Physics 541: Statistical Mechanics   Spring, 2018

Instructor: Prof. R. Shrock, tel. 632-7986, email: robert.shrock@stonybrook.edu office hrs. - after class

Meeting Time/Place: TBA; first meeting: Mon. Jan. 22, noon, Rm. S265.

Recommended preparation: PHY 540 or equivalent course.

Textbooks - We will not follow any one book, but will provide references to several recommended books and articles that students may wish to read throughout the course.

Course requirements include homework, midterm exam, and either a final exam or a research paper.

This course will cover modern statistical mechanics, including a subset of the topics in the list below (in different years we will cover a different subsets of topics)

- Brief review of thermodynamics and discussion of statistical ensembles
- Phase transitions and critical phenomena: examples with liquid-gas-solid systems and magnetic systems; experimental data; phase diagrams; order of transition; critical singularities; correlation length.
- van der Waals theory of liquid-gas transition; mean field theory and Ginzburg-Landau theory.
- Analysis of some models, including Ising, q-state Potts, O(N) vector, and ice models; exact solutions for 1D and quasi-1D cases; transfer matrix method.
- Potts model and connection to Tutte and chromatic polynomials in graph theory; ground state entropy
- Modern theory of second-order phase transitions: renormalization group; universality classes and critical exponents, dependence on spatial dimensionality and symmetry group of Hamiltonian; scaling relations, upper and lower critical dimensionalities; conformal algebra.
- Approximate methods: high-temperature and low-temperature series expansions, low-density series expansions, Padé approximants, Monte Carlo simulations
- Quantum statistics: Fermi-Dirac and Bose-Einstein distribution functions and applications to phonons, photons, Bose-Einstein condensation.
- Other types of phase transitions, e.g., Kosterlitz-Thouless, transition, liquid crystals and orientational ordering.
- Lattice field theory and connections with quantum field theory

Learning goals: Students will learn the principles, methods, and applications of modern statistical mechanics, with connections to condensed matter physics and quantum field theory.