# Physics 831: Statistical Physics of Fields

# Fall 2013

## General Information

Course Time and Place: Tues./Thurs. 9:30-10:50 PM in PB104N
Instructor: Dr./Prof. Schwarz
Office: PB215
Office Phone: 315-443-3887
Cell Phone: 607-342-0876
E-mail: phy831.fall2013@yahoo.com
Course Webpage: http://physics.syr.edu/∼jschwarz/PHY831.F2013/
Office Hours: Tuesdays/Thursdays 11:00AM-12:00PM or by appointment

## Course Objectives

If you were to ask a passerby on the street to name a physicist, presumably most would spout the name "Einstein". If you were to ask that same passerby to name a major theoretical physics development of the 20th century, hopefully some would respond with "Quantum Mechanics", others would respond with "General Relativity", a Brian Greene fan may say "String Theory", and there, of course, would be some who say, "Don't know". While, indeed, quantum mechanics, general relativity, and string theory are all important theoretical physics developments of the 20th century, there is another lesser known, but very important, theoretical physics development of the latter half of the 20th century, namely the Renormalization Group (RG). The RG provides a systematic framework to be able to identify what is called the universality class of some types of phase transitions. It does so by a systematic "integrating out" certain degrees of freedom of a system to identify a scale-invariant construction of the theory at some point(s) in the phase diagram. One of the jobs of a condensed matter physicist is to be able to describe and classify all possible states of matter and the possible phase transitions between these states. Therefore, the RG plays an important role in the life of a condensed matter physicist. The RG is also an underlying idea of Quantum Field Theory (QFT), so for those studying high energy systems, this course will also be of much use. In fact, Ken Wilson, a high energy theorist, was one of the key developers of the RG. Wilson was awarded the Nobel Prize in 1982 for his contribution.

Given the importance of the RG, we will spend the semester learning various aspects of it. Of course, by now you should be wondering why I have not said anything about the statistical physics of fields, which is the title of the course. I can respond to this inquiry with "Well, statistical field theory is one of the platforms used by the RG and so we will definitely be learning about statistical field theory as a result".

In addition to learning about phase transitions, statistical field theory, and the RG, I have another objective in mind for the course. 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. 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. Therefore, we will be focusing on several papers during the course. Here is a list of some papers we will be looking over:

(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) "Critical Exponents in 3.99 Dimensions", K. G. Wilson and M. E. Fisher, Phys. Rev. Lett. **28**, 240 (1972).

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

(5) "Theory of Branching and Annhiliating Random Walks", U. Tauber and J. Cardy, Phys. Rev. Lett. **77**, 4780 (1996).

## Textbooks

While there is no required textbook for the course, I will be pulling material from various places—-from Kardar's book on statistical field theory (*Statistical Physics of Fields*, M. Kardar, Cambridge University Press, 2007), from Goldenfeld's book on the Renormalization Group (*Lectures On Phase Transitions And The Renormalization Group*, N. Goldenfeld, Westview Press, 1992), and from various papers such as the ones specified above. I will make this material available to you as we proceed.

In addition to the Kardar and Goldenfeld books, there are a number of books out there on these topics. As any good graduate student should do at some point in their career, please go to the library (What!) and browse the stacks to skim through various books. Books beginning with call numbers QC173 and QC174 should be relevant. I will also list some authors that may be helpful. This list is subjective however: Amit, Binney, Cardy, Chaiken and Lubensky, Domb, Feynman, Kadanoff, etc.

## 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. In other words, PHY731, PHY661, and PHY662 (or some equivalent) would be good to have under your belt before taking this course. 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 some homework sets assigned during the course. I will not specify a number at this point other than stating that they will be less frequent than once a week.

Mid-term presentation: In place of a mid-term exam, there will be a mid-term presentation on a paper that we both agree on. There will not be a written component for this task.

Final paper/presentation: In place of a final exam, there will be a final presentation and accompanying write-up on a paper that, again, we both agree on.

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

Homework: 45 percent
Mid-term presentation: 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.