Invited Talks

STATPHYS KOLKATA VIII

01/12/2014, Monday, Day-1

1. **09:30 - 10:15 AM, 01/12/2014**

Relation of classical non-equilibrium dynamics and quantum annealing

Hidetoshi Nishimori
Tokyo Institute of Technology, Japan

Relations of simulated annealing and quantum annealing are studied by a mapping between the transition matrix of classical Markovian dynamics of the Ising model and a quantum Hamiltonian. It is shown that, if simulated annealing with slow temperature change does not encounter a difficulty caused by an exponentially long relaxation time, the same is true for the corresponding process of quantum annealing. One of the important differences between the classical-to-quantum mapping and the converse quantum-to-classical mapping is that the Markovian dynamics of a short-range Ising model is mapped to a short-range quantum system, but the converse mapping from a short-range quantum system to a classical one results in long-range interactions. This leads to a difference in efficiencies that simulated annealing can be efficiently simulated by quantum annealing but the converse is not necessarily true.

2. **10:15 - 11:00 AM, 01/12/2014**

Frenetic aspects of second order response

Christian Maes
Instituut voor Theoretische Fysica, Leuven, Belgium

Starting from second order around thermal equilibrium, the response of a statistical mechanical system to an external stimulus is not only governed by dissipation and depends explicitly on kinetic details: the change in dynamical activity due to the perturbation enters as an observable in the equilibrium correlation functions giving that response. That so called frenetic contribution in second order around equilibrium is illustrated in some physical examples, such as for non-thermodynamic aspects in the coupling between system and reservoir, for the dependence on disorder in dielectric response and for the nonlinear correction to the Sutherland–Einstein relation. Inversely, systems or particles with different friction, reactivity, couplings or other kinetic features when in contact with an equilibrium reservoir can be distinguished and possibly separated in nonlinear response.

3. **11:30 AM - 12:00 PM, 01/12/2014**

Large deviation in single-file diffusion.

Tridib Sadhu
CEA/Saclay, Gif-sur-Yvette Cedex, France

Single-file diffusion is referred to the motion of many particles in narrow channel where particles can not pass each other. As a consequence of the forbidden mutual passage the motion of individual particles is sub-diffusive. I will apply the macroscopic fluctuation theory to analyze the probability distribution of position of a tracer particle in a large class of single-file system. For Brownian point particles with hard-core repulsion this macroscopic approach leads to a parametric expression of the large deviation function of tracer position. I will compare the results with that obtained in an exact microscopic analysis. I will emphasize the unusual dependence of the statistics of the tracer position on the initial state.

References

[1] P. L. Krapivsky, Kirone Mallick, and Tridib Sadhu, Phys. Rev. Lett. 113, 078101.

4. **12:00 AM - 12:30 PM, 01/12/2014**

Heat and entropy fluctuation theorems for underdamped Langevin systems

Sourabh Lahiri
Korea Institute for Advanced Study, South Korea

When two bodies at different temperatures are placed in direct contact, the heat exchanged between them follows a detailed fluctuation theorem (DFT), as was shown by Jarzynski and Wojcik. However, in general, the bodies are connected through some conductor. We study the exchange fluctuation theorem for this system, where the conductor is modelled by a chain of interacting particles. We find that the heat exchanged with the hot (cold) heat bath follows a modified DFT, which is different from an exact DFT due the presence of an extra multiplicative factor. In the second part, I will present the fluctuation theorems for adiabatic and non-adiabatic entropies for underdamped systems, in a straightforward way without using the concept of dual dynamics (whose definition in this case is not as clear as in overdamped systems).

5. **12:30 AM - 1:00 PM, 01/12/2014**

Commensurate - Incommensurate domains and driving domain dalls Inside the vortex state in a nano patterned superconductor systems

Satyajit S. Banerjee
Indian Institute of Technology, Kanpur, India

Commensurate - incommensurate phases arise when a periodic structure tries to match an underlying basic lattice, for example, Krypton gas molecules adsorbing on a graphite lattice. In the context of superconductors, it is well known that superconductors patterned with artificial periodic array of holes exhibit periodic enhancements in the pinning force. Conventionally these periodic enhancements are considered to occur when the periodic lattice of vortices in type II superconductor generated with a magnetic field (B) becomes commensurate with the lattice of holes or pinning center patterned in the superconductor. Commensurability sets in when the intervortex separation ( ) becomes commensurate with the period (d) of the lattice of pins at integral multiples of the first matching field (B), where a_0 d. Recent theoretical work suggests the possibility of vortex phase separation in nano-patterned superconductors. The phase separation is considered to lead to a domain like state in the vortex configuration over the pins with soliton excitations in the system which correspond to the excitation of domain wall boundaries. Using high sensitivity magneto-optical imaging technique we quantitatively map the local magnetic field distribution in high quality superconducting single crystal. The surface of the single crystal was partially patterned with a periodic array of nanosized dimples, using Focused Ion Beam (FIB) milling. The dimples were arranged in a triangular array. We report [1] the observation of unusual terraced like features in local field distribution inside the nano-patterned region of the superconductor. While the average field distribution has features resembling a critical like state however detailed analysis reveals significant departure from the average critical state like profile. Infact we observe the presence of corrugated terraced like features in the field distribution. By mapping the local screening current distributions within the patterned regions we uncover regions with distinctly different gradients co-existing inside the patterned region. Our results we believe suggests evidence [1] for a patchy or domain like vortex distribution over the nanopatterned pins, where the vortex configuration in the presence of a correlated array of pins is composed of domains with commensurate - incommensurate phases separated by domains walls. We also can manipulate these domain boundaries which trigger drastic reorganization of flux within the nanopatterned region.

References

[1] Gorky Shaw, S. S. Banerjee, T. Tamegai and Hermann Suderow (submitted, 2014).

6. **03:30 - 04:00 PM, 01/12/2014**

Patterns, dynamics and phase transitions in Ising ferromagnet driven by propagating magnetic field wave

Muktish Acharyya
Presidency University, Kolkata, India

The nonequlibrium behaviours of Ising ferromagnet driven by propagating magnetic field wave are studied by Monte Carlo simulation. In the steady state, the patterns and dynamics of spin clusters are studied in details. Depending on the values of amplitude, frequency and the wavelength of the propagating magnetic field wave, various dynamical phases are observed. The transition from one phase to other is studied by tuning the temperature of the system. The fluctuation of the dynamic order parameter is observed to grow near the transition point. The comprehensive phase boundary is drawn.

7. **04:00 - 04:30 PM, 01/12/2014**

Mathematical understanding of violation of detailed balance and its application to Langevin dynamics

Masayuki Ohzeki
Kyoto University, Japan

An improved method of driving a system into a desired distribution, for example, the Gibbs-Boltzmann distribution, is proposed, which makes use of an artificial relaxation process. The standard techniques for achieving the Gibbs-Boltzmann distribution involve numerical simulations under the detailed balance condition. The violation of the detailed balance condition gives rise to an asymmetric component in the Fokker-Planck operator or transition matrix in the formulation of the master equation. This asymmetric component leads to shifts in the eigenvalues and results in the acceleration of the relaxation toward the steady state. In the present study, we propose a modified Langevin dynamics neglecting the detailed balance condition, which accelerates the relaxation toward the steady state.

02/12/2014-Tuesday-Day-2

8. **09:30 - 10:15 AM, 02/12/2014**

Singular large deviation functionals

Yariv Kafri
Technion, Haifa, Israel

The talk will present recent progress in understanding singularities in the density large deviation functional in non-equilibrium systems. First, a general overview of the methods for carrying out such calculations will be outlined. Then the analytical structure of the large deviation functionals, will be contrasted with that of equilibrium systems. Particular emphasis will be placed on cases where the functional become singular and how the singularities can be characterized. Time permitting a Casimir effect in diffusive systems will also be discussed.

9. **10:15 - 11:00 AM, 02/12/2014**

Probability distribution of time of detection of a quantum mechanical particle at a screen

Abhishek Dhar
International Centre for Theoretical Sciences, Bangalore, India

Imagine an experiment where a quantum-mechanical particle is released from some fixed region inside a box. On one side of the box there is a screen with detectors which click as soon as the particle "arrives" at the screen. One expects that the time of arrival of the particle is a stochastic variable and it is interesting to ask for it's probability distribution. This is similar to asking for the distribution of the time of absorption of a Brownian particle at some point. In this talk, an attempt will be made to explain why the quantum problem is subtle, and our recent attempts at understanding this in a framework where repeated projective measurements are made to detect the particle. This leads to a non-unitary time evolution of the wave-function of the particle, and we show that this is well described by an effective non-Hermitiian Hamiltonian. For some simple lattice models, we find power-law tails for the probability that the particle survives detection up to some time.

10. **11:30 AM - 12:00 PM, 02/12/2014**

Stall forces and catastrophes in a system of multiple cytoskeletal filaments pushing an obstacle

Dibyendu Das
India Institute of Technology - Bombay, Mumbai, India

Collective dynamics and force generation by cytoskeletal filaments are crucial in many cellular processes. Investigating growth dynamics of a bundle of N independent cytoskeletal filaments pushing against a wall, we show that chemical switching (ATP/GTP hydrolysis) leads to breakdown of force additivity for the collective stall force. Quite often, the stall force of N filaments may be greater than N times the stall force of a single filament. We show that this is related to the non-equilibrium nature of hydrolysis. Furthermore, we study fluctuation properties of such a multi-filament system, and find that they have slower catastrophes and more stability, in comparison to a single filament system.

11. **12:00 - 12:30 PM, 02/12/2014**

From actin filaments to the simple association-dissociation- aging process (SADAP)

Thomas Niedermayer
Max Planck Institute of Colloids and Interfaces,Potsdam, Germany

In the first part of the talk, the stochastic depolymerization dynamics of actin filaments will be considered and it will be shown that the theoretical analysis of this process leads to the identification of novel internal states of these bio-filaments. Single actin filaments exhibit abrupt changes in their depolymerization velocity which were prematurely interpreted as global structural transitions leading to increased filament stability with aging [1]. We derived distributions of interruption times for different hypothetical mechanisms and compared these to the measured distribution. It turned out that photo-induced dimerization of neighboring filament subunits is responsible for the interruptions [2]. Moreover, we could show that the hydrolysis of actin bound ATP occurs at random subunits within the filament [3]. In the second part of the talk, the simple association-dissociation-aging process (SADAP), which is a minimal stochastic model for the assembly and disassembly dynamics of actin filaments coupled to random hydrolysis, will be presented. Despite the generic character of the SADAP and its applicability to many other quasi one-dimensional processes, no satisfactory analytical solution of this non-equilibrium process has been found so far. I will present an analytical solution that is based on an ansatz for the complete and exact set of master equations. This solution predicts emergent properties of the process -such as the boundary between the regimes of growth and shrinkage -, which is validated by stochastic simulations.

In particular, all inter-subunit correlations are exactly reproduced.

