practical device applications. In this work, variation in growth parameters was involved, mainly temperature and oxygen partial pressure. Strain engineering along the b-axis helped tune the transition temperature from 65°C to 82°C with the out-of-plane b-strain varying from -0.71% to -0.44%. Comprehensive structural and property analyses, including X-ray diffraction (XRD), Reciprocal Space Mapping (RSM), X-ray Dispersive Spectroscopy (XPS), Raman spectroscopy, and Resistivity-Temperature (R-T) measurements, ab-initio DFT calculations using revised Perdew-Burke-Ernzerhof were performed to correlate structural properties with Tc. Our study provides critical insights of the interplay between strain and oxygen vacancies and their effect on the physical properties in VO_2 thin films.

Overcoming the meta-magnetic phase transition in Dy_2NiMnO_6 in thin films and its impact on the MCE

Saikarthikey Bhat

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: We have investigated the effect of strain on the strength of magnetic interactions in a double perovskite system containing multiple magnetic ions. Strain in thin films weakens the antiferromagnetic coupling between rare-earth and transition-metal ions, suppressing meta-magnetic transitions and reducing hysteresis loss. This reduction in hysteresis loss during the magnetic refrigeration cycle enhances operational efficiency, allowing for multiple cycles with lower energy consumption. We have grown epitaxial thin film of Dy_2NiMnO_6 (DNMO) on LAO and STO substrate using pulsed laser deposition technique. Epitaxial growth was confirmed with XRD. Magnetic and magneto caloric study was done on both thin films and bulk sample. The magnetic data clearly indicates the suppression of meta-magnetic transition in thin films compared to bulk. This leads to change in order of magnetic transition from first order to second order in thin film without considerable decrease in magnetic refrigeration capacity.

On-chip Microwave Frequency Combs based on Quantum Paraelectric Materials

Prasad M

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: A frequency comb is a spectral structure consisting of discrete, evenly spaced spectral lines, often described as an "optical ruler" due to its remarkable precision. They have become essential in fields such as astronomical spectrograph calibration, high-precision metrology, optical atomic clocks, frequency synthesis and spectroscopy. Though, optical frequency combs have been extensively studied, we use microwave frequency combs that are far less explored. In this experiment we realize a tunable on-chip micro-comb using a coplanar waveguide resonator on SrTiO3 exploiting the χ^3 nonlinearity of its dielectric constant. The χ^3 nonlinearity allows tuning of the cavity resonances with the application of voltage excitations which modulates the frequency of the reflected or transmitted cavity signals and a subsequent generation of the comb. The on-chip, all-electrical approach with a voltage tunable comb-lines makes our approach a suitable choice for various applications in the field of quantum technology.

Thickness dependent phase evolution of pulsed laser deposited $Hf_{0.5}Zr_{0.5}O_2$ thin films on c –Al_2O_3 substrates

Gurukrishna K

Indian Institute of Technology Kanpur

Abstract: Ferroelectricity in HfO_2 – ZrO_2 based solid solutions has revived the interest in ferroelectric memory technology due to its CMOS compatibility and robust electric dipoles at nanoscale thicknesses. We here in report on the evolution of structural phase in PLD grown $Hf_{0.5}Zr_{0.5}O_2$ thin films as the thickness is varied via controlling the number of laser pulses. Thin films deposited at 5000 laser pulses exhibit major monoclinic structure whereas the orthorhombic structure found to dominate as the laser pulses reduced to 3000, 1500 and 1000. Co – existence of different polymorphs is well confirmed by X- ray diffraction and confocal Raman spectroscopy. X - ray photoelectron spectroscopy has ensured the recommended ionic states of Hf^{4+} , Zr^{4+} and O^{2-} in as deposited films. The optical band gap of all the samples observed to be in the vicinity of 5.20 eV. The band gap was found to increase with decrease in the film thickness.

Unveiling cooling performance at quantum criticality in frustrated magnets via ADR

Sharath Kumar C

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Adiabatic Demagnetization Refrigeration (ADR) has emerged as a promising approach for achieving low temperatures in diverse applications. A home-built ADR setup was used to investigate phase transitions in novel materials, showcasing its potential as a cost-effective alternative to commercial systems. Its performance was tested on $GdCrTiO_5$, where antiferromagnetic ordering at 1.05 K and entropy accumulation around 1.2 T were observed. ADR experiments achieved a minimum temperature of 0.4 K, highlighting the material's suitability for continuous ADR systems. The setup was also employed to study the field-induced quantum critical end point (QCEP) in $DyVO_4$ near 5 kOe. A minimum temperature of 1.35 K was observed, along with a sign change in the magnetic Grüneisen parameter and critical exponents suggesting a new universality class. These results demonstrate the versatility of the ADR setup in exploring phase transitions and quantum criticality while validating its utility for modern low-temperature research.

