

## Phy690X: Advanced Quantum Statistical Mechanics

Instructor: Amit Dutta

Course Objectives: The aim of this course is to introduce the student to the physics of classical phase transitions and connection to the experimental situation; for example, how does the universality helps connecting the superconducting phase transitions and the same in the XY model through what is known as the Abelian Higgs mechanism. The students will be also be exposed to the many-body field theoretic techniques which will be illustrated using the example of superfluid Helium. With a brief note on the coherent state, we shall discuss Bose-Condensation and superconductivity. If time permits, there will be a couple of lectures on topological models for example the one dimensional Kitaev chains.

2. Pre-requisite: Phy431, Phy412 Desirable: Phy432

3. Course content: (No of lectures are very tentative):

Topics will evolve as the course progresses. Order of topics may change. However, all the changes will be commensurate with the students interest and to have a better coherence of the topics to be present.

Part A: **Classical Phase Transition:** Mean field theory, Landau theory and its variants, spontaneous symmetry breaking, real space renormalization group and basic notions of renormalization group, XY model and superconductivity: **7** lectures. Textbook: Chaikin & Lubensky, Nigel Goldenfeld

Part B: **Many body quantum systems:** First and second quantization, linear response theory, Transport in mesoscopic systems, Green's functions, Fermi liquid theory and Luttinger liquid, a brief note on path integrals Lectures: **26**. Textbook: 1. Henrik Bruus and Karsten Flensberg 2. Altland and Simon 3. P. Coleman Part 3:

C. **Quantum coherence:** Coherent states, Basic theories of superfluidity and superconductivity in the coherent state approach, Josephson Junction Arrays spin-qubit and flux-qubit **7** Textbook: J.F.Annett: Superconductivity, superfluids, and condensates.

4. Evaluation Components & Policies: End sem, Term paper based evaluation

5. Exams, Quizzes, Assignments, Attendance, Participation et al. :  
Participation in Term paper and end sem compulsory.

Students are instructed to attend all the lectures. There are likely to be many additional discussion hours which students are strongly urged to attend.