References
[1] Kueh et al., Science 325, 960 (2009)
[2] Niedermayer et al., PNAS 109, 10769 (2012)
[3] Jgou et al. PLoS Biology 9, e1001161 (2011)

12. **12:30 - 01:00 PM, 02/12/2014**

Dynamics of cell adhesion in presence of time varying stretch

Rumi De
Indian Institute of Science Education and Research, Kolkata, India

In recent years, it has been established that the biological cells are able to mechanically probe and feel their environment, the presence of external forces and can actively respond to them in various ways by adjusting their contractile forces, migratory activities and orientations. Understanding the active response of cells to mechanical forces is important for many cellular processes such as wound healing, muscle growth, tissue assembly and development. To get an insight into cellular mechanosensing, one needs to know how cells sense the mechanical forces and generate a contractile force pattern by regulating actin stress fibers and focal adhesions (FA) that connect cell to the extra cellular matrix (ECM). Focal adhesions are multimolecular protein assembly that act as mechanosensor and transmit forces to the extracellular matrix. Active cells continuously remodel the cell-ECM contacts, these ligandreceptor bonds to probe the mechanical properties of the surrounding matrix. We construct a theoretical model to describe FA as a cluster of ligand-receptor bonds. We study the dynamics of the adhesion cluster by coupling the elasticity of the cell-matrix system with the statistical behavior of bond breaking and rebinding process. We predict the stability and growth of the adhesion cluster to a sinusoidally varying applied stretch and its dependency on the stretching frequency and magnitude and also compare with recent experimental observation.

13. **03:30 - 04:00 PM, 02/12/2014**

Stochastic pump of interacting colloids

Debasish Chaudhuri
Indian Institute of Technology, Hyderabad, India

We consider dynamics of repulsively interacting Brownian particles under the influence of unbiased pumping forces that vanish under spatial or temporal averaging, but breaks time-reversal symmetry leading to a net directed current. We present several interesting features observed in such transport in one and two dimensions. Within a discretized one dimensional model of exclusion process analytic results are obtained, showing current reversal with increasing density. Surprisingly, the directed current in the corresponding continuum model does not show this current reversal. In two-dimensional colloids driven by flashing ratchets, molecular dynamics simulations reveal non-monotonic variation of current with density and switching frequency. The results are captured well by analytic expressions derived using scaling arguments. The system shows re-entrant dynamical transitions between solid and modulated liquid phases as a function of ratcheting frequency.

14. **04:00 - 04:30 PM, 02/12/2014**

Asymmetric exclusion process with stochastic gating

Mithun Mitra
Indian Institute of Technology - Bombay, Mumbai, India

I will discuss an open-chain totally asymmetric exclusion process (TASEP) with stochastic gates present at the two boundaries. The gating dynamics has been modelled with the physical system of ion-channel gating in mind. These gates can randomly switch between an open state and a closed state. In the open state, the gates are highly permeable such that any particle arriving at the gate immediately passes through. In the closed state, a particle becomes trapped at the gate and cannot pass through until the gate switches open again. We calculate the phase-diagram of the system and find important and non-trivial differences in the phase-diagram of a regular open-chain TASEP.

15. **04:30 - 05:00 PM, 02/12/2014**

Modulating the landscape of self-assembly of alzheimers amyloid β-peptide

Kanchan Garai
Tata Institute of Fundamental Research Centre for Interdisciplinary Sciences, Hyderabad, India

Self-assembly of amyloid-β (Aβ) peptide to one dimensional fibers, which are 6-10 nm wide and several microns long, in the brain is the major event in Alzheimers disease (AD). Recent experiments suggest that apolipoprotein E (apoE), an abundantly produced endogeneous protein, can modulate both the thermodynamics and kinetics of Aβ aggregation. We have established fluorescence methods to monitor both ordered and amorphous aggregation of Aβ and examined how apoE alters aggregation kinetics of Aβ. The kinetics of aggregation of Aβ shows an early oligomerization phase, followed by a long lag phase which is then followed by an exponential growth phase. Our results suggest that fragmentation is an important determinant of rate of the growth of the Aβ aggregates. Kinetically apoE even at substoichiometric concentrations is found to delay the aggregation of Aβ dramatically. Our data are consistent with apoE binding to the oligomers and the fibrils of Aβ leading to their stabilization with respect to fragmentation. We conclude that protein aggregation can follow multiple pathways which may be affected differently by different modulating agents.

03/12/2014-Wednesday-Day-3

16. **09:30 - 10:15 AM, 03/12/2014**

Stochastic thermodynamics of molecular motors

Udo Seifert
Universität Stuttgart, Germany

Stochastic thermodynamics provides a framework to describe, inter alia, molecular motors on the individual trajectory level [1]. Thermodynamic notions like work, entropy production and efficiency can be calculated for specific models and extracted from experimental data. After recalling the fundamental principles, I will describe our recent work mainly dealing with the F1-ATP-ase. Emphasizing the crucial role of the attached probe particle, I will first present a simple model that allows us to explain experimental data on efficiency [2]. Second, broadening the perspective, I will discuss the applicability and the necessary modifications of the fluctuation theorem for such systems where slow hidden degrees of freedom (like the directly not observable motor) play an important role [3,4]. Finally, I will present a thermodynamically consistent coarse-graining scheme for such models [5].

References

[1]U.S. Rep. Prog. Phys. 75, 126001, 2012.
[2] E. Zimmermann and U.S. New J. Phys. 14, 103023, 2012.
[3] J. Mehl, B. Lander, C. Bechinger, V. Blickle, and U.S., Phys. Rev. Lett. 108, 220601, 2012
[4] P. Pietzonka, E. Zimmermann, and U.S. EPL 107, 20002, 2014.
[5] E. Zimmermann and U.S., under review.

17. **10:15 - 11:00 AM, 03/12/2014**

Imbibition front roughening and in porous media with elongated pores

Heiko Rieger
University of Saarland, Germany

During spontaneous imbibition, a wetting liquid is drawn into a porous medium by capillary forces. Recently, anomalous scaling properties of front broadening during spontaneous imbibition of water in Vycor glass, a nanoporous medium, were reported [1]: the mean height and the width of the propagating front increase with time t both proportional to $t^{1/2}$. We argue that this anomalously large roughening exponent of $\beta = 1/2$ is due to long-lasting meniscus arrests, when at pore junctions the meniscus propagation in one or more branches comes to a halt when the Laplace pressure of the meniscus exceeds the hydrostatic pressure within the junction. From this hypothesis we derive the scaling relations for the emerging arrest time distribution in random pore networks and show that the average front width is proportional to the height [2], yielding a roughness exponent

of exactly $\beta = 1/2$ as measured in the Vycor glass imbibition experiments. Extensive simulations of a random pore network model confirm these predictions. Finally, using a microfluidic setup [3] as well as molecular dynamics simulations on the nanoscale, the basic hypothesis of the scaling theory is confirmed by demonstrating the existence of arrest events in Y- shaped junctions, analyzing them quantitatively and comparing them with the theoretical predictions.

Reference

[1] S. Gruener, Z. Sadjadi, H.E. Hermes, A.V. Kityk, K. Knorr, S.U. Egelhaaf, H. Rieger, and P. Huber; Proc. Nat. Acad. Sci. USA **109**, 10245 (2012).
[2] Z. Sadjadi and H. Rieger, Phys. Rev. Lett. **110**, 144502 (2013).
[3] Z. Sadjadi, M. Jung, R. Seemann, and H. Rieger; submitted (2014).

18. **11:30 AM - 12:00 PM, 03/12/2014**

Universal large deviations for the tagged particle in single file motion

Sanjib Sabhapandit
Raman Research Institute, Bangalore, India

Consider a gas of point particles moving in a one-dimensional channel with a hard-core inter-particle interaction that prevents particle crossings — this is called single-file motion. Starting from equilibrium initial conditions the motion of a tagged particle is observed. It is well known that if the individual particle dynamics is diffusive, then the tagged particle motion is sub-diffusive, while for ballistic particle dynamics, the tagged particle motion is diffusive. The large deviation function for the tagged particle displacement has been obtained exactly, which is shown to be universal, independent of the individual dynamics.

19. **12:00 - 12:30 PM, 03/12/2014**

To join or not to join: Collective foraging strategies

Kunal Bhattacharya
Birla Institute of Technology and Science, Pilani, India

We discuss the issue of how interaction between foragers influence the encounter rates with resources. Lone foragers are hypothesized to optimize encounter rates through Levy (scale-free) walks. The scenario is further complicated when the foragers are in groups. We consider a two-dimensional lattice model to study the optimal strategy for a group of foragers (walkers) searching for targets distributed heterogeneously. A forager who has not detected any target has a choice of, either joining other foragers who have detected targets, or continue searching independently. The optimal strategy appears to be a mixture of these choices. Remarkably, we observe that scale-free walks appear for strategies far from optimality. In general, we investigate the behaviour of the model with parameters characterizing the propensity of the foragers to aggregate and the degree of heterogeneity in the distribution of the targets. We also discuss other models of foraging and some real-world observations.

Reference

[1] K. Bhattacharya and T. Vicsek, J. R. Soc. Interface 11, 20140674 (2014).

20. **12:30 - 01:00 PM, 03/12/2014**

Propensity approach to nonequilibrium thermodynamics of a chemical reaction network

Gautam Gangopadhyay
S. N. Bose National Centre for Basic Sciences, Kolkata, India

We have developed an approach to nonequilibrium thermodynamics of an open chemical reaction network in terms of the elementary reaction propensities. The method is akin to the microscopic formulation of the dissipation function in terms of the Kullback-Leibler distance of phase space trajectories in Hamiltonian system. The formalism is applied to a single oligomeric enzyme kinetics at chemiostatic condition that leads the reaction system to a nonequilibrium steady state. The individual reaction contributions towards the total entropy production rate with experimentally measurable reaction velocity gives a useful insight in the relative magnitudes

of various energy terms and the dissipated heat to sustain a steady state of the reaction system operating at far-from-equilibrium.

21. **03:30 - 04:00 PM, 03/12/2014**

The multispecies Toom model

Arvind Ayyer
Indian Institute of Sciences, Bangalore, India

The Toom model was originally introduced to study interfacial growth in a dynamical two-dimensional Ising model at low temperatures. We study a finite multispecies variant of the Toom model which exhibits an exact solution. We will first describe the variant with two spins first, and then move on the general case. We will give explicit formulas for certain correlators and for the spectrum of the transition matrices.

This is joint work with A. Schilling, B. Steinberg and N. Thiery.

22. **04:00 - 04:30 PM, 03/12/2014**

The static length scale characterizing the glass transition at lower temperatures

Smarajit Karmakar
Tata Institute of Fundamental research, Hyderabad, India

The existence of a static length scale that grows in accordance with the dramatic slowing down observed at the glass transition is a subject of intense interest. In this talk I will discuss about different proposals for this length scale and then concentrate on two methods: one based on the point-to-set correlation technique and the other on the scale where the lowest eigenvalue of the Hessian matrix becomes sensitive to disorder. We will show that both approaches lead to the same length scale, but the former is easier to measure at higher temperatures and the latter at lower temperatures. But with standard molecular dynamics techniques the temperature range which is relevant to glass transition, one can reach is very limited and subsequently the growth of the length scale was also limited. Recently we are able to reach lower temperature using a modified monte carlo method known as swap Monte Carlo technique for a ternary systems. Using this method we are able to extract the length scale to very low temperature where this scale grows in accordance with at least 15 orders of magnitude increase in the relaxation time, competing with the best experimental conditions. Finally I will discuss the relationship between the observed length scale and various models of the relaxation time.

