Physics 556 - Advanced solid state physics

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Topics:

I will not necessarily spend an equal amount of time on these topics - it will depend to some extent on the background and desires of the class.

1. Green's function formalism for phonons and fermions, correlation functions, response theory, imaginary time formalism, fluctuation-dissipation theorem, Kubo formulae, experimental probes.

2. Symmetry breaking and critical phenomena. Introduction to the renormalization group, applications to non-linear sigma models, Kosterlitz-Thouless transition, Wilson-Fisher fixed point and epsilon expansion.

3. Fermi liquid theory from renormalization group perspective. Collective modes: second sound, plasma mode. BCS instability and basics of superconductivity.

4. Topology in condensed matter physics: emergent gauge theories, dualities, Chern-Simons theory, topological phases from a mathematical perspective.

Useful references:

I will not follow a single textbook, but rather draw on the following references:

- *Condensed Matter Field Theory,* Altland and Simons. Good modern treatment of response theory, and other areas of condensed matter - works with path integrals
- *Quantum Theory of Many Particle Systems,* Fetter and Walecka. Standard and exhaustive treatment of Green's functions in many body Bose and Fermi systems (somewhat old, but good)
- *Green's Functions for Solid State Physicists,* Doniach and Sondheimer. Condensed treatment of Green's functions
- *Critical Phenomena,* Cardy. Very good book on the renormalization group, universality, and critical phenomena.
- *Quantum Condensed Matter Physics - Lecture notes,* Nayak. Comprehensive and modern treatment of many of the important areas in hard condensed matter theory. Some ommissions and typos, but it is available free online (I can send you a pdf if you can't find it).

Grading:

45 minute final presentations will determine 100% of the grade; we will pick topics towards the beginning of the term.

Learning Outcomes for Solid State II (PHY556)

Students who have completed this course:

1. Should have a working knowledge of diagrammatics and Green's functions in many body physics
2. Should understand the renormalization group in the context of condensed matter theory
3. Should understand the universal features of Fermi liquids
4. Should know why topological field theories arise as effective descriptions of some condensed matter systems