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Abstract Booklet

Department of Physics, Indian Institute of Technology, Mumbai - 400076

CONTENTS:

Soft Matter Physics

Surface-Directed Spinodal Decomposition

PROF. SANJAY PURI

Jawaharlal Nehru University

Abstract: We discuss the problem of surface-directed spinodal decomposition (SDSD), i.e., the interplay of wetting and phase separation in an AB mixture in contact with a surface which is wetted by one of the components (say, A). We present scaling arguments and numerical results to discuss the growth laws for the wetting layer which grows at the surface. We separately discuss cases where material is transported via (a) diffusion or (b) hydrodynamic velocity fields.

Bio: Dr. Sanjay Puri is a statistical physicist and senior Professor at the School of Physical Sciences, Jawaharlal Nehru University. He completed his Master's in Physics from IIT Delhi in 1982, securing the institute silver medal. Subsequently, he moved to the US to secure another M.S. Physics degree from the University of Illinois at Urbana-Champaign in 1983, followed by a Ph.D. from the same institution in 1987 under Prof. Yoshitsugu Oono. After returning to India, he joined JNU the same year as an Assistant Professor and has been continuing as a Professor since 2001. During this period, Dr. Puri has made several visits abroad and has been a Visiting Professor at Johannes Gutenberg Universitat, Mainz (Germany); University of Manchester (UK); Cambridge University (UK); Kyoto University (Japan), etc.

Dr. Puri works in the areas of statistical physics and nonlinear dynamics. He has been particularly interested in problems of pattern formation in non-equilibrium systems. He has made many significant contributions to our understanding of the kinetics of phase transitions. These include the formulation of Cell Dynamical System models to study phase ordering systems, an analytical solution of ordering dynamics driven by the annealing of vector defects like vortices and monopoles, the modelling and understanding of surface-directed spinodal decomposition, etc. Dr. Puri has also made important contributions to understanding the dynamical properties of granular materials, with special focus on the cooling of freely-evolving granular gases. He has published around 200 papers and written or edited three books.

Dr. Puri is a recipient of many awards and honors. He received the INSA Young Scientist Medal from the Indian National Science Academy, New Delhi (1993); N. Satyamurthy Award from the Indian Physics Association, Mumbai (1995); B.M. Birla Science Award from the B.M. Birla Science Centre, Hyderabad (2001); Homi Bhabha Fellowship from the Homi Bhabha Fellowships Council, Mumbai (2003); and the S.S. Bhatnagar Prize from the Council of Scientific and Industrial Research, New Delhi (2006). He has been an Editor and Associate Editor of the journal Phase Transitions since 2000 and an associate member of ICTP, Italy from 1994 to 1999. He was elected Fellow of the Indian Academy of Sciences (IAS), Bangalore in 2006 and the Indian National Science Academy(INSA), New Delhi in 2012.

Pathway Selection by an Active Droplet

SHIVA DIXIT
Indian Institute of Technology Bombay

Abstract: We report the movement of an active 1-pentanol drop within a closed Y-shaped channel subjected to geometrical and chemical asymmetry. A Y-shaped channel was configured with an angle of 120◦between any two arms, which serves as the closed area of movement for the active drop. The arm where the 1-pentanol drop is introduced in the beginning is considered the source arm, and the center of the Y-shaped structure is the decision region. The drop always selects a specific route to move away from the decision region. The total probability of pathway selection excludes the possibility of the drop choosing the source channel. Remarkably, the active drop exhibits a strong sense of navigation for both geometrically and chemically asymmetric environments with accuracy rates of 80% and 100%, respectively. We hypothesize that the chemical asymmetry pathway selection of a droplet is based on the artificial negative chemo taxis, where the extra confined drop acts as a chemo- repellent. To develop a better understanding of our observations, a numerical model is constructed, wherein the particle is subjected to a net force which is a combined form of -(i) Yukawa-like repulsive interaction force (acting between the drop and the walls), (ii) a self-propulsion force, (iii) a drag, and (iv) a stochastic force. The numerics can capture all the experimental findings both qualitatively and quantitatively. Finally, a statistical analysis validates conclusions derived from both experiments and numerics.

Nature of barriers determine first passage times in heterogeneous media

SOUGATA GUHA
Indian Institute of Technology Bombay

Abstract: Usually time of passage across a region may be expected to increase with the number of barriers along the path. Can this intuition fail depending on the special nature of the barrier? To probe this fundamental question, we design a simple assay where a robotic bug navigates through a spatially patterned array of obstacles, referred to as either entropic or energetic, depending on the nature of the obstacles. For energetic barriers, our experiments show that timescales of first passage vary non-monotonically with the number of barriers, while for entropic barriers first passage times increase monotonically. For diffusive transport, we provide analytic results to show that the non-monotonicity of the mean first passage time is a generic phenomenon which crucially depends on the nature of barriers. This non-monotonicity further reflects in the behaviour of effective diffusivity as well. Finally, using numerical simulations, we show that this behaviour is general and extends to even super-diffusive transport.

Controlled active particle models in a programmable robot

SOMNATH PARAMANICK
Indian Institute of Technology Bombay

Abstract: The active matter system consists of active agents in continuous motion or exerting force locally on each other through consuming energy from the environment or utilizing their internal energy. Numerous examples of active matter systems can be found in nature, including herds of animals, schools of fish, army ants, and flocks of birds. In the lab, researchers have built various kinds of artificial active matter systems to explore this field's fascinating collective behaviour and out-of-equilibrium physics. However, these systems lack the ability to control individual particle dynamics. Here system with programmable robots comes into the picture, capable of mimicking different established models of active matter particles with control on various parameters. In our lab, we designed a centimeter-sized programmable robot with several built-in sensors. The built-in sensors enable the robot to detect boundary and response to light intensity. We have implemented active Brownian, Brownian, and run and tumble particle models into our robot. Also, successfully verified the models in the robot with existing theoretical results. This robotic model gives us a kick start to creating a more controlled, versatile, and robust active matter system.

Experimental Condensed Matter Physics

Semiconductor Nanostructures for Quantum Devices

PROF. SAMIT KUMAR RAY
Indian Institute of Technology Kharagpur

Abstract: Semiconductor nanostructures have drawn increasing attention since they provide a means to create artificial potentials for electrons and holes in semiconductors, at length scales comparable to exciton Bohr radius. Modern epitaxial techniques have made possible atomic scale features in the growth direction, and the advent of nanolithography has made feasible the control of lateral dimensions for the fabrication of quantum devices. Using the quantum confinement characteristics, new electronic and photonic devices with unique but tailored properties have become feasible with additional degrees of freedom in design. I shall discuss the progress of Si and two-dimensional (2D) transition metal dichalcogenides-based quantum photonic devices. The development of two-dimensional quantum hybrids for their applications in Si-compatible photonic devices using tunable light-matter interactions will also be discussed.

Bio: Born in 1961, Prof. Ray obtained his M.Sc., Physics (1982), M.Tech., Materials Science (1984) and Ph.D., Microelectronics (1991) from IIT Kharagpur. He worked as a Scientist-B for a brief stint in 1984-85 at Solid State Physics Laboratory, Delhi. He joined IIT Kharagpur as a Lecturer in 1991 and rose to Full Professor in 2004 and Professor (HAG) in 2010. He has served as the Head of the Department of Physics (2011-2014), founder Head of the School of Nanoscience and Technology (2014-2016) and Dean, Postgraduate Studies and Research (2015 – 2016) at IIT Kharagpur. He also served as the Director of SNBNCBS (2016 – 2021) on lien from IIT Kharagpur. Prof. Ray's research interest in the broad area of experimental condensed matter physics focuses on semiconductor nanostructures, epitaxial growth of quantum structures, nanophotonics, and the physics of nanodevices. His research has run the gamut from very practical fields such as pseudomorphic strained SiGe/SiGeC alloy heterostructures for high mobility MOSFETs to low dimensional quantum structures. His studies on Ge quantum dots and strained Ge to achieve light emission from an indirect bandgap semiconductor are useful to realize Si based lasers in future. His research results on floating-gate flash memory, 2D/3D heterostructures, quantum dot infrared photodetectors and nanowire heterojunctions are considered significant breakthroughs for future nanodevice applications. He has authored more than 600 research articles, two books and a few book chapters and an US patent on Terahertz devices.

Prof. Ray is a recipient of the INSA Young Scientist Award (1993), CDIL award of IETE (1997), Homi J. Bhabha Award by UGC (2001), MRSI medal lecture award (2007), MRSI-ICSC Superconductivity & Materials Science Annual Prize (2015), MRSI-ICSC Superconductivity & Materials Science Senior Award (2020) and INAE Chair Professorship Award (2022). He is a fellow of the Indian Nation Academy of Engineering (INAE) (2008), West Bengal Academy of Science & Technology (2011) and National Academy of Sciences (NASI) (2017). He has served as a visiting faculty / Scientist at the Tokyo Institute of Technology, Japan; University of Delaware, USA; University of Texas, USA; Max-Planck Institute for Solid State Research, Germany; Queen's University of Belfast, UK; National Taiwan University, Taiwan and CGU University, Taiwan. He is an editorial board member of Nanotechnology (IOP, UK), Scientific Reports, Frontiers in Materials: Optics and Photonics – Switzerland, Journal of Nano Energy and Power Research – USA and Nanotrends, India. He serves in a number of National committees that include Nano Science Advisory Group of DST, DST PAC member on Condensed Matter Physics & Materials Science and International bilateral projects, PRSG member, Deity

Centers of Excellence in Nanoelectronics and projects approved by the office of the Principal Scientific Adviser to the Government of India.