References

[1] Growing length and time scales in glass-forming liquids -S Karmakar, C Dasgupta, S Sastry, Proceedings of the National Academy of Sciences 106 (10), 3675-3679 (2009).
[2]. Direct estimate of the static length-scale accompanying the glass transition - S Karmakar, E Lerner, I Procaccia, Physica A: Statistical Mechanics and its Applications 391 (4), 1001-1008 (2012).
[3]. Finite-size scaling for the glass transition: The role of a static length scale - S Karmakar, I Procaccia Physical Review E 86 (6), 061502 (2012).
[4]. Comparison of Static Length Scales Characterizing the Glass Transition - G Biroli, S Karmakar, I Procaccia, Physical review letters 111 (16), 165701 (2013).
[5]. The Static Lengthscale Characterizing the Glass Transition at Lower Temperatures - R Gutirrez, S Karmakar, YG Pollack, I Procaccia - arXiv preprint arXiv:1409.5067 (2014).

23. **04:30 - 05:00 PM, 03/12/2014**

Learning to Balance: Extreme variability in convergence to structural balance in frustrated systems

Sitabhra Sinha
Institute of Mathematical Sciences, Chennai, India

In many complex systems, heterogeneous connections can subject constituent elements to conflicting influences, resulting in frustration. We show that an initially frustrated system can achieve structural balance by a novel link adaptation process with interaction strengths evolving in accordance with the dynamical states of its components.. It is inspired by Hebbs principle, that was originally proposed in the context of neuroscience ("neurons that fire together, wire together"), but may apply more broadly to a large class of systems, e.g., in gene regulation networks where the co-expression of genes has been suggested to result in their co-regulation over evolutionary time-scales. In the presence of fluctuations, the time required to converge to the balanced state exhibits large dispersion characterized by a bimodal distribution - pointing to an intriguing problem in the study of evolving energy landscapes.Our results suggest that environmental fluctuations can prevent a system from attaining a balanced state even in the presence of appropriate adaptive dynamics, which may have important implications for biological and social networks.

References

[1] R. Singh, S. Dasgupta and S. Sinha, EPL, **105** (2014) 10003

04/12/2014-Thursday-Day-4

24. **09:30 - 10:15 AM, 04/12/2014**

Thermodynamics of population dynamics

Jorge Kurchan
Physique et Mecanique des Milieux Heterogenes, Paris, France

It has been known for some time that population dynamics with Darwinian selection satisfies, in some circumstances, a dynamics with detailed balance. I shall argue that the conditions for this to hold are precisely satisfied in complex landscapes. This consideration brings into extremely close contact evolutionary and glassy dynamics.

25. **10:15 - 11:00 AM, 04/12/2014**

Theory of nonequilibrium processes conditioned on large deviations

Hugo Touchette
University of Stellenbosch, South Africa

Rare transitions in systems perturbed by weak noise typically occur by following unique trajectories known as reaction or fluctuation paths. These paths are described mathematically by the Freidlin-Wentzell theory of large deviations and are fundamental for characterizing many noise-activated escape (Kramers-type) processes arising in chemical reactions, biological processes, magnetic systems, and glassy systems.

The concept of fluctuation path is specific to the weak-noise limit: for processes with arbitrary random perturbations or noise, there is generally not a single fluctuation path leading to a rare event, but many different paths giving rise to what is called a 'fluctuation dynamics'.

In this talk I will discuss a general approach for studying fluctuation dynamics as applied to nonequilibrium systems modeled as Markov processes (either jump processes or diffusions). The approach is based on large deviation theory, and proceeds by conditioning a Markov process on a rare event and to derive from this conditioning a new Markov process - called the driven process - that describes this event. Applications in nonequilibrium statistical physics and the simulation of large deviations will be discussed.

This is joint work with Raphael Chetrite (Universite de Nice, France).

26. **11:30 AM - 12:00 PM, 04/12/2014**

On the behaviour of random K-SAT on trees

Sumedha
National Institute of Science Education Research, Bhubaneshwar, India

Phase transitions in random K-SAT problems are connected to their computational complexity. Recently we have studied random K-SAT and many of its variants on a Bethe lattice. We find that the solvability transition threshold for $K = 2$ matches with the exact value for regular random graph. For higher K the values are very close to those predicted using other techniques like cavity method.

27. **12:00 - 12:30 PM, 04/12/2014**

Inference of an effective physical model from STM imaging data.

Koji Hukushima
Department of Basic Science, University of Tokyo, Japan

Natural science has been developed traditionally by the methods of theory and experiment, which are combined with each other by the cyclic reiteration of hypothesis and test. In addition, the method of computer simulation has been established as the third method in the last $30 - 40$ years, associated with the enormous growth of available computer power, and has enabled us to study rather complex theoretical models. However, since large-scale and high dimensional data have been obtained by recently developed techniques of experiment and measurement, a systematic method to extract comprehensive information from the data, which is difficult in general, has been highly required in many cases. The difficulty of information extraction is a feature common to the problem of "big data". Here we discuss a method of analysis of imaging data of atoms absorbed on material surface obtained by scanning tunnel microscopy (STM) as an example of a recent attempt of the high-dimensional data analysis. Many conventional methods have been based on the forward-direction approach, in which some parameters in a phenomenological effective model are estimated by a first-principle calculation and the imaging view obtained by Monte Carlo or molecular-dynamics simulation of the effective model is compared with the experimental observed imaging data. As an alternative backward-direction approach, it is useful to extract an estimate of the parameters in the effective model from the imaging data directly, which is to be compatible with the estimate by the first-principle calculation. This can be obtained from the probability distribution function of the parameters given the observed image using the framework of Bayesian inference. We describe this approach to a problem of surface rearrangement of alkali atoms on Cu(110) surface and extract a statistical-mechanical lattice gas model from the imaging data with noise removal. This can be regarded as an application of data-driven science in condensed matter physics.

28. **12:30 - 01:00 PM, 04/12/2014**

Role of density field in an active nematic

Shradha Mishra
S. N. Bose National Centre for Basic Sciences, Kolkata, India

Active nematics are conceptually the simplest orientationally ordered phase of self-driven particles, but have proved to be a perennial source of surprises. We show here through numerical solution of coarse-grained equations for order parameter and density that the growth of the active nematic phase from the isotropic phase is necessarily accompanied by a clumping of the density. The growth kinetics of the density domains is shown to be faster than the 1/3-law expected for variables governed by a conservation law. Other results presented include the suppression of density fluctuations in the stationary ordered nematic by the imposition of an orienting field. We close by posing some open questions.

29. **03:30 - 04:00 PM, 04/12/2014**

Properties of probability distributions constrained by observables :Implication to maximum entropy modelling

Tomoyuki Obuchi
Tokyo Institute of Technology, Japan

Stochastic inverse problem is to construct a probability distribution based on some given data on certain observables of a target system. The inferred probability distribution is expected to well approximate the target probability distribution precisely describing the target system. Usually due to the curse of dimensionality, the given data is not enough to uniquely determine the probability distribution, thus there are many possible distributions which reproduce the data. We invent a formulation to analyze such many probability distributions constrained by observables. The formulation, based on technicalities of random spin systems, introduces a new probability measure on the possible probability distributions, which enables us to study several quantitative relations such as the one between the number of given data and the distance of typical inferred distributions from the target one. This formulation allows us to treat several different situations in an unified manner, and we focus on the role of the maximum entropy principle by using this flexibility. In this talk, I explain the formulation and the analytical solution in an ideal case. Some implications to more realistic cases will be also presented.

This work is in collaboration with Prof. Monasson and Cocco in Ecole Normale Superieure.

30. **04:00 - 04:30 PM, 04/12/2014**

Statistical physics of social systems

Arnab Chatterjee
Saha Institute of Nuclear Physics, Kolkata, India

Given that many laws of nature are statistical in origin, a well established fact that applies across many areas of modern physics gives statistical physics a status of an extremely useful discipline. The subject, developed in a general framework, makes it applicable to various areas outside the commonly perceived boundaries of physics as in biology, computer science, information technology, geoscience etc. It is not a big surprise that statistical physics description and modeling of social phenomena has been going on for sometime, although modeling social units is much more complex and challenging than doing the same for a collection of particles. Human society shows remarkable features similar to those observed commonly in physical systems. Many measurables show scaling and universality, dynamical socioeconomic systems exhibit self-similarity while going from one phase to the other, as observed commonly in phase transitions and critical phenomena common to physical systems. Statistical mechanical tools can be used to understand the effective regularities at a large scale, that emerge out of interactions of individual units, the social beings. I will present a general outline of the work done as well as a personalized perspective in terms of our work in several areas, including data analysis and modeling.

05/12/2014-Friday-Day-5

31. **09:30 - 10:00 AM, 05/12/2014**

Friction induced organization

Shankar Ghosh
Tata Institute of Fundamental Research, Mumbai, India

Externally driven many-body systems that self-organize are typically dissipative and governed by a set of local rules. Inherent to them are nonlinearity in the interactions and the ability of the individual elements to dynamically alter its response to a changing environment. A common form of self-organization in a driven state is related to threshold phenomena like in avalanches in sand-piles, formation of earthquakes and the depinning transition in systems with random quenched disorder; there the system makes a transition from a self-adjusting static state to a moving one. However, the moving state too exhibits a rich variety of organization, frequently studied in active matter, for example, in collective locomotion patterns in animals. Self-organizing systems also exhibit robustness and resilience against external perturbation, achieved through feedback processes wherein the individual elements suitably adjust their response according to inputs received from the environment and access available internal states. Therefore, identifying the relevant processes involved is of utmost importance in deciphering the underlying mechanism(s) of self-organization of a system, an aspect I wish to elucidate in the talk.

32. **10:00 - 10:30 AM, 05/12/2014**

Rise and fall of mutators inadapted populations

Kavita Jain
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India

Although mutation rates are expected to be as low as possible, mutators that have a 10-100 fold higher mutation rate than the wild type have been observed in many adapting populations. Recently some experiments have reported the lowering of mutation rates in well-adapted populations. Motivated by these observations, we consider the dynamics of an asexual population of wild type and mutators with high initial fitness. Using various analytical techniques, we calculate the dependence of fixation time for wild type and mutator population on various population-genetic parameters, and relate our results to experiments.

33. **10:30 - 11:00 AM, 05/12/2014**

Rheology of inertial suspensions: Effects of confinement

Dhrubaditya Mitra
Nordita, Stockholm, Sweden

Simple Newtonian fluids, e.g., water, with added solid particles can show a kaleidoscope of rheological behavior depending on the imposed rate of shear strain ($\dot{\gamma}$) and the volume fraction occupied by the solids (ϕ). For moderately large values of ϕ shear-thickening is observed, i.e., the effective viscosity of the suspension increases with strain-rate. If the dimensionless particle Reynolds number ($Re \equiv \rho\dot{\gamma}a^2/\mu$, where a is the radius of the spheres, ρ and mu are density and viscosity of the solute) is or the order of unity or more the suspension can no longer be described as a Brownian one. We call them "inertial suspensions". Shear-thickening in inertial suspensions has been observed in many natural and industrial flows, including flows of mud, lava, cement, and corn-starch solutions; for moderate values of strain-rate.

To be specific, we study a plain Couette flow of inertial suspensions using Direct Numerical Simulations. In the first part, we show that shear-thickening in inertial suspensions can be understood as an increase in effective volume fraction due to increases strain-rate. In the second part, we look at the effects of confinement on inertial shear-thickening. In particular, we find that when the thickness of the channel is a small integer (two or three) multiple of the particle diameters the effective viscosity decreases by almost a factor of two ! We demonstrate that this decrease in effective viscosity is because the rigid spheres self-organizes themselves into layers which slide on each other.

