PH302 Introduction to Statistical Mechanics

Credit: (2.5-0.5-0-3) Approval: Approved in 2nd Senate

Prerequisites: Mechanics of Particles and Waves

Students intended for: B.Tech

Elective or Core: Elective Semester: Odd/Even

Course objective:

Statistical mechanics is branch of physics that deals with understand collective response from the single particle behavior. This course explains how the statistical approach is effective in predicting the thermodynamics of system from the constituent particles. Methods of statistical mechanics are useful in understanding the microscopic origin of abstract quantities like entropy. The concept of the thermodynamic entropy is related to the entropy in the information theories. Statical mechanics deals not only with the physical particles like classical point particles,electrons ..etc. it also treats entities like lattice vibrations (phonons), light particles (photons), polarizations (polarons) in the same footing thus statical mechanics is useful in understanding diverse phenomena such as of heat capacity in solids, principles of lasers, electrons in solids, etc.

Course content

- Statistical concepts and examples - random walk problem in one dimension – mean values – probability distribution for large N. Probability distribution many variables. [6 Lectures]
- Statistical description of a system of particles – Statistical ensemble- Microstate and macrostate – Density of states. Connection between statistics and thermodynamics - Relation between number of macrostates and entropy – classical ideal gas. Gibb's paradox. [6 Lectures]
- Liouvellie's theorem- Phase space and connection between mechanics and statistical mechanics Microcanonical ensemble – Computational methods to calculate phase space trajectory- Molecular dynamics and Monte Carlo methods. [6 Lectures]
- Canonical ensemble – partition function. Thermodynamics from the partition function – Helmholtz free energy. Classical ideal gas- equipartition and virial theorem. System of harmonic oscillators and spin systems. Grand canonical ensemble- density and energy fluctuations- Gibbs free energy. [6 Lectures]
- Formulation of quantum statistical mechanics – density matrix- micro-canonical, canonical and grand canonical ensembles- Systems composed of indistinguishable particles, Slater determinant. [6 Lectures]
- Maxwell-Boltzmann , Fermi-Dirac, and Bose-Einstein statistics – Ideal gas in classical and quantum ensembles – Ideal Bose systems – Black body radiation- lattice vibrations in solids- Ideal Fermi systems – magnetic systems- Pauli paramagnetism-Landau diamagnetism – electron gas in metals [6 Lectures]
- Brownian motion – Langevin equation – Fluctuation-dissipation theorem-correlation functions and friction coefficient. [4 Lectures]

References

Fundamentals of statistical and thermal physics, F. Reif

Introduction to statistical physics, K. Huang

Statistical physics by F Mandl

Statistical Mechanics, R K Pathria

Statistical Physics by K Huang