Physics 576: Introduction to Solid State Physics

Spring 2016

General Information

Course Time and Place: Tues./Thurs. 2:00-3:20 PM in PB105
Instructor: Dr./Prof. Schwarz
Office: PB229A
Cell Phone: 607-342-0876
E-mail: phy576.spring2016@yahoo.com
Course Webpage: http://jmschwarztheorygroup.org/phy576
Office Hours: Tuesdays/Thursdays 1:00AM-2:00PM or by appointment

Course Objectives

Presumably at age 8, your teacher asked you "Why does matter matter?" and then went on to say that trees, air, and water are all matter, different states of matter, mind you, and then proceeded to talk about the properties of solids, liquids, and gases. A more ambitious teacher might even go on to talk about plasmas. And then they would say that as one adds energy to solid matter, it can go from a solid to a liquid to a gas to a plasma. Of course, you being a physicist-in-training know now that the story of the states of matter is a little more intricate than just solids, liquids, gases, and plasmas. You have heard about Bose-Einstein condensates and quark-gluon plasmas and Jahn-Teller metals (whose discovery was just reported back in May 2015 so if you have not heard of such a state, don't worry). Given the title of this course, it is relatively clear that we will focus on solids and address why some solids conduct and others do not and why some solids superconduct and others do not. We will also investigate some intriguing properties of disordered, or non-crystalline, solids and how electrons interacting in one dimension can be described as bosons.

Here is a detaiing of the topics to be covered (in the order they will be covered):
(1) Solids without considering microscopic structure (Drude theory of metals and Sommerfeld theory of metals)
(2) Toy models of solids in one dimension (vibrational modes, tight-binding model)
(3) The geometry of solids (lattices, reciprocal lattices)
(4) Solids now considering the microstructure (Bloch's theorem, band theory, conductors, insulators, semiconductors)
(5) Interacting electron gas and Fermi liquid theory
(6) Interacting electrons in one dimension and bosonization
(7) The Kondo problem and local magnetic moment formation in metals
(8) Superconductivity
(9) Localization and disorder-driven metal-insulator transitions
(10) Disordered solids
(11) Glasses—solid or liquid?
(12) The future of solid state and quantum computation

Since there are 15 weeks in the semester (excluding Spring Break week), most of the topics will take about a week to cover. The first objective of this course is to obviously learn about the above

topics. However, I have another objective in mind. I would like each of us to hone our paper-reading skills. As some of you may know by now, doing research in physics does not necessarily mean sitting down and reading a textbook, and then cranking out a new calculation as a result (some times it does, though). Rather, most research stems from recently published work, which is not in the textbooks. Therefore, one must be able to read and digest and perhaps reproduce the work presented in these recent publications. Good paper-reading skills certainly help in conducting research. So, we will be looking at some original papers throughout the course, some of which are Nobel Prize-winning ones.

Finally, while the course will focus mostly on the theory (since I am a theorist), we will also discuss applications of the theory. After all, solid state physics has been extremely useful for humanity in the form of computers, IPhones, and many other devices we take for granted.

Textbooks

While there is no required textbook for the course, I will be pulling material from several places, including *The Oxford Solid State Basics* by Steve Simon (Oxford University Press 2013), *Advanced Solid State Physics* by Philip Phillips (Cambridge University Press, 2012), and various papers. I will make this material available to you as we proceed.

In addition to the Simon and Phillips books, there are a number of books out there on solid state physics with *Solid State Physics* by N. Ashcroft and N. D. Mermin (Holt-Saunders, 1976) and *Introduction to Solid State Physics, 8th Edition* by C. Kittel (Wiley, 2005) being classics in the field, though both are a bit out of date in terms of more recent developments.

Prerequisites

I will presume that everyone knows a bit of thermodynamics, statistical mechanics, and quantum mechanics. In any event, if there are terms that I causally invoke and you do not understand or have not heard before, please stop me and ask. I will try to make the course as self-contained as possible.

Assessment

Homework: There will be homework sets assigned during the course. I will not specify a number at this point other than stating that there will be approximately an assignment a week.

Mid-term exam: There will be a mid-term exam that will be open notes but not open book.

Final paper and presentation: Given the some of the intracacies of the latter topics in the course, in place of a final exam, there will be a final presentation and accompanying write-up on a paper that we both agree on.

Combining these three components with class participation, which I consider to be important, here is the breakdown of how you will assessed on your performance in the class:

Homework: 45 percent
Mid-term exam: 15 percent

Final paper/presentation: 30 percent
Class participation: 10 percent

A Note About Working with Friends and Academic Integrity

Students are encouraged to discuss the course content with each other. However, when it comes time to complete your homework assignment, **the final work you turn in must be your own**. You should never copy anybody else's work, or even paraphrase it. Copying is against school policy and can ultimately result in expulsion. If you have not read over SU's academic integrity policy, it can be found online at http://supolicies.syr.edu/ethics/acad_integrity.htm. Enough said about that!

Academic Accommodations for Students with Disabilities

Students who are in need of disability-related academic accommodations must register with the Office of Disability Services (ODS), 804 University Avenue, Room 309, 315-443-4498. Students with authorized disability-related accommodations should provide a current Accommodation Authorization Letter from ODS to me (Dr. Schwarz) and we will review those accommodations together. Accommodations, such as exam administration, *are not provided retroactively*; therefore, planning for accommodations as early as possible is necessary. Please go to http://disabilityservices.syr.edu for further information.

New Religious Observance Policy

SU's religious observances policy, found at
http://supolicies.syr.edu/emp_ben/religious_observance.htm, recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holy days according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors before the end of the second week of classes. For fall and spring semesters, an online notification process is available through MySlice/Student Services/Enrollment/My Religious Observances from the first day of class until the end of the second week of class.

Once I am notified of each student's religious observances for the semester, I will discuss with each of you individually revised due dates for assignments, etc.