References

[1] Shear Thickening in Non-Brownian Suspensions: An Excluded Volume Effect Francesco Picano, Wim-Paul Breugem, Dhrubaditya Mitra, and Luca Brandt Phys. Rev. Lett. **111**, 098302

34. **11:30 AM - 12:00 PM, 05/12/2014**

Microscopic calculation of conformational thermodynamics in bio macromolecular complexes

Jaydeb Chakrabarti
S. N. Bose National Centre for Basic Sciences, Kolkata, India

Bio-macromolecules undergo conformational change while they form complexes. These complexes form the basis of a large number of bio-molecular processes. NMR experiments show that the entropy changes associated with conformational changes play vital role in stabilizing such complexes. The theoretical routes to calculate the thermodynamics of conformational changes are not explored in details. The conventional methods based on thermodynamic integration are computationally too expensive to be implemented for large bio-molecules. We show that the conformational thermodynamics including the free energy and entropy can be extracted

from the equilibrium distribution of the dihedral angles in bio-molecules with modest computational efforts. The conformational entropies calculated from such distributions agree well to those of protein-ligand complexes extracted from the NMR experiments [1]. We further show that the conformational thermodynamics data can (a) quantify the x-ray structural data of protein-protein interface [2] and (b) ascertain the functional roles of different residues in a protein [3].

References

[1] Das A, Chakrabarti J, Ghosh M. Conformational Contribution to Thermodynamics of Binding in Protein-Peptide Complexes through Microscopic Simulation. Biophysical Journal. 2013;104:1274-84.
[2] Das A, Chakrabarti J, Ghosh M. Thermodynamics of interfacial changes in a protein-protein complex. Mol Biosyst. 2014;10:437-45.
[3] Sikdar S, Chakrabarti J, Ghosh M. A microscopic insight from conformational thermodynamics to functional ligand binding in proteins. Mol Biosyst. 2014, 10:3280-3289.

35. **12:00 - 12:30 PM, 05/12/2014**

Translocation pathways in smectic liquid crystals facilitated by molecular flexibility

Biswaroop Mukherjee
S. N. Bose National Centre for Basic Sciences, Kolkata, India

We investigate translocation mechanisms in smectic A liquid crystals (LC's) by a realistic coarse-grained model of a LC compound comprising a sti ff azobenzene core with flexible tails. We observe that the molecules can permeate from one smectic layer to the next via two diff erent mechanisms, with and without significant reorientation, the former being facilitated through transverse interlayer intermediates. This is possible due to the intrinsic flexibility of the molecules. The two processes lead to characteristic signatures in the van-Hove self correlation function which can be also observed experimentally.

Poster-Abstracts
STATPHYS KOLKATA VIII

P-01. The frenetic origin of negative differential response

Urna Basu
Instituut voor Theoretische Fysica,KU Leuven, Belgium

The Green-Kubo formula for linear response coefficients gets modified when deal- ing with nonequilibrium dynamics. In particular negative differential conductivities are allowed to exist away from equilibrium. We give a unifying framework for such negative differential response in terms of the frenetic contribution in the nonequi- librium formula. It corresponds to a negative dependence of the escape rates and reactivities on the driving forces. Partial caging in state space and reduction of dynamical activity with increased driving cause the current to drop. These are time-symmetric kinetic effects that are believed to play a major role in the study of nonequilibria. We discuss various simple examples in context of particle and energy trans- port, which all follow the same pattern in the dependence of the dynamical activity on the nonequilibrium driving, made visible from recently derived nonequilibrium response theory.

P-02. Zeroth law of thermodynamics for nonequilibrium steady states in contact

Sayani Chatterjee
S. N. Bose National Centre for Basic Sciences, Kolkata, India

We ask what happens when two systems having a nonequilibrium steady state are kept in contact and allowed to exchange a quantity, say mass, which is conserved in the combined system. Will the systems eventually evolve to a new stationary state where certain intensive thermodynamic variable, like equilibrium chemical potential, equalizes following zeroth law of thermodynamics and, if so, under what conditions is it possible? We argue that the zeroth law would hold, provided both systems have short-ranged spatial correlations and they *interact weakly* to exchange mass with rates satisfying a balance condition - reminiscent of detailed balance in equilibrium. This proposition is proved for driven systems in general in the limit of small exchange rates (i.e., weak interaction) and is demonstrated in various conserved-mass transport processes having nonzero spatial correlations.

P-03. Nonequilibrium fluctuations in a sheared model-fluid

Pritha Dolai
Indian Institute of Technology, Madras, India

The fluctuation theorem (FT) which places conditions on the entropy production of nonequilibrium systems applies to systems driven arbitrarily far from equilibrium [1-4]. For finite systems undergoing Langevin dynamics, a fluctuation theorem (of the Gallavotti-Cohen type) was derived by Kurchan for average power flux of the system [5]. It was proved that the average power flux W_τ (averaged over duration τ) obeys the fluctuation relation $\lim_{\tau\to\infty} \frac{1}{\tau} \ln \frac{P(+W_\tau)}{P(-W_\tau)} = \beta W_\tau$ in the steady state.
We study fluctuations in the driven steady state of a many particle stochastic system that mimicks a fluid under shear at constant strain rate. The system has a rich phase diagram exhibiting a variety of phases similar to those seen in complex fluids under shear. We validate the FT in these phases. The FT allows us to define an effective temperature. We find its dependence on the imposed strain rate and the noise strength, and its relation to the system's phase behaviour is analysed. We also analyse fluctuations in the local strain rate $\dot{\gamma}_\tau$ (averaged over duration τ) in particular large deviations from mean value (which is the imposed strain rate $\dot{\gamma}$). The large deviation function (LDF) is defined as $F(\dot{\gamma}_\tau) \equiv \lim_{\tau\to\infty} -\frac{1}{\tau} lnP(\dot{\gamma}_\tau)$, where $P(\dot{\gamma}_\tau)$ is the probability distribution of local strain rate $\dot{\gamma}_\tau$. The antisymmetric part of the LDF of local strain rate obeys the fluctuation relation *i.e.* $F(\dot{\gamma}_\tau) - F(-\dot{\gamma}_\tau) \propto \dot{\gamma}_\tau$. The LDF shows a kink near zero strain rate for points at the boundary of two phases.

References

[1] D. J. Evans and D. J. Searles, Phys. Rev. E **50**, 1645 (1994).
[2] D. J. Evans and E. G. D. Cohen, and G. P. Morriss, Phys. Rev. Lett. **71**, 2401 (1993).
[3] G. Gallavotti and E. D. G. Cohen, Phys. Rev. Lett. **74**, 2694 (1995);
[4]G. Gallavotti and E. D. G. Cohen, J. Stat. Phys. **80**, 931 (1995).
[5] J. Kurchan *et al*, J. Phys. A: Math. Gen. **31**(1998) 3719-3729.

P-04. **Work fluctuation theorems under stochastic driving**

Arnab Pal
Raman Research Institute, Bangalore, India

Work Fluctuation Theorems" are one of the most important results in Non-equilibrium Statistical Mechanics in recent times. Their implications are also very important in the context of single molecular experiments spanning from nanotechnology to biology. These theorems quantify thermodynamics alike laws in micro/meso scale and also produce exact results far from equilibrium. Non-equilibrium situation generically arises due to thermodynamic affinities/external protocols like temperature or density gradients, dragging/pulling the system, time modulated oscillations, anisotropic shear flow etc . and they are modeled deterministically in practice. However, these microscopic perturbations are always accompanied by random fluctuations and one needs to put this fact into consideration. I will describe two such paradigm models which have been perturbed stochastically: a Brownian particle diffusing in a moving harmonic trap and an underdamped colloidal particle dragged through an ambient medium. I will present an analytical formulation to compute the relevant thermodynamical observables in these systems. Finally, I will discuss the validation of "Work Fluctuation Theorems" in these model systems and make a connection with the Large Deviation Functions. Our entire analytical results are supported by numerical simulations.

P-05. **Single particle stochastic heat engine**

Shubhashish Rana
Institute of Physics, Bhubaneswar, India

Small scale heat engines have been realized experimentally. They operate in presence of highly fluctuating input and output energy fluxes and are therefore much better characterized by fluctuating efficiencies. Finite time stochastic thermodynamics provides us with a consistent framework for small scale systems operating arbitrary far from equilibrium. Using this framework we report an extensive analysis of single particle heat engines by manipulating a Brownian particle in a time dependent harmonic potential with time-dependent coupling to two heat baths. Different cyclic protocols with and without inertia are considered. Thermodynamic quantities such as work, heat and stochastic efficiency exhibit strong fluctuations in time periodic steady states. The fluctuations of stochastic efficiency dominates over the mean value even in the quasi-static regime. The phase diagrams for system operations are qualitatively different for inertial and over-damped regimes. This is supported by our analytical results carried out in the quasi-static regime. In time periodic steady state there are several realizations where the system does not work as a heat engine. Such transient Second law violating realizations decrease as we increase cycle time. Hence for larger cycle times our system work more reliably as an engine. Some of our results differ qualitatively from earlier claims in the literature. We have also verified fluctuation relations for heat engines in time periodic steady state.

P-06. **Non-equilibrium entropic temperature and its lower and upper bounds for non-Markovian stochastic dynamics**

Somrita Ray
Department of Chemistry, Visva Bharati University, India

We have studied non-equilibrium entropic temperature (NET) extensively for a system coupled to a thermal bath[1]. The bath may be Markovian or non-Markovian in nature. Using the phase space distribution function, *i.e.* the solution of the generalized Fokker Planck equation for such a system, the entropy production (EP), NET and their bounds are calculated. Other thermodynamic properties like internal energy of the system, heat or work *etc.* are also measured to study their relations with NET. The present study reveals that the heat flux is proportional to the difference between the temperature of the thermal bath and the non-equilibrium temperature of the system. It also reveals that heat capacity at non equilibrium state is independent of both NET and time. We have also explored the time variations of the aforementioned and related quantities to differentiate between the equilibration processes for the coupling of the system with the Markovian and the non Markovian thermal baths. It implies that in contrast to the Markovian case, a certain time is required to develop maximum interaction between the system and the non-Markovian thermal bath (NMTB). It also implies that longer relaxation time is needed for a NMTB compared to a Markovian one. Quasi dynamical behavior of the NMTB introduces an oscillation in the variation of properties with time. Finally, we have displayed how the non-equilibrium state is affected by the memory time of the thermal bath.

P-07. Ferroelectric liquid crystalline order in systems of dipolar disk-like ellipsoids

Tushar Kanti Bose
Department of Physics, University of Calcutta, Kolkata, India

The realization of fluid phases with spontaneous overall polarization is considered as a subject of fundamental and technological interest. Recently, we reported that a system of dipolar achiral disklike ellipsoids can spontaneously exhibit a long searched ferroelectric nematic phase and a ferroelectric columnar phase with strong axial polarization. The major role is played by the dipolar interactions. The model system of interest consists of attractive-repulsive Gay-Berne oblate ellipsoids embedded with two parallel point dipoles positioned symmetrically on the equatorial plane of the ellipsoids. Here, we demonstrate the influence of the dipolar interactions upon the existence of different ferroelectric discotic liquid crystal phases. We present the results of extensive N-P-T Monte Carlo investigations of the phase behavior at different separations (between the two symmetrically placed dipoles) and different dipole strengths. Ferroelectric biaxial phases are obtained in addition to the uniaxial ferroelectric fluids where the phase biaxiality results from the dipolar interactions. The dynamical properties of some of the ferroelectric phases are also presented.