Oxychlorides as Current Collector Modifiers for Ultra-stable Sodium Metal Batteries

Nilesh Pande

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Alkali metals, like sodium, show promise as anodes for high-energy-density batteries due to their high capacity and low electrochemical potential. However, issues such as dendrite growth and unstable solid electrolyte interphase (SEI) formation hinder their performance. This study addresses these challenges by coating the sodium anode with indium oxychloride on the current collector. Unlike traditional alloy-based approaches like NaIn, the oxychloride chemistry facilitates the formation of a stable, hybrid SEI layer composed of NaIn and sodium oxychloride, which also acts as a solid electrolyte. This modification improves dendrite-free Na deposition and enhances interfacial stability. The shielded sodium anode demonstrates ultra-low polarization (25 mV) and a reversible plating/stripping cycle for over 2100 hours at 1 mAh cm^{-2} in ether-based electrolyte, compared to just 50 hours for unmodified sodium. The modified anode also supports high current densities (10 mA cm^{-2}) and stable full-cell cycling, offering a promising solution for next-generation sodium metal batteries.

Fusion studies around the coulomb barrier for the reaction 28Si+ 142^{Nd}

Anjali Merin

Deparment of Physics, Central University of Kerala

Abstract: The investigation of heavy-ion collision dynamics at sub-barrier energies has been the focus of significant experimental and theoretical research for several decades. An intriguing phenomenon in this energy regime is the enhancement of fusion cross sections, which is attributed primarily to quantum tunneling through the Coulomb barrier. Empirical studies consistently report a substantial increase in sub-barrier fusion cross sections, surpassing the theoretical predictions of the One Dimensional Barrier Penetration Model (1D-BPM). Such enhancement provides a path to explore various degrees of freedom between the interacting nuclei such as the static deformation, the dynamical effects, coupling of inelastic excitations and nucleon transfer channels. In order to ascertain the above mentioned aspects, fusion excitation function measurements have been performed for 28Si +142Nd system using the Heavy Ion Reaction Analyzer (HIRA) at Inter University Accelerator Center (IUAC), New Delhi. Data analysis is in progress to evaluate the fusion excitation functions. Coupled Channel calculations (CCFULL) will be performed to understand the influence of inelastic excitations on sub barrier fusion. Detailed results and analysis will be presented during the Symposium.

Deep-learning based photoacoustic image reconstruction

Arijit Paramanick

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: In photoacoustic imaging, piezoelectric micromachined ultrasound transducers (PMUTs) are employed for deep tissue imaging. However, the lower sensitivity of PMUTs, combined with electronic noise and motion artifacts, leads to significant degradation in resolution, contrast, and SNR, resulting in poor image quality. Enhancing resolution and overall image quality remains a challenging task. In this study, we present a deep learning-based approach to enhance image quality. A modified U-Net architecture was trained using simulated images, and its application to experimental images demonstrated a 74% improvement in FWHM, a 68% increase in SNR, and a 62% enhancement in CR. The network's performance was further validated through agar-phantom and ex-vivo imaging, confirming its capability to produce noise-free, high-resolution images.

Effects on the Structural, Magnetic, and Magnetoelectric Properties of Nd Doped BiFeO3 Multiferroic Nanoparticles

Jerin Abraham George

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: $BiFeO_3$ (BFO) is a widely studied multiferroic material exhibiting ferroelectricity and antiferromagnetism at room temperature, but its practical applications are hindered by leakage current, weak magnetization, and phase instability. To address these challenges, we synthesized pure and Nd-doped BFO nanoparticles (10% and 20% Nd) using the sol-gel method. XRD and Rietveld refinement revealed phase stabilization and lattice distortion, while TEM confirmed nanoparticle morphology and size distribution. Electron density mapping highlighted charge redistribution. Magnetic measurements showed enhanced magnetization, and P-E loop analysis indicated reduced polarization with doping, improving leakage current control. Nd doping optimizes BFO's properties for multifunctional applications.

Role of Defects in Enhancing Critical Temperature and Current Density in Superconductors

Shashank H A

Mangalore University

Abstract: Improving the critical temperature and current density in high temperature superconductors without lowering the temperature is crucial for their practical applications in advanced technology. This study explores the role of various types of defects including point defect, columnar defect, and artificial pinning centre in improving the superconducting property of high temperature superconducting materials. Point defect such as vacancy and substitutions can be facilitated electron pairing and enhance critical temperature by creating localised state within the crystal lattice. columnar defects in introduced through ion irradiation significantly improved vertex pinning allows high temperature superconductor to maintain high current density under external magnetic fields. Include the data from previous research studies that demonstrate the relationship between defect type and their effect on critical temperature. by systematically investigating defects types and density we demonstrate significantly improved in both critical temperature and current density paving the way for more reversed and efficient superconducting material sustainable for application in energy transmission and magnetic resonance imaging these research underscores the importance of defects engineering in advanced to perform the high temperature superconducting materials

Tuning the magnetic ground state of transition metal trilayers via electric field

Moinak Ghosh

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: Magnetic skyrmions are topologically protected swirling spin structures which are proposed as the building blocks of next-generation spintronic devices due to their nanoscale size and robust stability. The electric-field provides an energy-efficient way to manipulate these skyrmions as an alternative to conventional current-driven approaches. Despite the benefit, the experimental and theoretical studies on the electric-field induced modification are limited. To increase our understanding into the electric-field driven creation and annihilation of skyrmions, a systematic study is required. In this study, using first-principles based density functional theory, we have calculated the magnetic interactions, such as Heisenberg pairwise exchange and beyond Heisenberg high-order exchange interactions, in various unsupported 4d/Fe/Ir and 4d/Co/Ir trilayers. These magnetic interactions vary in a linear manner with the applied electric fields. We explain the observed variation in magnetic interactions from electronic structure.

