IN-HOUSE MEET 2022

27-29 APRIL

Information Booklet

Raman Research Institute,

Sadashivanagar, Bangalore.

Organized by the students of RRI, with cordial support from the administration, faculty and all other employees.

Welcome Note

We are pleased to welcome you to the RRI In-house 2022. The RRI In-House 2022 is quite distinctive as this is the first full-scale offline event at RRI following the global pandemic, COVID-19. This event provides a platform for the vibrant RRI scientific community to portray its efforts toward expanding the boundaries of human knowledge. As the organizers of this event, it is inspiring to witness the overwhelming participation from all departments. We committed our best efforts to make this a meaningful event that contributes to a positive atmosphere at RRI. We thank you for your participation.

In-House Organizers

Students Batch of 2019

Schedule for oral presentations

Day-1 (27/04/2022)			
Time	Speaker	Department	Topic
Session I (Chair - Ranjini Bandyopadhyay)			
9:30 AM	Director's Inaugural address		
9:45 AM	Tarun Souradeep	AA	Tests of fundamental assumptions in cosmology
10:00 AM	Saurabh Kaushik	SCM	Quantitative Study of Cell Mechanics
10:15 AM	Saptarishi Chaudhuri	LAMP	The Quantum Mixture Laboratory: An overview
10:30 AM	Ion Santra	TP	Effect of tax dynamics on linearly growing processes under stochastic resetting: A possible economic model
10:45 AM	Urbasi Sinha	LAMP	Loophole-Free Interferometric Test of Macrorealism Using Heralded Single Photons
High Tea			
Session II (Chair - Sanjib Sabhapandit)			
11:20 AM	Mandira Pal	LAMP	Precision Metrology using Optical Weak measurements
11:35 AM	Subhadip Ghosh	SCM	Banded spherulite formation by a thermotropic liquid crystal
11:50 AM	Supurna Sinha	TP	Measurements and analysis of response function of cold atoms in optical molasses: a perspective
12:05 PM	Tanuman Ghosh	AA	Hard X-ray flaring in an ultraluminous X-ray source
12:20 PM	Subhajit Bhar	LAMP	Experimental observation of the linear response of cold atoms subject to a transient force
Lunch			

Session III (Chair - Saptarishi Chaudhuri)			
2:00 PM	Rahul Sharma	AA	AstroSAT view of the Accretion-powered Millisecond X-ray Pulsars
2:15 PM	Animesh Sinha Roy	LAMP	Robustness of Intra Particle Entanglement under Quantum Decoherence
2:30 PM	Keerthipriya S	EEG	Development of RF over fiber modules for Radio Telescopes and Radiometers
2:45 PM	Vishnu Deo Mishra	SCM	Layer undulation in bent-core liquid crystals
3:00 PM	Raghunathan Agaram	EEG	Square Kilometer Array Project : RRI's Initiatives in Engineering and Developmental activities
3:15 PM	Sonali Sachdeva	AA	Dust in the Universe

High Tea			
Session IV			
4:00 PM - 6:00 PM	Poster Presentation		
Day-2 (28/04/2022)			
Time	**Speaker**	**Department**	**Topic**
Session V (Chair - Ritu Nehra)			
9:00 AM	Sanjukta Roy	LAMP	Quantum Technologies with ultra-cold Rydberg atoms
9:15 AM	Zaibudeen A.W.	SCM	Correlating the drying kinetics and dried morphologies of aqueous colloidal gold droplets of different particle concentrations
9:30 AM	Sanhita Kabiraj	AA	Diagnostics of the super-orbital intensity variation in LMC X-4
9:45 AM	Sreyas P. Dinesh	LAMP	Cavity QED Experiments For Multilevel Quantum Systems
10:00 AM	Dipak Patra	SCM	Time Dependent Ginzburg-Landau model for Banded Spherulitic Growth
10:15 AM	Mohamed Ibrahim	MES	Mechanical Engineering Services
High Tea			
Session VI (Chair - Vikram Rana)			
11:00 AM	Silpa B S	LAMP	Transition frequency measurement of highly excited Rydberg states of ^{87}Rb for a wide range of principal quantum numbers
11:15 AM	Joseph Samuel	TP	Why radioastronomers need to understand Holonomy/Wilson loops
11:30 AM	Hemanth M	AA	Probing the accretion environment of GX 301-2 during its spin-up phase
11:45 AM	Kaumudibikash Goswami	LAMP	Experimental characterisation of a non-Markovian quantum process
12:00 PM	Sachidananda Barik	SCM	Origin of two distinct stress relaxation regimes in shear jammed dense suspensions
12:15 PM	Keerthipriya S	EEG	Design of compact analog beam former for low frequency applications
12:30 PM	Anirban Dutta	AA	X-ray Properties of the Cataclysmic Variable Stars
Lunch			
2:00 PM	Open House discussion		

High Tea			
16:20 PM - 6:00 PM	Quiz and other events		
Day-3 (29/04/2022)			
Time	Speaker	Department	Topic
Session VII (Chair – Sayantan Majumdar)			
9:00 AM	Ritu Nehra	TP	Topological aspects of a multi-partite non-Hermitian Su-Schrieffer-Heeger model
9:15 AM	Sagar Sutradhar	LAMP	Design, implementation and characterization of a dual species magneto-optical trap of bosonic ^{23}Na and bosonic ^{39}K atoms with large atom numbers
9:30 AM	Mohammad Arsalan Ashraf	SCM	Bio-mechanics of growing neurons
9:45 AM	Mayuri S	AA	A space based cosmology experiment from RRI
10:00 AM	Dibyendu Roy	TP	Many-body quantum chaos
10:15 AM	Sourav Chatterjee	LAMP	QKD protocol implementations in the QUEST project
High Tea			
Session VIII (Chair - Urbasi Sinha)			
11:00 AM	Satya Ranjan Behera	LAMP	Effects of the static and dynamic properties of the atmosphere on uplink based quantum communications in space
11:15 AM	Sebanti Chattopadhyay	SCM	Inter-particle adhesion induced strong mechanical memory formation in a dense granular suspension
11:30 AM	Sanjib Sabhapandit	TP	Universal framework for the long-time position distribution of free active particles.
11:45 AM	Ashwin Devaraj	AA	Discovery of a cyclotron line feature in High Mass X-ray Binary GRO J1750-27
12:00 PM	Vardhan Thakar	LAMP	A discussion on Second Order Correlation Function
12:15 PM	Dipanshu Garg	AA	Mathematical representation of Statistical Isotropy of the CMB
Lunch			
Session IX (Chair - Mayuri S)			
2:00 PM	Sumati Surya	TP	Quantum Fields on Causal Sets - Causality, Non-locality and Entanglement
2:15 PM	Sayan Saha	AA	Eppur si muove
2:30 PM	Prabu T	EEG	Overview of the Square Kilometre Array Project activities at RRI

2:45 PM	Suraka Bhattacharjee	TP	Quantum Langevin Dynamics of a harmonically oscillating Brownian particle in a magnetic field
3:00 PM	Anand Prakash	LAMP	Precision Ion Trap for Quantum Interaction and Optical Clock Experiments
3:15 PM	Vaibhav Raj Singh Parmar	SCM	An experimental study of desiccation cracking in charged colloidal clay suspensions
High Tea			
Cultural Night and Banquet Dinner			

Schedule for poster presentations

Poster presentations will be held on 27th April from 4:00 PM to 6:00 PM at the first floor of main building.

- Aditi Agarwal*
  Multi-wavelength studies of Active Galactic Nuclei
- Akhil Mohanan*, Sachidananda Barik, Sayantan Majumdar
  Role of plasticity and fracture in the universal viscosity scaling of dense particulate suspensions
- B.Arul Pandian*
  Square kilometer array pulsar observation
- Divya Shet*, Serene Rose David and Gautam V Soni
  Protection of the target DNA against the CRISPR-Cas9 attack by nucleosomes
- Ketan Rikame*, Biswajit Paul
  X-ray Diwali in the sky: Flares during eclipses in High Mass X-ray Binaries
- Kinjal Roy*
  X-Ray reprocessing environment in High Mass X-Ray Binary Pulsars
- Sahana*
  SKA-LOW TPM Beamforming
- Sayari Majumder*, Dibyendu Roy, Maheswar Swar, Subhajit Bhar, Sagar Sutradhar, Shreya Bagchi, Bidyut Bikas Boruah, Sanjukta Roy and Saptarishi Chaudhuri
  SPIN COHERENCE IN THERMAL AND ULTRA-COLD ATOMIC ENSEMBLES AS A PROBE OF QUANTUM PHASE TRANSITION
- Shibil Adam*, Swarnadeep Bakshi, Akhil Mohanan, Abhishek Ghadai, Sayantan Majumdar
  Reversible tuning of mechanical response in Collagen-PNIPAM composite through internal stresses
- Shovan Kanti Barik*, Silpa B S, Saptarishi Chaudhuri and Sanjukta Roy
  Measurement of absolute transition frequencies and $g^{(2)}$ *correlation in thermal and cold Rydberg atoms*
- Shreya Bagchi*, Bidyut Bikash Boruah, Sagar Sutradhar, Subhajit Bhar, Anirban Misra, Gourab Pal, Sanjukta Roy and Saptarishi Chaudhuri
  Design and performance of an experimental set-up for simultaneous laser cooling of ^{23}Na *and* ^{39}K *atoms towards quantum degeneracy*
- Sourav Bhadra*
  COSMIC RAYS FROM MASSIVE STAR CLUSTER WD1
- Sukanya Sadhu*, Sumanth K.M., Manohara M, Punit K. N., Serene R. D, Divya S, Gautam V. Soni
  Structural analysis of protein-DNA complexes using nanopore device
- Yogesh Arya* and Ranjini Bandyopadhyay
  Behaviour of Laponite nanoplatelets in Ion Exchange Resin mixture