P-08. Super-cooled liquids in the presence of quenched disorder

Saurish Chakrabarty
Indian Institute of Science, Bangalore, India

In this poster, we present a study of super-cooled liquids in the presence of quenched disorder using molecular dynamics simulations. The quenched disorder is introduced by pinning a randomly chosen fraction of atoms in a super-cooled liquid at equilibrium. We obtain the phase diagram of two model systems in the temperature – pinning fraction plane. For both these systems, we observe that the temperature window between mode-coupling transition temperature T_C and the Kauzmann temperature T_K widens as we increase the pinning fraction ρ_{pin}. This result does not agree with an earlier prediction (based on mean-field and renormalization group calculations on certain spin systems) which says that these two temperatures approach each other as the ρ_{pin} is increased. We also observe a considerable change in the kinetic fragility of the super-cooled liquid on introduction of the random pinning and believe that this plays a role in giving us the phase diagram we get. Apart from this result, we also introduce a new length-scale which can be probed using the random pinning protocol and discuss its relation to the existing static length-scales in super-cooled liquids.

P-09. Spinodal decomposition in binary fluid mixtures : A model H study in $d = 3$

Prasenjit Das
School of Physical Sciences, Jawaharlal Nehru University, New Delhi, India

Using a *Model H* dynamics, we study the hydrodynamics effects on phase separation in binary fluid mixtures in a three dimensional system. The evolution equations for density and velocity fields are computed by using the Langevin technique. We study the morphological features of domain growth using the equal time correlation function and the structure factor. The characteristic size of domains in velocity field is purely diffusive: $L_v(t) \sim t^{1/2}$, where as the resultant growth law for density field shows crossover from viscosity controlled ($L_\psi(t) \sim t$) regime to fluid inertia controlled ($L_\psi(t) \sim t^{2/3}$) regime, observed for an extended period of time.

P-10. Characterizing critical behavior of disordered XY Model

Swarnajit Chatterjee
Indian Association for the Cultivation of Science, Kolkata, India

The 2D XY model is one of the simplest model exhibiting quasi-long range order ($QLRO$), which appears at low temperatures in a number of physical models of great importance. The critical behavior of pure XY system in 2D lattice is a very well studied phenomena. Real systems are mainly disordered systems as there are always some impurities and defects which are associated with it. Here, we study the critical behaviors of disordered ferromagnetic (exchange interaction J_{ij} ¿0) XY model numerically using Monte Carlo method with Wolff single cluster flipping algorithm. We have studied the site-diluted, bond-diluted and random bond 2D XY systems using both square and triangular lattice and determine the critical temperatures of the corresponding disordered systems using Binder's fourth order cumulant method. Our result shows that the values of critical temperatures (T_c) are decreasing in the disordered cases than the corresponding pure cases and it decreases with the decrease of site and bond occupation probabilities. There exits a threshold value of occupation probability for both site and bond diluted cases at which T_c becomes zero, which is the percolation threshold (p_c). For the random bond XY model, results showed that transition temperatures are decreasing with the increase of bond randomness. For all the above cases, although the T_c value is changing with the amount of disorder the nature of transition remains almost unaltered.

P-11. Ginzburg-Landau theory near the multicritical point of exotic superconductors

Arghya Dutta
Theoretical Physics Department, Institute of Mathematical Sciences, Chennai, India

We study the phase diagram of spatially inhomogeneous Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) superconducting state using the Ginzburg-Landau (GL) free energy, derived from the microscopic Hamiltonian of the system, and notice that it has a very clear Lifshitz tricritical point. We find the specific heat jumps abruptly near the first-order line in the emergent phase diagram which is very similar to the recent experimental observation in layered organic superconductor. Comparison with experimental data allows us to obtain quantitative relations between the parameters of phenomenological free energy. The region of the phase diagram where the specific heat jumps can be probed by doing a dynamical analysis of the free energy.

P-12. Direct probe to dynamical heterogeneity in a driven colloid

Suman Dutta
S. N. Bose National Centre for Basic Sciences, Kolkata, India

We study an equi-molar binary mixture of oppositely charged particles in presence of an external electric field in three dimensions via Brownian Dynamics (BD) simulation. We compute dynamic density correlation functions in the steady states. The dynamic density correlation function show a crossover from diffusive behavior to an exponential tail. When the crossover takes place, the system undergoes a crossover from homogeneous phase to lane of like charges via formation of domains of like charges. We argue that multi-scale diffusive behavior plays a vital role in the heterogeneous behavior of the dynamics in lane formation.

P-13. Wave propagation through Ising magnet: Pattern formation and phase transition

Ajay Halder
Department of Physics, Presidency University, Kolkata, India

The magnetic plane wave propagation through the two dimensional Ising ferromagnet has been studied by Monte Carlo Simulation at finite nonzero temperature. The nonequilibrium pattern of coherent spin motions are observed depending upon the value of temperature and amplitude of the propagating magnetic wave. Two different nonequilibrium phases are identified: propagating and nonpropagating. A continuous phase transition has been observed from one phase to another. The nonequilibrium phase transition has been studied and a comprehensive phase boundary is drawn.

P-14. Zero temperature dynamics of Ising model on complex networks

Abdul Khaleque
Department of Physics, University of Calcutta, Kolkata, India

The zero temperature dynamics of the ferromagnetic Ising model on WS network (Addition type) and Barabasi-Albert network (Preferential attachment models) are studied. For WS network (Addition type) long range connections are added randomly with probability q/N, N is the system size. In this network, which is embedded in a one dimensional space, the first neighbour connections always exist and the average degree is $2+2q$ per node. In Barabasi-Albert network (Preferential attachment models), initially $m_0 = 3$ nodes are fully connected then during each step, a new node is added to $m \le m_0$ existing nodes. The probability p_i of node i being connected to a new node depends on its degree k_i. The higher its degree, the greater the probability that it will receive new connections:

$$p_i = k_i / \sum_j k_j.$$

The probability distribution function $P(k)$ of the degree k of Barabasi-Albert network is described by:

$$P(k) = k^{-\lambda},$$

with $\lambda = 3$. The magnetization, energy and number of spins flipped all attain a saturation value in time for both the network models. We find that the dynamics leads to freezing. The saturation values of all the quantities show nonmonotonic behaviour as a function of the parameter q for WS network (Addition type). The freezing probability as a function of parameter q is studied. We also investigate the dynamical picture when the system freezes, whether it is in a active or absorbing state. These results are explained in the light of the topological properties of the network.

P-15. Pattern formation and morphological phase separation in thin liquid films on coated substrates under the influence of gravity

Avanish Kumar
Jawaharlal Nehru University, New Delhi, India

We present detailed study of morphological phase separation (MPS) in unstable thin liquid films on a 2-D substrate under the influence of gravity. We study the evolution morphology by different statistical tools. Markers of our study are correlation function, structure factor, domain size and defect size probablity distribution and growth laws. We mark the clear differences of MPS in thin films, with and without gravity. Our result shows that gravity makes the system to reach into dynamical scaling in the late stage kinetics where system follows classic Lifshit-Slyozov growth law ($\sim t^{1/3}$). We are able to show that thin films under gravity follows normal phase separation kinetics as seggregation kinetics in unstable binary mixtures. We also present the analogies and differences between MPS in thin films and phase separation kinetics in unstable binary mixtures.

P-16. Dynamics of clustering in freely cooling granular fluid

Subhajit Paul
Theoretical Sciences Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India.

Via event-driven molecular dynamics simulations, we have studied structure and dynamics in a model granular fluid of hard discs. Inelastic collisions among these discs lead to clustering, resembling kinetics in a vapor-liquid phase transition. The growth of these clusters are quantified via an application of finite-size scaling theory. We also present results for the decay of kinetic energy. A scaling argument, connecting the latter with the time dependence of clustering, is tested and its failure, for high value of restitution coefficient in space dimension higher than unity, is pointed out. Further, striking difference in finite-size effects of the kinetics with that of phase transition dynamics is pointed out.

P-17. Possibility of an adiabatic transport of an edge Majorana through an extended gapless region

Atanu Rajak
Condensed Matter Physics Division, Saha Institute Of Nuclear Physics, Kolkata, India

In the context of slow quenching dynamics of a p-wave superconducting chain, it has been shown that a Majorana edge state can not be adiabatically transported from one topological phase to the other separated by a quantum critical line. On the other hand, the inclusion of a phase factor in the hopping term, that breaks the effective time reversal invariance, results in an extended gapless region between two topological phases. We show that for a finite chain with an open boundary condition there exists a non-zero probability that an edge Majorana can be adiabatically transported from one topological phase to the other across this gapless region following a slow quench of the superconducting term; this happens for an optimum transit time, that is proportional to the system size and diverges for a thermodynamically large chain. We attribute this phenomenon to the mixing of the Majorana only with low-lying inverted bulk states. Remarkably, the Majorana state always persists with the same probability even after the quenching is stopped. For a periodic chain, on the other hand, we find a Kibble-Zurek scaling of the defect density with a renormalized rate of quenching.

P-18. Heterogeneous dynamics, glassiness and stretched exponential decay of correlations for Coulomb-interacting particles in confined systems

Biswarup Ash
Department of Physical Sciences, Indian Institute of Science Education and Research, Kolkata, India

We investigate the dynamical responses of Coulomb-interacting particles in confinements using molecular dynamics simulations. System shows a solid-like phase (known as Wigner molecules) at the lowest temperatures, which crosses over to a liquid-like phase with thermal fluctuations. Dynamical signatures, primarily derived from the Van-Hove correlations (VHC) across the melting, develop pivotal understanding of these phases and the intervening crossover, which are otherwise inaccessible from the static correlations. Constituent particles experience frustrated dynamics, the nature of which depends crucially on the symmetry of the confinement. The low temperature amorphous solid-like phase in an irregular confinement, identified by a (long-range) bond-orientational order but a depleted positional order, shows signature of dynamical heterogeneity, and so does the equivalent phase in circular confinement, though the two are quite different in nature. The self part of the VHC shows non-Gaussian behavior at long time, resulting into its stretched-exponential decay in space. The fluctuating orientational correlations show non-exponential decay in time depending on the symmetry of the trap. Mean-square displacement of the particles show that the low-temperature dynamics is governed by successive caging and non-caging motion. Our results for the distinct part of the VHC probe the details of the dynamic heterogeneity, uncovering relevant time scales.

P-19. Ion hydration: Propagating defects in Hydrogen bond network of water and reorientational slowdown at long distances

Upayan Baul
The Institute of Mathematical Sciences, Chennai, India

Effects of presence of ions, at moderate to high concentrations, on dynamical properties of water molecules are investigated through molecular dynamics simulations. Simulations reveal that the presence of magnesium chloride ($MgCl_2$) induces perturbations in the hydrogen bond network of water leading to the formation of bulk-like domains with 'defect sites' on boundaries of such domains: water molecules at such defect sites have less number of hydrogen bonds than those in bulk water. Reorientational autocorrelation functions for dipole vectors of such defect water molecules are computed at different concentrations of ions and compared with system of pure water. Earlier experimental and simulation studies indicate significant differences in reorientational dynamics for water molecules in the first hydration shell of many dissolved ions. Results of this study suggest that defect water molecules, which are beyond the first hydration shells of ions, also experience significant slowing down of reorientation times as a function of concentration in the case of $MgCl_2$. However, addition of cesium chloride(CsCl) to water does not perturb the hydrogen bond network of water significantly even at higher concentrations. This difference in behavior between $MgCl_2$ and CsCl is consistent with the well-known Hofmeister series.

