COOPERATIVE PHENOMENA IN CLASSICAL & QUANTUM SYSTEMS(PHY690Q)

Students are expected to complete a course on quantum mechanics (for example, at the level of Phy431) and a course on statistical mechanics (for example, at the level of phy412)

Instructor: Amit Dutta

Module I: Basics of cooperative phenomena in classical systems: Lectures **12**

Cooperative phenomena in classical spin systems: Phase transition in classical spin systems. Critical Phenomena. Mean field theories. Scaling theory and a brief note on renormalisation group. Dynamics of phase transitions: coarsening, nucleation and spinodal decomposition.

Books:
1. Nigel Goldenfeld: "Lectures On Phase Transitions And The Renormalization Group"

2. Chaikin and Lubensky: "Principles of condensed matter physics"

Module II: Cooperative Phenomena, superfluidity and super-conductivity and quantum coherence: Lectures **15**

Bose-Einstein condensation, Basic phenomenology of superfluidity, Bogoliubov theory. superconductivity, A brief note on Superconductivity in connection to quantum coherence, Landau theory of superconductivity and Abelian Higgs model, BCS theory, the macroscopic coherent state, Josepshon junctions and applications, flux qubit, charge qubits and connection to quantum information studies.

Books: 1. James F. Annett, Superconductivity, superfluids and condensates.
2. Tinkham, Superconductivity

Module III: Cooperative phenomena in quantum information and topology:
Lectures **15**

Quantum phase transitions in integrable models, geometrical aspects of quantum states (fidelity and Loschmidt echo ,Berry curvature etc.), topological phases in SSH and Haldane like models; topological invariants.

Books:1.Issac Chuang and Michael Nielsen, Quantum computation and quantum in formation.

2. Dutta et al, Quantum phase transitions in transverse field spin models: from statistical physics to quantum information, Cambridge University Press (2015).

3. Shun-Qing Shen, Topological Insulators: Dirac Equation

Order between modules II and III will be decided after discussion with students.

Total number of lectures: 42 (assuming class timing of 50 minutes)