Physics of charge carrier transport in organic semiconductor device

PROF. PRAMOD KUMAR

Indian Institute of technology Bombay

Abstract: Organic semiconductors are well known for their applications in OLED and solar cells. The advantage of using organic semiconductors are the low processing and fabrication cost due to solution processing and simple fabrication procedures. The low charge carrier mobility in these semiconductors is the bottleneck in organic semiconductor-based electronics. Devices based on organic semiconductors require band-level alignment for the injection of charge carriers, these charge carriers generally flow at the bottom of the Gaussian density of states (GDOS), which is the main cause of low charge carrier mobility. The problem can be addressed by filling the GDOS with charge carriers close to the center which makes the charge carrier mobility orders of magnitude higher. Organic field effect transistors have shown much higher mobility due to the accumulation of charge carriers in the GDOS which makes the center of GDOS accessible for transport.

Bio: Prof. Pramod Kumar is an Assistant Professor in the Department of Physics at IIT Bombay. He did his B.Sc.(Hons) and M.Sc. in Physics from University of Delhi (1998-2003) and Ph.D. from Jawaharlal Nehru University (2005-2010). After spending another year in JNU, he went abroad to do a couple of PostDocs at the Nanoelectronics Center of Technion, Haifa, Israel (2011-2016) and Sant'Anna School of Advanced Studies, Pisa, Italy (2017-2018). He joined IIT Bombay in 2018 and has been continuing since then.

Prof. Kumar is the Principal Investigator of the Applied Physics Laboratory in the Dept. of Physics at IIT Bombay. His group is interested in exploring new materials in nano-structure and nano-film forms for study and application in new age advanced sensors, field effect transistors (FETs), diodes, energy harvesting devices, tactile sensors array for electronic skin, self-powered sensors, and other piezoelectric sensors. The main aim is to reduce the cost of processing and fabrication by selecting suitable materials. He is working on high band-gap vertical well-aligned ZnO Nanorods which can be utilized in the development of biocompatible piezoelectric haptic sensors for new generation robotic applications. He is also working with organic semiconductor which are well known for their low cost processing techniques. To understand the physics of the devices, various AI-based simulations techniques are applied for the quantitative understanding of the devices and the materials. He has authored around 15 journal papers, 5 conference papers and one British Patent.

$H_{5.9}Li_{0.1}Ru_2O_6$ (Ru^{3+}, J_{eff}=1/2): a Kitaev Quantum Spin Liquid alternative to α –$RuCl_3$

SANJAY BACHHAR
Indian Institute of Technology Bombay

Abstract: Kitaev Quantum Spin Liquids (KQSL) host novel ground state and excited state properties. A prominent example is α − $RuCl_3$ having Ru^{3+} (J_{eff} = 1/2) on a honeycomb lattice. In zero applied field this compound is magnetically ordered and a field of 80 kOe is required to suppress the order and reveal the KQSL state. Herein we report the synthesis of $H_{5.9}Li_{0.1}Ru_2O_6$, with Ru^{3+} (J_{eff} = 1⁄2) on a honeycomb lattice. Our heat capacity measurements suggest no ordering down to 400 mK in spite of a large Curie-Weiss temperature of − 44 K as extracted from our susceptibility data. Our 7Li NMR measurements find a power law variation of the 7Li spin-lattice relaxation rate below 40 K. From zero-field muon spin relaxation, we find neither oscillations in the muon asymmetry nor any 1/3 tail in the muon asymmetry suggestive of the absence of long-range order and of the presence of dynamic moments. These results are similar to those of $H_3LiIr_2O_6$ (suggested to be a KQSL) except that the saturation of the muon depolarisation rate λ in $H_{5.9}Li_{0.1}Ru_2O_6$ sets in at 10 times the temperature in $H_3LiIr_2O_6$. Based on our data, we propose that $H_{5.9}Li_{0.1}Ru_2O_6$ is a KQSL even in zero field.

High-Detectivity Ultraviolet Photodetectors with epitaxial GaN on Si(111)

PINKI PAL
Indian Institute of Technology Bombay

Abstract: Fabrication and systematic characterization of GaN/Si(111)-based visible-blind ultraviolet photo detectors, with Pt/Au contacts, is reported. We demonstrate a record-high detectivity of 4.93×1014Jones, for bias voltages exceeding VB = 14 V. The high detectivity is obtained due to extremely low dark current (~ pA, even for VB = 40 V), and high responsivity, in the wavelength range of 320 nm -380 nm. The highest responsivity obtained for the measured devices is 255 A/W, at VB = 50 V and excitation wavelength of 353 nm.

Voltammetric pH sensing using 3D grapheme quinizarin electrodes in buffered and unbuffered systems

Mohd Salman Siddiqui
Indian Institute of Technology Bombay

Abstract: In this study, a simple pH-sensitive electrode has been fabricated via a thin coating of three-dimensional graphene and quinizarin composite. The 3D porous framework of few-layer graphene sheets is obtained by a template-free chemical reduction of graphene oxide that maximises the exposure of electrode surfaces to electrolyte. The performance of the pH probe sensor is investigated electrochemically with respect to buffered solutions across a wide pH range (1-13 pH) and various real samples. The peak potential of the electrodes varies with the change in pH of the solution due to a $2e^-/2H^+$transfer process of a pH-dependent quinone/hydroquinone redox couple. For buffer solutions, the sensitivity of the 3D graphene-based sensor is measured to be 65.6 mV/pH. Soil pH sensing results exhibit a relative error of less than 5% in comparison to commercial pH meter tested with different types of soil samples. Furthermore, a single designed electrode could be utilized to detect the pH of various environments by simply rinsing with deionized water before testing the next solution. The 3D grapheme/quinizarin composite demonstrates stable performance with the long-term stability of six months and good reproducibility for more than 500 cycles. These low-cost and reusable pH sensitive electrodes open up the idea of a durable pH monitoring device in industrial sectors, chemical laboratories, agricultural farming, and, so on.

Theoretical Condensed Matter Physics

Non-equilibrium dynamics in correlated quantum systems

PROF. PINAKI MAJUMDAR
Harish Chandra Research Institute

Abstract: Correlated quantum systems define a frontier in many-body physics, where there is often no convincing theory even for equilibrium properties. Experiments however have moved on to probing the non equilibrium properties of such systems, for example, the voltage bias-driven breakdown of a Mott insulator, or the pump-probe dynamics of charge density waves in a strong coupling electron-phonon system. I will present a couple of equation of motion approaches to such problems, one a Langevin scheme for thermal systems, another an explicitly energy-conserving dynamics for an isolated system.

Bio: Prof. Pinaki Majumdar is a condensed matter theorist and the Professor and Director of Harish-Chandra Research Institute, Prayagraj. He graduated from Jadavpur University in 1986 with B.E. in Electrical Engg. and did his M.Tech from IIT Madras in 1990 in Solid State Technology. He obtained a PhD in 1996 from IISC Bangalore, after which he did his post-doctoral work at Bell Laboratories, New Jersey for a couple of years. Returning to India, he joined HRI as a fellow in 1998 and became a full professor in 2007.

Prof. Majumdar's research is primarily focused on disordered and strongly correlated quantum systems. His studies have assisted in a wider understanding of the metal-insulator transition, high T_C superconductors, superfluidity, ultracold quantum gases, optical lattices, etc. He has also contributed to the studies of nanoscale texture formation and colossal response driven by external fields.

Prof. Majumdar won the Institute Merit Prize and Silver Medal of the Indian Institute of Technology, Madras in 1990 when he passed out of the institute. The Council of Scientific and Industrial Research awarded Pinaki the Shanti Swarup Bhatnagar Prize, one of the highest Indian science awards in 2007. He received two awards in 2008; the Outstanding Research Investigator Award of the Safety Review Committee of the Department of Atomic Energy (DAE-SRC) and the Global Indus Technovator Award of the Massachusetts Institute of Technology. He has published more than 150 articles in reputed journals.

Localization transition in bond disordered grapheme

NABA NAYAK
Indian Institute of Technology Bombay

Abstract: We numerically study a particle-hole symmetric disorder-driven quantum phase transition (QPT) in two dimensions, which is realized with dimerized random hopping disorder in graphene. Our aim is to understand the critical fluctuations across the QPT using Lyapunov spectra of the transfer matrix, conductance, and density of states. At weak disorder, the low energy density of states shows Gade singularity, while in the localized phase the density of states diverges in a power law with a disorder-dependent exponent. The sublattice Lyapunov spectra crossing zero dictates the critical disorder strength δc

and a one-parameter scaling collapse of ξ/M in the localized phase gives the critical exponent $\nu \sim 1.05$, satisfying Harris bound, where M is the transfer width of the system, and ξ being the correlation length. At the critical point, the conductance distribution becomes scale invariant.

