Negative differential mobility in interacting particle systems

Amit Kumar Chatterjee

SINP , Kolkata

Abstract

Driven particles in presence of crowded environment, obstacles or kinetic constraints often exhibit negative differential mobility (NDM) due to their decreased dynamical activity. We propose a new mechanism for complex many-particle systems where slowing down of certain non-driven degrees of freedom by the external field can give rise to NDM. This phenomenon, resulting from inter-particle interactions, is illustrated in a pedagogical example of two interacting random walkers, one of which is biased by an external field while the same field only slows down the other keeping it unbiased. We also introduce and solve exactly the steady state of several driven diffusive systems, including a two species exclusion model, asymmetric misanthrope and zero-range processes, to show explicitly that this mechanism indeed leads to NDM.

Quantum modeling of the low-dimensional strongly correlated antiferromagnets: determination of spin and charge correlations

Suraka Bhattacharjee

SNBNCBS , Kolkata

Abstract

Looking back to the last three decades, one can find that a considerable amount of researches have been carried out on the strongly correlated antiferromagnetic insulators, which show several interesting properties. However, a rigorous quantum mechanical treatment is required for analyzing the spin correlations and the other normal state properties of the doped phases. In our previous papers, we had predicted the detailed magnetic behavior and pointed out some other plausible quantum phenomena corresponding to the strongly correlated t-J model in one and two dimensions. The result in 1D also predicted a tendency of the spins to develop a coupling at a finite doping concentration, different from the original antiferromagnetic coupling in the parental phase. At present, we have deduced the charge(spin-symmetric) response on the basis of the t-J model using a similar approach like the previous one. The result shows a completely disparate behavior from that of the spin response, supporting a tendency of "spin-charge decoupling" in the very low doping regime. The outcome has been compared with the effective Coulomb interaction between the charge degrees of freedom extracted from experimental and relevant theoretical approaches; where we have derived the Coulomb interaction as the inverse of the dielectric function arising solely due to the electronic screening.

Microscopic insights into dynamical heterogeneity in a driven colloid

Suman Dutta

SNBNCBS , Kolkata

Abstract

The connection between dynamic heterogeneity and the structure formation in nonequilibrium systems is a topic of profound interest in recent times yet an open question. We address this issue, in a model system of constantly driven oppositely charged binary colloidal suspension using Brownian Dynamics simulations. We show that the system undergoes a cross-over from an initial fastrelaxing homogeneous state to a lane state via an intermediate heterogeneous state with anomalous dynamical responses, like the exponential tail in probability distributions of particle displacements and a stretched exponential structural relaxation. We show that the anomaly is due to heterogeneity in diffusion. This manifests in heterogeneous structures that has a spectrum of timescales of relaxation. We also show that the onset of this heterogeneity appears as soon as the field is switched on and persists till in the steady states. However, this is absent once the field is turned off while the lane state reverts back to equilibrium under thermal fluctuations. The framework could be adopted in exploring heterogeneous transport processes in similar systems with structural heterogeneity.

Majorana modes in a non-superconducting wire

Monalisa Singh Roy

SNBNCBS , Kolkata

Abstract

Searching for Majorana Fermions in condensed matter system has emerged as a very compelling field of research, especially as edge modes of topological materials, whose experimental synthesis has become possible only recently. The topological phase of a system is expected to host edge modes, which in 1D can manifest into Majorana Zero Energy Modes (MZMs). We discuss the possibility of the existence of a topological phase, and MZMs, in a 1D wire that obeys attractive Hubbard interactions, upon introduction of spin-orbit coupling and a Zeeman field. We show by calculation of the lowest excited energy gaps and spatial variation of single spin creation operators, that the existence of MZMs is more likely in systems with low electron filling, and can be created upon introduction of a parabolic potential in the system.

A mean field study of liquid crystalline materials

Sabana Shabnam

Lady Brabourne College, Kolkata

Abstract

Study of phase transitions in liquid crystalline materials are of extreme importance because of their various important applications. Most of these involve different experimental and theoretical studies to establish the existence and behaviour of different liquid crystalline phases. As both the anisotropic attractions and steric repulsions have equally important effects in nematic liquid crystal, any realistic theoretical model of nematics must include both repulsive and attractive interactions.

