STATISTICAL MECHANICS (PHY 540) Spring 2017

[http://tonic.physics.stonybrook.edu/~syritsyn/phy540_2017]

Instructor: Sergey Syritsyn (office C-140) sergey.syritsyn@stonybrook.edu
Lectures: 42 lectures starting Jan 23, MWF 10:00-10:53, Light Engineering #152
Lecture Notes: will be posted online
Office hours: Wednesday 1:30-3:30pm, Physics C-140
TA & Grader: Norton Lee

Main textbooks:
1. L.Landau and E.Lifshitz, Statistical Physics, Pt.1, 3rd ed.
2. K. Huang, Statistical Mechanics, 2nd ed.
3. K.Likharev, "Essential Graduate Physics", [http://commons.library.stonybrook.edu/egp/5] .

Homeworks: weekly, deadline 1 week after handout, grades and solutions 1 week after the deadline.

Course grading:
Homeworks: 20%
Midterm: 30%
Final exam: 50%

Exams: open books
Midterm: March 10
Final : May 15, 8:00-10:45am

SYLLABUS

1. Introduction and Review of Thermodynamics

Basic notions of statistical physics and thermodynamics: energy, entropy, temperature, work and heat. Thermodynamic potentials and circular diagram. Heat capacity and equation of state. Thermodynamics of ideal gas. Systems with variable number of particles and chemical potential.

2.Principles of Physical Statistics

Statistical ensembles and ergodicity. Probability, probability density, and density matrix. Microcanonical ensemble and the basic statistical hypothesis. Definition of entropy and relation to information. Canonical ensemble and the Gibbs distribution. Statistics of quantum oscillator, photons and blackbody radiation, phonons and heat capacity of crystals lattices. Grand canonical ensemble and distribution. The Boltzmann, Bose and Fermi distributions in systems of independent particles.

3. Ideal and Weakly Interacting Gases.

Thermodynamics of ideal classical gas and the Maxwell distribution. The Gibbs paradox. Quantum ideal gases, the Fermi sea and the Bose-Einstein condensation. Gases with weakly interacting particles.

4.Phase Transitions

First order phase transitions, phase equilibrium, latent heat, critical point, the Gibbs rule. The van der Waals equation. The Clausius-Clapeyron formula. Weak solutions, osmotic pressure. Second order phase transitions, the order parameter, critical exponents. Landau's mean field theory and the Ginsburg criterion. The Ising model, 1D solution via transfer matrix, Onsager's solution for 2D case. Numerical Monte Carlo methods, the Metropolis and the "heatbath" update algorithms. Renormalization group.

5. Fluctuations and Dissipations

Small fluctuations, variance, r.m.s. fluctuation. Fluctuations of energy and the number of particles. Fluctuations of temperature and volume. Time dependence of fluctuations, their correlation and spectral density. The fluctuation-dissipation theorem. Quantum noise and the uncertainty relation. The Einstein-Smoluchowski equation, the Fokker-Planck equation.

6. Elements of Kinetics

The Liouville theorem; the Boltzmann equation; the relaxation time approximation. Conduction of degenerate Fermi gas, electrochemical potential, thermoelectric effects, the Onsager reciprocal relations.