JF208: Thermodynamics and Statistical Mechanics (3:0)

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Classical Thermodynamics (12 Lectures): First, Second and Third Laws of Thermodynamics. Notion of Temperature and the Ideal-gas Temperature Scale. Carnot Cycle, Heat Engines and the Absolute Thermodynamic Temperature Scale. Clausius Theorem, Entropy and Irreversibility. Thermodynamic Potentials, Stability and Gibbs Phase Rule. Maxwell Relations and Legendre Transformations. Applications of Thermodynamics: Osmotic Pressure, Condensation, etc. Phase Transition in van der Waals (vdW) Fluid, and Power-law Behaviour of Susceptibilities near (Gas-Liquid) Critical Point.

(*Brief Review of***) Probability Theory (2 Lectures):** Probability Density and Characteristic Functions of Continuous Random Variables. Moments, Cumulants and Correlations. Graphical representation of Moments in terms of Cumulants. Sums of Random Variables, and Central Limit Theorem. Laws of Large Numbers and Stirling formula. PDF, Loss of Information and Shanon/Counting Entropy.

Kinetic Theory and Granular Gas (6 Lectures): Liouville's Theorem and Phase Space Densities. BBGKY Hierarchy and the Boltzmann Equation. H-theorem and Irreversibility. BGK-Model and Chapman Enskog Expansion. Hydrodynamics Equations and Transport coefficients. Microscopic Irreversibility and Granular Gas. Homogeneous Cooling State and Scaling Solution of Inelastic Boltzmann Equation.

Classical Statistical Mechanics (7 Lectures): Micro-States and Partition Function. Boltzmann/Configurational Entropy. Microcanonical, Canonical and Grand Canonical Ensembles. Relation between Thermodynamics and Statistical Mechanics. Two-level System and Ideal Gas. Gibbs Paradox and Mixing Entropy.

Interacting Systems (4 Lectures): Cumulant and Cluster Expansions. Debye-Hückel Theory and Ring Diagrams. Virial Coefficients. Derivation of van der Waals Equation following Kac-Uhlenbeck model. Breakdown of vdW Equation, and revisiting the Mean Field Theory of Condensation.

(*Return to***) Phase Transition and Critical Phenomena (4 Lectures):** Order Parameter Description and the Landau-Ginzburg Approach. Universality.

Textbooks

1. Kardar, M. (2007) *Statistical Physics of Particles*, Cambridge Univ. Press (Main Textbook).
2. Huang, K. (1992) *Statistical Mechanics*, Springer.
3. Fermi, E. (1936) *thermodynamics*, Dover Publications.
4. Callen, H. B. (1985) *Thermodynamics and an Introduction to Thermostatics*, John Wiley and Sons.