Physics 541: Advanced Statistical Mechanics Spring, 2021

Instructor: Prof. R. Shrock, email: robert.shrock@stonybrook.edu
office hrs. - after class; use zoom, skype,or email for further discussions

Mode: Online synchronous; first zoom meeting
Meeting Time/Place: first meeting: Mon. Feb 1, 2021
Technical: connection with zoom with your computer; otherwise contact me for other arrangements

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 throughout the course.

Course requirements include homework, class participation, and either a final exam or a research paper. Grade weightings: 50 %, 10 %, 40 %, respectively.

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 gain (i) an understanding of the principles and methods of modern statistical mechanics (SM); (ii) familiarity with models used in SM; and (iii) a working knowledge of applications of SM and connections with condensed matter physics and quantum field theory.