Physics 556 - Advanced solid state physics

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1 Topics

1.1 Interactions and diagrammatics

Last year I covered this using operator formalism, but this year I will do it using the more modern path integral formalism - c.f. Altland and Simons. I will also cover Fermi liquid theory and the basics of superconductivity, which we did not have time for last year. In the process I will introduce the renormalization group.

1.2 Topology in condensed matter physics

Last year we did not get to this at all - we will cover emergent gauge theories, dualities, Chern-Simons theory, and topological phases from a mathematical perspective.

2 Useful references

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

1. Condensed Matter Field Theory, Altland and Simons. Good modern treatment of response theory, and other areas of condensed matter - works with path integrals

2. 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)

3. Green?s Functions for Solid State Physicists, Doniach and Sondheimer. Condensed treatment of Green?s functions

4. Critical Phenomena, Cardy. Very good book on the renormalization group, universality, and critical phenomena.

5. Quantum Condensed Matter Physics - Lecture notes, Nayak. Comprehensive and modern treatment of many of the important areas in hard condensed matter theory. Some omissions and typos, but it is available free online (I can send you a pdf if you cannot find it).

3 Grading

I will encourage students to do derivations with me in real time. Don't worry, I'm not going to be calling on people to go to the board. The grade, however, will be entirely based on 45 minute final presentations at the end of the class on a topic of your choice - I will distribute a list of topics to choose from.

4 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