Keeping this in mind, we have modified the Maier-Saupe potential energy to include a volume dependent term and have studied a liquid crystalline material using a mean field approach. The mean field potential chosen by us is

$$U = u_4/v^4 - u_2/v^2 - Au_2/v^2 < P_2 > P_2(cos\theta) \quad (1)$$

where u_4, u_2 and A are constants and v is the mean molecular volume. P_2 is second order Legendre polynomial, θ is the angle between the long axes of any two nearest neighbour molecules. Here the volume dependence has been chosen to mimic the scaling behaviour of the familiar Lennard-Jones potential.

Using this mean field potential we have studied the pressure dependence of liquid crystalline phase transition for an isothermal-isobaric(NPT) system.

Quantum dynamics and quantum phase fluctuations of a pair of bosons and fermions in a double-well potential

Kingshuk Adhikary

IACS , Kolkata

Abstract

We consider a pair of interacting bosons and interacting fermions in a quasi-one dimensional double-well potential. Under two-mode approximation, we define unitary quantum phase difference operators for both bosonic and fermionic matter-waves. The results for the average quantities such as phase and occupation number of the wells for a pair of bosons are qualitatively similar to those of a pair of two-component fermions. However, the fluctuation quantities for the two cases are markedly different. Our results for the matter-wave phase operators will be particularly important for matter-wave interference and squeezing with small number of particles.

Hydrodynamics and universality of Manna fixed energy sandpiles [1]

Arghya Das

ICTS , Bangalore

Abstract

Sandpile models had been originally proposed as paradigmatic models of self-organised criticality. Here we consider the large-scale behaviour of a broad class of conserved stochastic sandpiles (CSS) that undergo an active-absorbing phase transition upon tuning density. We found that, these CSS possess a remarkable hydrodynamic structure. They obey the Einstein relation $\sigma^2(\rho) = \chi(\rho)/D(\rho)$ connecting bulk-diffusion coefficient $D(\rho)$, conductivity $\chi(\rho)$ and scaled variance of subsystem mass, $\sigma^2(\rho)$. Consequently, density large-deviations are governed by an equilibriumlike chemical potential[2] $\mu(\rho) \sim lna(\rho)$, $a(\rho)$ being the activity in the system. Remarkably, the above hydrodynamic structure leads to two scaling relations: As $\Delta = (\rho - \rho_c) \to 0+$ (ρ_c the critical density), (i) mass-fluctuation $\sigma^2(\rho) \sim \Delta^{1-\delta}$ with $\delta = 0$ and (ii) dynamical exponent $z = 2 + (\beta - 1)/\nu_\perp$, expressed in terms of two static exponents β and $\nu_\perp$ for activity $a(\rho) \sim \Delta^\beta$ and correlation length $\xi \sim \Delta^{-\nu_\perp}$, respectively. While these results are more general, we demonstrate it for conserved Manna sandpile, a well studied variant of the CSS. In particular, the scaling relations imply that conserved Manna sandpile belongs to a universality distinct from that of directed percolation (DP), which does not obey relation (ii).

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Evolution of ground state and tunnelling dynamics of a pair of interacing fermions and bosons in an asymmetrical double-well trap

Subhanka Mal

IACS , Kolkata

Abstract

We investigate the quantum dynamics of a pair of fermions or bosons trapped in an asymmetrical double-well. The particles interacting themselves with a finite-range interaction potential which brings on-site interaction as well as inter-site interaction to the system. We have shown that, by varying the asymmetry of the trap the interaction strength can be midified. Our results shows how the ground states of the system evolves with different interaction strength and with the tilt of the trap. Interesting physics of pair-tunnelling as well as single particle tunnelling by changing the tilt as well as changing the range of interaction, is observed. This work is the primary step of realization of ground-state Fermi-Hubbard system with this type of interaction potential.

Evolution of ground state and tunnelling dynamics of a pair of interacing fermions and bosons in an asymmetrical double-well trap

S. Bhuvaneswari

Bharathidasan University , Tiruchirappalli

Abstract

The recent advancement in the experimental realization of the Bose-Einstein condensation (BEC) has opened new research avenue in the ultracold atoms to investigate many interesting quantum phenomena both on fundamental and applied levels. A notable remark in this direction is spinorbit coupled BECs, which addresses various phenomena in the quantum regime such as spin Hall effect, topological insulators, etc. In this work, we study the ground state dispersion of spinorbit (SO) coupled Bose-Einstein condensates (BEC) with Rabi coupling in quasi-two dimensions characterized by unequal Rashba and Dresselhaus couplings. In the parametric space of interest, the system exhibit three different phases namely stripe, plane wave and zero momentum phase. It is observed that the strength of the Rabi coupling determines the phase transition and thereby defining the phases of the system. Interestingly, at a particular parametric condition, the system admits a critical point separating all three different phases, known as the tri-critical point. Further insight on the momentum distribution, the energy and the longitudinal/transverse spin polarization of the different quantum phases are discussed.

