Syllabus: PHZ7428 Spring 2019

Modern Condensed Matter Physics (Many Body Theory)

Instructor: Peter Hirschfeld, NPB2156 Dist. Prof. Physics with interests in superconductivity and low temperature physics.

Office Hours: Mon. xth, Wed. xth; Drop in anytime outside of office hours.

Text: Bruus and Flensberg, Many-Body Quantum Theory in Condensed Matter Physics, Oxford U. Press

Other many-body physics texts:

Rickayzen, Green's Functions for Condensed Matter Physics, Academic Press (cheap Dover paperback, my previous favorite textbook to teach many-body theory.)

Coleman, Introduction to Many-Body Physics, Cambridge (modern and up to date, with many physical examples, somewhat massive.)

Mattuck, A guide to Feynman diagrams in the many-body problem. (Completely intuitive and nonrigorous approach to many body theory.)

G. Mahan, Many-Particle Physics (Somewhat more modern text, excellent reference, too heavy to carry.)

Fetter and Wallecka , Quantum theory of many-particle systems (quite formal, overburdened by indices, still very useful reference, some unusual examples from nuclear physics)

Abrikosov, Gorkov, and Dzyaloshinski, Methods of quantum field theory in statistical physics (Dover paperback, very old fashioned, still the bible of the field)

Course Description: Brief introduction to many-body theory: formal treatment of 2nd quantization, Green's functions, and perturbation theory. These tools will be used to enhance a more physical discussion of normal metals, superconductors, quantum magnets, and topological insulators/superconductors.

Prerequisites: PHZ6426 and PHZ7427 preferred. The latter may be waived with permission of instructor.

Required Work:

- Homework: Problem sets will be handed out sporadically, roughly once every 2-3 weeks. I will try to grade them promptly if you try to hand them in promptly.
- Tests: There will be one take-home test on many-body theory, and one covering aspects of metals, magnets, and superconductors.

Consultation with other students & faculty is encouraged in all aspects of required work

Grading Policy: Anyone who shows a genuine interest in learning the material and completes the assignments will get an A.

Schedule of topics:

1. Introduction: Ideal Fermi gas and second quantization
   - Goals
   - Fermi gas
   - 2nd quantization
   - Green's function for Fermi gas
   - Observables from Green's functions
2. Analytic properties
   - Retarded and advanced functions
   - Quasiparticles/Fermi liquid
   - Finite temperatures
3. Perturbation theory
   - Feynman diagrams
   - Dyson equation
   - Hartree-Fock approximation
4. Interacting Fermi systems
   - Fermi Liquid Theory
   - Kubo Formula
   - Correlation functions
   - Coulomb Screening
   - Hubbard model & itinerant magnetism
5. Electron-phonon interaction
6. Superconductivity
   - Phenomenology
   - BCS Theory
   - Ginzburg-Landau Theory
   - Josephson Effect
7. Quantum Magnetism
8. Topological Matter