SYLLABUS P3707
Intermediate Quantum Mechanics
(Introduction to the quantum mechanics of many-body systems)
September 1, 2009

COURSE AND INSTRUCTOR INFORMATION

TERM	2101
CATALOG NBR.	3707
CLASS NBR:	12744
INSTRUCTOR:	David Jasnow
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LECTURES:	Tuesday, Thursday 9:30 – 10:50am 106 Allen Hall

OFFICE HOURS: Tuesdays, 3:00 pm, and by appointment. If you come to my office any time, I will try to help, or, if I am engaged, we can set up a time to meet.

RATIONALE AND BRIEF COURSE DESCRIPTION

It is difficult to find a current topic in physics that doesn't deal with many interacting degrees of freedom. The universe of such problems is conveniently divided into ones in which quantum descriptions are essential and others in which a classical description will suffice. Despite this seeming division, the ideas and concepts cross over; an example is the idea of a "field" description. Very similar effective field theories describe a superconductor at low temperatures, a quantum system, and a classical system like a quantity of liquid argon coexisting with its vapor. Concepts, for example, of broken symmetry and gauge invariance are portable. Many of the same general concepts and techniques carry over from one subfield to another; a number of examples can be cited and will be mentioned at appropriate points during the course.

This is a one-term "nuts-and-bolts" introduction to the quantum physics of interacting, many-particle systems. The course includes second quantization, many body physics and a brief introduction to relativistic quantum mechanics.

The approach will be intuitive and "hands-on". The course begins with second quantization for fermionic and bosonic systems, with examples involving electrons, phonons and photons, arising from the quantization of the electromagnetic field. Applications will include (i) the interacting electron gas and plasmons (ii) the interaction of the radiation field and matter, (iii) electron – phonon interaction, "dressed electrons" and the polaron problem. There will be some discussion of condensation phenomena and superfluidity (Bogoliubov theory, broken symmetry and Goldstone bosons); superconductivity (BCS and Landau-Ginzburg theories), broken symmetry and the

Meissner effect. There will be qualitative exposure to Green functions and Feynman diagrams. In addition the course will include an introduction to relativistic quantum mechanics and the Dirac equation. Throughout there will be discussion of applications of the techniques and concepts in various subfields of physics.

PREREQUISITES:

To have the right background and sophistication to get the most out of the material to be presented, it is highly recommended that students should have successfully taken two terms of quantum mechanics at the graduate level: P2565-2566 or equivalent (QM1 and QM2). In addition one term of E&M (P2555) is required, and the second course (P2566) would be a good idea. One term and (preferably two) of Statistical Physics at the graduate level (P2565) is also a prerequisite. If in doubt, please see the instructor.

RECOMMENDED TEXTS:

Unfortunately, there is no single suitable text containing the appropriate material at the appropriate level. There are a number of good books that will be held on reserve in the Engineering Library in Benedum Hall. Readings will be suggested as the lectures progress. Some of the reserve items will be:

1. C. Kittel, *Quantum theory of solids*. A standard reference for four decades. We will not be using many specific features of crystalline solids, but this monograph contains many of the ideas and techniques we will need.
2. Gordon Baym, *Lectures on quantum mechanics.* An excellent text for all conceptual aspects of quantum mechanics. Good for review and for some of the course material.
3. J. J. Sakurai, *Modern Quantum mechanics.* Also an excellent text on quantum mechanics. Also good for review and for some of the course material.
4. A. L. Fetter and J. D. Walecka, *Quantum theory of many-particle systems.* Has most of what we need, but the level is somewhat above the level for this course.
5. P. L. Taylor and O. Heinonen, *A quantum approach to condensed matter physics.* More specific to CM, but has many of the techniques and examples we will need.
6. P. W. Phillips, *Advanced solid state physics.* Also more specific than we need, but contains many of the techniques and some examples.
7. P. A. Martin and F. Rothen, *Many-body problems and quantum field theory.* Has most of the techniques and applications, but the approach is too formal for us to use as a text.

GRADING: There will be regular homework assignments. The final grade will be determined by performance on the homework assignments.