Physics 513, Quantum Theory of Solids II
Syllabus Spring 2003

Instructor:
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Time and Location:
11:15 am-12:30 pm, Tuesday and Thursday
106 Osmond.

Office hours:
3-5 pm. Wednesday, walk in or by appointment.

Pre-requisite:
Physics 512

No Text Book:

Reference Books put on reserve in the library:
G. D. Mahan, Many Particle Physics
Fetter and Walecka, Quantum Theory of Many Particle System
J. W. Negele and H. Orland, Quantum Many-Particle Systems, (1988)
Doniach and Sondheimer, Green Functions for Solid State Physics
De Gennes, Superconductivity of Metals and Alloys
Chaikin and Lubensky, Principles of Condensed Matter Physics

Grading information:
There will be one midterm exam, 6 homework sets and a final turn-in paper.
(1) Mid-term Exam, 30 %
(2) Turn-in paper, 40 %
(3) Homework: 5 % × 6 = 30 %.
A letter grade will be given as your final grade

Tentative Schedule:

1. Zero and Finite temperature Field Theory
   • Second Quantization
   • Green’s Function
   • Perturbation theory, Wick Theorem, Feymann Diagrams, Dyson equation
2. Electron conductivity
   • Linear Response, Kubo Formula
   • Electron scattering by impurities
   • Localization theory, scaling theory
3. Interacting electron gas
   • Lindhard dielectric function, density-density correlation functions, Random Phase Approximation, particle-hole excitations, plasmon mode, sum rules.
• Static (\( \omega = 0 \)) screening: Thomas-Fermi screening (\( q \sim 0 \)), Kohn anomalies (\( q = 2k_F \)), Friedel oscillations (\( q = 2k_F \))

• Single electron properties: Quasi-particle residue, effective mass, magnetic susceptibility, mean free path

4. Landau Fermi liquid theory

• Quasi-particles and their interactions
• Landau parameters: \( f(\theta) \) (charge channel), \( \phi(\theta) \) (spin channel).
• Specific heat, effective mass, compressibility, sound velocity, magnetic susceptibility
• * Collective modes: zero sound, spin waves

5. Electron-Phonon interaction

• The electron-phonon interacting Hamiltonian
• Phonon Green function
• Vertex correction, Migdal’s theorem
• Effective electron-electron interaction mediated by phonons

6. Superconductivity

• Cooper-pair instability
• BCS theory
• Josephson Effects
• The Ginzburg-Landau Theory
• Superconductor in magnetic field, Type I and Type II superconductors, flux quantization
• * d-wave superconductors, high temperature superconductors (Cuprates)

7. Magnetism

• Heisenberg Model
• Spin wave theory of quantum ferro-magnets, Holstein-Primakoff’s transformation, Bloch’s \( T^{3/2} \)’s law.
• Spin wave theory of Quantum Anti-ferromagnet, Bogoliubov’s transformation, the effect of external magnetic field, spin-flop transition
• Spin-wave in Ferri-magnet
• * Solitons in one dimensional quantum ferro-magnet, Non-linear Schrodinger equation