Ground state study of a two-leg ladder model

PABAN PATRA
Indian Institute of Technology Bombay

Abstract: We study the single and many-particle properties of a one-dimensional system with two legs and spatially varying flux. It is known that the low energy dispersion is quasi-flat at the single-particle level. The effect of interaction in the quasi-flat band was also shown to host a non-trivial ferromagnetic Mott insulator [1]. Here, we show the interaction-induced one-quarter filled state showing a ferromagnetic behaviour using the density matrix renormalization group method (DMRG). Similarly, at three-quarter filling, the spin-spin correlations suggest an anti-ferromagnetic behaviour. Further, as we increase the bandwidth, we show a transition from a ferromagnet to an anti ferromagnet.

Highly Efficient Hydrogen Storage of Sc Decorated Biphenylene Monolayer near Ambient-temperature: An Ab-initio Simulations

MUKESH SINGH
Indian Institute of Technology Bombay

Abstract: The energy demands for the growing development of society need to be catered with alternative and green fuels like hydrogen energy for a lasting and sustainable culture. One essential component of the hydrogen economy is the efficiency of its storage. We have studied the hydrogen storage capability on a recently synthesized Biphenylene (BPh) decorated with Sc using the first principles density functional theory (DFT) and ab-initio molecular dynamics (AIMD) techniques. Scandium attaches BPh sheet strongly with binding energy -3.84 eV, and single Sc decorated on BPh can absorb a maximum of five H2 molecules resulting in a high gravimetric weight percentage of 11.07, which is significantly higher than DoE's ultimate criteria (6.5 wt%). Using van't Hoff equation, strongly and weakly attached hydrogens correspond to desorption temperatures of 200 Kand 397 K with an average of 305 K. The high binding of Sc to BPh is due to charge donation of 3dorbital of Sc to 2p orbital of C. The interactions between absorbed H2 and BPh+Sc are due to charge transfer from 3d-orbital of Sc to σ* bond of H2 molecules and back donation from σ bond ofH2 to empty 3d-orbital of Sc known as Kubas type interaction. Furthermore, phonon and AIMD simulation confirm BPh+Sc stability, and the presence of an energy barrier shows no probability of Sc-Sc clustering on BPh. So theoretically stable BPh+Sc showing high gravimetric weight percentage with an average 305 K desorption temperature, might be a potential candidate for solid stage hydrogen devices.

Experimental High Energy Physics

Higgs physics at the LHC

PROF. KAJARI MAZUMDAR
Tata Institute of Fundamental Research

Abstract: The main scientific motivations of the LHC project are to understand the physics of the electroweak symmetry breaking (EWSB) and to probe the nature of the fundamental interactions among elementary particles at TeV energy scale. Towards the first mandate, we have been extremely lucky. The Higgs boson was discovered at the LHC in 2012, within a short while of the start of the data-taking in 2009 by the ATLAS and the CMS experiments. Since then, extensive studies about the nature of this newly discovered particle bolstered the description of EWSB in the standard model. This talk will present the important aspects of this journey till now.

Measurement of R2(Δη, Δφ) and P2(Δη, Δφ) correlation functions in pp collisions at $\sqrt{s}$ = 13 TeV as a function of charged particle multiplicity with ALICE at LHC

DIBAKAR BAURI
Indian Institute of Technology Bombay

Abstract: Two-particle azimuthal correlation functions have shown to be effective tools for comprehending the collective nature of heavy-ion collisions. Collectivity is observed in the two-particle differential number correlation function, R2(Δη, Δϕ), and transverse momentum correlation function, P2(Δη, Δϕ), in different centrality classes in Pb-Pb collisions. Additionally these correlation functions would provide key information about particle production mechanism, diffusivity, conservation of charge, and momentum in high-energy collisions. A significantly narrower near-side peak is observed for P2 as compared to R2 in recently published results in p-Pb and Pb-Pb collisions for both charge-independent (CI) and charge- dependent (CD) combinations. In this contribution, we have measured R2 and P2 as a function of relative pseudo rapidity and azimuthal angle difference (Δη, Δϕ) for un- identified charged particles produced in pp collisions at √s = 13 TeV using ALICE data for different multiplicity classes. These correlators are explored in $0.2 < pT \leq 2.0$ GeV/c range for better understanding of underlying events. The near-side and away-side correlation structures ofR2 and P2 are qualitatively similar but vary significantly

Multiplicity-dependent study of Λ(1520) resonance production in pp collisions at $\sqrt{s}$ = 5.02 and 13 TeV with ALICE

SONALI PRODHAN
Indian Institute of Technology Bombay

Abstract: Hadronic resonances are effective tools for studying the hadronic phase in ultra-relativistic heavy ion collisions. In fact, their lifetime is comparable to that of the hadronic phase, and resonances are sensitive to effects such as rescattering and regeneration processes, which might affect the resonance yields and shape of the transverse momentum spectra. ALICE has observed significant suppression for the ratio K^{*0}/K in pp collisions, while no such suppression has been observed for the ϕ/K ratio. The Λ(1520) resonance is particularly interesting due to its lifetime around (13 fm/c), which is in between the lifetimes of the K^{*0}(4 fm/c) and ϕ(46 fm/c) resonances, and thus provides more insight into the properties of the hadronic phase. Recently, ALICE observed the suppression of the Λ(1520)/Λ ratio in Pb–Pb collisions at √sNN = 2.76 TeV as a function of centrality. It is therefore interesting to study the multiplicity dependence of the Λ(1520)/Λ ratio for pp collisions, since this can serve as a baseline for heavy-ion collisions. In this contribution, we present new results on the measurement of the baryonic resonance Λ(1520)as a function of the charged-particle multiplicity in pp collisions at √s = 5.02 and 13 TeV. The transverse-momentum spectra, the integrated yields (dN /dy), the mean transverse-momentum (hpTi) and the Λ(1520)/Λ yield ratio will be presented as a function of the charged-particle multiplicity.

Heavy quark transport coefficients in viscous quark-gluon plasma

ADIBA SHEIKH
Indian Institute of Technology Bombay

Abstract: During the early stages of the heavy-ion collision experiments, the heavy quarks (charm and bottom) are created via hard scattering. Due to their large mass, they do not thermalize with the constituents of the quark-gluon plasma (QGP) over the lifetime of the plasma. Hence, they witness the entire evolution of QGP and are effective probes to study the strongly interacting matter. We study the heavy quark transport coefficients (drag and momentum diffusion) for collision and radiative processes, using perturbative QCD and kinetic theory for viscous QCD medium. The thermal medium effects are incorporated through the effective fugacity quasi particle model, based on the lattice QCD equation of state. The effective modelling of the QCD medium as quasi particles with encoded in-medium interactions modifies the momentum distribution function of the QGP constituent particles, i.e. light quarks, anti-quarks, and gluons by the introduction of a temperature-dependent effective fugacity parameter. Viscous corrections to heavy quark transport coefficients due to shear and bulk viscosities of the medium are incorporated at first-order in the thermal distribution function by solving the effective Boltzmann equation within relaxation time approximation. We observe that the soft gluon radiation substantially affects the heavy quark transport coefficients in the viscous QGP. Preliminary results for the effect of second-order shear viscous correction on the heavy quark transport coefficients will also be presented.

Plenary Speaker

ISRO – Indian Space Science Program – Recent Developments

DR. A.S KIRAN KUMAR

Professor and Ex-Chairman, ISRO

Abstract:- He will be talking about the latest developments as a part of the Indian Space Science Program at Indian Space Research Organisation (ISRO), going into the details of several topics like Quantum Communication and cold atom lasers.

Bio: Shri A. S. Kiran Kumar is Vikram Sarabhai Professor at ISRO, Bangalore and Member of the Space Commission, Govt of India. During 2015-2018, he has served as Secretary, Department of Space and Chairman, Indian Space Research Organisation.

Shri Kiran Kumar, born on October 22, 1952 in Hassan, Karnataka, holds M.Sc. Degree in Physics (Electronics) from Bangalore University and M.Tech. Degree in Physical Engineering from Indian Institute of Science, Bangalore. He has steered the implementation of the applications oriented Indian Space Programme, which has facilitated rapid development of the country in many important spheres of earth observation, communication, navigation, meteorology and space science, as well as the development of indigenous launch vehicles and related technologies for providing assured access to space. He has led design and development of more than 50 Electro-Optical Imaging Sensors flown on various Space borne platforms starting from Bhaskara in 1979. Further, his role in the success of Chandrayaan-1 mission and Mars Orbiter Mission has been significant.