Manipulating the mechanical properties of Ti_2C MXene : effect of substitutional doping

Poulami Chakraborty

SNBNCBS , Kolkata

Abstract

Two-dimensional transition metal carbides/nitrides $M_{n+1}X_n$ termed as MXenes have attracted immense interest as potential candidates for Li-ion battery anodes and as a hydrogen storage medium. Our work focuses on the specific case of Ti_2C and its oxygen passivated counterpart Ti_2CO_2 under various tensile strain using density functional theory (DFT). We consider substitutional doping of B and V at Ti and C sites of Ti_2C and Ti_2CO_2. In-plane stiffness, Young's modulus, and critical strain calculations conclude that B doping is highly effective in improving the elastic properties, the reason has been traced to the weakening in the covalency of the Ti-B bond compared to that of the Ti-C bond. This trend holds true even for B-doped and V-doped O terminated systems. However the O passivated compounds are found to have relatively higher critical strain values compared to their pristine counterparts. Thus B doped Ti_2CO_2 , $Ti_2(C_{0.5}, B_{0.5})O_2$, appears to be the best candidate among the studied systems, as compared to pure Ti2C. We also show that the ground state magnetic structure of pristine Ti_2C is A-type antiferromagnetic. Due to strong magnetostructural coupling, the magnetism strongly influences the electronic structure as well as the mechanical properties.

Additivity and mass fluctuation in two dimensional mass transport processes

Dhiraj Tapader

SNBNCBS , Kolkata

Abstract

We exactly calculate two-point spatial correlation function in steady state for a class of 2-dimensional conserved mass chipping model. Using additivity property we calculate subsystem mass distribution in steady state, which is gamma distribution.

Classical physics based agree with quantum physics to explanation phenomena on quantum

Krishna Kumar Choudhury

University of Calcutta

Abstract

The failure of classical physics was highlited by black body radiation and photoelectric effect where explanation Of both phenomena based on quantum physics prevails .This common understanding applies to based acknowledge To regime of whole classical physics on explaining of certain observed at weaking of completely belief the classical physics unfit to explain the quantum world .We procedure agree that can be expressed the quantization of the free radiation field that will be following a strategy that is free from quantum – mechanical concept idea.

Frustrated spin-1/2 ladder with ferro- and antiferromagnetic legs

Debasmita Maiti

SNBNCBS , Kolkata

Abstract

Two-leg spin-1/2 ladder systems consisting of a ferromagnetic leg and an antiferromagnetic leg are considered where the spins on the legs interact through antiferromagnetic rung coupling . These ladders can have two geometrical arrangements either zigzag or normal ladder and these systems are frustrated irrespective of their geometry. This frustration gives rise to incommensurate spin density wave, dimer and spin fluid phases in the ground state. The magnetization in the systems decreases linearly with, and the systems show an incommensurate phase for $0.0 < J_1 < 1.0$. The spin-spin correlation functions in the incommensurate phase follow power law decay which is very similar to Heisenberg antiferromagnetic chain in external magnetic field. In large limit, the normal ladder behaves like a collection of singlet dimers, whereas the zigzag ladder behaves as a one dimensional spin-1/2 antiferromagnetic chain.

Multipolar phase in frustrated spin-1/2 and spin-1 chains

Aslam Parvej

SNBNCBS , Kolkata

Abstract

The $J_1 - J_2$ spin-chain model with nearest-neighbor J_1 and next-nearest-neighbor antiferromagnetic J_2 interaction is one of the most popular frustrated magnetic models. This model system has been extensively studied theoretically [1] and applied to explain the magnetic properties of the real low-dimensional materials. However, the existence of different phases for the $J_1 - J_2$ model in an axial magnetic field h is either not understood or has been controversial. In this paper, we show the existence of higher order $p > 4$ multipolar phase near the critical point $(J_2/J_1)_c = -0.25$. The criterion to detect the quadrupolar or spin nematic (SN)/spin density wave of type two (SDW_2) phase using the inelastic neutron scattering (INS) experiment data is also discussed, and INS data of $LiCuVO_4$ compound is modeled [2]. We discuss the dimerized and degenerate ground state in the quadrupolar phase. The major contribution of binding energy in the spin-1/2 system comes from the longitudinal component of the nearest-neighbor bonds. We also study spin nematic/SDW_2 phase in spin-1 system in large J_2/J_1 limit.