Precision Ion Trap for Quantum Interaction and Optical Clock Experiments

Anand Prakash[1,*], Akhil Ayyadevara[1], Isita Chatterjee[2], E. Krishnakumar[1], M. Ibrahim[1], Sayan Patra[1,3] , Subhadeep De[2] , S. A. Rangwala[1]

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We present a Paul trap of end-cap geometry to trap a single ion and cool it to the motional ground state of its confining potential. Such a trap enables the creation and manipulation of tailor-made quantum states of a single ion. At RRI, we aim to study the interaction of a single trapped ion (Ca+) with atoms at ultra-low temperatures with high precision, using this trap. Such experiments will probe the boundary between classical and quantum interactions, entropy and information. This trap has also been designed to operate as a state-of-the-art ion clock at IUCAA (Yb+), and IIT Tirupati (Ca+). To this end, RRI and IUCAA have finalized the design of the sophisticated end-cap ion trap through rigorous simulations to obtain a nearly pure quadrupole confining potential, with the higher-order contributions suppressed by a factor of 103. Minimization of such trap-induced systematic effects preserves the motional quantum state of laser-cooled trapped ion for long experimentation times.

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[1] C. A. Schrama, E. Peik, W.W. Smith, H. Walther, Novel miniature ion traps. Opt. Commun. 101, 32–36 (1993)

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[3] Nisbet-Jones, P.B.R., King, S.A., Jones, J.M. et al. A single-ion trap with minimized ion–environment interactions. Appl. Phys. B 122, 57 (2016)

[4] Abdel-Hafiz, Moustafa et al. "Guidelines for developing optical clocks with 10−18 fractional frequency uncertainty." arXiv: Atomic Physics (2019)

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Robustness of Intra Particle Entanglement under Quantum Decoherence

Animesh Sinha Roy[*]

We study the effect of decoherence on the dynamics of entanglement. Specifically, we report a detailed theoretical investigation of the quantum decoherence of a pure intraparticle entangled state of two

degrees of freedom under amplitude damping channel, depolarizing channel and phase damping channel. Decoherence of intraparticle entanglement under the amplitude damping channel shows entanglement sudden death, a rebirth of entanglement, and creation of entanglement. These results are compared with the decoherence of a pure interparticle entangled state where we have not observed any "revival" or "creation" of entanglement and establish that intraparticle entanglement is much more robust to resist decoherence than interparticle entanglement under the effect of amplitude damping channel. Then the effect of decoherence on an intraparticle entangled pure state under phase damping channel as well as depolarizing channel is calculated and compared with that of decoherence of a pure interparticle entangled state under both phase damping and depolarizing channel. In this case also we show that intraparticle entanglement is much more robust against decoherence compared to interparticle entanglement under these two damping channels.

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X-ray Properties of the Cataclysmic Variable Stars

Anirban Dutta*

Cataclysmic Variable stars are a type of binary star system where a white dwarf accretes material from its companion star. The process of accretion is so energetic that they can produce a copious amount of X-ray emissions. These objects act as useful laboratory to study the properties of the accretion on compact objects – like how the material channels towards the white dwarf in the presence of a strong magnetic field, how the material fall on the white dwarf when an accretion disk is formed, how the X-rays are produced in the final stage of accretion. In this talk, I shall give a brief overview of the accretion physics for these sources.

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Discovery of a cyclotron line feature in High Mass X-ray Binary GRO J1750-27

Ashwin Devaraj*

The Be/X-ray binary, GRO J1750-27 was discovered in 1995 with the CGRO-BATSE during a major outburst. The source has shown significant activity only three more times since then i.e, in 2008, 2014 and most recently in 2021. It is a relatively poorly studied source and is one of the farthest known galactic X-ray pulsar located almost behind the galactic center at a distance between 14-22 kpc. Previously, during the 2014-2015 outburst, using the standard theory of accretion torque on magnetized neutron stars and the spin-up rate of this pulsar measured with Fermi-GBM along with its X-ray flux measured with Swift-BAT, the magnetic field strength was determined to be ~3.5-4.5 x 10^12 G. The uncertainity in the distance measurement led to the large uncertainty in the estimated magnetic field. The source was observed during the latest outburst using the NuSTAR telescope during the rising phase of the outburst. We estimate the spin period of the source to be ~ 4.45s using which we produced energy resolved pusle profiles between 3 and 79 keV. The broadband spectrum of this source was described by a power law modified by an exponential cut off and we report the discovery of a cyclotron resonant scattering feature (CRSF) in this hard x-ray spectrum of this source at ~43 keV indicating a magnetic field strength of 3.7 x 10^12 G. Our estimate of the magnetic field strength using the cyclotron line is consistent with the estimate made using the accretion torque model.

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Correlating the drying kinetics and dried morphologies of aqueous colloidal gold droplets of different particle concentrations

AW Zaibudeen* and Ranjini Bandyopadhyay

The evaporation of a gold nanorod (Au-NR) dispersion droplet, containing residual surfactant, on a hydrophilic silicon substrate results in a coffee stain with different microstructures. The distinct regions in the coffee stain, formed during different stages of droplet drying, are presumably correlated with the dynamics of the evaporating droplet. We drop-cast 2 µL CTAB capped Au-NR dispersion droplets on a hydrophilic substrate, and study their evaporation kinetics, and dried patterns using optical, electron, and atomic force microscopy. We report that droplet retraction, pinning, and quick evaporation during the initial, intermediate, and final phases of droplet drying are clearly correlated with the different coffee stain aggregation regions for a range of Au-NR concentrations. The receding velocity of the evaporating gold colloidal droplet decreases with increasing Au-NR concentration, resulting in random to cluster-like aggregations of Au-NRs outside the coffee stain. The droplet depinning is followed by a concentration-dependent droplet pinning process which results in the formation of a coffee stain edge comprising distinct domains that consists of smectic phase-like structures of Au-NRs. The duration of droplet pinning increases with gold nanorod concentration and therefore, the widths and heights of the outer coffee stain edge also increases that is consistent with the Popov theoretical model. Finally, the rapid evaporation of the droplet leads to the formation of non-uniform depletion region and inner coffee stain regions. Our study demonstrates that the solute deposition pattern can be tailored by controlling the evaporating droplet kinetics.
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Many-body quantum chaos

Dibyendu Roy*

The motion in classical mechanics can be regular for integrable systems and irregular or chaotic for nonintegrable systems. Quantum chaos is a branch of physics that tries to identify and understand the chaotic motion of nonintegrable systems when the quantum effects are significant. One key goal of quantum chaos is to establish a relationship between the universal spectral fluctuations of chaotic quantum systems and the random matrix theory (RMT). It took significant research efforts spanning over twenty years to obtain such a goal for single-particle systems whose corresponding classical dynamics are fully chaotic. A series of recent studies can make further progress in establishing such a relationship for interacting, nonintegrable many-body systems where local degrees of freedom, e.g., spin-1/2's, fermions, qubits, have no classical limit. These studies have analytically computed the spectral form factor (SFF) characterizing spectral fluctuations at high energies, and the derived SFF shows a good agreement with the RMT form, which is solely determined by the symmetry of underlying dynamical systems. The study of quantum chaos and its connection to RMT is essential in describing ergodicity and thermalization in closed quantum systems.

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Time Dependent Ginzburg-Landau model for Banded Spherulitic Growth

Dipak Patra* and Arun Roy

Time dependent Ginzburg-Landau (TDGL) models have been applied in various research fields. Here, we have developed a TDGL model by defining a conserve and a nonconserved order parameters to account for the rhythmic growth assisted banded spherulite formation of 8OCB liquid crystal. Spherulitic growth is associated with the spherical growth front and noncrystallographic branching during crystallization. Along with these, banded spherulites additionally exhibit a periodic radial variation of birefringence. In a quasi-two-dimensional system, this variation of birefringence produces concentric interference color bands during the microscopic observation under crossed polarizers. The model predicts that the radial modulation of two order parameters produces the ring-banded structure. The variation of band spacing with temperature obtained from the model matches very well with the experimental result. In addition, the model describes the existence of other patterns for different model parameters.

