



Quantum Many-Body Physics (PHY607)

Instructor: Sudeep Kumar Ghosh, FB-386, skghosh@iitk.ac.in, 0512-259-2318.

Prerequisites: Master's-level Statistical Mechanics (e. g. PHY412) and Condensed Matter Physics (e. g. PHY623).

Course Objective:

This is an advanced course in Quantum Condensed Matter Theory, designed to provide the conceptual framework and technical tools necessary to understand and describe many-body phenomena in quantum materials.

Contents (28 lectures in total)

1. **Part I. Overview and Formalism** 2 lectures
Course overview and scope; many-body quantum mechanics; second quantization.
2. **Part II. Quantum Statistical Field Theory and Green's Functions** 12 lectures
Imaginary-time partition functions; bosonic and fermionic coherent-state path integrals; Matsubara Green's functions, Wick's theorem and diagrammatic perturbation theory; self-energies and Dyson equations; Hubbard–Stratonovich transformation; applications to the Anderson impurity and Hubbard models.
3. **Part III. Linear response, the Lindhard function, and RPA** 6 lectures
Kubo formula; density–density response and the polarization bubble; Lindhard function; static and dynamic screening; random-phase approximation (RPA); dielectric response and plasmons.
4. **Part IV. Off-diagonal long-range order, superfluidity, and superconductivity** 8 lectures
ODLRO and spontaneous symmetry breaking; Bogoliubov theory of weakly interacting bosons; Cooper instability, BCS theory, Nambu–Gor'kov Green's functions, electromagnetic response of superconductors.

Credits: 3-0-0-0 (9); **Lecture Timings:** 3:30pm-4:45pm (Mon, Wed)

Evaluation: Assignments- 30%, Midsem exam/Term paper- 30%, Final exam- 30%, Attendance- 10%

Recommended textbooks:

1. “Introduction to Many-Body Physics” by *Piers Coleman*.
2. “Condensed Matter Field Theory” by *A. Altland and B. Simon*.
3. “Feynmann Diagram Techniques in Condensed Matter Physics” by *Radi A. Jishi*.
4. “Many-Body Quantum Theory in Condensed Matter Physics” by *H. Bruus and K. Flensberg*.