DTP Annual report 2013-2014

I. TEXT

A. Condensed matter physics

1. Stochastic strategies for Minority Games

The Minority Game is a model of interacting agents, who try to choose between two options every day, and those who are in the minority are winners. In an earlier paper, efficient stochastic strategies for this game was analyzed when the number of agents is 3, 5, 7. When the number of agents is large, the behaviour is qualitatively different, and as the discount parameter is varied, there is a sudden transition from random choice to win-stay-lose-shift strategy. [V. Sasidevan and D. Dhar]

2. Collapse transition in directed branched polymers

Branched polymer in solution undergo a random-coil to globule transition as the solvent conditions are varied. In general one expects that the critical exponent ν describing the continuous transition takes the same value on the two sides of the transition. Recent numerical studies have shown that this special case seems to be an exception. This happens because in this case, the amplitude of the the leading singularity in one phase may be exactly zero, or very small, and the next term in the expansion, which is usually a correction-to-scaling term, becomes the leading term. [D. Dhar, with D. and M. Knezevic (Univ. of Belgrade)]

3. Deconfined criticality in honeycomb lattice antiferromagnets

A spin-1/2 $SU(2)$ model with nearest-neighbour antiferromagnetic exchange J that favours Néel order, and competing 6-spin interactions Q which favour a valence bond solid (VBS) state in which the bond-energies order at the "columnar" wavevector $\mathbf{K} = (2\pi/3, -2\pi/3)$ was studied on the honeycomb lattice using Quantum Monte-Carlo. The study found a direct continuous quantum phase transition between Néel and VBS states, with exponents and logarithmic violations of scaling consistent with with those at analogous deconfined critical points on the square lattice. Although this strongly suggested a description in terms of deconfined criticality, the measured three-fold anisotropy of the phase of the VBS order parameter showed unusual near-marginal behaviour at the critical point. This has thrown up an interesting question regarding a consistent description of deconfined criticality with three-fold anisotropy in the phase of the valence-bond-solid order parameter at criticality. [K. Damle with S. Pujari and F. Alet (Toulouse)]

4. Controlling extra Dirac points in graphene superlattices

The energy spectrum of massless Dirac particles subjected to a periodic potential can show a number of 'extra' Dirac points. The number of such extra Dirac points is determined by the ratio of the amplitude of the periodic potential and the inverse time of flight of the Dirac electrons through one period of this potential. Graphene superlattice structures were fabricated in TIFR with tuneable amplitude and average position of the external periodic potential. Electrical transport measurements showed oscillations in resistance as a function of the amplitude of the superlattice potential, and their number increased with the amplitude. It was also observed that the average value of the conductance increased with the Fermi energy. A simple calculation of the diffusion constant using the computed energy spectrum showed resistance oscillations as a function of the amplitude of the superlattice but the change with respect to increasing Fermi energy was in a direction opposite to the observations. Further studies revealed that this anomaly arose from disorder in the system: for sufficiently strong disorder, such that the Dirac particles are localised, transport takes place through hopping between localised centres due to inelastic processes. The conductivity in this case is proportional to the density of states at the Fermi energy. This picture nicely explained not only the resistance oscillations but also the trend with increasing chemical potential as well as the temperature dependence. The work highlighted the importance of understanding disorder effects while studying graphene nanostructures. [R. Sensarma and V. Tripathi, with S. Dubey, V. Singh, A. K. Bhat, P. Parikh, R. Sensarma, M. Deshmukh (all TIFR)and K. Sengupta (IACS, Kolkata)]

5. *Ferromagnetic response of a high temperature antiferromagnet*

The finite temperature antiferromagnetic phase of the ionic Hubbard model was studied in the strongly interacting limit using quantum Monte Carlo based dynamical mean field theory. The ionic potential was found to play a dual role in determining the antiferromagnetic order. A small ionic potential (compared to Hubbard repulsion) increased the super-exchange coupling in the projected sector of the model, leading to an increase in the Neel temperature of the system. A large ionic potential led to resonance between projected antiferromagnetically ordered configurations and density ordered configurations with double occupancies, thereby killing antiferromagnetism in the system. This novel way of degrading antiferromagnetism resulted in spin polarization of the low energy single particle density of states. The dynamic response of the system thus showed ferromagnetic behaviour, although the system was still an antiferromagnet in terms of static spin order. [R. Sensarma, with X. G. Wang (Maryland) and S. Das Sarma (Maryland)].

6. *Opinion dynamics model with weighted influence*

Exit probability and dynamics: A stochastic model of binary opinion dynamics had been introduced, in which, the opinions are determined by the size of the neighbouring domains. The exit probability showed a step function behaviour indicating the existence of a separatrix distinguishing two different regions of basin of attraction. This behaviour in one dimension was in contrast to other well known opinion dynamics models where no such behaviour has been observed so far. The coarsening study of the model also yielded novel exponent values. A lower value of persistence exponent was obtained in the present model, which involved stochastic dynamics, when compared to that in a similar type of model with deterministic dynamics. This apparently counter-intuitive result was justified using further analysis. Based on these results it was concluded that the proposed model belongs to a unique dynamical class. [S. Biswas, with S. Sinha and P. Sen (Calcutta University)]

7. *Exit probability in inflow dynamics*

Several models of quench dynamics were studied to settle long debated issues about exit probability in these models, where the states are represented by Ising spins and the information flows inwards. At zero temperature, these systems evolve to either of two absorbing states. The exit probability $E(x)$, the probability that the system ends up with all spins up starting with x fraction of up spins, was found to have the general form $E(x) = x^\alpha/[x^\alpha + (1-x)^\alpha]$. The exit probability exponent α strongly depended on r, the range of interaction, the symmetry of the model, and the induced fluctuation. Even in a nearest neighbour model, the nonlinear form of EP could be obtained by controlling the fluctuations, and, for the same range, different models gave different values for α. Non-universal behaviour of the exit probability was thus clearly established and the results were compared to existing studies in models with outflow dynamics to distinguish the two dynamical scenarios. [S. Biswas, with P. Roy and P. Sen (Calcutta University)]