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Mathematical representation of Statistical Isotropy of the CMB.

Dipanshu Garg*

Observations of the cosmic microwave background (CMB) anisotropies have played a key role in developing modern cosmology. Detailed and accurate measurements of the CMB anisotropies tell us a lot about the global properties, the constituents, and the history of the universe. Standard cosmological model assumes SI and Gaussianity of the CMB anisotropy in FRW cosmology. There have been detections of the breakdown of SI in WMAP and Planck, whose origins have remained mysterious and not thoroughly explained. In this talk, I will discuss statistical measures to study deviations from SI. We will discuss the Bipolar Spherical Harmonic (BipoSH) representation of the general covariance structure on the sphere and reduction scheme for BipoSH leading to angular correlation functions for SI violation signatures.

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Probing the accretion environment of GX 301-2 during its spin-up phase

Hemanth M*

GX 301-2 is an accreting X-ray pulsar in a High-Mass X-ray binary stellar system, located 4 kpc away. The X-ray emission is powered by accretion of matter from the companion in an eccentric 42-day orbit. A very unusual aspect of this X-ray binary is that it consistently shows large orbital intensity variation by a factor of ~12 in hard X-rays, the peak luminosity appearing slightly before the periastron passage, and not during or after the periastron passage where the accretion for the companion wind is expected to increase. Several models for this unusual X-ray intensity variation have been proposed. X-ray spectral

data have been utilized to study the X-ray reprocessing environment of the pulsar (fluorescence emission and photoelectric absorption) at all orbital phases of the binary. Another unusual aspect of this pulsar is that it shows both a) spin-up and spin-down episodes with frequent switch-overs which is a characteristic of pulsars with supergiant companion, and b) transient episodes of rapid spin-up which is a characteristic of pulsars with Be star companion. During a rapid spin-up episode of this source in 2019, the pulsar frequency increased by 2% in about 80 days associated with an overall increase in the X-ray luminosity. We probed the accretion and reprocessing environment during this spin-up phase using data from the Gas Slit Camera on The Monitor of All-sky X-ray Image (MAXI) telescope onboard International Space Station. We found a significant change in the circumstellar/circumbinary environment compared to the long term behaviour of this source which holds clues for the rapid spin-up episodes.

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Effect of tax dynamics on linearly growing processes under stochastic resetting: A possible economic model

Ion Santra*

We study a system of N agents, whose wealth grows linearly, under the effect stochastic resetting and interacting via a tax-like dynamics---all agents donate a part of their wealth, which is in turn redistributed equally among all others. This mimics a socio-economic scenario where people have fixed incomes, suffer individual economic setbacks and pay taxes to the state. The system always reaches a stationary state, which shows a trivial exponential wealth distribution in the absence of tax dynamics. The introduction of the tax dynamics leads to a number of interesting features in the stationary wealth distribution. In particular, we analytically find that for an ordered system (where all agents are alike), increase in taxation results in a transition from a society where agents are most likely poor to another where rich agents are more common. We also study disordered systems, where the growth rates of the agents are chosen from a distribution and the taxation is proportional to the individual growth rates. We find an optimal taxation, which produces a complete economic equality (average wealth is independent of the individual growth rates), beyond which there is a reverse disparity, where agents with low growth rates are more likely to be rich. We consider three income distributions observed in real world and show that they exhibit same qualitative features. Though a simple, minimalistic model, this model provides some good analytical insight into the subject and has scope for step by step addition of more complexity observed in the real world. All our analytical results are in the $N \rightarrow \infty$ limit and backed by numerical simulations.

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Why radioastronomers need to understand Holonomy/Wilson loops

Joseph Samuel*

Astronomers use interferometry to observe and study objects in the sky. The early evidence for compact objects like black holes and neutron stars came from radioastronomy. More recently the Event Horizon Telescope has imaged a black hole in the centre of M87 using VLBI (very long baseline interferometry). These observations are important to fundamental physics as they push the limits of our understanding. However these interferometric observations are dogged by noise, which can alter the amplitude and phase of the signal received at each telescope. This noise introduces spurious effects which come in the way of getting an accurate image of the object in the sky. There is a need for extracting information from the measurements which is immune to such distortions. Astronomers call these quantities closure phases and closure amplitudes. The current state of understanding of such quantities is incomplete, especially in the case of polarised observations, which would be needed to understand the magnetic field structure of a source. This is where fundamental physics can help astronomers. I will describe recent progress in understanding closure invariants in terms of gauge theory. The theory of Wilson loops (aka gauge theory, Geometric Phase, anholonomy, loop variables) permits us the identify a complete and independent set of closure quantities. Our treatment gives a unified view of closure phases and closure amplitudes and sets the theory on a firm mathematical basis.

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Experimental characterisation of a non-Markovian quantum process

Kaumudibikash Goswami*

Every quantum system is coupled to an environment. Such system–environment interaction leads to temporal correlation between quantum operations at different times, resulting in non-Markovian noise. In principle, a full characterisation of non-Markovian noise requires tomography of a multitime processes matrix, which is both computationally and experimentally demanding. In this talk, I will discuss a more efficient solution. We use machine learning models to estimate the amount of non-Markovianity, as quantified by an information-theoretic measure, with tomographically incomplete measurement. We test our model on a quantum optical experiment, and are able to predict the non-Markovianity measure with 90% accuracy. Our experiment paves the way for efficient detection of non-Markovian noise appearing in large-scale quantum computers.

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Development of RF over fiber modules for Radio Telescopes and Radiometers

Keerthipriya S*

Optic fibers are commonly used for digital data transmission over long distances, as they provide excellent reverse Isolation and lesser attenuation. However, they can also be used to transmit RF signals. Commercial RF over Fiber transmitters have in-built Switched-mode power supplies (SMPS), which is undesirable as it contributes to conductive RFI for Cosmological experiments. They are also expensive for large-scale deployment in Radio Telescopes. Therefore, we have developed In-house RF over Fiber transmitters and Receiver systems with Automatic Power control for Gain stabilization without using any SMPS. These modules have been designed and tested to operate over the frequency range of 30 – 360MHz. They have also been characterized for their Temperature dependence using an In-house developed Peltier control system. The talk will give a brief outline of the optical module’s development and discuss the results of integrating the modules with our Radiometers and Telescopes.

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Design of compact analog beam former for low frequency applications

Keerthipriya S*

Microstrip lines are commonly used as delay lines in analog beamformers for forming multiple beams in the sky in an array of antennas. For a given delay in general, the physical length of the transmission line required is inversely proportional to the square root of the dielectric constant of the material on which it is implemented. We have explored the use of water as a dielectric medium for developing compact delay line because of its high dielectric constant (ε_r=80). In the process, a composite dielectric medium consisting of distilled water and FR4 – glass-reinforced epoxy laminate has been developed. Its electrical characteristics have been studied extensively, both analytically and in simulation. We present in this talk the design methodology adopted in the implementation and the preliminary results obtained.

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Precision Metrology using Optical Weak measurements

Mandira Pal*

Weak measurement is an extraordinary concept that enables faithful amplification and high precision measurement of small physical parameters and is under intensive investigation as an effective tool in metrology. The weak measurement process involves preparation of the system state in a definite initial state, which due to weak coupling to the observable results in a superposition of "slightly" shifted eigenstates and subsequent post selection in a final state which is nearly orthogonal to the initial state. The outcome of a weak measurement, which is called 'weak value', can become exceedingly large and lie outside the eigenvalue spectrum of the observable. This extraordinary feature of weak measurement has made it an attractive tool for metrological applications. This quantum mechanical concept can also be formulated within the realm of classical electromagnetic theory of light and indeed, carefully designed experiments were able to verify the validity of weak measurement in optical systems. We have already demonstrated the concept of weak measurements on spin optical effects and developed optimized weak measurement schemes based on polarization states of light.

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A space based cosmology experiment from RRI

Mayuri S*

Probing Reionization of the Universe using Signal from Hydrogen is proposed cosmology experiment from the CMB DISTORTION Lab at RRI. It seeks to detect the faint signature from the formation of the very first stars and galaxies in the Universe. In its final edition, PRATUSH will orbit the Moon, making scientific observations when in the clean environs of the lunar farside. PRATUSH has been funded by ISRO for pre-project studies and been recommended by an ISRO appointed committee for project mode. Phase I of PRATUSH will fly in a Low Earth Orbit followed by Phase II in lunar orbit. The PRATUSH concept model is currently being tested. This will be followed by the engineering and flight model, subject to project approval. This talk will present the baseline design of PRATUSH, the current status, and future activities.

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Mechanical Engineering Services

Mohamed Ibrahim*

The Mechanical Engineering Services (MES) provides customized solutions, tailoring to the specific needs and requirements of individuals and research groups in various departments of the Institute. They range from preliminary design concepts to final stage fabrication of various components, equipment, and experimental setups. Mechanical Engineering Services has four sections

1. Basement Section
2. General Section
3. Painting section
4. Carpentry section.

MES provides mechanical assistance for various labs and overall infrastructure development of the campus and its facilities. MES mainly consists of a basement workshop with Conventional machines such as BFW universal milling machine, two lathe machines, HMT high-precision radial drilling machine, a Bandsaw machine, and CNC machines, including CNC Vertical milling center, CNC Turning center, CNC router, and five-axis pocket NC machine.