ML Based Classification of Bacterial Species using Nanopore Sequence Data

Chinmayi R. Galigekere

Indian Institute of Science Education and Research, Thiruvananthapuram

Abstract: DNA sequencing and identifying short sequences to belong to categories at various levels of classification, among organisms or within their genomes, play an important role in the healthcare sector. Nanopore sequencing, a third generation sequencing technology, uses the Coulter counter principle to sequence DNA strands. We provide a brief introduction to this technique, and further, delve into the problem of sequence identification. Many techniques existing today use alignment algorithms which come with certain drawbacks, high computational time being one of them. Motivated by the recent growth in usage and success of Machine Learning in fields including data mining from DNA sequences, we endeavour to identify short bacterial DNA sequences from two classes of bacteria. We map sequences to simple feature vectors and use the classification algorithms – SVM, KNN, and XGBoost for the purpose, obtaining impressive accuracies of around 97%.

Active magneto gyrator: Memory induced trapped diamagnetism

Muhammed Muhsin A.

University of Kerala, Trivandrum

Abstract: We analytically explore the dynamics of a charged active particle coupled to two thermal baths kept at two different temperatures in two dimensions. The particle is confined to an asymmetric harmonic potential and a magnetic field of constant magnitude is applied perpendicular to the plane of motion of the particle. For such a system, as opposed to the Brownian gyrator, the potential asymmetry and temperature gradient are not the key factors for the gyration, as long as finite activity and magnetic field are present. The system shows only a paramagnetic behavior in the absence of either potential asymmetry or temperature gradient. However, by tuning the temperature gradient or potential asymmetry, the system as a function of the duration of activity can exhibit paramagnetic, diamagnetic, or co-existence of both phases. Interestingly, the magnetic moment vanishes for parameters for which the system possesses a non-equilibrium steady state and hence, a magnetic transition is observed through these non-magnetic points. Further, when the system is suspended in a viscoelastic medium characterized by a finite memory, it exhibits a magnetic transition in the activity-memory parameter space through a non-magnetic line. This non-magnetic line is sensitive to temperature gradient and potential asymmetry. It interestingly forms a closed loop with a diamagnetic phase inside the loop and the entire regime outside as paramagnetic. This results in the emergence of a trapped diamagnetic phase existing only within a finite regime of activity-memory parameter space. This phase eventually disappears as the temperature gradient increases (or decreases) depending on the sign of the potential asymmetry. Moreover, it is observed that by tuning the system parameters, one can obtain zero magnetic moment even for parameter ranges that defy the equilibrium condition of the system.

References:

[1] Active magneto gyrator: Memory induced trapped diamagnetism. M Muhsin, F Adersh, and Mamata Sahoo. arXiv:2411.03804 (2024)

Ru, Co nanocluster anchored on nitrogen-doped carbon matrix promotes OH- desorption boosting alkaline hydrogen evolution reaction activity

Vipin Yadav

Indian Institute of Science Education and Research, Thiruvanathapuram

Abstract: Ruthenium nanoclusters are emerging as highly effective catalysts for hydrogen evolution reaction (HER) in alkaline media, primarily due to their ability to dissociate water during the Volmer step (rate-limiting step) in this media. However, the strong adsorption of OH^- ions on ruthenium sites hinder the HER kinetics by blocking and deactivating the active sites. To address this challenge, several approaches have been explored, such as using quinary metal alloys (e.g., PtCoCuNiZn) and RuPt alloys doped on defective tungsten oxide, aimed at promoting OH^- desorption. Despite these advances, the high metal loading and scarcity of platinum (Pt) limit the commercial viability of these catalysts. Here, we present the preparation of an efficient and cost-effective electrocatalyst with a low metal loading, consisting of ruthenium and cobalt nanoclusters supported on a nitrogen-doped carbon matrix (Ru-Co-NC) for alkaline HER. Electrochemical testing in both acidic and alkaline media revealed that Ru-Co-NC outperforms Ru-NC in alkaline conditions, while Ru-NC demonstrates higher activity in acidic conditions. Ru-Co-NC demonstrated excellent HER activity with an overpotential of 39 mV@ 10 mA cm^{-2}, along with an impressive 100 h stability @ 10 mA cm^{-2} in 1.0 M KOH. The superior performance of Ru-Co-NC in alkaline media results from the synergistic contribution in terms of improved water dissociation as well as optimized OH^- desorption. After the Volmer step, Co nanoparticles aid in OH^- desorption, owing to its unique electronic structure. This further mitigates the Ru active site blockage, resulting in improved proton (H^+) adsorption. The present study underscores the critical importance of optimizing water dissociation and OH^- desorption to achieve high catalytic activity and stability for alkaline HER.

Engineering of MoO_2-$MoSe_2$ heterostructure for self powered gas sensing applications

Dipanjana Mondal

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: We have demonstrated a single-step CVD method to synthesis the metal-semiconductor interface of a two-dimensional MoO_2-$MoSe_2$ heterostructure flakes for self-powered gas sensing application. Here, we have compared two types of flakes with different stoichiometry. Sample 1 which is mainly composed of MoO_2, has lower photoresponse with selective response to hydrogen gas. Whereas sample 2, of MoO_2-$MoSe_2$ heterostructure, shows huge increase in photoresponse with higher affirmity towards NO_2 sensing with LOD of 10 PPM. Our devices pave the way for the fabrication of a self-powered gas sensor, operating at RT with zero external bias, offering promising prospects for future nanoelectronics.