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Enhanced dynamics of active brownian particle in periodic and confined channel

Sudipta Pattanayak

SNBNCBS , Kolkata

Abstract

Biological microorganisms, intracellular particles often encounters crowded environment during their motion. Earlier studies about microswimmers in random environment found that ABPs perform the same subdiffusive motion as ballistic and diffusive particles. Here we study the motion of active Brownian particle (ABP) in soft repulsive periodic environment. Mean square displacement shows a crossover from initial ballistic to superdiffusive to late time diffusive behaviour. Superdiffusive region increases with increasing self-propulsion speed and it saturates for larger speed. Crossover time from ballistic to diffusive motion in periodic environment varies with self-propulsion speed, and it is much larger than for the free space. Hence periodicity enhances the dynamics of the particle. Motivated with this we also study the motion of particle in confined periodic environment, where in one direction potential is periodic and other direction the particle is confined. We find that introduction of soft repulsive periodic boundary in single file diffusion leads a subdiffusion at intermediate time and directed motion at late time for active Brownian particle. Whereas for random Brownian particle subdiffusion persist for late time. We further confirm the directed motion from velocity autocorrelation function and finite mean velocity of the particle. Hence activity leads to directed transport of particles inside the channel with varying cross section.

Phase transition in a frustrated $J_1 - J_2$ system with long-range interaction

Sudip Kumar Saha

SNBNCBS , Kolkata

Abstract

The frustrated spin system with nearest and next nearest neighbor interaction is an extensively studied model in the literature. This model shows various exotic phases like vector chiral phase, multipolar phases, dimer phase [1, 2]. We have studied a frustrated spin system with ferromagnetic nearest neighbor interaction J_1, anti-ferromagnetic next nearest neighbor interaction J_2 and in presence of anti-ferromagnetic long-range interactions that decay with distance as $1/r^\gamma$ for $\gamma > 0$. High γ suppresses the long-range interaction and the system behaves similar to the $J_1 - J_2$ frustrated model. The long-range interaction dominates for small γ. We have studied different exotic phases with both absence and presence of axial field. In absence of field, the system has fully polarized ferromagnetic state for high γ and small α. The system goes to anti-ferromagnetic state with increasing $\alpha(= J_2/|J_1|)$. Long-range interaction does not favor the fully polarized state in the system. In the anti-ferromagnetic state, the correlation decays with power law and at high $\alpha(= \alpha_M)$, the correlation saturates to quasi long-range order with pitch angle $\pi/2$. α_M decreases with increasing γ. We have calculated the phase transition in the parameter space of α vs. $1/\gamma$. We have also shown that the long-range interaction destroys the multipolar phases at non-zero axial field.

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Hydrodynamics, density fluctuations and universality in conserved stochastic sandpiles

Sayani Chatterjee

SNBNCBS , Kolkata

Abstract

We study conserved stochastic sandpiles (CSS), which exhibit an active-absorbing phase transition upon tuning density ρ. We demonstrate that a broad class of CSS possesses a remarkable hydrodynamic structure: There is an Einstein relation $\sigma^2(\rho) = \chi(\rho)/D(\rho)$, which connects bulk-diffusion coefficient $D(\rho)$, conductivity $\chi(\rho)$ and mass-fluctuation, or scaled variance of subsystem mass, $\sigma^2(\rho)$. Consequently, density large-deviations are governed by an equilibriumlike chemical potential $\mu(\rho) \sim \ln a(\rho)$ where $a(\rho)$ is the activity in the system. Using the above hydrodynamics, we derive two scaling relations: As $\Delta = (\rho - \rho_c) \to 0^+$, ρ_c being critical density, (i) mass-fluctuation $\sigma^2(\rho) \sim \Delta^{1-\delta}$ with $\delta = 0$ and (ii) dynamical exponent $z = 2 + (\beta - 1)/\nu_\perp$, expressed in terms of two static exponents β and $\nu_\perp$ for activity $a(\rho) \sim \Delta^\beta$ and correlation length $\xi \sim \Delta^{-\nu_\perp}$, respectively. Our results imply that conserved Manna sandpile, a well studied variant of the CSS, belong to a distinct universality - *not* that of directed percolation (DP), which, without any conservation law as such, does not obey scaling relation (ii).