Shri Kiran Kumar has been the Chair of the Committee on Earth Observation Satellites (CEOS) in 2012. He has made valuable contributions to Coordination Group of Meteorological Satellites (CGMS), Expert Team on Satellite Systems – World Meteorological Organisation (ETSAT of WMO) and Indo-US Joint Working Group on Civil Space Cooperation.

Shri Kiran Kumar is Fellow of Indian National Academy of Engineering, National Academy of Sciences India, Indian Society of Remote Sensing, Institution of Electronics & Telecommunications Engineers, Indian Society of Systems for Science & Engineering, Indian Meteorological Society, Indian Society of Geomatics, Gujarat Science Academy, Andhra Pradesh Akademi of Sciences and an elected member of International Academy of Astronautics. He has been conferred with Honoris Causa and DSc by 18 Indian academic institutions. He has co-authored 85 publications in various national/international scientific journals/conferences/symposiums.

In recognition of his contributions, he was conferred Padma Shri by the President of India in 2014. Other notable honours conferred on him include, Rajyostava Award by for 2015, `Sir M. Visvesvaraya Senior Scientist State Award' for 2013 by Government of Karnataka, Lifetime Achievement Award from Karnataka Science and Technology Academy in 2016, IISc Distinguished Alumnus Award for 2015, Gujarat Ratna `Life for Innovation' Award conferred by Gujarat Innovation Society in 2014, Lifetime Achievement Award by Andhra Pradesh Akademi of Sciences in 2016, Bharat Ratna Sir M. Visvesvaraya Centenary Award by University of Mysore in 2016, G.M. Modi Science Award in 2016, H K Firodia Vijnan Ratna Award in 2017, Santokbaa Award instituted by SRKKF Surat in 2018 and ISRO Lifetime Achievement Award 2018. He has been conferred with the prestigious ***2018 International von Karman Wings Award*** instituted by the Aerospace Historical Society, together with the Graduate Aerospace Laboratories at the California Institute of Technology, in 2018 and the ***Chevalier de l'Ordre national de la Légion d'Honneur*** – the highest civilian honour by the Government of France in 2019

Quantum Information and Computing

Locally hidden information

PROF. SOMSHUBHRO BANDYOPADHYAY
Bose Institute

Abstract: Information may be understood as the ability to distinguish between possible alternatives reliably. This implies that different messages must be encoded by states of a physical system that can be reliably distinguished from one another. So information encoded in quantum states can only be perfectly retrieved when the quantum states are orthogonal, for no measurement can reliably distinguish between non-orthogonal states. In this talk, we will consider the situation where information is encoded in orthogonal states of a composite quantum system in a distributed setting, i.e. where parts of the system are held by observers separated from each other. We will present examples of orthogonal quantum states that cannot be reliably distinguished in this scenario, which implies the existence of locally hidden information and a new kind of quantum non locality that, in some cases may be viewed as dual to Bell-nonlocality.

Bio: Professor Somshubhro Bandyopadhyay is an Associate Professor at Bose Institute, Kolkata. He obtained a Master's degree in Physics from Jadavpur University, Kolkata and Ph. D. in Physics from Bose Institute. After postdoctoral research at UCLA, University of Toronto and Universite de Montreal he has been at Bose Institute since 2008.

His research interests concern quantum information theory and foundations of quantum mechanics. His research focuses on the theory of quantum entanglement and its applications to quantum information and cryptography. He has worked in quantum communication, entanglement transformation, quantum state discrimination, quantum channels, and quantum networks.

He has studied the role of quantum entangled states in Quantum Information, including, characterizing quantum entanglement in many body systems, developing constraints that highly entangled many body systems must obey, entanglement transformations in finite copy cases, and entanglement cost of measurements that may not be done only by local operations and classical communication (LOCC). He is also interested in the problem of how much information that can be accessed by probing individual subsystems when some global information is encoded in a many body entangled system.

Non-destructive rotational sensing using squeezed light interacting with atomic superfluid

RAHUL GUPTA
Indian Institute of Technology Bombay

Abstract: We present a method for enhancing the rotational sensitivity for non-destructive measurements using Bose-Einstein condensates (BECs). Our method involves probing the BEC trapped in a toroidal trap using squeezed states of light beams with optical angular momentum (OAM). We find that by using squeezed OAM states, we are able to significantly improve the sensitivity of the measurement, as compared to using coherent states of light, further at certain squeezing angles we were able to be at the standard

quantum limit of the noise spectrum. This improved sensitivity allows for more precise measurements of rotational quantities such as angular velocity and torque. Further it is also possible to entangle the sideband modes of the BEC itself via this interaction which can overcome the decoherence and losses arising due to collisions. The results have implications for a broad range of applications including inertial sensing, metrology, quantum control of BEC states and fundamental tests of physics.

Zeno Time Crystal

MIDHUN KRISHNA
Indian Institute of Technology Bombay

Abstract: Time crystals are novel phases of matter with broken time-translational symmetry. Based on the type of symmetry breaking involved, these non-equilibrium phases of matter come in two varieties, namely discrete time crystals and continuous-time crystals (CTC). On the other hand, strong measurement usually restricts the dynamics of a finite system to the Zeno subspace, where subsequent evolution is unitary. Here we discuss how CTC can be induced in the Zeno limit of strong measurement in a spin star system [1]. We demonstrate, in a spin star system, how competition between strong measurement and thermodynamic limit could result in qualitative changes in steady-state properties. We see a dissipative phase transition in the ancilla spins between a phase with stationary magnetization and the time crystal phase with persistent oscillations of magnetization.

Study of Entanglement Swapping of two mixed states

MD SOHEL MONDAL
Indian Institute of Technology Bombay

Abstract: Entanglement is a key resource for quantum communication. But establishing entanglement at large distances is a challenge for us. Entanglement swapping is a way to establish long-distant entanglement where entanglement is created at smaller distances and by local operation (such as, Bell state measurement) they are swapped to establish entanglement at larger distance. There are studies already done for studying the concurrence (measure of entanglement for bipartite system) of the resulting state after entanglement swapping of two entangled pure states. In this talk I will discuss about the distribution of concurrence after entanglement swapping of two mixed states.

Transfer and protection of quantum information in hybrid systems

PROF. HIMADRI SHEKHAR DHAR
Indian Institute of Technology Bombay

Abstract: From quantum computation to communication, design of protocols and peripheral technology often rely strongly on the quantum interaction of light with matter. Hybrid quantum systems based on spin ensembles have shown exciting properties in the storage, transfer, and protection of information. In this talk, we show some theoretical results that demonstrate how a hybrid system can be engineered to allow for efficient transfer of quantum states of light to a mesoscopic spin ensemble and, in another instance, also allow for strong protection of the transferred quantum information.

Bio: Prof. Himadri Shekhar Dhar is an Assistant Professor in the Department of Physics at IIT Bombay. He completed his B.Sc.(Hons) in Physics in 2007 from St. Xavier's College, Calcutta; M.Sc. in Physics in 2009 from School of Physical Sciences, Jawaharlal Nehru University and received his PhD in 2015 from Jawaharlal Nehru University, New Delhi, followed by a year as a postdoctoral fellow at Harish-Chandra Research Institute (HRI), India. In 2016, he joined Vienna University of Technology (TU Wien) as Lise-Meitner fellow, and then in 2019 he moved to London to work as a research associate at Imperial College London before joining IIT Bombay in 2021. He is also an academic visitor at Imperial College London.

Prof. Dhar's research is on the theoretical study of quantum dynamics at the interface of quantum information theory, quantum optics and many-body systems. In the last few years, his works has focussed on how tools from many-body physics and open systems can be harnessed to study quantum light-matter interaction and hybrid quantum systems, with the motivation to implement quantum information and computing protocols and related technology, along with study of basic non-classical and non-equilibrium dynamics.

Prof. Dhar was awarded Best Poster at SPS March Meeting–2012, School of Physical Sciences, Jawaharlal Nehru University, and 'Best Young Physicist' at the 31st Young Physicists' Colloquium: YPC–2013, organized by the Indian Physical Society at Saha Institute of Nuclear Physics, Kolkata. He has published more than 30 articles in peer-reviewed journals, one peer-reviewed book chapter (Springer, 2017) and two proceedings in an international conference and a prestigious colloquium in India.

Theoretical High Energy Physics

Novel Mechanisms for Tiny Neutrino masses

PROF. SUDHIR KUMAR VEMAPTI
Indian Institute of Science, Bangalore

Abstract: Neutrinos have been one of the most confounding particles of the Standard Model. They possess tiny masses established by the observation of neutrino flavour oscillations. To generate such tiny masses several mechanisms are proposed in literature including the famed seesaw mechanisms, radiative mechanisms, etc. While they are excellent in their own right, novel mechanisms are being proposed. These mechanisms aim to generate large hierarchies in relevant couplings assuming O(1) parameters in the fundamental parameters of the model/theory. The ideas are influenced from both physics of extra dimensions in particle physics to Anderson localization in condensed matter physics. The most striking of these are models based on fractal structures in theory space. After presenting these models, we discuss some possible signatures of them in various sectors like flavour factories, cosmology, and direct experiments like LHC.

