Physics 765: Models of Condensed Matter Spring 2006

General Information

Course Time and Place: Mon. and Wed. 3:45-5:05 pm in Physics 105
Instructor: Jen Schwarz
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Office Hours: Wednesday 2-3pm or by appt.

Course Objectives

When P. W. Anderson of Princeton changed his group's name from Solid-State Theory to Condensed Matter Theory in 1967, a new term was coined. So now when I tell non-scientists that I work in the field of Condensed Matter Theory, they respond, "So you study condensed milk?" It suffices to say that I have never been a fan of the term myself, but it does denote that the fact that we study the properties of not just solids, but liquids as well—-any material where the atoms are "close" to each other—hence the word condensed. In other words, gases generically would be considered uncondensed matter. One can place a quantative measure on the word "close" by computing how far apart are atoms on average in an ideal gas.

Given the title of the course, there are indeed many models of condensed matter out there, ranging from models of equilibrium systems to nonequilibrium systems, from models of ordered systems to disordered systems, and from models of electronic-based systems to biological systems. To make sure that we will actually be able to walk away with some concrete ideas, I have chosen 8 papers in field of condensed matter theory that are definitely worth your while to understand. A majority of them deal with various phase transitions–an important concept in the work of a condensed matter theorist since to truly understand a material, one must understand all the phases it can exhibit. Given the timescale of the class we will spend *approximately* two weeks per paper— at least that is the goal. Together, we will understand as much as we can about each paper—its motivation, its analysis, its conclusions, and the new questions it raises. Not only will you be imbued with knowledge of some of the most important papers in condensed matter theory, the skill of dissecting a paper that may be relevant to your research is an important one.

Here is a list of the papers (which one could also construe as the reading requirement for the course):

(1) "Why is the DNA Denaturation Transition First Order?", Y. Kafri, D. Mukamel, and L. Peliti, Phys. Rev. Lett. **85**, 4988 (2000).

(2) "Crystal Statistics I: A Two-Dimensional Model with an Order-Disorder Transition", L. Onsager, Phys. Rev. **65**, 117 (1943).

(3) "Universal Behavior in Nonlinear Systems", M. Feigenbaum, Los Alamos Science **1**, 4 (1980).

(4) "Critical Exponents in 3.99 Dimensions", K. G. Wilson and M. E. Fisher, Phys. Rev. Lett.

28, 240 (1972).

(5) "Absence of Diffusion in Certain Random Lattices", Phys. Rev. **109**, 1492 (1958).

(6) "Effective Field Theory and the Fermi Surface", J. Polchinski, arXiv:hep-th/9210046.

(7) "Diffusion-Limited Aggregation, a Kinetic Critical Phenomenon", Phys. Rev. Lett. **47**, 1400 (1981).

(8) "Theory of Branching and Annhiliating Random Walks", Phys. Rev. Lett. **77**, 4780 (1996).

Keep in mind that this list may be subject to change.

Course Assignments

(1) Homework (100 pts./300 pts.): There will be a homework assignment following the presentation of each paper, which means there will be eight homework assignments. Some will be a little more involved than others. I encourage you to talk to me about them and each other, especially if you are having problems getting started. In the end, however, each person should write up his/her own solutions. Points will be deducted from late homework assignments (due dates will vary but will be posted on each assignment). I suppose I also should mention that a few of the problems may have a computational component to them. In particular, the DLA paper is essentially numerical so I definitely envision a numerical component to that assignment.

(2) Class participation (100/300): Not only are you encouraged to ask questions in class (and via e-mail), for the latter half of the class, since there are 5 registered students (this may change), for the last four papers one or two students will work with me (to some extent) in preparing lectures on that paper. This task will be factored into your class participation grade.

(3) Final project (100/300): In place of a final exam, you will be required to choose your favorite paper in theoretical condensed matter and present it to the class for the duration of one hour. The paper you choose is subject to my veto (sorry guys) and you will also be required to hand in .pdf file of your notes.

Prerequisites

I presume that everyone knows a bit of thermodynamics, statistical mechanics, quantum mechanics, and a little bit of solid state, meaning the concept of conduction electrons and resistance, etc. However, if there are terms that I causally invoke and you do not understand or have not heard before, please stop me and ask. This seminar should be as self-contained as possible.

Other Readings

There are too many books to name as relevant background reading. For each paper I may highlight a book or two. In any event, as any good graduate student should do at some point in their career, please go to the libraries and simply browse the stacks and skim through various books. Books beginning with call numbers QC173 and QC174 should be relevant. Also, I will list some authors that may be helpful. This list is subjective however: Anderson, Amit, Ashcroft and Mermin, Binney, Cardy, Chaiken and Lubensky, Domb, Feynman, Goldenfeld, Kadanoff, Kittel, Reif, Schrieffer, etc.

Secret Course Objective

To have **fun** learning about some of the major discoveries in CMT over the last century. Of course, fun does not necessarily mean rolling on the floor with laughter throughout the majority of the class. Fun means that the learning experience should be enjoyable and inspiring.