Manoranjan Kumar

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Dr. Manoranjan Kumar completed his MSc in Physics from School of Physical Sciences JNU New Delhi (2003) and PhD from IISc Bangalore (2009). He joined Princeton University New Jersey USA as Postdoctoral Research Associate in 2009. He joined as Assistant Professor at SNBNCBS in 2012.

Supervision of Research / Students

Ph.D. Students

1. Aslam Parvej, Exotic Phases in Frustrated Low Dimensional Spin Systems (Ongoing).
2. Hrishit Benerjee, Study of Electronic Structure of Organic and Inorganic Complexes, (Ongoing) in Collaboration with Professor Tanusri Saha-Dasgupta.
3. Rakesh Das, Non-equilibrium phenomena in nematic systems, (Ongoing) With Dr. S Mishra (IIT BHU).
4. Sudipta Pattanayak, Collective Behaviour of Polar Self-Propelled Particles (Ongoing), With Dr. S Mishra (IIT BHU).
5. Monalisa Singh Roy, Edge Modes in 1D Chains of Correlated Electrons and Their Junctions (Ongoing).
6. Debasmita Maiti, Frustrated Magnetic Ladders: A DMRG Study (Ongoing).
7. Sudip Kumar Saha, Search of Majorana Modes in low dimensional Topological systems (Ongoing).

Post Doctoral Research Scientists

1. Dayasindhu Dey

Teaching activities at the Centre

1. Spring 2017, Computational Methods in Physics II, PHY 204, No of students 9, Shared with Prof. S S Manna.

Publications in Journals

1. D. Dey and **Manoranjan Kumar** and Zolt'an G Soos; *Boundary-induced spin-density waves in linear Heisenberg antiferromagnetic spin chains with S≥ 1;* Physical Review B; 2016; **94;**144417.
2. Dayasindhu Dey, Debasmita Maiti and **Manoranjan Kumar;** *An Efficient Density Matrix Renormalization Group Algorithm for chains with Periodic Boundary condition;* Papers in Physics; 2016; **8;** 080006.
3. Rabaya Basori, **M. Kumar** and Arup Kumar Raychaudhuri; *Sustained Resistive Switching in a Single Cu:7,7,8,8-tetracyanoquinodimethane Nanowire: A Promising Material for Resistive Random Access Memory;* Scientific Reports; 2016; **6;** 26764.

Independent publications of students

1. S. Pattanayak and S Mishra; Boundary induced convection in a collection of polar self-propelled particles; Physica A: Statistical Mechanics and its Applications; 2017; **477;** 128.

Lectures Delivered

Speaker in Conference & Meeting -

1. International conference on Frustrated Magnets IMSc Chennai India (2017)
2. Ramanujan Conclave Dec 2016

Sponsored Projects

1. Ramanujan Fellowship (DST) 5 years

Conference / Symposia / Workshops / Seminars etc. organized

1. Ramanujan conclave Dec 2016.

Collaborations including publications (Sl. No. of paper/s listed in 'Publications in Journals' jointly published with collaborators)

International

Sl. No. 1

National

Sl. No. 3

Significant research output / development during last one year

General research areas and problems worked on

Frustrated magnets, Topological Insulators, Majorana Fermions, Electronic properties of fermionic wire Junctions, Exotic phases in low Dimension.

Interesting results obtained

1. Quantum phase Diagram of Frustrated J1-J2 model The spin-1/2 chain with isotropic exchange J1, J2 > 0 between first and second neighbors is frustrated for either sign of J1 and has a singlet ground state (GS) for J1/J2 ≥ – 4. The J1-J2 model has rich quantum phase diagram supports gapless, gapped, commensurate (C), incommensurate (IC) and other phases. Critical points J1/J2 are evaluated using exact diagonalization (ED) and density matrix renormalization group (DMRG) calculations. The wave vector qG of spin correlations is related to GS degeneracy and obtained as the peak of the spin structure factor S(q). Variable qG indicates IC phases in two J1/J2 intervals, [– 4, –1.24] and [0.44, 2], and a C-IC point at J1/J2 = 2. The decoupled C phase in [–1.24, 0.44] has constant qG = π/2, nondegenerate GS, and a lowest triplet state with broken spin density on sublattices of odd and even numbered sites. The lowest triplet and singlet excitations, E m and Eσ , are degenerate in finite systems at specific frustration J1/J2. Level crossing extrapolates in the thermodynamic limit to the same critical points as q G. The S(q) peak diverges at q G = π in the gapless phase with J1/J2 > 4.148 and quasi-long-range order (QLRO(π)). S(q) diverges at ± π/2 in the decoupled phase with QLRO(π/2), but is finite in gapped phases with finiterange correlations. Numerical results and field theory agree at small J2/ J1 but disagree for the decoupled phase with weak exchange J1 between sublattices. Two related models are summarized: one has an exact gapless decoupled phase with QLRO(π/2) and no IC phases; the other has a single IC phase without a decoupled phase in between. We have constructed a new phase diagram of J1-J2 model shown in Fig. 1

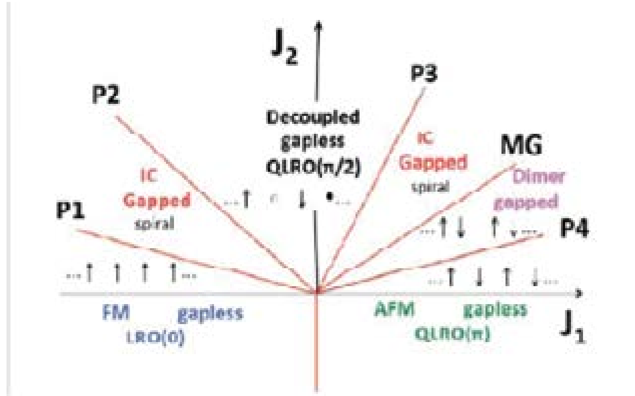

Fig.1 Quantum phase diagram of H(J1,J2), equation (1). The J1/J2 values at the critical points are P1 = −4, P2 = −1.24, P3 = 0.44 and P4 = 4.148. The exact point P1 is between a gapless FM phase and a gapped incommensurate (IC) phase. The gapless decoupled phase is between P2 and P3; open and closed circle denote spins pointing in and out of the plane. The gapped IC phase extends to the MG point, J1 = 2J2, and the dimer phase to P4 = 4.148, beyond which lies a gapless AFM phase.

2. Development of Efficient DMRG technique one dimensional periodic boundary condition system The Density Matrix Renormalization Group (DMRG) is a state-of-the-art numerical technique for a one dimensional quantum many-body system; but calculating accurate results for a system with Periodic Boundary Condition (PBC) from the conventional DMRG has been a challenging job from the inception of DMRG. The recent development of the Matrix Product State (MPS) algorithm gives a new approach to find accurate results for the one dimensional PBC system. The most efficient implementation of the MPS algorithm can scale as O(p × m3), where p can vary from 4 to m2 . In this paper, we propose a new DMRG algorithm, which is very similar to the conventional DMRG and gives comparable accuracy to that of MPS. The computation effort of the new algorithm goes as O(m3) and the conventional DMRG code can be easily modified for the new algorithm .

Proposed research activities for the coming year

1. Currently we are working on XYZ Heisenberg model and attractive Hubbard model to search the Majorana like modes in low dimensional systems.
2. We are also trying to understand the two dimensional frustrated magnetic systems and various magnetic phases.
3. Our group is also interested in the non-equilibrium phenomenon in active systems where we are focusing on the effect of obstacles on the phase kinetics and steady state. We are also trying to apply these studies to some realistic system.