In the General section, we have a Hydraulic shearing machine, Hydraulic bending machine, Hydraulic notching machine. We have a qualified and skilled team of employees working in unison and further equipped with modern CNC machines and CAD-CAM software, which helps visualize the final product and reduces a considerable number of iterations before the final product is manufactured.

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Bio-mechanics of growing neurons

Mohammad Arsalan Ashraf*

Neurons make nervous system of animal body, they receive and transmit sensory signals from external world and also responsible for signalling muscle motor activity. Understanding bio-mechanics of neurons may help us better understand the cause of neuro degenerative diseases like Alzheimer, Parkinson’s etc.

I will be describing our work towards understanding the force generation mechanism which is used by neurons to grow in order to find targets. We present experiments with chic neurons and a toy model which explains the results and gives insight into the microscopic details of the mechanism.

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Square Kilometer Array Project : RRI's Initiatives in Engineering and Developmental activities

Raghunathan Agaram*

Square Kilometer Array (SKA) is the world's largest and most sensitive radio telescope being built to address several fundamental problems in radio astronomy. Raman Research Institute's contribution to this mega science project involves development of state of the art in technology in both analog and digital domains. The primary goal of RRI's participation is twofold : i) to develop an in-house facility which can serve as a platform for testing and validating the hardware and firmware developed by RRI for SKA and ii) to use the same for its scientific studies in niche areas at very low frequencies (30-300 MHz). Electronics Engineering Group (EEG) has undertaken development of wideband antennas and compact analog beam former capable of operating over more than an octave bandwidth. The present talk outlines the progress made in its investigation of technology in increasing the operating bandwidth of the antenna and presents some of the initial results obtained.

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AstroSAT view of the Accretion-powered Millisecond X-ray Pulsars

Rahul Sharma*

Neutron Stars (NSs) are among the most exotic objects in the Universe. They represent the most compact stable configuration in which degeneracy pressure can still balance gravity, further compression leading to collapse and formation of a black hole. NSs are the fastest rotating stars known, with periods as short as a millisecond. In this talk, I will discuss about subclass of NS systems in X-ray binaries which show millisecond X-ray pulsations powered by accretion of matter. These are called Accretion-powered Millisecond X-ray Pulsars (AMXPs). Currently, 23 AMXPs are known and all of them are transient in nature. They are generally observed during outburst phase. AstroSat, India’s first multi-wavelength mission, is a boon to studying this class of objects due to its wide-band and fast timing capabilities. I will discuss the results from such sources observed with AstroSat observatory and their implications.

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Topological aspects of a multi-partite non-Hermitian Su-Schrieffer-Heeger model

Ritu Nehra*

Non-Hermitian systems such as open or lossy systems are ubiquitous in nature. The basic ways to create a non-Hermitian system are by employing the on-site gain and loss energies or imbalance/non-reciprocal hoppings. This leads to the directional asymmetry in the system and special singularities known as exceptional points. In this talk, I will discuss the multipartite non-Hermitian Su-Schrieffer-Heeger model as a prototypical example of one-dimensional systems with several sublattice sites for unveiling intriguing insulating and metallic phases with no Hermitian counterparts. These phases are characterized by composite cyclic loops of multiple complex-energy bands encircling single or multiple exceptional points (EPs) on the parametric space of real and imaginary energy. We show the topology of these composite loops can be quantified by a nonadiabatic cyclic geometric phase which includes contributions only from the participating bands. We analytically derive a complete phase diagram with the phase boundaries of the model. We further examine the connection between encircling of multiple EPs by complex-energy bands on parametric space and associated topology.

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Overview of the Square Kilometre Array Project activities at RRI

By RRI SKA Team

The Square Kilometre Array (SKA) is a most sensitive radio telescope currently built by an international collaboration. The current phase of the telescope will have two arrays, SKA1-Mid: a mid-frequency dish array in South Africa and SKA1-Low: a low-frequency aperture array in Western Australia. One major challenge in constructing the SKA1-Low telescope comes from the enormous digital signal processing requirements of the 131,072 wide-band antennas operating 50-350 MHz and spread over a 40 km radius. A second major challenge is in the SKA Science supercomputing required to process about 60 petabytes/day for pulsar-search in real-time. In the current interim phase of the SKA, the Raman Research Institute is leading the Indian contributions to the SKA1-Low and Pulsar search programs and helping to improve the critical designs and achieve very high confidence for the SKA construction. This involvement would expand during SKA construction to implement, validate and commission the digital beam formers for about 50,000 antennas of the SKA low and to develop the accelerated pulsar search functionalities for the SKA. Besides this RRI is also designing a most modern FPGA based digital receiver suitable for the next generation radio telescope applications. This talk will provide an overview of these activities at RRI.

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Origin of two distinct stress relaxation regimes in shear jammed dense suspensions

Sachidananda Barik* and Sayantan Majumdar

Many dense particulate suspensions show a stress induced transformation from a liquid-like state to a solid-like shear jammed (SJ) state. However, the underlying particle-scale dynamics leading to such striking, reversible transition of the bulk remains unknown. Here, we study transient stress relaxation behaviour of SJ states formed by a well-characterized dense suspension under a step strain perturbation. We observe a strongly non-exponential relaxation that develops a sharp discontinuous stress drop at short time for high enough peak-stress values. High resolution boundary imaging and normal stress measurements confirm that such stress discontinuity originates from the localized plastic events,

whereas, system spanning dilation controls the slower relaxation process. Furthermore, we find that the peak-stress in the system establishes an intriguing correlation between the nature of transient relaxation and the steady state shear jamming phase diagram obtained from the Wyart-Cates Model.

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Design, implementation and characterization of a dual species magneto-optical trap of bosonic ^{23}Na and bosonic ^{39}K atoms with large atom numbers

Sagar Sutradhar*, Subhajit Bhar, Shreya Bagchi, Bidyut Bikash Boruah, Anirban Mishra, Gourab Pal, Sanjukta Roy, and Saptarishi Chaudhuri

I shall present the design, implementation and characterization of the newly developed state-of-the-art experimental facility in QuMix laboratory, which produces large number of ultra-cold ^{39}K and ^{23}Na atoms. Presently, we have trapped more than 2×10^9 ^{39}K atoms and more than 10^7 ^{23}Na atoms in the magneto-optical trap (MOT), which are simultaneously loaded from two independent 2D$^+$ MOTs with high cold atomic flux. In this talk, I shall present our characterization and optimization procedures to increase the trapped atoms numbers in both the traps. The dual cold atomic clouds would be further simultaneously cooled to tens of μK via sub-Doppler cooling. Thereafter, this cold mixture of ^{23}Na and ^{39}K atoms will be transferred into a quadrupole magnetic trap and will be magnetically transported towards the “Science cell” for Bose-Einstein condensation after evaporative cooling. This versatile experimental system provides a favourable starting point for the realization of the quantum degenerate Bose-Bose mixture for quantum simulation with ultracold quantum gases in optical potentials.

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Diagnostics of the super-orbital intensity variation in LMC X-4

Sanhita Kabiraj*

LMC X-4 is an eclipsing X-ray binary pulsar with a pulse period of ~13.5 seconds and a binary period of ~1.4 days. It also exhibits a periodic long-term intensity variation of 30.5 days called super-orbital periodicity. Super-orbital variabilities in X-ray binaries are attributed to the periodic obscuration of the X-ray emitting region by a precessing warped accretion disk. In this work, using data from several space X-ray observatories, we have investigated the soft X-ray spectrum of LMC X-4 to detect the absorption of the X-ray spectrum by material in the line of sight which presumably leads to the super-orbital intensity variation. Along with the column density of absorbing material we also measure the relative strength of the iron fluorescence line, which is another indicator of suppression of the continuum X-rays. The results will be discussed in the context of similar studies on other sources with known super-orbital intensity variation.

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Universal framework for the long-time position distribution of free active particles.

Sanjib Sabhapandit*

Active particles self-propel themselves with a stochastically evolving velocity, generating a persistent motion leading to a non-diffusive behavior of the position distribution. Nevertheless, an effective diffusive behavior emerges at times much larger than the persistence time. Here we develop a general framework for studying the long-time behaviour for a class of active particle dynamics and illustrate it using the examples of run-and-tumble particle, active Ornstein Uhlenbeck particle, active Brownian particle, and direction reversing active Brownian particle. Treating the ratio of the persistence-time to the observation time as the small parameter, we show that the position distribution generically satisfies the diffusion equation at the leading order. We further show that the sub-leading contributions, at each order, satisfies an inhomogeneous diffusion equation, where the source term depends on the previous order solutions. We explicitly obtain a few sub-leading contributions to the Gaussian position distribution. As a part of our framework, we also prescribe a way to find the position moments recursively and compute the first few explicitly for each model.