Hydrothermal synthesis of Cobalt sulfide micro flowers for electrocatalytic alkaline oxygen evolution reaction

Meera Nair L

University of Calicut

Abstract: Despite advancements since the industrial revolutions, most technologies rely on carbon-based fuels, leading to resource depletion and environmental issues. This has driven interest in green energy alternatives like water electrolysis, which includes the Hydrogen Evolution Reaction (HER) and the more energy-intensive Oxygen Evolution Reaction (OER). Reducing the high overpotential of OER is crucial, requiring efficient catalysts. This study explores the synthesis of flowerlike cobalt sulfide (CoS) using a hydrothermal method. Characterized by XRD, FTIR, Raman, UV-Vis, and SEM, the material demonstrated promising catalytic performance with a low overpotential of 284 mV at 10 mA cm^2 in 1M KOH, a Tafel slope of 51 mV dec^{-1}, and stability over 1500 cycles. The findings confirm that hydrothermally synthesized cobalt sulfide significantly enhances OER efficiency, offering a sustainable solution for energy conversion.

Identification and modelling of optically thin inverse Compton scattering in the prompt emission of GRB131014A

PRAGYAN PRATIM BORDOLOI

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: The mechanism responsible for the prompt gamma-ray emission of a gamma-ray burst continues to remain an enigma. The detailed analysis of the spectrum of GRB 131014A observed by the Fermi gamma ray burst monitor and Large Area Telescope has revealed an unconventional spectral shape that significantly deviates from the typical Band function. The spectrum exhibits three distinctive breaks and an extended power law at higher energies. Furthermore, the lower end of the spectrum aligns with power-law indices greater than -0.5, and in the brightest region of the burst, these values approach +1. The lowest spectral break is thereby found to be consistent with a blackbody. These observed spectral characteristics strongly suggest the radiation process to be inverse Compton scattering in an optically thin region. Applying the empirical fit parameters for physical modeling, we find that the kinetic energy of the GRB jet of bulk Lorentz factor, $\Gamma \sim 400$, gets dissipated just above the photosphere, approximately at a radius of $\sim 10^{14}$ cm. The electrons involved in this process are accelerated to a power-law index of $\delta = -1.5$, and the minimum electron Lorentz factor, γ_{min}, is approximately 3. In summary, this study provides a comprehensive identification and detailed modeling of optically thin inverse Compton scattering in the prompt emission of GRB 131014A.

Ultrafast dynamics of Intervalley Bi-excitons in a 2D semiconductor alloy

Chandan Prasad Kushwaha

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: We observe room-temperature polarization anisotropy in the 2D-semiconductor alloy Mo0.6W0.4Se2. Cross-polarized, quasi-two-color pump-probe experiments reveal a short lived negative component in the transient reflectivity signal, which we term as the coherent component. Only a weak coherent signal is detected in the co-polarized case. The short-lived coherent signal appears only when pump-probe energies are below the exciton resonance.[1] [2] [3] The optical selection rules for excitons and intervalley biexcitons in the 2D alloy account for the negative transient reflectivity signal at energies below the exciton resonance.[4] [5] [6] We model the light-matter interaction in the alloy using a four-level Jaynes-Cummings Hamiltonian, which supports the idea that the observed coherent phenomena arises from the absorption of the probe photons by the pump generated excitons, leading to the creation of intervalley biexciton s.The observed bi-excitonic effect at room temperature could be crucial in future research on optical switches and modulators operating in ambient environments.

Generation And Imaging Of Orbital Angular Momentum Of Light Using Digital Micro Mirror Device

Gadha T

University Of Kerala

Abstract: Advancements in optical communication utilize orbital angular momentum (OAM) modes to enhance data transmission through advanced beam shaping and multiplexing. Scalable OAM-based systems for free-space and fiber-optic communications, as well as quantum cryptography, rely on digital micromirror devices (DMDs) for precise phase and amplitude encoding. This study demonstrates the generation of OAM modes, including Laguerre-Gaussian (LG) beams, using computer-generated forked gratings. A repurposed DMD projector (10.8 μm pitch, 800 × 600 resolution) served as a spatial light modulator to project these forked gratings, and the resulting OAM beam patterns were captured using a CCD camera (6.3MP BFS-U3 1/1.8 CMOS C-Mount, 12 mm UC Series FL lens). Higher-order OAM modes were achieved by varying the angular momentum quantum number of the binary forked gratings which diffract light into multiple OAM modes. Despite minor distortions from DMD imperfections, this cost-effective approach validates its potential for OAM generation and supports further advancements in the field.

Proximity Effects in Photoluminescence of TaSe2/MoSe2 van der Waals Heterostructure

Navya Biju

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: We investigate the optical signatures of the interlayer coupling between the semiconducting 2H-MoSe2 and CDW layer 2H-TaSe2. The heterostructure consists of monolayer MoSe2 stacked over bulk TaSe2, exfoliated onto SiO2/Si substrate by dry transfer technique. We report the photoluminescence (PL) spectra TaSe2/MoSe2 heterostructures at 6 K, showing new transitions with narrow line widths, with trions red shifting more than neutral excitons. Factors such as twist angle, strain, and the number of TaSe2 layers contribute to these spectral changes. Band structure calculations indicate that the Γ point extrema of the valence band (VB) shifts upwards while the VB extrema at the K point shifts downwards in energy with the increase in TaSe2 layers. This suggests that indirect transitions become more probable with an increasing number of TaSe2 layers, explaining the new transitions observed at lower energy levels than the neutral exciton energy in the PL spectra.