Bio: Sudhir Kumar Vempati is an Indian high energy physicist and a professor at the Centre for High Energy Physics of the Indian Institute of Science. He is known for his studies in neutrino physics, especially Large Hadron Collider Inverse problem and has published a number of articles, papers.
He is a member of the Indo-French Collaboration on High Energy Physics. The Council of Scientific and Industrial Research, the apex agency of the Government of India for scientific research, awarded him the Shanti Swarup Bhatnagar Prize for Science and Technology, one of the highest Indian science awards, for his contributions to physical sciences in 2016.

Prof. Vempati has made outstanding contributions, with the common theme of Flavour violation, which span a wide range of Particle Physics from supersymmetry to extra dimensions and from the Higgs boson to neutrino physics.

Bethe-like ansatz and Thermodynamic Bethe Ansatz in one dimensional Quantum Mechanics

AYAZ AHMED
Indian Institute of Technology Bombay

Abstract: Bethe ansatz is a powerful tool to obtain exact solutions of many integrable models including the familiar Heisenberg XXX spin chains. Interestingly, such Bethe-like equations appear in quantum mechanical systems. The energy spectrum and wave function of the hydrogen atom can be obtained using Bethe-like ansatz. However, for a general polynomial potential, we need to go beyond the Bethe-like approach. I will briefly review exact WKB method and the thermodynamic Bethe ansatz (TBA) for polynomial potentials and

the same with an inverse and a centrifugal term. Using these ingredients, we investigate the energy spectrum of |x| potential which has derivative discontinuity.

Symmetry Resolved Entanglement in de Sitter Space

HIMANSHU GAUR
Indian Institute of Technology Bombay

Abstract: In de Sitter space, disjoint observers eventually become causally disconnected but however still remain correlated. The study of entanglement between causally disconnected regions characterises the long-range correlations in de Sitter space. To this end, entanglement between the symmetric patches in the hyperbolic chart on de Sitter is considered. When a theory possesses a global internal symmetry, the entanglement entropy may be decomposed into the local charge sectors in either subsystem, thus resolving the entanglement entropy. In this talk, I will discuss the symmetry decomposition of the entanglement entropy for complex scalar and Dirac fermion fields on the de Sitter space. Both, complex scalar and Dirac fermion fields possess a global U(1) symmetry, and the symmetry decomposition of the entanglement entropy into the corresponding local charge sectors will be discussed.

Effective-One-Body formalism for leading order radiative effects in the post-linear framework

KARTHIK RAJEEV
Indian Institute of technology Bombay

Abstract: In recent years, significant progress has been made in the computation of conservative and dissipative scattering observables using the post-Minkowskian approach to gravitational dynamics. However, for accurate modelling of unbound orbits, an appropriate effective-one-body (EOB) resummation of the post-Minkowski results that also accounts for dissipative dynamics is desirable. As a step in this direction, we consider the electromagnetic analog of this problem here. We show that a six-parameter equation of motion encapsulates the effective-one-body dynamics for the electromagnetic scattering problem appropriate to third order in the coupling constant. Three of these six parameters describe the conservative part of the dynamics, while the rest correspond to the radiation-reaction effects. Here we show that only two radiation-reaction-related parameters are important at the desired order, making the effective number of parameters in our formalism to be five. We compute the explicit forms of these five parameters by matching EOB scattering observables to that of the original two-body ones computed by [Saketh et al., Phys.Rev.Res. 4 (2022) 1]. Interestingly, our formalism leads to a conjecture for the sub- leading angular momentum loss, for which no precise computations exist. In addition, we demonstrate that the bound-orbit observables computed using our method are in perfect agreement with those calculated using unbound-to- bound analytical continuation techniques. Lastly, we qualitatively discuss the extension of our formalism to gravity.

Photonics

Broadband laser and UV-Visible light generation using non-linear photonics

PROF. R. VIJAYA
Indian Institute of Technology, Kanpur

Abstract: Nonlinear photonics experiments are not new as several ideas have been successfully commercialized. Our group has worked on multiple experiments in nonlinear photonics in the last 25 years; in this talk, I will present two specific examples from our work, related to the development of broadband lasers and UV- visible light generation. Even though a majority of lasers are quasi-monochromatic in nature, broadband lasers are also possible using nonlinear concepts; I will discuss one method. Coherent light sources emitting at different wavelengths in the ultraviolet (UV) range are not commonly available. I will discuss a method to generate UV light without involving second- or third-harmonic generation. This UV light is part of a correlated photon pair relevant to quantum communications.

Bio: Professor R. Vijaya is a professor of physics at the Indian Institute of Technology (IIT) Kanpur. She received the master's and Ph.D. degrees from IIT Madras. She was a Professor with IIT Bombay for several years. She joined IIT Kanpur in 2011, where she is currently a Professor with the Centre for Lasers and Photonics and the Department of Physics, IIT Kanpur.

Her research work spans several topics in experimental photonics, and significantly in fiber optics, photonic crystals, nonlinear optics, and integrated optics, miniature lasers, microstrip patch antennas and metasurfaces—all with an emphasis on applications. She has mentored masters and Ph.D. students, and has a large number of publications and sponsored projects to her credit in a research career spanning 20 years. Prof. Vijaya has held several leadership roles at IIT Kanpur, including serving as the Head of the Centre for Lasers and Photonics from 2017 to 2018 and as the Head of the Department of Physics from 2018 to 2021.

A Semiautomated Tool for Fabrication of Vacuum base Optoelectronic Devices: Cluster Tool

NRITA GAUR
Indian Institute of Technology Bombay

Abstract: An indigenous semi-automated design which is unique in its design aspect to provide an economical solution for lab-scale research on ambient sensitive optoelectronic semiconductor materials for multi-stack device. This invention deals with development of a customized tool to fabricate a multilayer thin-film optoelectronic device. Cluster tool design is a solution, however, designing such a multi-chamber tool requires lots of iteration to get an optimal performance. The novelty of this instrument is that each chamber can be isolated from central chamber through gate valve to avoid the cross contamination in another chamber due to material deposited in one chamber. The optimized geometry of the sample holder and the effusion cells makes the smooth and uniform films. This high vacuum system (1*10-6mbar) is used to fabricate highly efficient small molecule evaporation process based Organic Light Emitting Diodes (OLEDs). An efficient Thermally Activated Delayed Fluorescence (TADF) based OLEDs are fabricated with a uniform

and thin emissive doped layer. In this tool each chamber is equipped with guided crystal monitor which enhance the fine doping for the co-evaporation in the chamber. Our results show the more efficient OLEDs than worldwide for the same device structure fabricated in our unique semi-automated instrument with other studies performed on these devices for different doping concentration in the emissive layer of the device.

Generation of Circularly-Polarized High-Harmonics with Identical Helicity in Two-Dimensional Materials

NAVDEEP RANA

Indian Institute of Technology Bombay

Abstract: Generation of circularly-polarized high-harmonics with the same helicity to all orders is indispensable for chiral-sensitive spectroscopy with attosecond temporal resolution. Solid-state samples have added a valuable asset in controlling the polarization of emitted harmonics. However, maintaining the identical helicity of the emitted harmonics to all orders is a daunting task. In this work, we demonstrate a robust recipe for efficient generation of circularly-polarized harmonics with the same helicity. For this purpose, a non-trivial tailored driving field, consisting of two co-rotating laser pulses with frequencies ω and 2ω, is utilized to generate harmonics from graphene. The Lissajous figure of the total driving pulse exhibits an absence of rotational symmetry, which imposes no constraint on the helicity of the emitted harmonics. Our approach to generating circularly-polarized harmonics with the same helicity is robust against various perturbations in the setup, such as variation in the sub cycle phase difference or the intensity ratio of the ω and 2ω pulses, as rotational symmetry of the total driving pulse remains absent. Our approach is expected to be equally applicable to other two dimensional materials, among others, transition-metal dichalcogenides and hexagonal boron nitride, a sour approach is based on the absence of rotational symmetry of the driving pulse. Our work paves the way for establishing compact solid-state chiral extreme ultraviolet sources, opening a realm for chiral light-matter interaction on its intrinsic timescale.

Purchell Enhancement in the plasmonic cavity

ARJUN UPADHYAY

Indian Institute of Technology Bombay

Abstract: Being the most fundamental process controlling spontaneous emission is the key to many applications. When the emitter is placed near an optical cavity, its spontaneous decay rate is either enhanced or suppressed depending on the condition. The maximum value of enhancement is given by the well-known Purcell factor. To get a maximum value of the Purcell factor, a high-quality factor (Q) and small volume (V) cavity is needed. The ability of metal nanostructures to localize the light to the ultra small volume provides a path to achieving a high Purcell factor. So far, many plasmonic cavities have been explored for different applications. We studied the metal nano gaps filled with dielectric material (alumina). We did a numerical simulation in COMSOL Multiphysics to get the transmission and field distribution of the metal nano gaps. We also estimated the value of the Purcell factor within these nano gaps. Later we also experimentally recorded optical transmission through these metal nano gaps.