P-20. Investigation of activated escape of nonadiabatically, periodically driven dynamical system via Kapitza-Landau time window

Anindita Shit
Dept. of Chemistry, Indian Institute of Engineering Science and Technology, Shibpur, India

We microscopically analyze the dynamics and barrier crossing phenomena of a classical Brownian particle moving through a damping medium in a confined potential in the presence of random impulses due to the surrounding medium, which is further subjected to a space dependent, high-frequency time-periodic force (with frequency ω). Though the problem may seem to be time-dependent, there exists a multiple scale perturbation theory (¡93¿Kapitza window¡94¿) by means of which the dynamics can be treated in terms of an effective time-independent potential that is derived as an expansion in orders of ω^{-1} to the order ω^{-3}. With the resulting time-independent equation, we come up with the expression for the escape rate for barrier crossing process analytically by exploiting the appropriate Fokker¡96¿Planck equation (FPE) for the stochastic system driven by a rapidly oscillating potential in the Kramers¡92¿ (moderate-to-large friction) limit to investigate the effect of ω on the resulting rate in conjunction with the thermal energy. With large value of ω, we find that the environment with moderate-to-large damping impedes the escape process of the particle while high amplitude of the periodic driving force allows the particle to cross the barrier with a large escape rate. Comparison of our theoretical expression with numerical simulation gives a satisfactory agreement.

References

[1] L. D. Landau and E. M. Lifshitz, Mechanics (Pergamon, Oxford, 1976).
[2] A. Shit, S. Chattopadhyay and J. Ray Chaudhuri, Chaos 22, 013131 (2012).
[3] A. Shit, S. Chattopadhyay and J. Ray Chaudhuri, J. Chem. Phys. 136, 234506 (2012).

P-21.

Driven inelastic Maxwell gases

Prasad V.V.
Raman Research Institute, Bangalore, India

We consider the inelastic Maxwell model, which consists of a collection of particles that are characterized by only their velocities, evolving through binary collisions and external driving. At any instant, a particle is equaly likely to collide with any of the remaining particles. The system evolves in continuous time with mutual collisions and driving taken to be point processes with rates τ_c^{-1} and τ_w^{-1} respectively. The mutual collisions conserve momentum and are inelastic, with a coefficient of restitution r. The velocity change of a particle with velocity v, due to driving, is taken to be $\Delta v = -(1 + r_w)v + \eta$, mimicing the collision with a vibrating wall, where r_w the coefficient of restitution of the particle with the wall and η is Gaussian white noise. The Ornstein-Uhlenbeck driving mechanism given by $\frac{dv}{dt} = \Gamma v + \eta$ is found to be a special case of the driving modeled as a point process. Using both the continuum and discrete versions we show that while the equations for the one-particle and the two-particles velocity distribution functions do not close, the joint evolution equations of the variance and the two-particles velocity correlation functions close. With the exact formula for the variance we find that for $r_w \neq 1$, the system goes to a steady state. On the other hand, for $r_w = -1$, the system does not have a steady state. Similarly, the system goes to a steady state for the Ornstein-Uhlenbeck driving with $\Gamma \neq 0$, whereas for the purely diffusive driving ($\Gamma = 0$), the system does not have a steady state.

P-22.

Transport of intra-cellular organelles by elastically coupled motor proteins

Deepak Bhat
Department of Physics, India Institute of Technology, Madras, India

Motor-driven intracellular transport is a complex phenomenon where, on a single intracellular cargo, multiple motor proteins are simultaneously engaged in pulling activity, sometimes leading to tug-of-war and bidirectional motion. This phenomenon has been the subject of a large number of mathematical and numerical studies. However, in general, the effective interaction between the cargo-bound motors has not been treated satisfactorily. More realistic models of cargo transport, which includes an elastic motor-cargo coupling have been studied in recent years. However, these studies are restricted at most to two motor proteins, hence missing the big picture. Here, we present a generic model in which multiple motors are elastically coupled to a cargo, which itself is subject to thermal noise in the cytoplasm. By employing a technique analogous to Van Kampen's system size expansion, we compute the average velocity of the motor-cargo assembly from "macroscopic" dynamical equations for average positions of the cargo and cargo-bound motors. The fluctuations and correlations in all relevant quantities are calculated using a Fokker-Planck equation under the linear noise approximation, which leads to an explicit analytical expression for the diffusion coefficient of the motor-cargo complex. The procedure also allows us to determine the average force experienced by the individual motor and quantify the load sharing features among all the cargo-bound motors.

P-23.

E. coli chemotaxis: A first passage time analysis

Subrata Dev
S. N. Bose National Centre for Basic Sciences, Kolkata, India

In presence of inhomogeneous nutrient concentration in a medium, E.coli bacteria migrate towards the region of higher nutrient concentration and this motion is called chemotaxis. We are interested in the first passage time of a single bacterium to the nutrient-rich region. We measure average first passage time of the bacterium using Monte Carlo simulations and analytical calculations for fixed initial position and also for the initial positions which are drawn from uniform and steady state distribution. We consider a Gaussian concentration profile of the nutrient, which may describe a physical situation where nutrient is also diffusing in the medium. For slow nutrient diffusion, we find that the average first passage time shows a minimum as a function of the width of the Gaussian profile. When the time-scale of nutrient diffusion is comparable to that of bacterial motion, our results indicate that in this case there is an optimum nutrient diffusivity that minimises the average first passage time.

P-24. **Role of relaxation time scale in noisy signal transduction**

Alok Kumar Maity
Department of Chemistry, University of Calcutta, Kolkata, India

Some specialised biological network motifs that are subject to stochastic fluctuations convey extracellular signals with great accuracy. During signal propagation, fluctuations are integrated in every regulated step. Thus, it is expected that a highly fluctuating output signal are responded with respect to a definite input signal. But in reality, such high level of fluctuations in cellular components is not observed. This phenomenon injects our eagerness to investigate most conspicuous network motifs that how these motifs are performed more reliably. In the present paper we theoretically quantify fluctuations in output (in terms of Fano factor) as well as mutual information for linear and branch chains gene transcription regulatory network motifs. We analyse how fluctuations propagation depend on life time (decay/relaxation rate constant) and population of network components. We also examine how intermediate components behave as noise filter and how branch chain motifs facilitate living organism to endure in awful nuisances.

P-25. **Gene regulation with time-dependent transcription rates**

Shubhendu Nandi
Department of Physics, Indian Institute of Science Education and Research, Kolkata, India

Transcriptional regulation dictates cell response to uctuating environmental conditions. Cellular transcrip- tion is inherently stochastic and can be modeled as a birth-death process corresponding to synthesis and degradation of mRNAs. We obtain an exact analytic solution to the chemical master equation that governs transcription with time-dependent rates. Our analytical results combined with stochastic simulations confirm that the transcriptional machinery behaves as a low-pass filter. We also demonstrate that depending on the system parameters, the mRNA levels in a cell population can show synchronous/asynchronous fluctuations and can deviate from Poisson statistics. In particular, we show that the system undergoes a transition from a super-Poissonian (bursty) to sub-Poissonian (anti-bursty) phase which has a close correspondence to the information transfer in the system.

P-26. **Biological switch: Robustness versus noise-induced transitions**

Mainak Pal
Bose Institute, Kolkata, India

A biological switch has two stable steady states, the so-called OFF and ON states. In the OFF state, the concentration of a specific biomolecule, say, a protein is low whereas the concentration is high in the ON state. A common physical principle underlying the operation of a biological switch is based on bistability accompanied by hysteresis. In a bistable region, two stable steady states are possible separated by a branch of unstable steady states. The region separates two regions of monostability corresponding to the OFF and ON states respectively. Critical parameter values (bifurcation points) separate the region of bistability from the two regions of monostability. At a bifurcation point, a discontinuous switch occurs from one stable steady state (say, the OFF state) to the other (the ON state). The reverse transition occurs at a lower bifurcation point due to the loss of reversibility in the form of hysteresis. An efficiently designed biological switch is operationally robust, i.e., noise-induced transitions do not occur or are minimal. Noise-induced transitions occur when the fluctuations in the biomolecular concentration are sufficiently strong to cross the threshold set by the unstable steady state value. In this paper, we examine two well-known biological switches, the genetic toggle and a micro-RNA-mediated biological switch and show that the latter type of design is operationally more robust. We carry out both the linear noise approximation to the Master Equation and stochastic simulation based on the Gillespie algorithm to establish the result. We further point out the key differences in the dynamics of two types of switch and the operational significance of the features.

P-27. **Study of Linear response in glycolytic oscillator**

Prasun Sarkar
Department of Chemistry, Bose Institute, Kolkata, India

The process of glycolysis, is one of the most fundamental as well as important biochemical phenomena for every living cells, which usually occurs in cytoplasm. The standard time range of the entire process is around 20 minutes. The process of glycolysis can be thought in terms of a non-linear oscillation, An elegant mathematical analog, for such oscillation, was suggested by Sel'kov (1968) where, the variables are the concentrations of the components of glycolysis.

Here, we study the linear response of a glycolytic oscillator in presence of a periodic field, incorporating the noise effect. The noise, considered here, is the standard dichotomous type. The response shows a non-monotonic dependence on the noise-strength and noise-correlation rate. In addition, we observe the Stochastic Resonance in glycolytic oscillation.

P-28. The story of stable spindle formation

Sabyasachi Sutradhar

Department of Solid State Physics, Indian Association for the Cultivation of Science, Kolkata, India

Mitosis is mediated by a bipolar sub-cellular machinery termed as the spindle that uses filamentous protein microtubule (MT) and MT associated proteins to assemble itself and to facilitate accurate chromosome segregation. The spindle poles nucleate dynamic MTs that captures the centromeres (Kinetochores) of the chromosomes through a biased search and capture mechanism. During the search process some microtubules capture the kinetochores(KTs) and are stabilized through the interactions with some of the kinetochore proteins. A similar interaction between the sister kinetochore and the opposite pole leads to chromosome bi-orientation. Degenerate sets of MTs interacting with the kinetochores (kMT), cell cortex (astral), chromosome arms and inter polar MTs act as independent force generators manuevering the chromosomeleading to a bipolar spindle. We construct a mechanistic framework that allows us to probe the role of different forces on stable spindle configuration. Our model can predict cellular phenotypes arising from the perturbation of different molecular motors, MT dynamics and MT-KT interactions as observed during experiments.

P-29. System of interacting particles in a periodically moving potential

Rakesh Chatterjee

Condensed Matter Physics Division, Saha Institute of Nuclear Physics, Kolkata, India

Naturally occurring systems are generically driven out of equilibrium by forces or currents present in the system. Unlike equilibrium systems, there are no general framework available for nonequilibrium systems, so it is often useful to construct and study simple models, where questions about basic principles can be answered explicitly. We have used analytical theory and computation to model real system experiments to capture the physical mechanisms involved. Many experiments can be realized through simple models in nonequilibrium statistical physics, to study the behaviour of various materials like polymers and suspensions in terms of their microscopic constituents. This type of models exhibits interesting nonequilibrium phenomenon regarding time periodic steady state as well as in the context of forming new materials by active self assembly. We propose a minimal but nontrivial model that describes diffusion of hardcore particles where the diffusion dynamics is locally modified at a uniformly moving defect site, mimicking the effect of the periodically moving external potential. We find that the particle current has interesting non-monotonic dependence on the velocity of the moving defect and particle density. The current reverses its direction to show positive and negative peaks with the parameters sets the condition for the optimum transport of particles, which can be achieved in both directions along the ring.