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Quantum Technologies with ultra-cold Rydberg atoms

Sanjukta Roy*

Atoms excited to Rydberg states with high principal quantum numbers n have exaggerated properties such as strong dipole-dipole interaction ($\propto n^4$), large values of polarizability ($\propto n^7$) and longer life-times scaling as ($\propto n^3$). These exotic characteristics and highly degree of controllability make ultra-cold Rydberg atoms versatile atomic building blocks for a variety of quantum technologies such as scalable quantum information networks, precision electrometry as well as single photon source for secure quantum communications.
In this talk, I will give an overview on Quantum Technologies with Rydberg atoms, summarise recent results from our Rydberg experiment at RRI and give future perspectives on Quantum Simulation and Quantum Sensing with ultra-cold Rydberg atoms.

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The Quantum Mixture Laboratory: An overview

Saptarishi Chaudhuri*

I shall give an overview of the various research activities involving cold atoms and precision spectroscopy techniques happening at newly commissioned Quantum Mixture laboratory at Raman Research Institute. In particular, I shall present the design, implementation and characterization of a new state-of-the-art machine for simultaneous trapping and cooling of bosonic ^{23}Na and ^{39}K atoms towards Bose-Einstein Condensation. Our versatile experimental system provides a favourable starting point for quantum simulation with ultracold quantum degenerate gases in optical potentials.
I shall also highlight our publication on first detection of intrinsic spin-coherence from an ensemble of cold atoms using non-invasive Faraday rotation fluctuation measurements [3]. The main goal of this research is to study the spin properties in an ensemble of ultracold atoms along with development of a high-resolution time-resolved magnetometer [4]. I shall also indicate experimental measurements of the position response function of laser-cooled neutral Rubidium atoms subjected to a transient force in optical molasses [2]. Recently, we have completed a precision spectroscopic measurement performed on atomic ensembles to determine the absolute transition frequencies for highly excited Rydberg levels in neutral Rubidium atoms [1]. I shall give a brief overview of this experiment as well.

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Quantitative Study of Cell Mechanics

Saurabh Kaushik*

The mechanical nature of the biological cell and its nucleus is important to maintain tissue homeostasis as well as regulate disease states. A quantitative study of mechanisms of biomechanical sensing and response is important to understand the role of physical force in controlling cell morphology and function. We use our micropore based electrofluidic platform to measure the physiological changes in the cell and bacteria by quantitively measuring relative changes in their volumes when exposed to different chemicals. These small changes in relative volume are not observed in the microscopic images, but we are able to detect these changes using the resistive pulse technique with our micropore device. Using our electrofluidic system we could show changes in micron-sized particles as small as 100 nm in diameter or 0.6 fL in volume. We also demonstrate temporal changes (shrinkage and recovery rates) in Cells when they are introduced to certain chemicals. We envisage that our high-throughput and high resolution platform is a versatile tool and can be used for disease based cell screening purposes. To make our device point-of-care ready we custom-designed a low-noise amplifier which makes our device low-cost and portable. Further, we want to correlate cellular mechanical properties to cell health and disease by two methods: first by using Force-mapping modes of AFM and secondly by resistive pulse sensing of cells translocating through constrictions smaller than the cell diameter. These studies will be useful to establish high-throughput screening of cell-stiffness as a useful bio-marker in detection of blood based disorders in humans (Sickle Cell Disease, Diabetic retinopathy, low- load of pathogen carrying cells etc) as well as in veterinary sciences.

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Effects of the static and dynamic properties of the atmosphere on uplink based quantum communications in space

Satya Ranjan Behera*

We are working on a project in collaboration with the Indian Space Research Organisation, which aims at quantum communication using a satellite as a trusted node. Our aim is to get this to work using an uplink-based free space channel. In this case, the transmitter module is at the ground station and receiver is at a low earth orbit satellite. In this process, the beam encounters the atmosphere at the initial phase of its propagation. Atmospheric constituents will tend to scatter the beam which causes beam spreading. Turbulence will cause scintillation at the receiver causing the beam to wander. In this talk, we discuss our new results wherein the overall effect of the atmosphere on the quantum beam and the final link budget is calculated for two prominent astronomical observatories sites of India namely, IAO Hanle and Aries Nainital.

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Eppur si muove

Sayan Saha*

In this presentation, I shall discuss the effects of the motion of our local frame, i.e., the Solar System barycentre, on the observation of the Cosmic Microwave Background (CMB). The largest fluctuation observed on the CMB sky is the dipole (in mK level), which is believed to be caused by this motion. This motion also affects the CMB in small angular scales causing violations of the statistically isotropic nature of the CMB. In our work (arXiv:2106.07666), we infer the motion of our observation frame from these subtle signatures in small angular scale to constrain the possibility of any intrinsic dipole in the observed CMB dipole.

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Inter-particle adhesion induced strong mechanical memory formation in a dense granular suspension

Sebanti Chattopadhyay*

Repeated/cyclic shearing can drive amorphous solids to a steady state encoding a memory of the applied strain amplitude (γ). However, recent experiments find that the effect of such memory formation on mechanical properties of the material is rather weak. We study the memory effect in a yield stress solid formed by a dense suspension of cornstarch particles in paraffin oil. Under cyclic shear, the system evolves towards a steady state when the intra-cycle stress as a function of strain shows a gradual transformation to a highly non-linear strain stiffening behaviour starting from a quasi-linear response in the untrained state. By applying a readout after training, we find that the system encodes a strong memory of the training amplitude (γ_T) as indicated by a sharp change in the differential shear modulus by orders of magnitude. We observe that memory can be encoded for a wide range of both above and below the yielding, albeit, the strength of the memory decreases with increasing γ_T. In-situ boundary imaging shows that the system develops narrow fluidized regions near the shearing boundaries while the bulk of the sample moves like a solid plug. In the steady state, the average particle velocity inside the solid-like region slows down with respect to the moving plate as γ approaches γ_T, however, as the readout strain crosses γ_T, suddenly increases. We demonstrate that inter-particle adhesive interaction is crucial for such strong memory effect. Interestingly, our system can also remember multiple inputs only if the training strain with smaller amplitude is applied last.

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Transition frequency measurement of highly excited Rydberg states of ^{87}Rb for a wide range of principal quantum numbers

Silpa B S*, Shovan Barik, Saptarishi Chaudhuri, Sanjukta Roy

We describe our absolute transition frequency measurements of highly excited Rydberg states of ^{87}Rb atoms. The spectroscopic measurements were performed using Electromagnetically Induced Transparency (EIT) in ladder-type three-level systems with the probe transmission modified by coupling the intermediate level of the ladder-type system to high-lying Rydberg levels. We measure the absolute transition frequencies $5P_{3/2}$, $F = 3$ to nS and nD Rydberg States with an accuracy of $\leq 2MHz$, for a wide range of principal quantum numbers (n= 45 -124). Various nS and nD levels are addressed by tuning the coupling laser, operating at 480 nm. We also determine the values of the Rydberg-Ritz

parameters for $nS_{1/2}$, $nD_{3/2}$, $nD_{5/2}$ states of ^{87}Rb from our experimental measurements of the transition frequencies. Our measurements of the absolute transition frequencies of the highly excited Rydberg states would be useful for diverse applications in quantum information processing, quantum simulation and quantum sensing with Rydberg atoms.
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Dust in the Universe

Sonali Sachdeva*

I will tell about the omnipresent nature of dust in the cosmos, the manner in which it affects the light emitted by galaxies over the spectrum and the ways in which astronomers try to account for its affect. Note that our Milky Way would have been doubly bright in the optical if dust was not present. I will discuss the processes through which it is expected to have formed and destroyed inside galaxies and the critical role it plays in the formation of stars.
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QKD protocol implementations in the QUEST project

Sourav Chatterjee*

Quantum key distribution (QKD) refers to protocols for generating a secret key between two parties. In this talk, we report the development of a practical toolkit for simulating QKD protocol implementations while considering realistic imperfections [1]. We also highlight a novel in lab demonstration of a modified version of the prepare-and-measure based B92 protocol using a heralded single-photon source and evaluate the performance of the simulator against our experimental results [2]. Using novel optimization strategies that consider an information theoretic threshold for the quantum-bit-error-rate (QBER), we show that the simulated results are in good agreement with those obtained from the actual experiment. Our experimental demonstration provides the best key rate compared to other B92 demonstrations using heralded single photons available in literature, within the tolerable QBER threshold as per the information-theoretic security criterion. Lastly, we also report our in-lab entanglement-based BBM92 protocol demonstration, where we generate a bright stream of polarization entangled photon pairs from a Sagnac interferometer-based spontaneous parametric down-conversion source.

