Paper-12

Elective (AP: General Theory of Relativity/ CP: Crystallography (Group Theoretical and Structural Aspects)) and Advanced lab II

Group A: (Elective)

For AP

General Theory of Relativity **[36 Lectures]**

Non-inertial frames and non-Euclidean geometry; Concept of curved space-time; Equivalence principle; General coordinate transformations and the general covariance of physical laws.

[4L]

Recapitulation of tensors: Tangent space and dual space, Contravariant and covariant vectors (Tangent vectors and 1-forms), Metric tensor, Christoffel connection on a Riemannian space and Covariant derivative. Parallel transport and the affine connection; Intrinsic derivative and Equation of geodesics. Gravitation as space-time curvature: Curvature tensor and its properties; Bianchi identities; Equation for geodesic deviation; Relativistic Tidal Forces.

[6L]

Energy-momentum tensor of dust and perfect fluid; Conservation laws; Hilbert's variational principle and Einstein-Hilbert action; Einstein's equation; Newtonian approximation; geodesic equations from variational principle. Weak field metric and gravitational energy-momentum pseudo tensor; linearized field equations. Gravitational waves: wave equation in linearized theory, gravitational wave solutions, plane waves, transverse traceless gauge, quadrupole formula, effect on test particles.

Observation of Gravitational waves with LIGO and discussion of the proposed INDIGO consortium.

[17L]

Static, spherically symmetric space-time; Schwarzschild's exterior solution and Schwarzschild geodesics; form of metric in the Newtonian limit. Effective potential for particle orbits in Schwarzschild metric, nature of R=2M surface, ISCO; Classical tests of GR: Motion of perihelion of Mercury; Bending of light; Gravitational red shift; Radar echo delay.

[6L]

Elements of Cosmological dynamics: Weyl's postulate and the cosmological principle, comoving coordinates; Maximally symmetric spaces and Robertson-Walker metric (no derivation); Expanding universe; anisotropies, vorticity and shear; Raychaudhuri equation

[3L]

Reference Books:

1. A.K. Raychaudhuri, S. Banerji, and A. Banerjee: General Relativity, Astrophysics and Cosmology

2. J.V. Narlikar: An Introduction to Relativity

3. P.A.M. Dirac: General Theory of Relativity

4. L.D. Landau and E.M. Lifshitz: The Classical Theory of Fields

5. M. P. Hobson, G. P. Efstathiou and A. N. Lasenby: General Relativity - An Introduction for Physicists

6. R.M. Wald: General Relativity

7. S. Weinberg: Gravitation and Cosmology

8. C.W. Misner, K.S. Thorne and J.A. Wheeler: Gravitation

9. W. Rindler: Relativity - Special, General, and Cosmological

For CP

Crystallography (Group Theoretical and Structural Aspects)

Symmetry groups and group representation: Crystal symmetry operators, symmetry elements and interrelations, stereographic projection, crystallographic point groups, Schoenflies notation, Hermann – Mauguin notation, irreducible representation of point groups, three dimensional rotational groups, translation group and space groups, crystal field splitting of atomic energy levels.

[14L]

Diffraction of x-rays: Scattering by a single electron and an atom, integrated intensity, Laue and Bragg equation, limiting sphere, structure factor equation, limiting conditions and systematic absences, space group determination. Data collection techniques for single crystals and polycrystalline material, data reduction, Lorentz and polarization factors, extinction, absorption correction, temperature factor.

[8L]

Fourier series method in structure determination, phase problem, methods for structure solution, Heavy-atom method, Patterson function & its properties, Harker lines, Harker planes, isomorphous replacement and anomalous scattering methods. Direct method, structure invariants & semi-invariants, Hasker-Kasper inequality, sign relationship, Sayre's equation, Karle-Hauptmann procedure, Tangent formula, least squares refinement, Goodness of fit. Elements of neutron diffraction.

[14L]

References :

1) Group Theory and Quantum Mechanics – Michael Tinkham
2) Group Theory and its application to the Quantum Mechanics of Atomic Spectra – Eugene P. Wigner
3) Elements of Group Theory for Physicists – A. W. Joshi
4) Structure determination by X-ray crystallography – M. Ladd & R. Palmer
5) X-ray diffraction – B. E. Warren

Group B: Advanced lab II

List of Experiments

1. To study the temperature dependent Dielectric constant of a given specimen.
2. To find the magnetic susceptibility of a paramagnetic specimen using Guoy's balance or other suitable method.
3. Characterization of a Solar cell.
4. To study the Hall effect in metal.
5. To study surface roughness using a surface profilometer.
6. Determination of Band gap of a given semiconductor material.
7. Rotating viscometer.
8. Study of colour centers and thermoluminescence of alkali halides.
9. Viscous fingering in Hele-Shaw cell.