Astronomy, Cosmology and Gravity

The evolution of baryon content of galaxies

PROF. JAYARAM CHENGALUR
Tata Institute of Fundamental Research

Abstract: Over cosmic time, galaxies grow by merger, and/or by the accretion of matter via inflows. As galaxies evolve they also convert their gas into stars. On a cosmic scale, it is well established that the star formation peaked about 10 billion years ago and that the average star formation rate per unit volume has declined sharply since then. Hydrogen is dominant baryonic component of galaxies, and atomic hydrogen is also the primary fuel for star formation. Stars form as the gas cools to become molecular hydrogen, and then cools further and collapses into stars under self gravity. Understanding the evolution of the atomic hydrogen content of galaxies is hence key to understanding the evolution of the star formation rate with cosmic time, as well as the total baryonic content of star forming galaxies. Atomic hydrogen emits a spectral line at a wavelength of 21cm, (i.e. in the radio regime), which can be observed by radio telescopes, such as the Giant Metre wave Radio Telescope (GMRT), located near Pune. The recent upgrade to this telescope has allowed for significant progress to be made in our understanding of the evolution of gas in star forming galaxies. In this talk, I will discuss some of the results from ongoing atomic hydrogen surveys of star forming galaxies using the upgraded GMRT.

Bio: Professor Jayaram N. Chengalur is the 10th director of Tata Institute of Fundamental Research. Since early 2018, Prof. Chengalur has served as dean, National Centre for Radio Astronomy (NCRA) faculty and he has been associated with the TIFR-NCRA since 1996. Professor Jayaram N. Chengalur obtained his B.Tech. in Electrical Engineering from IIT-Kanpur in 1987. He then moved to Cornell University for his doctoral studies, completing his PhD in 1994. Following this, he worked as a postdoctoral fellow at the Netherlands Institute for Radio Astronomy (ASTRON) in the Netherlands before joining the National Centre for Radio Astrophysics in 1996. He is a Fellow of the Indian Academy of Sciences, the National Academy of Sciences, India, and the Indian National Science Academy.

Professor Jayaram's research work ranges from cosmology to interstellar medium, extragalactic astronomy and fundamental constant evolution. His main work is on dwarf irregular galaxies sheds light on the hierarchical galaxy formation and dark matter. Within these, major works have been on neutral hydrogen absorption (HI) in galaxies showing high red-shift and the evolution of neutral hydrogen content in the universe. He played a key role in setting up of the upgraded Giant Metre wave Radio Telescope (uGMRT), a unique low frequency radio telescope operating in Pune.

Asymptotic quantum correlations of field modes in time-dependent backgrounds

S MAHESH CHANDRAN
Indian Institute of Technology Bombay

Abstract: Studying quantum fields in strong gravity poses several fundamental questions, like the quantum-classical transition of primordial density perturbations in the early Universe and the information paradox. To understand these questions, in this talk, we consider a simple model of a massive quantum scalar field in a time-dependent background and study various quantum correlation measures - entanglement entropy, GS fidelity, and Loschmidt echo. We show that the time-dependent systems possess a scaling symmetry that leaves the dynamical evolution of such measures invariant. The leading order behaviour of these measures is related via simple expressions at late times, serving as a diagnostic tool for instabilities in the system. We quantify such instabilities in terms of scrambling time and Lyapunov exponents and show that the system mimics classicality under certain conditions. We also show that the entropy scaling oscillates between the area-law and volume-law for a scalar field that undergoes a global quench. We then discuss its implications for the quantum-classical transition of scalar perturbations in the early Universe.

Finding the rare: Disruption of a star by a supermassive black hole

HARSH KUMAR
Indian Institute of Technology Bombay

Abstract: Tidal disruption events (TDEs) are bursts of electromagnetic energy that are released when supermassive black holes at the centers of galaxies violently disrupt a star that passes too close. These events provide a window through which accretion onto supermassive black holes can be studied; in some rare cases, this accretion leads to launching of a relativistic jet but the necessary conditions are not fully understood. The best-studied jetted TDE so far is Swift J1644+57, which was discovered in -rays, but was too obscured by dust to be seen at optical wavelengths. Here we report the optical detection of AT2022cmc, a rapidly fading source at cosmological distance redshift z = 1.19) the unique light curve of which transitioned into a luminous plateau within days. GROWTH-India Telescope, a project led by IIT Bombay and IIA, observed this event at a crucial time of rapid decay and laid foundation of further follow up. Our observations of the bright source, triggered follow-up of the counterpart at other wavelengths, including X-ray, sub millimetre and radio. Our multi-wavelength study supports the interpretation of AT2022cmc as a jetted TDE containing a synchrotron 'afterglow', probably launched by a supermassive black hole with spin greater than approximately 0.3. Jetted TDE are rare events with a rate of 0.02+0.04−0.01 per giga parsec cubed per year for on-axis jetted TDEs. This rate confirms that approximately 1percent of TDEs have relativistic jets. Optical surveys can use AT2022cmc as a prototype to unveil a population of jetted TDEs.

Astrometric Microlensing of Primordial Black Holes with Gaia

HIMANSHU VERMA

Indian Institute of Technology Bombay

Abstract: The Gaia space telescope allows for unprecedented accuracy for astro metric measurements of stars in the Galaxy. In this work, we explore the sensitivity of Gaia to detect primordial black hole (PBH) dark matter through the distortions that PBHs would create in the apparent trajectory of background stars, an effect known as astrometric micro lensing (AML). We present a novel calculation of the lensing probability, and we combine this with the existing publicly released Gaia eDR3 stellar catalog to predict the expected rate of AML events that Gaia will see. We also compute the expected distribution of a few event observables, which will be useful for reducing backgrounds. We argue that the astrophysical background rate of AML like events due to other sources is negligible (except possibly for events with very long durations, or equivalently for high mass PBHs), and we use this to compute the potential exclusion that could be set on the parameter space of PBHs with a monochromatic mass function.

We find that Gaia is sensitive to PBHs in the range of $0.4M_{\odot} - 5 \times 10^{7} M_{\odot}$,and has peak sensitivity to PBHs of $\sim 10M_{\odot}$for which it can rule out as little as a fraction $3 \times 10^{10}$of dark matter composed of PBHs. With this exquisitesensitivity, Gaia has the potential to rule out a PBH origin for the gravitational wave signals seen at LIGO/Virgo. Our novel calculation of the lensing probability includes for the first time, the effect of intermediate duration lensing events, where the lensing event lasts for a few years, but for a period which is still shorter than the Gaia mission lifetime. The lower end of our predicted mass exclusion is especially sensitive to these types of lensing events. As and when time-series data for Gaia is released, our prediction of the lensing rate and event observable distributions will be useful to estimate the true exclusion/discovery of the PBH parameter space utilizing this data.

Poster Abstracts

Role of Monovalent Cation in the Dielectric Relaxation Processes and Correlation of Defects with the Thermal Stability of Hybrid Metal Halide Perovskite Solar cells

KASHIMUL HOSSAIN
Indian Institute of Technology Bombay

Abstract: Perovskite solar cells (PSCs) are the fastest growing photovoltaic devices in the solar cells community and offer a bright future for cheap solar electricity. In the last few years, it has been observed that the efficiency and stability of the PSCs can be enhanced by introducing multi cations into the perovskite crystal structure. Herein, we have examined the triple monovalent cation-based PSC $(FA_{0.83}MA_{0.17})_{0.95}Cs_{0.05}Pb(I_{0.90}Br_{0.10})_3$ (CsFAMA) over single monovalent cation based PSC MAPbI3 (MAPI) through frequency-dependent photo-current and dielectric measurements in terms of the dielectric relaxation process. The dielectric relaxation time constant (τd) is lower for the CsFAMA based PSC as compared to the MAPI based PSC. The lower τ_d is attributed to lower defect density in the CsFAMA based PSCs. Unprecedentedly, the relaxation process is correlated with the presence of monovalent cation of CsFAMAvs MAPI as an absorber in PSCs, which is well correlated with the presence of relative defect density. Our study suggests that τ_d is higher for higher defect density semiconductors in PSCs. Further, defects formation under illumination conditions reduces JSC as major in the case of MAPI, however, it is relatively insignificant in CsFAMA based PSCs and can be hypothesized based on relative ion density accumulation at the interface of charge extracting contact. This study provides a unique in-depth knowledge towards the role of monovalent cation in the dielectric relaxation process and their connection with the defects and thermal stability of halide perovskite semiconductors-based solar cells.