P-30. Self-organized dynamics in local load sharing fiber bundle models

Soumyajyoti Biswas

Department of Theoretical Physics, The Institute of Mathematical Sciences, Chennai, India

We report the dynamics of a local load sharing fiber bundle model in two dimensions, under an external load (which increases with time at a fixed slow rate) applied at a single point. Due to the local load sharing nature, the redistributed load remains localized along the boundary of the broken patch. The system then goes to a self-organized state with a stationary average value of load per fiber along the (increasing) boundary of the broken patch (damaged region) and a scale free distribution of avalanche sizes and other related quantities are observed. In particular, when the load redistribution is only among nearest surviving fiber(s), the numerical estimates of the exponent values are comparable with those of the Manna model. When the load redistribution is uniform along the patch boundary, the model shows a simple mean-field limit of this self-organizing critical behaviour, for which we give analytical estimates of the saturation load per fiber values and avalanche size distribution exponent. These are in good agreement with numerical simulation results. We also discuss the effects of quenched and annealed noises on the dynamics.

References

[1] S. Biswas, B. K. Chakrabarti, Phys. Rev. E **88**, 042112 (2013)

P-31. **Inequality and universality of citation distribution**

Asim Ghosh
Saha Institute of Nuclear Physics, Kolkata, India

Social inequality is traditionally measured by the Gini-index (g). The g-index takes values from 0 to 1 where $g = 0$ represents complete equality and $g = 1$ represents complete inequality. Most of the estimates of the income or wealth data indicate the g value to be widely dispersed across the countries of the world: g values typically range from 0.30 to 0.65 at a particular time (year). We estimated similarly the Gini-index for the citations earned by the yearly publications of various academic institutions and the science journals. The ISI web of science data suggests remarkably strong inequality and universality ($g = 0.70 \pm 0.07$) across all the universities and institutions of the world, while for the journals we find $g = 0.65 \pm 0.15$ for any typical year. We define a new inequality measure, namely the k-index, saying that the cumulative income or citations of $1k$ fraction of people or papers are held by fraction k of the people or publications respectively. We find, while the k-index value for income ranges from 0.60 to 0.75 for income distributions across the world, it has a value around 0.75 ± 0.05 for different universities and institutions across the world and around 0.77 ± 0.10 for the science journals.

P-32. **The fate of cooperation in random networks: The roles of community structure and noise**

Shakti N. Menon
Institute of Mathematical Sciences, Chennai, India

Cooperation is a fundamental organizational mechanism, whose emergence in systems of interacting agents is a nontrivial phenomenon. While previous studies of this process have utilized the paradigm of the spatial Prisoners Dilemma (PD) game on heterogeneous random networks, the role of community structure in the evolution of collective strategies has been not been thoroughly understood. In this talk, I will present results for the PD on a modular network with a stochastic temperature-mediated update rule. In particular, I will discuss an observation for the highly modular regime, in which individual communities settle into distinct collective strategies. I will connect this result with a known observation for the behaviour of a temperature-mediated Ising spin model.

P-33. **Brittle to quasi-brittle transition in fiber bundle model**

Subhadeep Roy
Institute of Mathematical Sciences, Chennai, India

In Fiber Bundle Model with equal load sharing scheme there is critical disorder of threshold strength of individual fibers at which the model shows a brittle to quasi-brittle like transition. Below this transition point the model breaks abruptly in brittle manner while above it we get a quasi-brittle like continuous fracture. The criticality of this point is calculated analytically and argued numerically by the the divergence of relaxation time as well as the scale free behavior of avalanche size distribution and probability of abrupt fracture.

P-34. **Statistical mechanics approach to division of labour using modified spatial fixed-threshold model**

Amrita Singh
School of Computational and Integrative Sciences, Jawaharlal Nehru University, New Delhi, India

In context of Division of labour (DoL) in insects/ants society, we extend the fixed-threshold model (FTM) by explicitly including space and this modification induces a spatial percolation effect in which small differences amongst agents in their response threshold are related to large differences in their probabilities of performing work. We consider about more realistic form of interaction or stimulus rather than sigmoidal form and use the modified form of Bonabeaus functional form of stimulus response which is of the type: $F(s, x) = 1/2(u(s) + erf[(s - x)/y])$ Where s is the stimulus response and u is another function. We present the study of the dynamics of such colonies and self organization systems. We also study the effect of changing environment, cross-breeding of ants from different colonies, antenna sensitivity, insect distribution in the organization.

P-35. Cyclic and coherent states in flocks with topological distance

Biplab Bhattacherjee
Satyendra Nath Bose National Centre for Basic Sciences, Kolkata, India

A simple model of the two dimensional collective motion of a group of mobile agents has been studied. Like birds, these agents travel in open free space where each of them interacts with the first n neighbors determined by the topological distance with a free boundary condition. Using the same prescription for interactions used in the Vicsek model with scalar noise it has been observed that the flock, in absence of the noise, arrives at a number of interesting stationary states. One of the two most prominent states is the single sink state where the entire flock travels along the same direction maintaining perfect cohesion and coherence. The other state is the cyclic state where every individual agent executes a uniform circular motion, and the correlation among the agents guarantees that the entire flock executes a pulsating dynamics i.e., expands and contracts periodically between a minimum and a maximum size of the flock. We have studied another limiting situation when refreshing rate of the interaction zone (IZ) is the fastest. In this case the entire flock gets fragmented into smaller clusters of different sizes. On introduction of scalar noise a crossover is observed when the agents cross over from a ballistic motion to a diffusive motion. Expectedly the crossover time is dependent on the strength of the noise η and diverges as $\eta \to 0$.

P-36. Inference of optimal characteristics of thermodynamic processes with prior information

Preety Aneja
Indian Institute of Science Education and Research, Mohali, India

Bayesian methods have been used in many different areas of research. The choice of an appropriate prior distribution has been a crucial issue in Bayesian analysis. The uncertainty in the system parameters due to incomplete information is captured by deriving a prior probability distribution, or, simply called a prior. Bayesian approach in heat engines was first proposed in [1] and then further applied in quantum and classical models of heat engines [2,3]. We used this Bayesian approach to infer the optimal characteristics for a constrained thermodynamic process in which entropy remains conserved [4]. The inferred characteristics for the reversible model of heat engine with incomplete information show correspondence with the optimal behavior of the system with complete information. The universal feature of efficiency beyond the linear term, $\eta \approx \eta_c/2 + {\eta_c}^2/8$, is also inferred within this approach, where η_c is Carnot efficiency. What will be the form of prior if the constraint equation cannot be solved analytically? To answer this question, we perform the inference using spin-1/2 systems as finite reservoirs [5]. A general form of prior is derived for the entropy conserving process as well as for energy conserving process. The analytical as well as numerical estimates of thermodynamic quantities for this model show good agreement with the corresponding optimal values. The significance of taking into account the prior information can be seen from the results with uniform prior in far from equilibrium regime, where informative prior (based on prior information) gives better results than uniform prior which involves minimal information. However, near-equilibrium, both types of priors are equally good. Another thermodynamic process i.e pure thermal interaction is also analysed within this inference based approach. The results for estimated entropy production are in good agreement with optimal case. It seems striking that upon quantifying ignorance of thermodynamic control parameters in a process, one obtains estimates which are very close to the observed behavior, which is actually the optimal one and seen in the case of complete information.

P-37. Relaxation and possible dynamical transition in electron glass

Preeti Bhandari
Jamia Millia Islamia University, New Delhi, India

We consider here the relaxation properties of electron glass, which is a system in which all the electron states are localised and the dynamics occurs through phonon-assisted hopping amongst these states. We model the system by a lattice of localised states which have random energies and interact through the Coulomb interaction. The presence of disorder and the long-range interaction makes the system glassy which results into slow tendency to equilibrium, aging (system dynamics depending on the history) and memory effects. Further a much-discussed question is whether there is an equilibrium transition to glassy phase or not as the temperature is lowered. The wide range of timescales involved in such systems makes it more difficult to solve it numerically. We have modelled the kinetics of site-occupation numbers as Ising spins by Kawasaki Dynamics (spin-exchange) as in our system only half the sites are occupied and the number of particles are conserved. The master equation governing the dynamics is approximated by making mean field approximation. We have calculated the eigenvalues and localization characteristics of the linear dynamical matrix. The behaviour of the eigenvalues at different temperature is used

to detect the presence of a possible dynamical transition. We have also calculated eigenvalues of inverse susceptibility matrix and its behaviour with temperature is used as additional input to analyse the slow dynamics and ageing.

P-38. **Glassy dynamics and rheology of dense network forming colloids**

Chandana Mondal
Indian Association for the Cultivation of Science, Kolkata, India

Using molecular dynamics simulations we study, in two dimensions, the glassy dynamics and rheology of a model patchy colloid system. Each colloid particle consist of three small, strongly attractive, Lennard-Jones type patches and three almost repulsive patches on the equator of a large particle at the centre. The particles interract with Hamacker potential of colloids as implemented in LAMMPS. The total interaction potential between two such colloids is highly directional, because of the patches, and consists of three-fold symmetry. Working in the NVT ensemble, we determine the tentative phase diagram in the density-temperature plane from the free energy curves, obtained following the steps of Morris and Ho. We show that the system when quenched from high to low temperatures along isochores, undergoes a strong glass transition. However, the glass transition is strongly dependent upon cooling rate as expected. We further show that rheological property of the system is identical to that of glass. While the quenched, glassy states undergo ductile deformation under shear, different crystalline ground states of the system show brittle nature. We claim that due to the geometrical fustration arising from the presence of many crystalline ground states and their coexistance, dynamics as well as rheology of the system is indistinguishable from that of glass. We believe our study may throw some light on the origin of liquid-glass transition.

P-39. **Dynamical Localization in coherently driven quantum spin-fermion systems**

Analabha Roy
Saha Institute of Nuclear Physics, Kolkata, India

Dynamical localization is one of the most startling manifestations of quantum interference, where the evolution of a simple system is frozen out under a suitably tuned coherent periodic drive. In this poster, I demonstrate that such freezing occurs even in the presence of extensive disorder in a many-body system. I consider a disordered quantum Ising chain where the transverse magnetization relaxes exponentially with time with a decay time-scale τ due to random longitudinal interactions between the spins. Using Floquet theory and Renormalization Group techniques, I show that this relaxation can be slowed down (τ is enhanced) by orders of magnitude due to employing periodic drives at certain specific values of frequencies and amplitudes (the freezing condition) regardless of the initial state. Under the freezing condition, τ diverges exponentially with the drive frequency ω. The results can be easily extended to a larger family of disordered fermionic and bosonic systems.

P-40. **Cluster-factorized steady states in finite range processes**

Amit Kumar Chatterjee
Saha Institute of Nuclear Physics, Kolkata, India

We study a lattice model where particles hop from a site to one of its neighbours with a rate that depends on occupation of all the neighbouring sites within a range R. This finite range process (FRP) for $R = 0$ reduces to the well known zero-range process giving rise to factorized steady state (FSS) for any arbitrary hop-rate. We show that the steady state of FRP has have $(R + 1)$-cluster wise product form if the hop rates satisfy a specific condition and provide a transfer-matrix formulation to calculate the spatial correlations.