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Cavity QED Experiments For Multilevel Quantum Systems

Sreyas. P. Dinesh*, Arun Bahuleyan, V.I. Gokul, Vardhan. R. Thakar, S. A. Rangwala

A hybrid trap, which co-traps atoms and ions at the centre of a Fabry-Perot cavity, is a versatile tool to study the interaction between co-trapped species [1]. This trap has previously been used for performing a non-destructive detection for trapped ions via atom-cavity strong coupling [2]. However, cavity detection methods are usually applied for two-level non-interacting atoms since the loss of atomic population to dark states happens at a rate faster than the detection time scale [3]. To address this problem, a recent proposal has been developed to extend the cavity measurement technique to detect even multi-level systems with decay channels, making the cavity based non-destructive detection viable even for ultracold ground state molecules [4]. Before this becomes an experimental reality, multiple technologies and experimental strategies need to be in place. A significant development for a cavity-

based detection scheme is to have an actively stabilized cavity that can be locked to or tuned across the resonance of the trapped species with precise control. Here, we present the methodology towards non-destructive detection of ultracold molecules, the technique we use to stabilize the cavity and glimpses of the cavity QED experiments by this stabilization, which are important proving milestones for cavity experiments.
All the authors acknowledge supports from Ministry of Electronics and Information Technology (MIETY) and Department of Science and Technology (DST).

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Banded spherulite formation by a thermotropic liquid crystal

Subhadip Ghosh* and Arun Roy

The spherulitic growth of solid is a ubiquitous phenomenon exhibited by many different types of materials. In spherulitic growth, the solid phase after nucleation grows with a spherical growth front with continuous orientational symmetry in contrast to the growth of a crystal having discrete orientational symmetries. For some materials, the spherulitic growth is accompanied by a series of equidistant concentric bands and is known as banded spherulite. In quasi two dimensional geometry, these banded spherulite domains appear as flattened disks with circular boundary and the bands appear as concentric circular rings. Under crossed polarisers banded spherulites produce concentric interference colour bands due to the periodic variation of effective birefringence along its radial direction. For pure materials, the alternation of effective birefringence is found to be formed by coherent twisting of radially oriented crystalline units. In this talk, I shall discuss about banded spherulite formed by 8OCB (4'-octyloxy-4-cyanobiphenyl) thermotropic liquid crystal. This spherulite consists of untwisted fibrillary nano crystallites embedded in an amorphous solid phase. The coexistence of two different phases in this most stable solid state is quite unusual for this kind of small molecular system. Experimentally we have found that the banded spherulite is formed due to the rhythmic variation of composition of these two different coexisting solid phases along the radial direction of the domain which produces an alternating concentric crystallite-rich and crystallite-poor bands with different interference colour under crossed polarisers. To the best of our knowledge, this is the first example of banded spherulite formation by rhythmic variation of composition of two different solid phases of a pure compound.
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Experimental observation of the linear response of cold atoms subject to a transient force

Subhajit Bhar*, Maheswar Swar, Urbashi Satpathi, Supurna Sinha, Rafael Sorkin, Saptarishi Chaudhuri, and Sanjukta Roy

We present our experimental measurements of the position response function of laser-cooled neutral Rb atoms subjected to a weak external perturbation in optical molasses [1]. The linear response to an external perturbation can be expressed in terms of spontaneous stochastic fluctuations of the system in thermal equilibrium and vice versa in accordance with the fluctuation-dissipation theorem. A well-known technique to describe the dynamics governed by fluctuations in the dissipative environment is given by the generalized Langevin equation. The experimental observations agree with the predictions of our theoretical framework based on the Langevin equation. The transition from a damped oscillatory motion to an over-damped relaxation will be highlighted in this talk. I shall also present the scheme of our ongoing experiments on the dual-species transient response of cold atoms following the first set of measurements presented above.

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Quantum Fields on Causal Sets - Causality, Non-locality and Entanglement

Sumati Surya*

I will give an overview of some of the research done at RRI over the last couple of years on causal set theory. One of the focus areas has been to try to understand how the free scalar field vacuum behaves on discrete spacetimes which provide a covariant UV cutoff. I will give a short introduction to causal sets and describe how to measure entanglement entropy between complementary regions for a free quantum field. I will attempt to make the talk simple, with as few equations as possible.
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Measurements and analysis of response function of cold atoms in optical molasses: a perspective

Supurna Sinha*

The talk will give a perspective on our recently published work Measurements and analysis of response function of cold atoms in optical molasses (Optics Continuum, Vol. 1, No.2, 171 (2022); SUBHAJIT BHAR, MAHESWAR SWAR, URBASHI SATPATHI, SUPURNA SINHA, RAFAEL SORKIN, SAPTARISHI CHAUDHURI AND SANJUKTA ROY) where we use the Quantum Langevin Equation as a starting point and discuss the broader relevance of the work in the context of diffusion in the quantum domain. The talk will also touch upon some work in progress.
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Quantum Langevin Dynamics of a harmonically oscillating Brownian particle in a magnetic field

Suraka Bhattacharjee*

Brownian Motion is a century old phenomenon that has attracted the interests of many Physicists for a long time, starting from the motion of pollen grains suspended in water. Later, the Quantum Brownian motion of a neutral particle at the low temperature regime has also been studied in several researches. In the present work, our focus is on the Quantum Brownian motion of a charged particle in the presence of a magnetic field and a harmonic oscillator potential and attached to Ohmic and Drude heat baths. The response function, position autocorrelation function are derived using the Langevin dynamics, coupled to a heat bath via position coordinate coupling. The results are extended for calculating the position-velocity correlation and velocity autocorrelation, which are immensely important from the experimental point of view. Moreover, the long time tail behaviour analysis has shown that the position autocorrelation function varies as t^{-2} at long times for Ohmic and Drude bath models. However, the inclusion of the magnetic field and memory time scale in Drude bath affects the coefficients of the power laws and thus affects the overall trends of decays of the correlation functions.
The harmonic confining potential also restricts the growth of mean square displacement and leads to a faster decay of the correlation functions. We have also revisited the entire calculation considering the coupling between particle and bath variables via momentum coordinate coupling, which leads to drastically different results and one notices a much faster decay of the correlation function in case of momentum coordinate coupling. The comparison is highlighted in terms of its relevance to the correlation functions and mean square displacement.

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Hard X-ray flaring in an ultraluminous X-ray source

Tanuman Ghosh*

Ultraluminous X-ray sources are one of the brightest, albeit most enigmatic X-ray binaries. X-ray luminosity of these sources exceed the classical Eddington limit of a 10 solar mass black hole. Distinctive spectral features classify most of these sources as super Eddington stellar mass accretors. Although many ULXs have been studied so far, only a few of them showed transient flaring incidents. We will discuss the first detection of such flaring events in a nearby soft ULX, NGC 4395 ULX1. The flares are spectrally hard and can be attributed to the higher accretion rate in the inner slim accretion disk. The non-varying nature of soft spectral components in flaring and non-flaring epochs indicate that the variability is predominantly due to advection dominated accretion.

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Tests of fundamental assumptions in cosmology

Tarun Souradeep*

The remarkable success of recent cosmology in pinpointing a consistent concordance model disconcertingly relies on a few fundamental tenets, such as, isotropy of the universe, scale free primordial power spectrum, acoustic phenomena. Exquisite measurements of the CMB sky from Planck allow model independent test of these assumptions. I will mention a few interesting results from my research program along an agnostic data driven path.

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Loophole-Free Interferometric Test of Macrorealism Using Heralded Single Photons

Urbasi Sinha*

We show unambiguous violations of the different macrorealist inequalities, like the Leggett-Garg inequality (LGI) and its variant called Wigner's form of the Leggett-Garg inequality (WLGI) using a heralded, single-photon-based experimental setup comprising a Mach-Zehnder interferometer followed by a displaced Sagnac interferometer.

In our experiment, negative result measurements are implemented as control experiments, in order to validate the presumption of non-invasive measurability used in defining the notion of macrorealism. Among the experiments to date testing macrorealism, the present experiment stands out in

comprehensively addressing the relevant loopholes. The clumsiness loophole is addressed through the precision testing of any classical or macrorealist invasiveness involved in the implementation of negative result measurements. This is done by suitably choosing the experimental parameters so that the quantum mechanically predicted validity of the relevant two-time no-signaling in time (NSIT) conditions is maintained in the three pairwise experiments performed to show the violation of LGI or WLGI. Furthermore, importantly, the detection efficiency loophole is addressed in our experimental scheme by adopting suitable modifications in the measurement strategy, enabling the demonstration of the violation of LGI or WLGI for any nonzero detection efficiency. We also show how other relevant loopholes like the multiphoton emission loophole, coincidence loophole, and the preparation state loophole are all closed in the present experiment.

We report an LGI violation of 1.32 ± 0.04 and a WLGI violation of 0.10 ± 0.02 in our setup, where the magnitudes of violation are respectively 8 times and 5 times the corresponding error values, while agreeing perfectly with the ranges of quantum mechanically predicted values of the LGI and WLGI expressions that we estimate by taking into account the nonidealities of the actual experiment. At the same time, consistent with quantum mechanical predictions, the experimentally observed probabilities satisfy the two-time NSIT conditions up to the order of 10^{-2}. Thus, the noninvasiveness in our implemented negative result measurement is convincingly upper bounded to 10^{-2}.