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Interacting particles in a periodically moving potential: A molecular dynamics study

Shubhashis Rana

SNBNCBS , Kolkata

Abstract

We have studied interacting colloidal particles driven by time periodic force. For simplicity we have taken these colloidal particles are confined in one dimension with periodic boundary condition. An external Gaussian potential barrier is applied on the system. We have considered two different cases. First the barrier is moved continuously. For second case, the barrier makes discrete instantaneous jump, then stays there for a while, after that, again makes another jump and so on. The system reaches unique steady state. For both cases the current decreases as barrier hight decreases or temperature increases. However for continuous barrier movement current remains always positive. While for the later case, an interesting current reversal is observed. We have also analyzed the origin of this current reversal. Although the dynamics are completely different, we have found that the current obeys same scaling for both cases. However, the nature of the dynamics affects the density profile.

Brittle to quasi-brittle transition in fiber bundles with bimodal distribution of breaking thresholds

Chandreyee Roy

SNBNCBS , Kolkata

Abstract

The brittle to quasi-brittle transition in the random fiber bundle model with a bimodal type distribution of the breaking strengths of the fibers following equal load sharing dynamics has been studied. The distribution has a discontinuity which is symmetric around 1/2 and is characterised by three different parameters: (i) the separation s, (ii) the width d and (iii) the fraction of fibers in the first block of the distribution f_1. Extensive numerical calculations exhibit that in some cases the transition exists while in some cases it does not. When s and f_1 are fixed and d is tuned, it is observed that with an increase in s the transition exists only when there are sufficient number of fibers in the first block of distribution.

Current distribution in a conserved-mass transport

Anirban Mukherjee

SNBNCBS , Kolkata

Abstract

We study current large deviation in a conserved-mass transport process, governed by fragmentation, diffusion, and coalescence of neighboring masses. We calculate current distribution, which can be described by gamma distribution.

Colored Percolation

Sumanta Kundu

SNBNCBS , Kolkata

Abstract

A model named 'Colored Percolation' has been introduced with its infinite number of versions in two dimensions. The sites of a regular lattice are randomly occupied with probability p and are then colored by one of the n distinct colors using uniform probability $q = 1/n$. Denoting different colors by the letters of the Roman alphabet, we have studied different versions of the model like $AB, ABC, ABCD, ABCDE, ...$ etc. Here, only those lattice bonds having two different colored atoms at the ends are defined as connected. The percolation thresholds $p_c(n)$ asymptotically converges to its limiting value of p_c as $1/n$. The model has been generalized by introducing a preference towards a subset of colors when m out of n colors are selected with probability q/m each and rest of the colors are selected with probability $(1-q)/(n-m)$. It has been observed that $p_c(q, m)$ depends non-trivially on q and has a minimum at $q_{min} = m/n$. In another generalization the fractions of bonds between similar and dissimilar colored atoms have been treated as independent parameters. Phase diagrams in this parameter space have been drawn exhibiting percolating and non-percolating phases.

Additivity property and number fluctuation in systems of self propelled particles

Subhadip Chakraborti

SNBNCBS , Kolkata

Abstract

Using an additivity property, we study particle-number fluctuations in systems of selfpropelled particles. We consider two model systems: Active Brownian particles and Vicsek models. These model-systems usually consist of interacting polar particles with random self-propulsion velocities. We compute subsystem particle-number distributions in the disordered fluid-like phase using additivity property and compare the number distributions with those obtained from simulations of such systems. We find quite good agreement between theory and simulations.

