

219A Statistical Mechanics

Course Description

Basic introduction to statistical mechanics ideas. Topics to be covered include: Statistical basis of thermodynamics, ensemble theory, canonical and grand canonical ensembles in classical statistical mechanics, indistinguishable particles and quantum statistics, quantum Bose and Fermi systems: applications: ideal gas, Bose-Einstein condensates, black body radiation, Fermi gas, and Chandrashekar limit. Introduction to lattice models, eg., 1d and 2d Ising models.

Detailed syllabus

Statistical basis of thermodynamics: review of basic aspects of thermodynamics (zeroth, first and second laws), thermodynamic potentials. Basic concepts in statistics: random walk and probabilities (2-3 lectures)

Ensemble Theory: Phase space and Liouville's theorem. The microcanonical ensemble and the postulate of equal a-priori probabilities. Entropy from state counting and thermodynamics. (2-3 lectures)

Canonical & Grand Canonical Ensembles: Derivation of canonical probability distribution from systems coupled to reservoir, density of states, partition functions and thermodynamics in the canonical ensemble. Ensemble equivalence and fluctuations. (3 lectures) Generalization to systems with conserved charges; grand canonical ensemble. (2 lectures) optional: large deviations and non-equilibrium work statistics. optional: Connections between ensemble theory & Euclidean time formalism of quantum mechanics. (1-2 lectures)

Quantum Statistics: Identical particles, density matrices, Bose-Einstein and Fermi-Dirac counts, and particle number probabilities. Derivations of thermodynamic formulae. (2 lectures)

Applications: Ideal gas: study of ideal gas in various ensembles Fermi gas and non-zero and zero temperature Degeneracy pressure and the Chandrashekar limit for stellar collapse Ideal Bose gases, Bose-Einstein condensation, and black body radiation (5-6 lectures)

optional: Lattice spin models: Ising models in 1 and 2 dimensions; transfer matrices, critical phenomena (2 lectures)

Resources:

R K Pathria and Paul Beale, Statistical Mechanics (3rd ed).

M Kardar, Statistical Mechanics of Particles (1st ed)

K Huang, Introduction to Statistical Physics