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A discussion on Second Order Correlation Function

Vardhan Thakar* and Sadiq Rangwala

In this talk, I would like to share with everyone, my understanding of second order correlation function. Second order correlation function g^2 (delay) is a tool to classify sources of light into classical or non-classical anti-bunching ones by measuring statistical properties of intensity fluctuations. In our current experiment, emission is observed from a Fabry-Perot cavity in two different configurations. Our claim is that one of these configurations is a coherent source of light and the other incoherent. We intend to test the claim by measuring second order correlation of the two configurations.
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An experimental study of desiccation cracking in charged colloidal clay suspensions

Vaibhav Raj Singh Parmar*, Ranjini Bandyopadhyay

The films of colloidal suspensions, when subjected to desiccation, crack due to the development of drying-induced stresses. This phenomenon produces a range of patterns and the final profile depends on the processes that occur during the desiccation. We show the evolution of crack patterns during desiccation of aqueous Laponite suspensions in a controlled environment. Temporal observation of the desiccation cracks shows that the onset of cracking decreases if the elasticity of the colloidal film is increased. The saturated crack patterns are characterized by measuring the areas of the cracks and angels between them. The observed differences in the crack onset and growth are attributed to the evolution of elasticity in the aqueous Laponite suspensions.

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Layer undulation in bent-core liquid crystals

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The achiral bent-core (BC) molecules are known to exhibit spontaneous polar order and macroscopic chirality in their layered configuration (Smectics). The uniform macroscopic polarization in a medium introduces higher free energy resulting in a splayed polar ordering. The competition between the polar ordering and the tendency for local splay leads to a global frustration in the system. Under the competing influences, the system acquires structures with complex molecular ordering yielding a variety of different ordered phases. In this talk, I'll present the experimental investigations on a homologous series of compounds comprised of strongly asymmetric BC molecules, which suggest the existence of a layer undulated liquid crystal phase. Unlike the usual layer undulated phases, we found no evidence of layer polarisation. An electro-optic response, however, has been evident due to coupling between dielectric anisotropy and the applied electric field. The experimental findings can be explained with a 'leaning' director (average molecular orientational order) structure, in which the molecules are tilted within the layers keeping the layer normal ($\hat{k}$), director ($\hat{n}$), and molecular bent axis ($\hat{p}$) in one plane.

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Poster Presentation

Multi-wavelength studies of Active Galactic Nuclei

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Small bright regions in the center of massive galaxies having bolometric luminosities between 10^{41}–10^{48} erg s^{-1} are called active galactic nuclei (AGNs). One such subclass of AGNs characterized by non-thermal radiation over entire electromagnetic (EM) spectra and having jets pointing at a line of sight angle of $\leq 10^{\circ}$ are known as blazars. From their optical spectra, blazars are classified as BL Lacertae objects (featureless optical spectra) and flat spectrum radio quasars (broad emission lines in optical spectra). Blazars are a class of AGN, one of their jets is pointed towards the earth. Here, we report about the multi-wavelength study for blazar S5 1803+78 between MJD 58727 to MJD 59419. We analysed γ-ray data collected by Fermi-LAT, X-ray data collected by Swift-XRT & NuSTAR, and optical photons detected by Swift-UVOT & TUBITAK observatory in Turkey. Three flaring states are identified by analysing the γ-ray light curve. A day scale variability is observed throughout the flares with the similar rise and decay times suggesting a compact emission region located close to the central engine. Cross-correlation studies are carried out between γ ray, radio, and X-ray bands, and no significant correlation is detected. The γ-ray and optical emission are significantly correlated with zero time lag suggesting a cospatial origin of them. The broadband spectral energy distributions (SEDs) modeling was performed for all the flaring episodes as well as for one quiescent state for comparison. SEDs are best fitted with the synchrotron-self Compton (SSC) model under a one-zone leptonic scenario. The SED modeling shows that to explain the high flaring state strong Doppler boosting is required.

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Role of plasticity and fracture in the universal viscosity scaling of dense particulate suspensions

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Increase in viscosity under increasing shear stress, known as shear thickening, is a remarkable property of many dense particulate suspensions. Under appropriate condition they can exhibit discontinuous shear thickening (DST), where the viscosity increases dramatically, and can also enter into a solid-like shear jammed (SJ) state. The microscopic mechanism giving rise to such interesting phenomena is still a topic of intense research. A recent study demonstrated that the viscosity of dense suspensions can be scaled into a universal curve for a range of volume fraction and applied stress values. The universal curve shows two clear scaling regimes with different critical exponents implying the cross-over from frictionless to frictional jamming regime. However, the difference in microscopic flow fields giving rise to these two scaling regimes for the bulk sample remains unexplored. Here, using steady state shear rheology and in-situ imaging in the flow-gradient plane for diverse dense suspensions we address this issue. We find that in the frictional flow regime there are plasticity and failures in the sample. However, flow remains smooth and affine in the frictionless jamming regime. Thus, our study provides a physical origin for the observed scaling behaviour in dense suspensions.

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Square kilometer array pulsar observation

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Protection of the target DNA against the CRISPR-Cas9 attack by nucleosomes

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Clustered Regularly Interspaced Palindromic Repeat (CRISPR)/ Cas9 system is a bacterial adaptive immune system. It is a versatile tool for genome editing and gene regulation in eukaryotic cells. Using guide RNA or Cr-tracrRNA complexed with Cas9 enzyme it introduces double stranded breaks on the target DNA. We aim to investigate how the smallest unit of chromatin, a nucleosome, constrains the activity of the CRISPR-Cas9 system. The accessibility of nucleosomal DNA to Cas9 is variable over several orders of magnitude of the following. It depends on dynamic properties of the linker DNA sequence which is buried in the presence of chromatin remodelers. To better understand this regulation mechanism, we target the mononucleosomes and the nucleosomal arrays with the CRISPR-Cas9 system. We deduce the results in the direction of the length from the nucleosomal diad being protected in the presence and absence of the chromatin architectural proteins that stimulate Cas9 activity on nucleosomal templates. To understand the dynamics of chromatin compaction using PRC2 and RCC1, and protection against Cas9 attack, a lab model of reconstituted DNA and histone octamer bound to remodelers is a preliminary requirement. The spontaneous breathing of nucleosomal DNA together with the action of chromatin remodelers allow Cas9 to effectively act on chromatin *in vivo*. Along with applications in gene therapy, it can also be used to study the epigenomic gene regulatory implications in human diseases.

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X-ray Diwali in the sky: Flares during eclipses in High Mass X-ray Binaries

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In X-ray binary systems, X-rays are produced close to the compact object due to matter accretion from the companion star. This radiation can interact with the surrounding matter to give rise to secondary radiation called reprocessed emission, which also includes fluorescence lines. The reprocessed emission contains clues about the environment of the compact object and can help better understand the matter around the compact object, its chemical composition and ionization levels etc. In eclipsing X-ray binary systems, during eclipse, the direct emission of X-rays produced near the compact object are blocked by the companion star and only reprocessed emission is observed making them ideal systems to study the reprocessed emission. Some X-ray binaries also show rapid flares and study of the flares during the eclipses give additional clues regarding size of the reprocessing region, and also help distinguish between different components of the X-ray spectrum observed during the eclipses. In this work, we have searched for flares during the eclipses of X-ray binaries in a large volume of archival X-ray data and detected flares in three sources during eclipse: Vela X-1, LMC X-4 and 4U 1700-37. We compare the spectral properties of the flares and persistent emission data during and outside eclipse in these systems. We observe soft excess in the spectrum of the persistent emission data during eclipse, compared to the flare data during eclipse, indicating a possibility of a blackbody source in the system, located such that its emission is not obstructed by the companion star during the eclipse. Some rapid flares are also detected which help constraint the size of the reprocessing region.

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X-Ray reprocessing environment in High Mass X-Ray Binary Pulsars

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Compact object binaries are central engines of high energy emissions including X-Ray. High Mass X-Ray Binaries(HMXBs) with B or O spectral type companion can generate very clumpy stellar winds. A X-Ray pulsar in such extreme environments creates ideal conditions to study the high energy reprocessing regions around compact objects. My current project is on the study of Iron Kα reprocessing region. We have used data primarily from X-ray Multi-Mirror Mission(XMM-Newton) of the European Space Agency(ESA).

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SKA-LOW TPM Beamforming

Sahana*

SKA-Low is an international effort to design and build Worlds's largest telescope with vast collecting area of 1 km square. SKA-Low operates in frequency range 50-350 MHz. It is to impliment a complex receiver to provide large field of view through multiple beams in the sky.In this poster we will be describing about TPM architechture and testing procedure to develop the same archtecture to produce 48 beams.

