AMP: Atomic and Molecular Physics

Programme: MSc. Year: 2019-20 Semester: 3rd semester
Course : Science Credits : 4 L T P: 3:1:0
Hours: 52

Course Context and Overview (100 words):
Atomic and molecular physics (AMP) is one of the canonical fields of physics. This course is developed by using quantum mechanics to provide the basic understanding for advanced courses in all branches of modern physics, physical chemistry and partially even biological and material sciences. AMP is highly productive in modern developments in experimental techniques especially spectroscopy. Few spectroscopic techniques will be discussed at appropriate places.

Prerequisites Courses:

First course on Quantum Mechanics

Course outcomes (COs):

On completion of this course, the students will have the understanding of the following:
CO1: necessity of quantum mechanics to explain the atomic spectra of one electron and multi electron atom.
CO2 : behavior of atoms under the influence of external fields such as electric and magnetic
CO3: explain the molecular spectra and different applications such NMR, ESR and RAMAN spectra
CO4: Laser and its applications

Topics	**Hours (Including Tutorials)**
<u>UNIT 1: Spectra of one-electron atom</u> Introduction to Spectroscopy and types of Spectra: Bohr Model for Hydrogen Atom, Bohr-Sommerfeld model of Hydrogen Atom, Sommerfeld's Relativistic Correction for energy levels of hydrogen atom, Fine Structure of Hydrogen Atom Magnetic Dipole Moments, Stern-Gerlach Experiment, Electron Spin, Spin-orbit interaction, Vector Atom Model, Spectroscopic terms Solution of Dirac equation in a central field; Relativistic correction to the energy of one electron atom. Fine structure of spectral lines; Selection rules; Lamb shift.	**10**

UNIT 2: Spectra of multi electron atoms: (An Introduction) Pauli's exclusion principle, Central-field and Hartree approximations field approximation; angular momentum, L-S and J-J coupling, Helium Spectra, Alkali Spectra,	**10**
UNIT 3: Interaction of atoms with electric and magnetic field (Hyper fine structure) Zeeman effect, Paschen-back effect, Stark effect, Hyperfine structure and isotope shift, Hyperfine splitting of spectral lines, selection rules, width of spectrum, X-ray spectra,	**10**
UNIT 4: Molecular Spectra Quantum mechanics of Molecules, Born-Oppenheimer approximation, Frank- Condon principle, rotational, vibrational, Electronic, and Raman spectra of diatomic molecules, Selection rules, Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR),	**15**
UNIT 5: Lasers Laser; Spontaneous and stimulated emission, Einstein A & B coefficients, Optical pumping, population inversion, rate equation, Modes of resonators and coherence length, Types of the lasers	**7**

Text Book

1. B.H.Bransden and C.J. Joachain, Physics of Atoms and Molecules, 2nd edition, Pearson Education, (2003).
2. G. Herzberg, Atomic Spectra and Atomic Structure, Dover Publications, (2003).
3. C. N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Forth Edition, McGrawHill (2016)
4. K. Thyagarajan and A.K. Ghatak, Lasers, Theory and Applications, 2nd edition, Springer US, (2011)
5. Gordon W. F. Drake, ed , Springer handbook of atomic, molecular, and optical physics Springer(2006).
6. H.E. White, Introduction to Atomic Spectra, McGraw-Hill, (1934)

Reference Book

1. **H.A.Bethe and R.W. Jackiw, Intermediate Quantum Mechanics, 3rd edition, Addison-Wesley, 1997.**
2. **L.L.Landau and E.M.Lifshitz , Quantum Mechanics-non-relativistic theory, Pergamon(1965).**
3. **R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and particles, 2nd Edition Wiley (2006)**
4. W. Demtroder , Laser Spectroscopy, 3rd Ed., Springer, (2003)

5. Online resources (NPTEL, MIT)

Evaluation Methods:

Item	Weightage
Quizzes/Assignments/ presentation/ attendance	25
Midterm	25
Final Examination	50

Prepared By

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Last Update: 19 May 2019