Physics 212: Statistical mechanics II, Spring 2014

Course information sheet

Website: http://cmt.berkeley.edu/p212

Instructor
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Lectures: TuTh 2:10-3:30, 31 Evans Hall.
Office hours: Th 11:00-12:00, 549 Birge Hall

Syllabus

The first one-third to one-half of the course will cover strong and weak nonequilibrium statistical physics. The second part will cover the modern theory of scaling in equilibrium statistical physics (the “renormalization group”), applied to understand continuous phase transitions. At the end of the course, we will discuss a few other topics. We will make occasional reference to the textbook “Statistical Physics of Fields” by Mehran Kardar, but most topics are covered somewhere in lecture notes that will be provided. Some problems will be assigned from Kardar, and it will definitely be useful for people wanting to learn more details of the field-theoretic approaches.

In some previous offerings, there has been an opportunity for students to complete a written final project and short oral presentation. I believe that the course is too large this time for oral presentations, but we will still have the written report. The weighting of grades (as in the slides from lecture I) is 30% problem sets, 35% midterm, 35% final project. There will be no exam during the final exam period.

The prerequisites are a strong undergraduate background in statistical physics and quantum mechanics; Phys 211 is helpful but not required. Some ability to program (in C, Mathematica, Matlab, ...) is not strictly required but is an important skill for students intending to do research in this area. A recent textbook with a modern perspective on introductory statistical physics is “Statistical Mechanics: Entropy, Order Parameters, and Complexity” by James P. Sethna.

1. Basic methods of nonequilibrium statistical mechanics

   - Phenomenological derivation of Boltzmann equation and normal hydrodynamics
   - BBGKY hierarchy
   - Relationship between chaos and hydrodynamics
   - Linear response and fluctuation-dissipation theorem: classical and quantum versions, including applications such as the Kubo formula
   - Detailed balance
   - Model dynamics and Monte Carlo simulations

2. Introduction to scaling, renormalization group, and critical phenomena

   - Basic phenomenology of critical points: critical exponents and amplitudes
• Mean-field theory
• Elementary real-space and momentum-shell RG methods
• Universality and other predictions of RG
• Geometric critical phenomena: polymer physics
• Mapping between quantum and classical phase transitions
• Dynamics at phase transitions

3. Other applications of RG and nonequilibrium ideas to classical and quantum physics.
   • Thermalization, localization, typicality, and quantum integrability
   • Quantum information and entanglement