Strong Interaction between emitter and SPP on noble metal

YADAV ROHIT UMASHANKAR
Indian Institute of Technology Bombay

Abstract: Many sources of light involve transitions between the electronic energy levels of a well distinct quantum systems for e.g.,: - dye molecules, quantum dots. If the interactions between the emitter and its local optical environment is strong enough, then the entire system enters into the hybrid state which is very different from those of the emitter and optical system individually. The system is then said to be in strongly coupled regime. Here, we tried to simulate and show the strong coupling phenomenon between Cyanine-dye j-aggregates and SPPs (Surface Plasmon Polaritons) on silver/ gold films. The simulations had been done using COMSOL MULTIPHYSICS software. Strongly coupled systems found wide applications such as in the development of Single photon switches, Quantum Gates etc.

Role of spatial organization of chromatin in dynamics of transcription factors

SHUVADIP DUTTA

Indian Institute of Technology Bombay

Abstract: Proteins search for target sites on the DNA backbone, in order to complete essential biological processes. The landscape of this DNA polymer is fluctuating, and characterized by collapsed domains called TADs with large numbers of inter segmental contacts. Search processes and exit times on such highly connected and fluctuating domains thus regulate timescales of biological events. Using a minimal model, we investigate the exit times from a one-dimensional network with additional inter segmental contacts. We show that exit times show a non-monotonic dependence on the number of the inter segmental contacts, suggesting an optimal compaction of polymer domains for which exit times are minimum. We show our results continue to hold true for more realistic polymer models. Further, we show the relevance of our results using chromatin network structures generated from experimental data. Our results give an insight into how chromatin self-organizes into multiple domains affects search and exit times of DNA-binding proteins.

Strong coupling between metal nanoparticle and metal-dielectric nanocavity mode for an efficient photocatalysis application.

DIPMALA MOHINTA

Indian Institute of Technology Bombay

Abstract: The rational design of a metal plasmonic nanoparticle embedded in an insulating thin film coated over a thick Au film is not only useful in tuning existing functionalities but also elicits many novel and unforeseen responses. Efficient coupling between metal plasmons and nanocavity mode can migrate towards the splitting in the plasmon extinction band. Here, we showcase optical extinction over a wide range of wavelengths by an efficient coupling between Au nanoparticle (NP) and nanocavity. The extinction spectrum covers almost the whole visible region. We propose that this type of strongly coupled plasmonic system can be used for efficient photo catalysis in the thin-film solar energy conversion and photoelectric devices. The combined structure of few-layered MoS2 coated over such structures, can be used for efficient photo catalysis. Various methods have been suggested over the years for synthesizing MoS2(monolayer or few-layer MoS2) such as mechanical exfoliation and chemical synthesis, but effectively controlling the size and purity of these flakes can prove to be challenging however. The Liquid Phase Exfoliation (LPE) process is an effective method of producing few-layered nanosheets of MoS2 dispersed in different organic solvents and herein we have demonstrated the same as well.

Electrostatically driven AuNRs self-assembly controlled by Laponite particles

IRFAN KHAN
Indian Institute of Technology Bombay

Abstract: Self-assembly is a process of spontaneous association of the individual units into highly arranged/ ordered structures/ patterns with no external intervention. Evaporation induced self-assembly process is advantageous over other mode of self-assembly because of its cost effectiveness and ease of operability. In Evaporation induced self-assembly process, droplet containing non-volatile solute is dried on the solid surface and resulting pattern formation studied by various techniques such as SEM, TEM and so on. Patterns on solid's surface depend on interatomic interactions, particle morphology, solution-solid interactions, temperature and surfactants etc. In this work we present the self-assembly of CTAB coated AUNR at varying concentration of nanoclay particles. Laponite is an anisotropic charged particle having disk shape with around 25nm diameter and 1nm thickness. The negative charge on nanoclay's surface has been utilized to facilitate the electrostatically driven assembly of positively charged CTAB coated gold nanorods. We present a mechanism to tune the inter particle distance of the smetically ordered AUNR within the coffee ring deposit [1] via controlled addition of nanoclay particles into the colloidal solution. The presence of nanoclay particles promotes chain like morphology with well-spaced AuNR ordered in smetic structure. With increase in nanoclay concentration the inter chain spacing is found to exhibit non-monotonous behaviour. For pure CTAB-AuNRs, smectic ordering occurs because of depletion, van der Waals and dipole-dipole attraction being dominant over the randomizing thermal motion. Addition of Laponite weakens attraction between the AuNRs, thus a chain of AuNRs are observed. Inter-AuNRs distance (Side-Side) is increasing with Laponite concentration. At higher Laponite concentration, Side-Side distance between AuNRs of chains becomes saturated.

Optical response of PPV film in hybrid nanostructures

BHAVYA SHARADBHAI SANGHAVI
Indian Institute of Technology Bombay

Abstract: Poly p-phenylenevinylene (PPV) is a conducting polymer. PPV can be processed into a highly ordered crystalline thin film. Due to electroluminescent property of the PPV film, it may extensively couple to the surface plasmons excited on the metal nanostructures. This technique has been used to increase the efficiency of optoelectronic devices, biological and chemical sensors, nanotip emitters in field emission displays and electro chromic devices. In this poster we present how the optical properties (luminescence efficiency and colour) of the PPV film may get affected due to the coupling in metal hybrid nanostructures.

Non-identical particle femtoscopy in Pb-Pb collisions at 5.02 TeV with ALICE

PRITAM CHAKRABORTY
Indian Institute of Technology Bombay

Abstract: Femtoscopy is a tool that can be used to measure the space-time dimensions of the particle-emitting source created in heavy-ion collisions using two particle correlations. Additionally to the measurement of the system size, one can extract the average pair-emission asymmetry between two particles with different masses. In this context, the measurement of femtoscopic correlations between charged pion and kaon pairs for different charge combinations obtained in Pb−Pb collisions at √sNN = 5.02 TeV with ALICE at the LHC is presented. The spherical harmonics representations of the correlation functions (C00 and RC11) have been studied in different centrality bins. The obtained correlation functions are analysed after taking into account a precise treatment of the non-femtoscopic background. The extracted source size (R) and the pair emission asymmetry (μ) show an increase from peripheral to central events. Moreover, it is observed that pions are emitted closer to the centre of the particle-emitting system than kaons and this result is associated to the hydrodynamic evolution of the source. Also, the source radii are found to be decreasing with increasing average momentum (kT) and transverse mass (mT) of the pair which indicates the presence of strong radial flow in the system.

Marangoni Driven Path Minimization Using Active Particles

KALPITA DAS
Indian Institute of Technology Bombay

Abstract: Motility in biological organisms is of great importance. We can mimic this behaviour in our lab with active particles. Such experiments with a 1-pentanol drop in a simple linear channel showed an autonomous uniaxial oscillation of that drop in the pentanol plus aqueous medium. Two drops showed anti-phase oscillation, three drops showed relay synchronization and in the case of four drops relay synchronization as well as anti-phase oscillation of the two pairs was observed. Further experiments are done to see if the drop can sense any asymmetry in its environment. The drop being able to sense the geometrical asymmetry with 80% probability and the chemical asymmetry with 100%probability we are further proceeding with pentanol disk, pentanol drop and camphor disk to check if the disks or drop are choosing the least past in a channel with two arms of different length, leading to the same reservoir. As pentanol/camphor diffuses there will be a surface tension gradient created in the medium. The surface tension gradient will be higher along the shortest path which leads to a larger Marangoni Force along the shortest path therefore the disks or drop would choose the shortest path. Then we can extend this to a channel of any number of paths and use this Marangoni force driven drop/disk to see if the drop/disk selects the shortest path.

Strong coupling between metal-plasmonic nanoparticle and nanocavity mode for an efficient photocatalysis application.

KRISHNA NAND PRAJAPATI
Indian Institute of Technology Bombay

Abstract: The rational design of a metal plasmonic nanoparticle embedded in a semiconducting thin film coated over a thick Au film is not only useful in tuning existing functionalities but also elicits many novel and unforeseen responses. Efficient coupling between metal plasmons and nanocavity mode can migrate towards the splitting in the plasmon absorption band. Here, we showcase a strong light harvest with a responsivity over a wide range of wavelengths by an efficient coupling between Au nanoparticle (NP) and nanocavity. A thick layer of Au film (100nm) is coated over a cleaned Si (100) substrate using a sputtering technique. Later, a thin layer of titanium dioxide (TiO_2) is coated over the Au film/Si substrate by again using sputtering technique. A 3 nm thin layer of Au is coated over TiO_2/Au film/Si substrate using a thermal evaporator. After annealing at 300 °C Au NPs appears on the surface of TiO_2. The typical size of Au NPs is 12 nm and the depth is 14 nm. The Au NPs lying over TiO_2/Au film/Si substrate surface do not show a plasmon absorption splitting. However, when the Au NPs are partially embedded (7nm) into the TiO_2 thin film, a strong coupling-induced absorption band splitting is evident in the reflectivity spectrum recorded. The twin dips in the reflectivity spectrum that covers almost the whole visible spectrum, are indicative of the absorption band splitting. With increase or decrease of the TiO_2 film thickness, the position and intensity of these hybridized dips change. We propose that this type of strongly coupled plasmonic system can be used for efficient photo catalysis for the degradation of methyl orange analytes. The combined structure of MoS_2 coated over Au NP/TiO_2/Au film can be used as efficient photo catalysis whereas, MoS_2 has been synthesized using the liquid phase exfoliation process. The strongly coupled plasmonic system may also find its application in the thin-film solar energy conversion and other opto-electronic devices.

