Condensed Matter Theory II or Advanced Condensed Matter

Instructor: Dr Sudeep Kumar Ghosh, FB-382, skghosh@iitk.ac.in, 0512-259-2318

Lecture Schedule: Tuesday, Wednesday and Friday (15:00 - 16:00)

Office hour: Mondays (16:00 – 17:00)

Prerequisites: Courses on Basic Quantum Mechanics (e. g. at the level of PHY431), Basic Statistical Mechanics (e. g. at the level of PHY412) and Basic Condensed Matter Physics (e. g. at the level of PHY543).

Course Objective:
This course is an advanced undergraduate/ graduate course on Quantum Condensed Matter Physics. In this course, we will learn some of the conceptual and technical machinery available to understand physical phenomena observed in condensed matter materials.

Contents (38 lectures in total)

1. Overview and scope, Introduction to the Electron Liquid – Born-Oppenheimer Approximation, Second quantization.   *5 lectures*
2. Non-interacting electron gas – Sommerfeld theory of Metals   *2 lectures*
3. Effect of electron-electron interaction – Jellium model, Hartree-Fock theory (exchange and correlation effects); Screening and collective phenomena – Random-Phase Approximation, Plasma Oscillations.
                                                                                  8 lectures
4. Fermi liquid theory – Concept of quasiparticles, thermodynamics   *5 lectures*
5. Hubbard Model – Charge and Spin density waves, Metal-insulator transitions, Magnetism
                                                                                  6 *lectures*
6. Electrons in Magnetic fields – Quantum Hall effect   *2 lectures*
7. Superconductivity – Electron-phonon interaction, Cooper problem, BCS theory, Computation of observables, Unconventional superconductivity   *10 lectures*

Evaluation: Assignments- 40% (Roughly one every 15 days), Midsem exam- 30%, Final exam- 30%

Recommended textbooks:
1. Advanced Solid State Physics by Philip Phillips
2. Quantum Theory of the Electron Liquid by Giuliani and Vignale
3. Modern Condensed Matter Physics by Girvin and Yang
4. Solid State Physics by Ashcroft and Mermin
5. Introduction to Many-Body Physics by Piers Coleman