Optimal methylation noise for best chemotactic performance of E. coli

Subrata Dev

SNBNCBS , Kolkata

Abstract

In response to a concentration gradient of chemo-attractant, E. coli bacterium modulates the rotational bias of flagellar motors that control its run-and tumble motion, to migrate towards regions of high chemo-attractant concentration. Presence of stochastic noise in the biochemical pathway of the cell has important consequence on the switching mechanism of motor bias, which in turn affects the runs and tumbles of the cell in a significant way. We model the intra-cellular reaction network in terms of coupled time-evolution of three stochastic variables, kinase activity, methylation level and CheY-P protein level, and study the effect of methylation noise on the chemotactic performance of the cell. A good performance consists of reaching the favorable region quickly and localizing there in the long time limit. Our simulations show that the best performance is obtained at an optimal noise strength. While it is expected that chemotaxis will be weaker for very large noise, it is counter-intuitive that the performance worsens even when noise level falls below a certain value. We explain this striking result by detailed analysis of CheY-P protein level statistics for different noise strengths. We show that when the CheY-P level falls below a certain (noise-dependent) threshold, the cell tends to move down the concentration gradient of the nutrient, which impairs its chemotactic response. This threshold value decreases as noise is increased, and this effect is responsible for noise-induced enhancement of chemotactic performance. In a harsh chemical environment, when the amount of nutrient depletes with time, the amount of nutrient intercepted by the cell trajectory, is an effective performance criterion. In this case also, depending on the nutrient lifetime, we find an optimum noise strength when the performance is at its best.

Quantum systems on the heisenberg spin sequence and double helix DNA

Subhamoy Singha Roy

ISI , Kolkata

Abstract

We have considered here that the conformational properties of a DNA molecule can be mapped onto a Heisenberg spin system when spins are located on the axis forming an antiferomagnatic chain. This helps us to study the topological and elastic properties of a DNA molecule in terms of $SU(2)$gauge fields. The entanglement entropy of the spin system in a supercoil has been determined and it is pointed out that this effectively corresponds to the thermodynamic entropy. The model reproduces salient features of the Rod-Like-Chain model avoiding the "RLC model crisis".

Dynamical phase transitions in generalized Kuramoto model with distributed Sakaguchi phase

Amitava Banerjee

Presidency University, Kolkata

Abstract

We have numerically studied the dynamical phase transitions in the Kuramoto–Sakaguchi model of oscillator phase synchronization with disorder in the coupling Sakaguchi phases. We have used order parameters measuring coherence and continuity to distinguish the phases and phase transitions. Interestingly, the phase diagrams bear a striking resemblance to those of spin-glass Hamiltonians, even if the system in this case is a dissipative one. For the case of quenched disorder, the nature of transitions is deduced by studies of the ensemble averaged order parameter changes across the transtion and Binder's cumulants. The results show that the nature of phase transitions, as well as the phase diagram depends on the range of interaction of the oscillators. This is also true for annealed disorder, except for the fact that in that case, disorder strength does play no major role. We also study the microscopic dynamics of the system across the transition, paying much attention to the fate of the partially synchronized chimera states under disorder. We use Landau free energy landscape-like constructs to explain our findings conceptually. Finally, we seek analytic justification of our results from simulations of the mean-field Ott–Antonsen ansatz.

Entanglement dynamics following a sudden quench

Supriyo Ghosh

SINP, Kolkata

Abstract

In this work we present an exact and analytical treatment of the entanglement dynamics for an isolated system of N interacting oscillators following a sudden quench of the system parameters. We have setup an exact analytic expression for the time dependent entanglement entropies (for all orders of Rényi entropy) for any arbitrary time dependence in the Hamiltonian parameters. We use the solution of the time dependent Schrödinger equation, which are obtained using the solutions of nonlinear Ermakov equations. It is shown that the entanglement entropies exhibit a multi-oscillatory behaviour with time and the time scales of the oscillations are generated dynamically. The number of independent time scales increases with N, the numerical value dependence on the frequency and the interaction strength. The largest time scale that dominates the long time behaviour of the entropies is determined by the post quench value of the harmonic coupling. For N=2 we have shown that this model could be related to two site Bose-Hubbard model, which could be realized in the cold atom systems.

Internal structure of a chiral quasi-particle wave packet

Subhajit Sarkar

IOP, Bhubaneswar

Abstract

In this poster I shall describe my recent work on the internal structure of a chiral quasi-particle wave packet occurring in the chiral Fermi liquid, i.e., the Fermi liquid in the presence of Rashba spin-orbit coupling (RSOC) in 2-dimensions. A chiral quasi-particle wave packet (c-QPWP) is defined as a conventional superposition of chiral quasi-particle states corresponding to the chiral Fermi liquid. I investigate its internal structure via studying the charge and the current densities within the first order perturbation in the electron-electron interaction. It is found that the QPWP contains a localized charge which is less than the bare charge and remaining charge resides at the system boundary. The amount of charge delocalized turns out to be inversely proportional to the degenerate Fermi velocity $v_0(=\sqrt{\alpha^2+2\mu/m})$ when RSOC (with strength α) is weak, and therefore externally tunable. For strong RSOC, the magnitudes of both the delocalized charge and the current further strongly depend on the direction of propagation of the wave packet. Both the charge and the current densities consist of an anisotropic r^{-2} tail away from the center of the wave packet. I shall explain the possible implications of such delocalizations in real systems corresponding to 2D semiconductor heterostructures are also discussed within the context of particle injection experiments, and also comment on some future directions.

