Atomic and Molecular Physics - Web course

COURSE OUTLINE

This course is an introduction to atomic and molecular physics with non-relativistic quantum mechanics and elementary mathematical physics as prerequisites. This course of lectures is designed to serve two main objectives- to develop the skills to solve real physical problems using quantum mechanics and to provide background necessary for advanced courses in other branches of physics such as optics, astrophysics, condensed matter physics and nuclear physics. Several examples from these areas are integrated in the course, often as problems with sufficient hints

Similarly, modern developments in experimental techniques especially spectroscopy are covered at appropriate places. Some advanced topics are included which can be covered in a 40 lecture course by dropping some of the more elementary topics which are normally covered in a second course on quantum mechanics. It is envisaged that this course could be a useful addition to the M Sc syllabus in universities.

COURSE DETAIL

S.No	Topics and contents	Number of Lectures
1	Introduction and perspective. Recall Hydrogen atom spectrum, separation of centre of mass and relative coordinate motion, isotope effect. Introduction to approximation methods in for stationary states - perturbation theory and variational principle. Atomic units.	5
2	Interaction of one electron atoms with electromagnetic radiation. Time dependent perturbation theory , Fermi golden rule, Virtual and real transitions, higher order perturbation effects. Density matrix description for mixed states. Louiville equation for density matrix, Bloch equations for resonant interaction.	5
3	Fine structure of H atom spectrum: spin orbit interaction and other relativistic corrections , perturbation theory estimates, other hydrogen like systems. Identical particles in quantum mechanics, structure of wave functions for spin independent Hamiltonian. He atom problem, perturbation and variational solutions.	5
4	Many electron atoms: central field approximation and the periodic table, Hartree- Fock equations, exchange interaction, Thomas Fermi model , Introduction to Density functional Theory.	5
5	Optical spectra of atoms, spectroscopic terms, Fine	5

NP-TEL

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Physics

Pre-requisites:

First course on Quantum Mechanics

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	structure and hyperfine structure, Zeeman effect, electron paramagnetic resonance and nuclear magnetic resonance.	
6	Molecules and clusters, Born Oppenheimer approximation, electron states in Hydrogen molecule ion and hydrogen molecule. Other diatomic molecules. Rotational vibrational spectra of diatomic molecules, nuclear spin effects, orthoand para- H_2.	5
7	Polyatomic molecules, symmetry classification of vibrational states, Rotational states, infra-red spectroscopy and Raman spectroscopy.	5
8	Atom-atom and electron atom collisions.	5
9	Advanced Topics: Nonlinear optical spectroscopy of atoms and molecules, Doppler free two photon spectroscopy and Coherent Anti-Stokes Raman spectroscopy. Laser cooling and trapping of atoms and ions.	5
	Total number of lectures	45

References:

1. B.H.Bransden and C.J.Joachain, Physics of Atoms and Molecules, 2nd edition, Pearson Education, (2003).
2. Gordon W. F. Drake, ed , Springer handbook of atomic, molecular, and optical physics Springer(2006).
3. H.A.Bethe and R.W. Jackiw, Intermediate Quantum Mechanics, 3rd edition, Addison-Wesley, 1997.
4. L.L.Landau and E.M.Lifshitz , Quantum Mechanics-non-relativistic theory, Pergamon(1965).