P-41. **Exit probability in inflow dynamics**

Parna Roy
University of Calcutta, Kolkata, India

Of late, there is a debate on whether inflow dynamics is different from outflow dynamics. To settle the debate, exit probability $E(x)$ is one of the important features that has been studied for models with inflow and outflow dynamics. We studied several models in one dimension where the states are represented by Ising spins and the information flows inward. For models involving spins, exit probability is the probability that the system ends up in a state where all the spins are up starting with x fraction of up spins. For all the models with inflow dynamics exit probability is found to have a general form $E(x) = \frac{x^\alpha}{x^\alpha + (1-x)^\alpha}$. The exit probability exponent α depends on different factors incorporated in the dynamics. $E(x)$ shows range dependence in models with inflow of information in contrast to models with outflow of information. Apart from the range dependence, also the asymmetry present in the models and induced fluctuations show their effect on $E(x)$ in inflow dynamics. We have also estimated analytical expressions for $E(x)$ using Kirkwood approximation for models with either nearest neighbor interactions or both nearest and next nearest neighbor interactions and compared the results with those obtained by numerical simulations.

P-42. Branching random walk with step size coming from a power law

Ayan Bhattacharya
Statistics and Mathematics Unit, Indian Statistical Institute, Kolkata, India

In his seminal works, Durrett (1979, 1983) computed the scaling limit of the displacement of the rightmost particle of a supercritical branching random walk with heavy-tailed step size. However, the limiting behavior of the corresponding point process sequence remained an open problem for more than thirty years. In this poster, we shall discuss the solution to this open problem when the underlying branching process satisfies Kesten-Stigum condition. It will be shown that the point process sequence of properly scaled displacements coming from the n^{th} generation converges weakly to a Cox cluster process. As a consequence, we shall recover a slightly improved version of Durrett's result in our setup and establish many more limit theorems using continuous mapping arguments. This poster is based on a joint work with Rajat Subhra Hazra and Parthanil Roy.

P-43. Quantum random walker : Detector really matters

Sanchari Goswami
S. N. Bose National Centre for Basic Sciences, Kolkata, India

If a quantum random walker is free to move and a detector is present at a particular position, then, in general, detector absorbs the walker with probability unity. In this work, the occupation probability of a quantum walker have been studied where the absorption probability of the detector varies as $exp(-\lambda t)$. Here λ is a parameter which controls the absorption probability of the detector. As λ increases the occupation probability of sites quickly approach the infinite walk picture. The ratio of occupation probabilities in presence of detector and that of an infinite walk show interesting features. In that regard, comparison with the classical walker have also been done. For a quenching problem with a quantum random walker, it has been considered that initially the detector was absent and it has been put at a particular position at a random time. After keeping the detector at that position upto some particular time, it has been removed from that position. Occupation probabilities of sites in that case show interesting features.

P-44. Multiple phase transitions in extended hard-core lattice gas models

Trisha Nath
The Institute of Mathematical Sciences, Chennai, India

A system of hard spheres in two dimensions is known to undergo a two-step freezing process from a liquid to solid phase with increasing density. The lattice analogue of the hard-sphere system is the k-NN hard-core lattice gas model where the first k next nearest neighbours of a particle are excluded from being occupied by another particle. Increasing k corresponds to decreasing lattice spacing. However, the lattice model is known to exhibit only one ordering transition with increasing k. Here, based on Monte Carlo simulations and high-density expansions of the free energy and density, we conjecture that if the high-density phase is columnar and the system is not a hard-square system, then the model should show multiple transitions. The conjecture predicts multiple transitions for k=4,10,11,..., and a single first-order transition for k=6, 7, 8, 9. Using Monte Carlo simulations, we confirm the same. For the 4-NN model, the presence of two transitions resolves an existing puzzle as to why the system had a continuous transition when analogy with the Potts model predicted a first-order transition.

P-45. Tagged particle diffusion in one-dimensional Hamiltonian systems

Anjan Roy
Raman Research Institute, Bangalore, India

Observing the dynamics of a single tagged particle in a many particle system constitute a simple way of probing the complex dynamics of an interacting many body system. We present our results on tagged particle diffusion in a one-dimensional gas of classical point particles evolving under Hamiltonian dynamics between fixed and periodic walls. Systems studied include equal and alternate mass hard particle gas, the harmonic chain and anharmonic chains such as Fermi-Pasta-Ulam and Lennard-Jones chains. We have studied both short time regime when the effect of boundary is not felt and the tagged particle behaves as if in an infinite system, as well as long time regime when the boundary effect comes into play.

P-46. Monte Carlo study of random phase Ising model at $T = 0$ and $T > 0$

Soumyajit Pramanick
Lady Brabourne College, Kolkata, India

The 3d random field Ising model (RFIM) at zero temperature possesses a critical point at a critical value of the disorder parameter and this critical point is believed to determine the behaviour of the continuous line of $T > 0$ critical points in the temperature-disorder parameter phase diagram. We shall study this feature of the RFIM by elaborate Monte Carlo study. The ground state of the RFIM will be investigated using the Push-Relabel algorithm for generating the $T = 0$ state and the finite temperature system will be studied using the Wang-Landau algorithm. The random field will have a Gaussian distribution. The lattice size to be used for the $T = 0$ case will have the linear dimension of at least 128 and for the finite temperature study smaller lattices will be used. The critical exponents will be extracted by finite size scaling analysis.

P-47. Monte Carlo study of random phase Ising model at $T = 0$ and $T > 0$

Shauri Chakrabarty
S. N. Bose National Centre for Basic Sciences, Kolkata, India

We study a system of particles sliding under gravity on a fluctuating surface in one dimension. The particles tend to slide towards the local valleys of the surface, thus pushing it downward. In the long time limit, the system shows strong phase-separation (SPS), i.e. the surface rearranges itself to into a single deep valley wherein all the particles are clustered together, and for arbitrarily high but finite temperatures this ordering persists. Unlike other nonequilibrium lattice models where SPS has been reported recently (e.g. Lahiri-Ramaswamy model or ABC model), our system does not get stuck in metastable states and the relaxation time to SPS scales as L^2 for a system of size L. We have been able to find the exact steady state measure for our system in terms of an effective Hamiltonian with long-ranged interaction. The static and dynamic characterization of the steady state reveals rich behavior, which was not seen earlier in systems showing SPS. For example, the macroscopic phase-separated domains move around the system diffusively with two distinct time-scales, for short times L^2 the domain performs diffusion with diffusivity $1/L$ but the energy cost associated with large excursion of the domain restricts its motion within a region of size L. However, for very large times, the domain finally gets untrapped and explores the whole system with a diffusivity $exp(-L)$. Our Monte Carlo simulations, exact calculations, mean-field treatment accompanied by scaling arguments give insights into the rich steady state behavior.

P-48. Additivity Principle in Conserved Mass Transport Processes: Condensation Transition and Emergence of Power Laws

Arghya Das
S.N.Bose National Centre for Basic Sciences, Kolkata, India

We argue from an additivity principle that, in conserved-mass transport processes, a singularity (a simple pole of finite order) in the functional dependence of variance on density leads to a condensation transition. Such phase transitions have been verified in a wide class of conserved mass aggregation models. We also show that, when the variance diverges as a power law in the limit of large density or near criticality, the subsystem mass distributions will be governed by power laws [1].

References

[1] Manuscript under preparation.

P-49. **Network Topology of a Desert Rose**

Sumanta Kundu
S.N.Bose National Centre for Basic Sciences, Kolkata, India

A desert rose is a colloquial name given to a rose like formation of the crystal gypsum or barite. The crystal habit, in the shape of a rosette is usually formed in semi - arid sandy environment due to continuous deposition and evaporation of the crystal. The growth process of a desert rose resembles the hydraulic fracture, which is extremely important globally as it is an economic way to extract natural gas from shales. We investigate the topology of such a real desert rose by considering each disk like structure to be a node and linking those disks that are connected. The computed tomography (CT) scan of the desert rose is taken and analysed to get the degree distribution of the sample. The clustering coefficient is an order of magnitude larger for the desert rose than for the rewired graph, while the efficiency is of the same order of magnitude, indicating a small-world network. A theoretical model of the desert rose is being presented by constructing a three-dimensional growth model consisting of disks with random orientation and radius. Each disk is placed such that the center of the new disk lies on a randomly selected previously placed disk.The results from the dual networks generated from such samples of this model is in correspondence with the real sample for a power law distributed radius within a particular range.

P-50. **Response of an Ising Ferromagnet driven by a Plane Travelling Magnetic Wave**

Monalisa Singh Roy
S.N.Bose National Centre for Basic Sciences, Kolkata, India

The Ising ferromagnet is one of the most extensively studied magnetic systems in statistical physics. Driving such a system with an external magnetic field gives rise to many interesting new phenomena and critical transition behavior. We present here some numerical results of the nearest-neighbour Ising ferromagnet, maintained at a finite temperature, driven by a magnetic field that varies as a sinusoidal plane travelling wave. Depending upon the temperature of the system as well as the amplitude, frequency and the wavelength of the magnetic wave, four distinct stationary states are observed. They are: (i) The *Pinned* state with all spins aligned in the same direction; (ii) the *Frozen* state of spins forming alternate bands of up and down spins, completely invariant with time; (iii) the *Propagating* state where the alternate bands of up and down spins travel like the driving magnetic wave, and (iv) the *Disordered* state in which all spins are randomly aligned. We are trying to produce the phase diagram of such a system in the entire temperature vs. amplitude plane. Further, the associated critical exponents of the dynamical phase transition are also being evaluated.

P-51. **Effect of Preferential Attachment on the Survival of the Smallest**

Suman Aich
S.N.Bose National Centre for Basic Sciences, Kolkata, India

We examine the effects of preferential attachment on a model of competing clusters. In the original model, cluster masses grow at the expense of their neighbours; on a lattice, this is known to result in the asymptotic survival and indefinite growth of clusters which are isolated from each other. The presence of preferential attachment results in an inhomogeneous topology, where hubs monopolise the connections, while most other nodes are sparsely connected. Interestingly, this results in the protection of the less massive clusters from annihilation, to which the hubs are doomed.

P-52. **Fiber Bundle Model with Highly Disordered Breaking Strengths**

Chandreyee Roy
S.N.Bose National Centre for Basic Sciences, Kolkata, India

We studied the fiber bundle model(FBM) with equal load sharing(ELS) dynamics where the breaking threshold of the fibers are drawn randomly from a power law distribution of the form $p(z) \sim z^{-1}$ between the range $10^{-\beta}$ to 10^{β}. Depending on the value of β the critical behavior of the fiber bundle has been studied both numerically and analytically. Few among our observations are (i) The critical load $\sigma_c(\beta, N)$ for the bundle of size N and a given value of β approaches its asymptotic value $\sigma_c(\beta, \infty)$ as $\sigma_c(\beta, N) = \sigma_c(\beta, \infty) + AN^{-1/\nu(\beta)}$, (ii) $\sigma_c(\beta, \infty) = 10^{\beta}/(2e\ln 10^{\beta})$ for $\beta \geq \beta_m$, where $\beta_m = 1/(2\ln 10)$. For $\beta < \beta_m$ weakest element failure leads to the catastrophic breakdown of the fiber bundle, (iii) The fraction of broken fibers just before complete breakdown of the bundle has a form $1 - 1/(2\beta\ln 10)$, (iv) The avalanche size distribution $D(\Delta)$ of the avalanche of size Δ follows a power law $D(\Delta) \sim \Delta^{-\xi}$ with $\xi = 5/2$ for $\Delta >> \Delta_c(\beta)$ and $\xi = 3/2$ for $\Delta << \Delta_c(\beta)$, where $\Delta_c(\beta) = 2/(1 - e10^{-2\beta})^2$.