Actin filaments growing against a fluctuating barrier with elastic properties

Raj Kumar Sadhu

SNBNCBS, Kolkata

Abstract

Actins are cytoskeletal proteins whose polymerization can generate significant force and propel the cell forward. We study force generation by a set of parallel actin filaments growing against a non-rigid barrier or membrane whose shape undergoes thermal fluctuations. We consider two different types of barrier: one which is acted upon by an external load that pushes the membrane in a direction opposite to that of polymerization, and another in which the elastic tension prevents formation of local distortion in the membrane shape. We are mainly interested to study the dependence of the velocity of the membrane on the external load or elastic tension, which will enable us to understand the force generation mechanism. We find the shape fluctuations of the barrier or its elasticity strongly affects force-velocity or the elasticity-velocity relationship, particularly the relative time-scale between the filament polymerization and membrane fluctuations is crucial. In both the cases, the above relative time-scale plays an important role in determining the shape of the curve (convex or concave).

Schriefer-Wolf transformation and Gutzwiller approximation for site dependent hole/doublon projection: Application to strongly correlated Ionic Hubbard Model and Binary Alloys

Anwesha Chattopadhyay

SINP, Kolkata

Abstract

We consider strongly correlated limits of variants of the Hubbard model (HM) in which on parts of the system it is energetically favourable to project out doublons while on other sites of the system it is favourable to project out holes while still allowing for doublons. As an effect the low energy Hilbert space itself varies with sites of the system. Though the formalism is well developed for the case of doublon projection in the literature, case of hole projection has not been explored in details so far. We derive a generalised framework by defining new creation and annihilation operators for electrons in a restricted Hilbert space where holes are projected out but which still allows for doublons. To be specific, we provide detailed analysis of strongly correlated limit of the ionic Hubbard model (IHM) which has a staggered potential $\triangle$ on two sublattices of a bipartitie lattice and the correlated binary alloys which have binary disorder $\pm V$ randomly distributed on sites of the lattice. In both the cases, for $\triangle \sim U \gg t$ and for $V \sim U \gg t$, where U is the Hubbard energy cost for having a doublon at a site, there are sites on which doublons are allowed while holes are maximum energy states. We do a systematic generalization of Schriefer-Wolf transformation for both these cases and obtain the effective low energy Hamiltonian. We further derive Gutzwiller approximation factors which provide renormalization of various terms in the effective low energy Hamiltonian due to the Gutzwiller projection operators excluding holes on some sites and doublons on the remaining sites. We also describe briefly the case of fully disordered strongly correlated Hubbard model with disorder being of the same order or larger than the Hubbard term which also has some sites on which doublons are a part of the low energy Hilbert space but holes are projected out.

No long-range order in polar flock in the presence of random quenched rotators

Rakesh Das

SNBNCBS, Kolkata

Abstract

Characterisation of steady-states of polar self-propelled paraticles (SPPs) in inhomogeneous substrate is important not only to understand fundamental laws of frequently encountered natural active systems, but also to design efficient mechanism for swarm of microrobotics to navigate through complex substrates, e.g., inside human body [1]. Here we study a collection of SPPs on a two-dimensional substrate in presence of random quenched rotators. Rotators rotate the direction of SPPs randomly by an angle determined by the orientation of the rotators. Our numerical model is analogous to the celebrated Vicsek model [2], but without rotators. We note that in the presence of rotators, the absolute value of the average normalised velocity decays algebraically with system size, and therefore a quasi long-range order prevails in the system rather than the usual long-range order observed in the clean SPPs [3]. Orientaion fluctuation of SPPs in inhomogeneous system increases logarithmically with system size, which further supports our claim. We write hydrodynamical equations for this system, and a linear calculation predicts an enhanced fluctuation, which we suggest responsible for the destruction of long-range order in the presence of rotators. We propose an experimental system where one can realise our findings.