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SPIN COHERENCE IN THERMAL AND ULTRA-COLD ATOMIC ENSEMBLES AS A PROBE OF QUANTUM PHASE TRANSITION

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Measurements of atomic spin properties, in particular, spin life time (T_1) and spin coherence time (T_2) can be categorized under the broad field of spintronics with fundamental research interests in metrology and quantum magnetism, to mention a few. Ultracold atomic systems are ideal testbeds for demonstrating quantum effects such as quantum phase transitions, cross-correlation of spin properties between intra- and inter- species atoms etc. The various properties of the ultracold atomic systems can be investigated by non-invasively probing the intrinsic spin dynamics of the system. Recently our group demonstrated the detection of intrinsic spin-coherence from an ensemble of cold atoms using non-invasive Faraday rotation fluctuation measurements [1]. The main goal of this work is to study the detection and investigation of those quantum properties in an ensemble of ultracold atoms. The same technique has been used to demonstrate high-resolution and time-resolved magnetometry [2].
In this poster, I will begin with presenting our current activities on detecting spin correlation in various homo and hetero-nuclear thermal atomic systems using traditional spin noise spectroscopy (SNS) technique. Next, I will present the roadmap towards implementing this technique to detect the spin correlation in ultracold atomic mixtures. Finally, I shall present the schematic of our future experiments to non-invasively probe quantum phase transition using SNS in a system of ultra-cold atoms in optical lattices.

[1] Detection of spin coherence in cold atoms via Faraday rotation fluctuations Maheswar Swar, Dibyendu Roy, Subhajit Bhar, Sanjukta Roy, and Saptarishi Chaudhuri Phys. Rev. Research 3, 043171 (2021)
[2] A Real-Time Digital Receiver for Correlation Measurements in Atomic Systems V Mugundhan, Maheswar Swar, Subhajit Bhar, Saptarishi Chaudhuri IEEE Transactions on Instrumentation and Measurement, 70, 1 (2021)

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Reversible tuning of mechanical response in Collagen-PNIPAM composite through internal stresses

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Collagen is the most abundant protein in the mammalian extracellular matrix. In-vitro collagen-based materials with specific mechanical properties are important for various bio-medical and tissue-

engineering applications. Here, we study the architectural-dependent mechanical response of a biocompatible composite material formed by collagen networks seeded with thermo-responsive PNIPAM microgel particles. We find that by switching the temperature over LCST of microgels, the shear modulus of the composite can be reversibly tuned over a wide range. Using fluorescence microscopy, we could confirm such tunability is directly attributed to the mesh size of the collagen network.
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Measurement of absolute transition frequencies and $g^{(2)}$ correlation in thermal and cold Rydberg atoms

Shovan Kanti Barik*, Silpa B S, Saptarishi Chaudhuri and Sanjukta Roy

We present our precision spectroscopic measurements performed on atomic ensembles to determine the absolute transition frequencies for highly excited Rydberg levels in neutral Rubidium atoms. We measured the absolute transition frequencies of $nS_{1/2}$ and nD ($nD_{3/2}$ and $nD_{5/2}$) Rydberg levels of ^{87}Rb atom from $5P_{3/2}$, F=3 level for a wide range of principal quantum numbers (n = 45-120) with an accuracy of ≤ 2 MHz. We used Rydberg Electromagnetically Induced Transparency (Rydberg-EIT) technique to measure the transition frequencies in ladder type three-level systems. We also determine the Rydberg-Ritz parameters (Quantum Defects) for $nS_{1/2}$ and nD levels as well as the ionisation energy of the $5P_{3/2}$ F=3 states from our measurements. We present our initial measurements on photon arrival time statistics or $g^{(2)}$ correlation from cold atoms as a first step towards measurements of quantum correlation in cold atoms in the presence of Rydberg excitation. Our measurements on highly excited Rydberg atoms is useful for diverse applications such as quantum sensing and quantum information processing with Rydberg atoms.
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Design and performance of an experimental set-up for simultaneous laser cooling of ^{23}Na and ^{39}K atoms towards quantum degeneracy

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We present the design, implementation and characterization of a new state-of-the-art machine for simultaneous trapping and cooling of bosonic ^{23}Na and ^{39}K atoms. At present, we have realized dual species Magneto Optical Trap (MOT) that contains ~10^9 ^{39}K atoms and ~10^7 ^{23}Na atoms which are loaded via high flux cold atomic beams from their respective $2D^+$ MOTs. We report on the optimisation procedures of parameters for the best performance of this system of cold atomic mixture.
We also present the roadmap for further cooling of the dual species cold atomic cloud to tens of μK via sub-Doppler cooling and Gray molasses technique. The cold atomic mixture will be magnetically transported to the "Science cell" where we will perform evaporative cooling to reach quantum degeneracy. Our versatile experimental system provides a favourable starting point for quantum simulation with ultracold quantum degenerate gases in optical potentials.
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COSMIC RAYS FROM MASSIVE STAR CLUSTER WD1

Sourav Bhadra*

Recent observations of γ-rays from star clusters have motivated the study of the dynamics of stellar wind from massive star clusters, as potential sites of Cosmic Rays (CRs) acceleration. We checked these ideas with detailed studies, with regard to the details of CR acceleration in star clusters. We focus on the accelerations of CRs in the young massive star cluster Westerlund 1 (WD1) with the help of

hydrodynamical simulation. The γ-ray observations in star clusters reported a radial distribution of the projected CR energy density with a 1/r profile. The wind termination shocks of stellar winds have been identified as an important acceleration site, although CRs can also be injected in the central region of the cluster. Using idealized two-fluid simulations, we study these different CR injection methods in WD1 to explain the observed projected γ-ray luminosity, mass, and inferred projected CR energy density. We investigate whether or not this profile can help to distinguish between (1) continuous CR acceleration in the star cluster, stellar wind-driven shocks, and (2) discrete CR acceleration in multiple supernova shocks. We find that the inferred CR energy density profiles from observations of γ-ray luminosity and mass can be much different from the

true radial profile. We cover a large range of diffusion co-efficient and CR injection fractions to explain the observation and determine the optimum values of these parameters in the close vicinity of clusters. CR acceleration at either the cluster core or the termination shock can explain the observation if the diffusion coefficient is 1027 cm^2s^{-1} and 10-20% of the total energy goes into CRs. We also studied the multiple discrete supernova explosion scenario in the cluster with an appropriate supernova rate and found that this scenario can also explain the observed γ-ray profile. We also found that the hadronic origin of gamma rays can explain the observations of WD1 whereas the leptonic origin was not able to explain it. This denotes that the WD1 acts as a hadronic accelerator of cosmic rays.

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Structural analysis of protein-DNA complexes using nanopore device

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Chromatin is a highly dynamic and complex molecule. In eukaryotes, DNA and histones are packed into nucleosomes, and nucleosomes are further consolidated to constitute chromatin fiber. This higher level of compaction and packaging inhibits many necessary biological processes such as DNA-replication, repair, transcription, or recombination. Transient structural changes in chromatin fiber allow overcoming these restrictions resulting in required sites to open up to complete the vital processes. Nanopore has been proven to be an excellent label-free, high throughput tool to study conformational changes in various protein-DNA complexes. We have used the nanopore device to understand the polymeric behavior of different lengths of linear DNA (3kbp-10kbp) as well as the structural modifications of nucleosomes with changing electric fields. We have seen that the folding ratio of different lengths of DNA is proportional to the length but inversely proportional to the external voltage applied. Also, we observe that the electrical signatures corresponding to linear DNA translocation through nanopores contain information about the internal geometry of the pore. In our in vitro assembled nucleosome experiments, we show that under increasing electric field, the nucleosome systematically breakdown into partial structures such as tetrasome and hexasomes. We also show similar findings in our in vitro assembled 12-mer nucleosome arrays which breakdowns into single, multiple or partial nucleosome structures in a voltage-dependent manner. We hence demonstrate that the nanopore platform can be a reliable tool to quantitatively study the structural changes of intermediate sub-structures of chromatin fiber under the application of external parameters such as electric field.

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Behaviour of Laponite nanoplatelets in Ion Exchange Resin mixture

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A suspension of the synthetic clay Laponite exhibits physical aging behavior with time due to the time-evolution of inter-particle electrostatic interactions. They show phase transitions from a liquid state to either a glass state or a gel state which depend on several factors such as clay concentration, ionic concentration, external additive concentrations, etc. We modify the inter-particle electrostatic interactions by adding ion exchange resins. A significant fraction of ions are exchanged (Na + ions on

the Laponite particles being replaced by H + ions) with the incorporation of ion exchange resin in aqueous Laponite suspensions, which can be observed in a decrease in conductivity in our experiments. Our dynamic light scattering (DLS), rheology, and cryogenic scanning electron microscopy data reveal that increasing resin concentration significantly affects the aging dynamics of the aqueous Laponite suspensions studied here. The increase in resin concentration for a fixed concentration of Laponite suspension leads to decreasing average microscopic pore area and an increase in macroscopic yield stress and results in the accelerated kinetic arrest of the suspension.

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