Govt. Degree College (Autonomous), Baramulla

B.Sc. (Honors) Physics – 4 years (8th Semester)

COURSE NAME: ATOMIC AND MOLECULAR SPECTROSCOPY

COURSE NO. PHYC2822M PHYR2822M

TOTAL CREDITS = 04	THEORY = 04	PRACTICAL = 02

COURSE OBJECTIVES

- To develop a rigorous understanding of atomic structure and spectra.
- To study fine, hyperfine, and external field effects.
- To analyze molecular spectra using theoretical models.
- To introduce modern spectroscopic instrumentation and applications.

COURSE OUTCOMES

After completing this course, students will:

- Understand advanced atomic models and coupling schemes.
- Interpret spectral lines and splitting mechanisms.
- Analyze molecular rotational, vibrational, and electronic spectra.
- Apply spectroscopy in scientific and industrial contexts.

UNIT I: Atomic Structure and Spectral Terms

Limitations of Bohr Model of the Atom and the need for the development of Quantum Mechanics. Basic idea of the Schrödinger Equation and introduction to quantum numbers. Orbital angular momentum and its space quantization. Electron spin and spin angular momentum; space quantization of spin. Orbital and spin magnetic moments of the electron. Spin orbital interaction.Vector atom model and addition of angular momenta. L–S (Russell–Saunders Coupling) coupling and j–j coupling schemes. Term symbols, multiplicity, and spectroscopic notation. Simple selection rules for spectral transitions: allowed and forbidden transitions (qualitative treatment only).

UNIT II: Fine Structure and Interaction with External Fields

Origin of fine structure in atomic spectral lines. Spin–orbit coupling and energy level splitting (quantitative treatment). Zeeman Effect: normal and anomalous Zeeman effect Paschen–Back effect (conceptual). Stark effect in weak and strong electric fields(qualitative treatment). Hyperfine structure due to nuclear spin interaction. Line broadening mechanisms: natural, Doppler, pressure, and collision broadening (basic concepts).

UNIT III: Molecular Spectroscopy – Rotational and Vibrational

Born–Oppenheimer approximation and separation of electronic, vibrational, and rotational motions. Rotational spectra: rigid and non-rigid rotator models. Vibrational spectra: harmonic oscillator model. Anharmonic oscillator and Morse potential(conceptual introduction).Vibration–rotation interaction and

UNIT IV: Applications of Nanotechnology **(15 Lectures)**

Nanotechnology in energy (solar cells, batteries); Hydrogen storage and fuel cells; Environmental applications (water purification); Nanotechnology in agriculture; Nanomedicine (drug delivery, diagnostics); Biosensors and nano-sensors; Nanoelectronics and quantum devices; Nano photonics; Smart materials and coatings; Nanotechnology in textiles; Waste management and sustainability; Role in climate-sensitive regions; Future trends (AI + nanotech, nano-robotics); Biological interactions at nano-scale.

Practicals:

1. Synthesis of nano-particles by Chemical route.
2. Synthesis of nano-particles by hydrothermal method.
3. Fabrication of a thin film of nano-particles by suitable method and study its spectra
4. To study the electrical properties (mobility and carrier concentration etc) of nano particles.
5. Growth of quantum dots by thermal evaporation.
6. Estimation of particle size of nano-particles using various methods.
7. To study optical properties of nano-particles by using UV-visible Spectroscopy.
8. Synthesis of Carbon nanotube nano-composites.
9. Preparation of a thin film capacitor and study capacitance as a function of temperature or frequency.
10. Visit to nearby research laboratories to study working of XRD, SEM, UV-visible Spectrophotometer instruments etc.

Reference Books:

1. Introduction to Nanoscience and Nanotechnology: Charles P Poole and Frank J. Owens; Wiley India Pvt. Ltd.
2. Nanotechnology—The Science of Small: M A Shah and K A Shah; Wiley India Pvt. Ltd.
3. Introduction to Nanotechnology : Sulabha K. Kulkarni; Capital Publishing Company.
4. Textbook of Nanoscience and Nanotechnology: B.S. Murty, P. Shankar, et al.
5. Nanotechnology: Recent Trends, Emerging Issues and Future Directions: Nazrul Islam.
6. Nanotechnology: Richard Booker, Earl Boysen; John Wiley and Sons.
7. Introduction to Nanoscience and Technology: K K Chatopadhyay and A N Banerjee; PHI Learning PHI Learning Pvt. Ltd.
8. Springer Handbook of Nanotechnology: Bharat Bhushan; Springer-Verlag

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