Active magneto gyrator as a heat engine or refrigerator

Adersh Fernandez

University of Kerala

Abstract: We investigate the thermodynamic performance characteristics of an active magneto gyrator consisting of a charged active particle confined in an asymmetric potential and in contact with two thermal baths kept at two different temperatures. A magnetic field of constant magnitude is applied in a direction perpendicular to the plane of motion. In such a system, the particle exerts a torque on the confining potential as long as the potential is asymmetric and hence it can be operated as an active magneto heat pump in the presence of a load force. Interestingly, we observe that the magnitude of the effective torque can be tuned by varying the strength of the applied magnetic field, whereas the direction is independent of the field. In addition, the activity or self-propulsion has impact on the performance characteristics of the heat pump only in the presence of the magnetic field. We examine two scenarios: first, applying a load opposing the effective torque, and second, applying a load in the same direction of the torque. In the first case, the heat pump is found to act as an engine or a refrigerator depending on the strength of the applied load whereas in the later case, it can only be operated as a refrigerator. In the first case, the magnetic field is detrimental for performing the heat pump as an engine or a refrigerator whereas the duration of activity has a non-monotonic impact on both efficiency and coefficient of performance. Both efficiency and coefficient of performance increase with duration of activity, shows a maximum, then decreases, and saturates to a constant value. For the latter case, the magnetic field favors the heat pump performing as a refrigerator and the activity has similar impact to that of the first case.

Valley splitting in a Si/SiGe strained Quantum well heterostructures

Lucky Donald Lyngdoh Kynshi

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: We investigate the optical signatures of the interlayer coupling between the semiconducting 2H-MoSe2 and CDW layer 2H-TaSe2. The heterostructure consists of monolayer MoSe2 stacked over bulk TaSe2, exfoliated onto SiO2/Si substrate by dry transfer technique. We report the photoluminescence (PL) spectra TaSe2/MoSe2 heterostructures at 6 K, showing new transitions with narrow line widths, with trions red shifting more than neutral excitons. Factors such as twist angle, strain, and the number of TaSe2 layers contribute to these spectral changes. Band structure calculations indicate that the Γ point extrema of the valence band (VB) shifts upwards while the VB extrema at the K point shifts downwards in energy with the increase in TaSe2 layers. This suggests that indirect transitions become more probable with an increasing number of TaSe2 layers, explaining the new transitions observed at lower energy levels than the neutral exciton energy in the PL spectra.

Highly Graphitized Biomass derived Carbon as Anode for Lithium-Ion Batteries

Sruthy E S

Digital University Kerala, Thiruvananthapuram

Abstract: Graphite, a widely used fossil material, is highly valued for its multifunctional applications due to its high thermal conductivity, stability, low electrical resistivity, excellent electronic conductivity, and superior chemical stability. While producing graphitic carbon from biomass offers a promising alternative, the process typically requires extremely high temperatures of up to 3000 °C, resulting in significant energy consumption. Here, we introduce a greener and more sustainable method for preparing highly graphitized biomass carbon at a significantly lower temperature (900 °C). This approach employs pure boron as a catalyst, KOH as an activation agent, and logging residues (LR) as a carbon source, emphasizing the relationship between the structural transformation of precursors into graphitic carbon and their electrochemical performance as anodes for lithium-ion batteries(LIBs). The anode developed from the as-prepared boron-treated sample (BCLR) demonstrated 505 mAh g^{-1} at 1 C after 200 cycles when tested in LIBs.

Magnetic properties of a highly frustrated spin- ½ depleted-kagome antiferromagnet $Cu_7(TeO_3)_2(SO_4)_2(OH)_6$

Akshay K U

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: Kagome lattice antiferromagnets are known for their highly frustrated geometry. Herein, we report the structural and magnetic properties of Cu7(TeO3)2(SO4)2(OH)6, a depleted kagome lattice compound in which 5/16 sites of kagome geometry are missing from the compound. We investigated its properties using X-ray diffraction, DC and AC magnetization, and heat capacity measurements. No range-order anomalies have been observed on DC magnetization data, but ZFC-FC bifurcation was observed at T ≃ 3.8K. Magnetic isotherm data indicates no saturation up to 7 T, while a small hysteresis was observed, indicating a small ferromagnetic component. No sharp peaks were observed at heat capacity, except a broad hump on Cp/T at around the same temperature at which ZFC-FC splitting occurred. Full entropy calculation yields only 25% of Rln(2) = 5.76 J/mol-K, which points towards a spin-glass transition or partial ordering.

Active Ornstein-Uhlenbeck particle under stochastic resetting

Uma Shankari M

University of Kerala, Karyavattom Campus, Thiruvananthapuram

Abstract: We investigate the dynamics of an inertial active Ornstein-Uhlenbeck particle (AOUP) in the presence of stochastic resetting. Using a renewal approach, we have exactly calculated the mean displacement, the mean square displacement(MSD), and the probability distribution functions of position in both the overdamped and underdamped regimes. In contrast to a normal AOU particle, the MSD of an AOU particle with resetting displays an initial time difussive and long time or steady state non-diffusive behaviour. The steady-state MSD has a dependence on the stochastic resetting rate and the duration of activity. It interestingly gets reduced with increase in the resetting rate and approaches zero for infinitely large resetting rate, that might be due to the induced local confining mechanism caused by the frequent resets. Moreover, the MSD has a non-monotonic impact on the duration of activity. These results are further supported by the position probability distribution functions which initially widens with increase in activity time, shows maximum spreading and narrows with further increase in activity time scale.

