MPHC4203

Statistical Mechanics II and Relativity & Relativistic Electrodynamics

Group A: Statistical Mechanics II

Density matrix: Idea of quantum mechanical ensemble. Statistical and quantum mechanical approaches, Properties. Quantum Liouville's theorem, density matrices for microcanonical, canonical, grand canonical

Pure and Mixed states. Density matrix for stationary ensembles. Application to a free particle in a box, an electron in a magnetic field. Density matrix for a beam of spin ½ particles. Construction of the density matrix for different states (pure and mixture) and calculation of the polarization vector.

[12 lectures]

Systems of indistinguishable particles – BE and FD distributions, Ideal Bose and Fermi gas, statistics of occupation number, equation of state, BE condensation, Thermodynamic behaviour of an ideal Bose gas, blackbody radiation, thermodynamic behaviour of ideal Fermi gas, the electron gas in metals, statistical equilibrium of white dwarf stars.

[12 lectures]

Interacting systems: Ising model. Idea of exchange interaction and Heisenberg Hamiltonian. Ising Hamiltonian as a truncated Heisenberg Hamiltonian. Equivalence of the Ising model to other models: Lattice Gas and Binary alloy. Spontaneous Magnetization. Exact solution of one-dimensional Ising system (Matrix methods).

[12 lectures]

References:

1. K. Huang, Introduction to Statistical Mechanics
2. R. K. Pathria, Statistical Mechanics
3. David Chandler, Introduction to Modern Statistical Mechanics
4. Kadanoff, Statistical Mechanics. World Scientific.
5. R. Kubo, Statistical Mechanics. (Collection of problems)
6. M. Plischke and B. Bergersen, Equilibrium Statistical Physics, World-Scientific.

Group B: Relativity & Relativistic Electrodynamics

Relativity & Relativistic Electrodynamics:

Postulates of the special theory of relativity. Galilean & Lorentz transformation. Applications of Lorentz transformation: Length contraction, time dilation, simultaneity, transformation equations for velocity and acceleration. Thomas Precession. Space-like, time-like and light-like intervals. Lorentz invariance of space-time intervals. Relativistic mass & energy. Conservation of momentum and energy. Geometric representation of space-time: Minkowski diagrams and applications. Twin paradox.

[10 lectures]

Four-vectors: Definitions and components, transformation properties. Time derivative of a four-vector. Scalar product of four-vectors and its invariance under Lorentz transformation. Orthogonality. Lorentz invariance of four-dimensional differential volume element. Interaction of particles: conservation of momentum four-vector.

Tensors: contravariant & covariant, rank of a tensor, transformation properties, contraction, symmetric and anti-symmetric tensors, metric tensor. Four-gradient, four-divergence. Four-dimensional Laplacian operator. Wave number four-vector and Doppler effect. Relativistic Lagrangian and Hamiltonian.

[10 lectures]

Relativistic electrodynamics: Maxwell's equations, scalar and vector potentials, four-vector representation of electromagnetic potentials. Transformation of charge density. Current four-vector. Continuity equation: covariant form. Maxwell's equations in terms of potential four-vector and current four-vector. Electromagnetic field tensor and its transformation properties. Lorentz force law in terms of field tensor and its covariance.

Covariance of Maxwell's equations. Dual field strength tensor and its application. Electromagnetic field invariants. Transformation laws for the components of electric field and magnetic field. Fields due to a point charge in uniform motion.

Electric & magnetic fields produced by an accelerated charge.

[16 lectures]

Books:

1) Relativity, Gravitation and Cosmology by, Robert J. A. Lambourne (Cambridge University Press, 2010).

2) The Special Theory of Relativity by Dennis Morris (Mercury Learning and Information)

3) Classical Theory of Fields by Landau and Lifshitz (Butterworth-Heinemann; 4th edition, 1987)

4) Introduction to Electrodynamics by, D J Griffiths (Prentice Hall, 1999.)

5) The Special Theory of Relativity by Banerji & Banerjee (Prentice Hall of India, 2006)

6) Electricity and Magnetism by, Nayfeh & Brussel (John Wiley & Sons, 1985)

7) Classical Electrodynamics by J D Jackson (John Wiley, 2007)

8) Classical Electricity and Magnetism by Panofsky & Phillips (Dover Publications, 2005)