

PHYSICS 880.20: Winter 2010

MANY BODY PHYSICS I

Time & Place: Mon. and Wed. 2:30 to 4:18 PM in Smith 1186

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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 Spring 2010.

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

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 Landau's theory of Fermi liquids.

Syllabus: In the Winter Quarter, I will introduce the following techniques:

- Review of Second Quantization
- Linear response, sum rules, and Kramers-Kronig
- Canonical Transformations
- Variational Wavefunctions
- Green's functions
- Feynman Diagrams

and illustrate these techniques with an analysis of

- Bosons: Bogoliubov theory and superfluid Helium-4
- Electron gas: Hartree-Fock & RPA

In Part II (Spring Quarter) I plan to cover the Matsubara Technique; Functional integrals; BCS theory of superconductivity; and one more topic: either Fractional Quantum Hall Effect or Quantum Phase Transitions.

Grading:

- (1) Homework problems will be assigned periodically.
- (2) Each student will have to write a term paper.

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) [ISBN-10: 0486428273; ISBN-13: 978-0486428277]. A rather inexpensive paperback edition is available and is well worth owning. It contains most of the material I will cover in the Winter Quarter, 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 hard for most beginners. It is also available in an inexpensive paperback edition, and definitely worth owning if you plan to do any work in many-body physics.
- 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 which we will cover in the Spring Quarter.