Densing in the Dark: Neutron Stars with BHF Informed Density-Dependent Nucleon Masses and Weakly Interacting Dark Matter

Arijit Das

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: This work investigates fermionic dark matter admixed neutron stars using the SU(2) chiral sigma model, incorporating scalar and vector mediators. Unlike previous studies, we include realistic medium effects on nucleon effective masses derived from the Brueckner-Hartree-Fock (BHF) approach at zero temperature. We analyze the impact of this density-dependent effective mass on neutron star equations of state and their macroscopic properties in static and rotating scenarios. Our results reveal that BHF corrections significantly alter neutron star compactness and provide a high-energy density speed of sound behavior more consistent with Bayesian analysis of experimental data compared to pure EFT predictions.

Prospect Study of Vector-Like Lepton through Leptoquark at the HL-LHC

Shruti Dubey

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: Vector-like leptons (VLLs) are hypothetical heavy partners of Standard Model (SM) leptons and are present in many extensions of the SM. In certain quark-lepton unification theories, VLLs coexist with leptoquarks (LQs), another proposed coloured particle that connects the quark and lepton sectors. Because VLLs are colour-neutral particles, their production is primarily governed by weak interactions, making them generally suppressed. In this study, we propose an interesting production mechanism for VLLs via LQs. We explore the prospect of producing VLLs at the High-Luminosity Large Hadron Collider (HL-LHC) through various production channels involving LQs. We also combine various production channels to enhance the sensitivity.

Turbulent Dynamo In A Collapsing Plasma

Muhammed Irshad P

International Centre for Theoretical Sciences

Abstract: Astrophysical plasmas often undergo collapse in contexts such as galaxy and star formation. This collapse significantly influences magnetic field growth during the kinematic stage of the fluctuation dynamo, where turbulent kinetic energy is converted into magnetic energy. In this stage, the Lorentz force is negligible, and the magnetic field typically grows exponentially. However, during a homologous plasma collapse, analytical calculations reveal a super-exponential growth of the magnetic field, beyond the amplification due to flux freezing. These calculations are derived by solving the induction equation in supercomoving variables, which account for the collapsing background. To verify this, we conducted simulations of the MHD equations in supercomoving variables within a periodic box. The results confirm the presence of super-exponential magnetic field growth during the kinematic stage of the turbulent dynamos. This enhanced growth could play a crucial role in shaping cosmic structure formation.

Remote control of resistance states in nickel doped HfO_x based RRAM device using magnetic field

RISHAN HAASIB

Indian Institute of Science Education and Research, Thiruvananthapuram.

Abstract: Resistive random access memory devices (RRAM) devices are energy efficient non-volatile memory devices that store data by varying resistance of material within the device. While a wide range of materials including transition metal oxides (TMO), Perovskites, amorphous oxides and organic compounds is being investigated for optimal performance of the device, HfO2 based RRAM devices have exhibited high switching speed, low power consumption, high endurance and retention, ideal for neuromorphic applications[1]. In our work, we studied the tunability of resistance states using magnetic field on Nickel doped HfO2 based metal-insulator-metal (MIM) type RRAM device[2], to mimic synaptic potentiation and depression. We could successfully demonstrate magnetic field induced resistive switching and tunability of resistance states of the device. By tuning the doping concentration of Nickel, the overall performance of the device can be enhanced, enabling remote control of memory in neuromorphic systems[3].

References:

1. R. W. Z. W. Y. S. J. A. Q. L. Tuo Shi, "A Review of Resistive Switching Devices: Performance,&quot, small structures, 2021.
2. Y. D. a. A. C. a. Y. S. a. G. Z. a. H. L. a. X. Z. b. Tingting Tan a, & quot; The resistive switching characteristics of Ni-doped HfOx film and its application as a synapse," Journal of alloys and compounds, vol. 766, pp. 918-924, 2018.
3. Sun, B., Liu, Y., Zhao, W., & Chen, P. (2015). Magnetic-field and white-light controlled resistive switching behaviors in Ag/[$BiFeO_3$/γ-Fe_2O_3]/FTO device. RSC Advances, 5(18), 13513–13518

Role of internal tides in energy transfers across spatio-temporal scales

Rajarshi Chattopadhyay

International Centre for Theoretical Sciences

Abstract: Fast-evolving internal tides are a major component of the internal wave continuum present across the ocean. Their interactions with slow-evolving, large-scale, balanced eddies control the turbulent mixing of nutrients, CO2, temperature and salinity in the ocean. Through such interactions, internal tides dissipate the eddies and scatter in the ocean. Interestingly, these interactions differ significantly at mesoscales (~100 km, small Rossby numbers) compared to submesoscales (~10 km, large Rossby number), and are poorly captured in current global climate models.We numerically investigate how internal tides dissipate eddies and transfer energy to small scales across different Rossby numbers. In mesoscale flows, eddy-tide interaction is minimal, preserving the large-scale structure of the eddies. Consequently, any internal wave continuum is absent. But, at submesoscales, tides break the large-scale eddies into small-scale structures through regions of strong eddy-tide interactions. At such scales, tides, in the presence of the balanced flow, form an internal wave continuum.Our findings identify pathways of energy exchanges in the ocean across mesoscales and submesoscales, and the mechanism that leads to an internal wave continuum in submesoscale flows.