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Large compact clusters and fast dynamics in coupled nonequilibrium systems

Shauri Chakraborty

SNBNCBS, Kolkata

Abstract

We study a coupled nonequilibrium system where two species of particles, one lighter (L) and the other heavier (H), move stochastically on an energy landscape, which also fluctuates in time. The particles tend to minimize their energy by moving along the local potential gradient and also by modifying the landscape around their position in such a way that the energy is further lowered. The H particles preferentially displace the L particles while sliding downward along the landscape. Upon variation of the coupling between the particles and the landscape, the system shows a rich phase diagram which holds in both one and two dimensions for all particle densities. There are three different ordered phases where the particle species phase separate completely to form pure domains at all temperatures, while the landscape develops macroscopically ordered regions coexisting with a current-carrying disordered sector. The organisation in the landscape results in coarsening and rich domain wall dynamics in the steady state on time scales which grow algebraically with size, not seen earlier in systems with pure domains. We demonstrate this by measuring various steady state dynamical correlation functions in the different parts of the phase diagram.

Dynamics of Particle moving on a Random and Periodic Lorentz Lattice Gas

Sameer Kumar

IIT BHU , Varanasi

Abstract

Dynamics of particle in complex enviournment is ubiqutous. Motion of Vesicles inside our cell, bacteria in fluid medium, ant moving in medium filled with food particles, traffic on road are all exapmles of such systems. Although all these systems are very different in details. But it suggest us that dynamics of particle very much depends on the surrounding medium. In general motion happens in one, two and three dimensions. In this work we describe a lattice model to study the motion of a particle in 1-dimensional lattice with randomly placed, non-overlapping scatterers (the Lorentz Lattice gas). It have been seen that the particle performs three different kind of motion, Ballistic , Anomalous - diffusion and Confinement (trapping), depending upon the properties of the system (i.e. the system parameters). Also there is a transition from one kind of motion to other kind as we change the system parameters. Our model is consists of a one dimensional lattice on which two types of scatterrars are present, both are randomely distributed. The first one is Ref lector and another one is Transmitter. Transmitter let the particle move in the same direction from which it was coming whereas Reflector turns it back to opposite direction. Reflectors (R) and Transmitters (T) also flips i.e. $R \leftrightarrow T$ and $T \leftrightarrow R$ with a probability $\beta = (1-\alpha)$. For $\alpha = 0$ or $\beta = 1$ there is always flipping and for $\alpha = 1$ or $\beta = 0$ there will be no flipping (deterministic). And for $0 < \alpha < 1$ the flipping is probablistic. We also choose the concentration of Ref lectors and Transmitters according to a number r, choosen randomely from a uniform distribution such that if $r = 0$, all are Transmitters and if $r = 1$, all are Reflectors, if $r = 0.5$, scatterrars are in equal ratio.

Phase separation in active system with variable speed

Jay Prakash Singh

IIT BHU , Varanasi

Abstract

Understanding the collective behaviour of self-propelled particles is an active area of research. In most of the natural system we always observe only one type of species are moving together. Although different species differ in their biological complexity, but they have one thing common that they are all active and have tendency to intract their neighbours. We ask the question what happen if we mix two types of species together. In our ongoing work, we modal a binary system of self-propelled particles. Two types of particle differ in their alignment intraction with neighbours. In real schools fish and bacterial colonies it is found that the speed of particle depends on their neighbour's orientation. We define a variable speed parameter where a power law dependency of the speed of each partcle on degree of polarization order of their neighbours. A variable speed parameter is introduced such that for larger parameter speed is sensitive to degree of polarization and for zero parameter modal reduces to famous vicsek's model. We ask the question what happens if we mix two such species together having two different speed parameter. Will they phase separate?. And if they phase seprate then the kinetics of phase sepration slower or faster than that of in equllibrium phase separation. In our preliminary result we found three different types of phases (a)orderd mixed (b)order phase separated (c)disorder mix.

A novel Recurrence-Transience transition and Tracy-Widom growth in a cellular

Rahul Dandekar

IMSc, Chennai

Abstract

We have studied the growing patterns formed by a deterministic cellular automaton, the rotor-router model, in the presence of quenched noise. By the detailed study of two cases, we show that: (a) the boundary of the pattern displays KPZ fluctuations with a Tracy-Widom distribution, (b) as one increases the amount of randomness, the rotor-router path undergoes a transition from a recurrent to a transient walk. This transition is analysed here for the first time, and it is shown that it falls in the 3D Anisotropic Directed Percolation universality class.