PHYSICS 880A20: Autumn 2007

MANY BODY PHYSICS I

Time & Place: Mon. and Wed. 2:30 - 4:18 PM; AV 115

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Course Website:
www.physics.ohio-state.edu/∼randeria/courses/manybodyI/manybodyI.htm

This is Part I of a two-quarter course on non-relativistic many-body theory. Part II will be taught in the Winter 2008 quarter.

Prerequisites: Quantum Mechanics (827, 828 & 829 or equivalent) and Statistical Mechanics (846 & 847 or equivalent). In addition, I will assume that the students have some knowledge of complex variables including contour integration, poles, residues, branch cuts etc.

Goal: In Many Body Physics I & II, students will learn:

- the language and formalism for analyzing and understanding interacting many-particle systems
- examples illustrating the use of these techniques for solving concrete problems
- the relation of Greens functions and correlation functions to experimentally observable quantities

The goal of these two courses is to help students understand how interactions affect the collective properties of many particle systems. In some cases, interactions lead to emergent properties like superconductivity, magnetism, and the fractional quantum Hall effect, which are not observed in non-interacting systems. In other cases interactions, even if they are strong, do not lead to qualitative changes and produce only quantitative renormalizations, as in the case of metals and normal He-3, which are well described by Landaus theory of Fermi liquids.

Syllabus: An optimistic plan for the Autumn Quarter is to introduce:

- Second Quantization
- Linear response theory
- Green's functions
- Diagrams

and to illustrate these techniques with an analysis of

- Dilute Bose gas: Bogoliubov Theory
- Electron gas: Hartree-Fock & RPA

Among the topics I plan to cover in Part II (winter quarter) are: functional integrals; elementary aspects of Fermi liquid theory; BCS theory of superconductivity; and one more topic (either FQHE or Kondo or SF-Mott transition) depending on students' interests and time.

Grading:
(1) Homework problems will be assigned periodically.
(2) Each student will have to write a term paper.
Title/topic: due Oct. 1; Outline: due Oct 29; Term paper: due Nov. 21

Text Book: No one book covers all the material that I plan to teach in the two quarter sequence. For the first quarter, the assigned text book is:
• "Quantum Theory of Many-Particle Systems" by A. L. Fetter and J. D. Walecka, (Dover, 2003). A rather inexpensive paperback edition is available and is well worth owning, even though I will not follow it in detail.
Useful references:
•"Methods of Quantum Field Theory in Statistical Physics", A. A. Abrikosov, L. P. Gorkov and I. E. Dzyaloshinski, (Dover, 1975). AGD is the universally acknowledged classic text in the field, but may be hard for most beginners.
•Piers Coleman's Lectures: A modern introduction to the subject available on the net: http://www.physics.rutgers.edu/∼coleman/mbody.html
•"Green's Functions in Solid State Physics" by S. Doniach and E. Sondheimer, (World Scientific, 1998).
•"Many-Particle Physics" by G. Mahan (Kluwer/Plenum, 2000).
•"Quantum Many-Particle Systems" by J. W. Negele and H. Orland (Westview, 1998). Particularly useful for its chapters on coherent state path integrals.