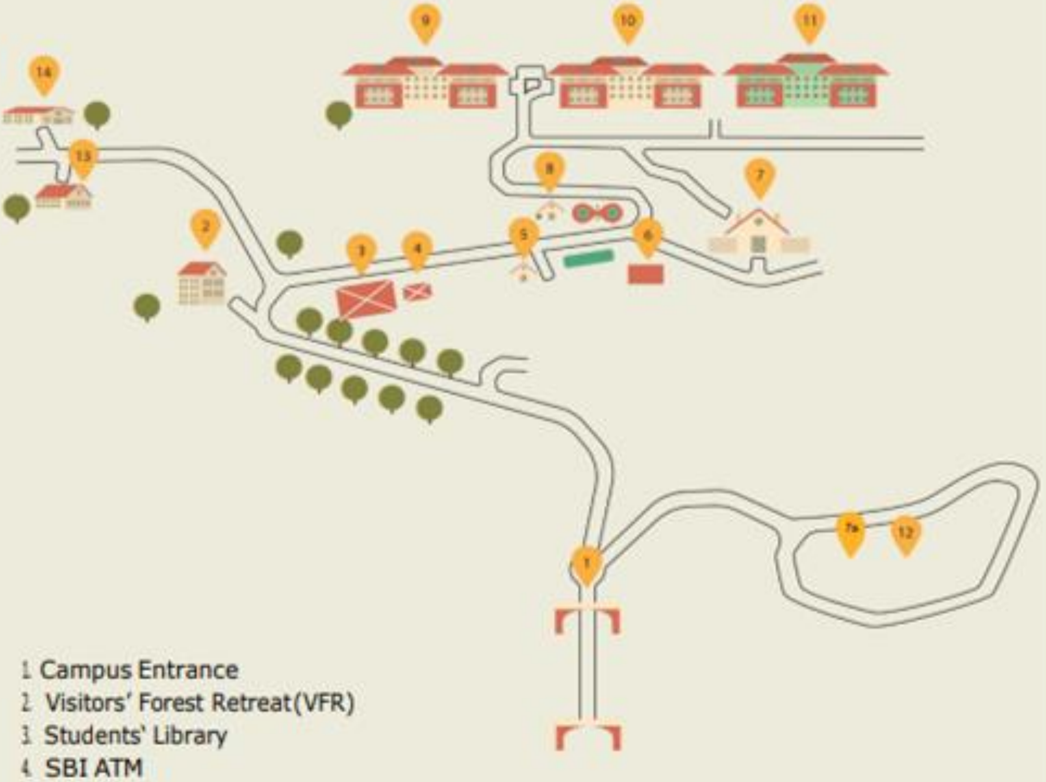
Versatile Zinc Oxide Nanorods: Comparative Study of Co-precipitation and Hydrothermal Synthesis for Enhanced Energy Storage Applications

Mahalakshmi V

Vellore institute of technology –Vellore

Abstract: Zinc oxide (ZnO) nanorods were synthesized using two methods: co-precipitation and hydrothermal. The co-precipitation method involved the reaction of zinc acetate and sodium hydroxide, while the hydrothermal method utilized zinc nitrate and hexamethylenetetramine (HMT). Field Emission Scanning Electron Microscopy (FESEM) analysis confirmed the formation of nanorods with lengths ranging from 200 to 400 nm and diameters from 1 to 4 μm for both methods. Fourier transform infrared (FTIR) spectroscopy, UV-visible spectroscopy, and energy dispersive X-ray (EDX) spectroscopy were employed to characterize the structural, optical, and elemental properties of the synthesized nanorods. Electrochemical measurements, conducted using a three-electrode system with 0.5 M H2SO4 as the electrolyte, revealed that the hydrothermally synthesized ZnO nanorods exhibited superior specific capacitance compared to those prepared via co-precipitation. At a scan rate of 10 mV/s, the hydrothermal ZnO nanorods achieved a specific capacitance of 22.4 F/g, significantly higher than the 14.2 F/g obtained for the co-precipitated ZnO nanorods. These findings highlight the effectiveness of the hydrothermal method in producing ZnO nanorods with enhanced electrochemical performance, making them promising candidates for energy storage applications.