Development of electrically gated devices with potential superconducting semiconductor.

BIKASH CHANDRA BARIK
Indian Institute of Technology Bombay

Abstract: Carrier densities in thin films of metals ($10^{23} cm^{-3}$) can not be controlled by anyconventional solid-state gate in Field Effect Transistor (FET) configuration. Because, to observe a reasonable change in carrier concentration (even $\sim$1 %), an unsustainable electric field would be required. Semiconductor channels with low carriers can be tuned easily because of their much lower concentration ($10^{16} - 10^{17} cm^{-3}$). However, for highcarriers semiconductors ($10^{18} - 10^{21}\ cm^{-3}$), it is again a challenge to observe the gating effect. This is one key reason a superconductor cannot be gate-controlled very easily because superconductors are usually metals, some semiconductor with high carriers, alloys or oxides which have carrier densities much higher than $\sim 10^{20} cm^{-3}$. Electrolytic gating is a powerful technique to modulate the density of charge carriers in high carrier density thin films, having two-dimensional carrier density as

highas $\sim 10^{17} cm^{-2}$. Here, we applied this potential technique on a high carrier density semiconductor (InN) with carrier density $\sim 10^3 - 10^4$times less than conventional metals. For typical high K-dielectrics where the breakdown field is about 1V/nm, limitsthe maximum carrier density induced to about $\sim 5 \times 10^{13} cm^{-2}$. Such a density isnot sufficient to completely deplete the carriers in a metal film or in a high density semiconductors, which would lead to nobel devices. To reach these carrier densities different mechanism is required. Dia to ferromagnetic transition, electric field-induced superconductivity etc. have been achieved by using this potential technique.[1][2] This technique is expected to enable us to get into unexplored regions of the phase diagram in various physical systems.[3][4][5]

Using Bayesian Inference to distinguish between IMBH binary signals and Noisy Transients

Sayantan Ghosh
Indian Institute of Technology Bombay

Abstract: Glitches are non-Gaussian, non-astrophysical transients in the strain data of ground-based gravitational wave observatories like Advanced LIGO and Advanced Virgo. With morphologies similar to intermediate mass black hole binaries, these glitches reduce the gravitational wave search sensitivity to intermediate-mass black hole (IMBH) binary signals and affect their characterisation. In this poster, I will present Bayesian parameter estimation results of a few such noisy transients. This analysis is an important step towards distinguishing IMBH binary signals from short-duration glitches in the upcoming observational runs of the International Gravitational Wave Network.

Thermonuclear Bursts in X-ray Binaries

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In the Low Mass X-ray Binary (LMXB) sources, during the active accretion from the secondary star, the accumulated fuel (a mixture of Hydrogen and Helium) undergoes hydrostatic compression as more matter keeps piling up. When temperature and density conditions reach ignition levels (typically within a few hours to days), the entire fuel layer on the NS surface burns rapidly, leading to a thermonuclear burst. During these bursting episodes, the X-ray intensity rises by order of magnitude within a few seconds – reaching peak luminosities of 10^{39} erg/s. The flux then exponentially decays at a slower rate (tens to hundreds of seconds). Studying the spectral and timing properties of thermonuclear bursts helps us probe the Neutron stars' fundamental properties and the binary systems' accretion environment. This work presents our preliminary results of analyzing AstroSat data of well-known thermonuclear burst source 4U 1728-34. We report 22 type-1 thermonuclear bursts throughout 8 AstroSat observations. We have fitted the continuum with cutoff power law and a broad iron line at 6.92 +/- 0.28 keV. A time spectral analysis of the burst spectrum was also done, fitting it with blackbody radiation and examining the evolution of various parameters over time. We will present a detailed comparison of the continuums and bursts of the source, spanning over years of observation

Optical response of PPV film in hybrid nanostructures

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Abstract: Poly p-phenylene vinylene (PPV) is a conducting polymer. PPV can be processed into a highly ordered crystalline thin film. Due to electroluminescent property of the PPV film, it may extensively couple to the surface plasmons excited on the metal nanostructures. This technique has been used to increase the efficiency of optoelectronic devices, biological and chemical sensors, nanotip emitters in field emission displays and electrochromic devices. In this poster we present how the optical properties (luminescence efficiency and colour) of the PPV film may get affected due to the coupling in metal hybrid nanostructures.

Dynamics of Driven Active Chain

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Abstract: Inside the cell, many biopolymers produce autonomous motion by utilising the chemical energy stored in the cell through ATP hydrolysis. It's the nature of this 'active drive', which determines the structural and dynamical properties of such systems. To study such systems theoretically, the model of active chain is being used where active stresses are introduced on a standard bead-spring model. For example, to study the active driving of DNA by Polymerase, active forces are modelled as force monopoles acted on each bead along the local orientation of bond vectors [1]. According to this model the active force of a fixed magnitude on the bead is directed along the local tangent to the chain, i.e along the vector connecting to bead. The dynamics is governed by an Overdamped Langevin Equation. With this model, the authors had shown that with increasing activity, the chain tends to form densely packed globular state in the presence of noise. We studied the conformation of such chains in the presence of an added external active force. We observed, that in the presence of low thermal fluctuations, the chain shows a number of dynamic morpho-states as a function of the ratio of the external driving force to the internal activity. For example we observed a transition from a complete collapsed state to a travelling helix and eventually to a travelling planar wave. These morphological states are remarkable since they are formed in the absence of any bending rigidity. We quantified these configurations and studied their variations as a function of changing activity ratio. Further we have examined the stability of such configurations in the presence of non-local hydrodynamics. Our studies show that a combination of external drive and a constrained internal activity can give rise to a range of dynamic structures in a system containing many degrees of freedom.

Benchmarking Gaussian Basis Sets in Quantum-Chemical Calculations of Photoabsorption Spectra of Light Atomic Clusters

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Abstract: The choice of Gaussian basis functions for computing the ground state properties of molecules and clusters, employing wave function-based electron correlated approaches, is a well-studied subject. However, the same cannot be said when it comes to the excited-state properties of such systems, in general, and optical properties, in particular. The aim of the present study is to understand how the choice of basis functions affects the calculations of linear optical absorption in clusters, qualitatively and quantitatively. For this purpose, we have calculated linear optical absorption spectra of several small charged and neutral clusters, namely, Li^2, Li^3, Li^4, B^{2+} , B^{3+}, Be^{2+}, and Be^{3+} , using a variety of Gaussian basis sets. The calculations were performed within the frozen-core approximation, and a rigorous account of electron correlation effects in the valence sector was taken by employing various levels of configuration interaction (CI) approach both for the ground and excited states. Our results on the peak locations in the absorption spectra of Li^3 and Li^4 are in very good agreement with the experiments. Our general recommendation is that for excited-state calculations, it is very important to utilize those basis sets which contain augmented functions. Relatively smaller aug-cc-pVDZ basis sets also yield high-quality results for photoabsorption spectra and are recommended for such calculations if the computational resources are limited.

First-principles investigation of doped borophene quantum dots as donor materials for solar cell applications

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Because of fast depleting fossil fuel reserves, there is an urgent need for harvesting alternative sources of energy, in general, and solar energy, in particular. In this work, we present a first-principles atomistic study of borophene quantum dots (BQDs) B35 and B36 for their possible utilization in solar cells, light-emitting diodes, and photo-detectors. We first optimize the geometries of the pristine BQDs and the ones doped by C, N, and O atoms, and find that they have non-planar bowl-like structures in the ground state. Next, we perform a detailed study of the electronic and optical properties of both the pristine QDs, and the ones doped by C, N, and O atoms. The strongest absorptions at 3480 nm and 1363 nm for oxygen doped B36-QD and B35-QD, respectively, suggest more light harvesting at longer wavelengths for these systems. Because the chemical potentials of several of these BQDs are slightly higher than that of popular solar-cell acceptor system PC71BM, they will act as electron donors in a PC71BM-based solar cell. The calculated values of the open-circuit voltage (Voc) corresponding to PC71BM and BQD based device indicate efficient electron injection from the BQDs to PC71BM. Oxygen doped B36-QD and B35-QD have the highest value of short-circuit current density (Jsc) attributed to their reduced HOMO-LUMO gap and high HOMO energy levels as compared to all other considered doped systems further enhancing the photoelectric properties. We also compute the power conversion efficiency (PCE) of both the pristine and doped BQDs, and find that B35-QD shows significant improvement after oxygen doping, while B36-QD exhibits the same trend after both carbon and oxygen doping. The efficiencies of oxygen doped B36-QD and B35-QD are maximum due to their high electron injection rate in PC71BM. Present calculations show that adding a foreign atom in B36-QD and B35-QD makes it a suitable candidate for next-generation high-performance solar cells.