Campus map



1. Campus Entrance
2. Visitors' Forest Retreat (VFR)
3. Students' Library
4. SBI ATM
5. Restaurant
6. Bus Stop
7. Central Dining Hall 1 (CDH1 and iCafe) & 7a. Central Dining Hall 2
8. Student Lounge and Cafe
9. Physical and Mathematical Sciences Block (PSB & Conference Venue - PSB 3201)
10. Chemical Sciences Block
11. Biological Sciences Block
12. Students' Hostel area (Anamudi - D & Anamudi - E blocks)
13. Medical Center
14. General Store

KSRTC Bus timing from Thiruvananthapuram to Vithura

From	Departure Time	To	Arrival Time
Thiruvananthapuram /Thampanoor	06:40	Vithura Bus Stand	08:00
Thiruvananthapuram /Thampanoor	07:30	Vithura Bus Stand	09:30
Thiruvananthapuram /Thampanoor	08:50	Vithura Bus Stand	10:50
Thiruvananthapuram /Thampanoor	09:10	Vithura Bus Stand	11:10
Thiruvananthapuram /Thampanoor	10:10	Vithura Bus Stand	12:10
Thiruvananthapuram /Thampanoor	10:20	Vithura Bus Stand	12:20
Thiruvananthapuram /Thampanoor	10:40	Vithura Bus Stand	12:40
Thiruvananthapuram /Thampanoor	10:45	Vithura Bus Stand	12:45
Thiruvananthapuram /Thampanoor	10:50	Vithura Bus Stand	12:50
Thiruvananthapuram /Thampanoor	11:00	Vithura Bus Stand	13:00
Thiruvananthapuram /Thampanoor	11:55	Vithura Bus Stand	13:55
Thiruvananthapuram /Thampanoor	12:05	Vithura Bus Stand	14:05
Thiruvananthapuram /Thampanoor	12:20	Vithura Bus Stand	14:20
Thiruvananthapuram /Thampanoor	13:10	Vithura Bus Stand	15:10
Thiruvananthapuram /Thampanoor	13:20	Vithura Bus Stand	15:20
Thiruvananthapuram /Thampanoor	13:40	Vithura Bus Stand	15:40
Thiruvananthapuram /Thampanoor	13:50	Vithura Bus Stand	15:55
Thiruvananthapuram /Thampanoor	14:35	Vithura Bus Stand	16:35
Thiruvananthapuram /Thampanoor	15:30	Vithura Bus Stand	17:30
Thiruvananthapuram /Thampanoor	16:10	Vithura Bus Stand	18:10
Thiruvananthapuram /Thampanoor	16:20	Vithura Bus Stand	18:20
Thiruvananthapuram /Thampanoor	16:30	Vithura Bus Stand	18:30
Thiruvananthapuram /Thampanoor	16:50	Vithura Bus Stand	18:50
Thiruvananthapuram /Thampanoor	17:00	Vithura Bus Stand	19:00
Thiruvananthapuram /Thampanoor	17:20	Vithura Bus Stand	19:20
Thiruvananthapuram /Thampanoor	17:30	Vithura Bus Stand	19:30
Thiruvananthapuram /Thampanoor	17:50	Vithura Bus Stand	19:50
Thiruvananthapuram /Thampanoor	18:00	Vithura Bus Stand	20:00
Thiruvananthapuram /Thampanoor	18:05	Vithura Bus Stand	20:05
Thiruvananthapuram /Thampanoor	18:10	Vithura Bus Stand	20:10
Thiruvananthapuram /Thampanoor	18:20	Vithura Bus Stand	20:20
Thiruvananthapuram /Thampanoor	18:30	Vithura Bus Stand	20:30
Thiruvananthapuram /Thampanoor	18:40	Vithura Bus Stand	20:40
Thiruvananthapuram /Thampanoor	18:50	Vithura Bus Stand	20:50
Thiruvananthapuram /Thampanoor	19:10	Vithura Bus Stand	21:10
Thiruvananthapuram /Thampanoor	20:10	Vithura Bus Stand	21:50
Thiruvananthapuram /Thampanoor	20:50	Vithura Bus Stand	22:50
Thiruvananthapuram /Thampanoor	21:50	Vithura Bus Stand	23:50

KSRTC BUS TIMINGS – THIRUVANATHAPURAM BUS STAND TO IISER CAMPUS			
From	Departure Time		Arrival Time
Thiruvananthapuram /Thampanoor	05:00	IISER Campus	07:00
Thiruvananthapuram /Thampanoor	06:40	IISER Campus	08:40
Thiruvananthapuram /Thampanoor	06:50	IISER Campus	08:50
Thiruvananthapuram /Thampanoor	08:30	IISER Campus	10:30
Thiruvananthapuram /Thampanoor	14:40	IISER Campus	16:40
Thiruvananthapuram /Thampanoor	15:15	IISER Campus	17:15

Patron

Prof. J. N. Moorthy
Director, IISER Thiruvananthapuram

Local Organizing Committee

Prof. M. M. Shaijumon
Prof. Ramesh Chandra Nath
Dr. Tanumoy Mandal
Dr. Vinayak B. Kamble
Dr. Suraj S Hegde
Dr. Tuhin Subhra Maity

Volunteers

- Vipin Yadav
- Shivam Kumar Singh
- Bhargav Rajbongshi
- Varsha Biswas
- Shrestha Gupta
- Ayush Kumar Shaw
- Neha Ahlawat
- Mansi Yogesh Sathe
- Aishwarya K
- Riya Pathak
- Mohammed Yaseen
- Amit Choudhary
- Maanav Srihari
- Shruti Dubey
- Ratnamay Kolay
- Chandan Prasad Kushwaha
- Satyam Puri
- Saikarthikey Bhat
- Deepayan Samanta
- Naveen Reule
- Soumyadip Kundu
- Akshay K U
- Nilesh Pande
- Raktim Maity
- Shruti S
- Devesh Paliwal
- Satarupa Mandal
- Sampriti Ghosh


IISER
THIRUVANANTHAPURAM
© Allipra