PH-418: Atomic and molecular Physics

Fall 2019

Resource Person: Badar Suleman

Text and reference books:

1. The standard text book is "Physics of Atoms and molecules" 2nd edition, by Bransden and Joachain. Pearson Education, Inc.
2. Reference will be made to "Concepts of Modern physics" 6th edition' by Beiser, McGraw Hill
3. Reference will also be made to "Atoms, Molecules and Photons" by Wolfgang Demtroder

Course Contents:

Week 1: Introduction. Modern Physics, Electron, Millikan Oil drop, JJ Thomson model of Atom. Rutherford Atom Model. Spectroscopy: emission and Absorption, High resolution. Line and band spectrum. (Beiser)

Week 2: The hydrogen Spectrum. Units used in Atomic Physics. Bohr atom model, Bohr-Sommerfeld model.

Week 3: The line series. The Rydberg constant. H_α line. The relativistic effects, Fine structure, Magnetic moment of electron. Zeeman Effect, The vector atom model. (Beiser).

Week 4: Review of Quantum Mechanics. Hydrogen wave equation solution and wave functions. Perturbation theory. Electron Spin, Angular momentum. Identical Particles. (Zettili + Beiser)

Week 5: Einstein A and B coefficients. Atomic Transitions and selection rules. Line width and line shapes. Natural Line broadening, Doppler broadening, pressure broadening. (Zettili)

Week 6: The Hydrogen and hydrogen like atoms. Spin orbit coupling. Fine structure constant. The hyperfine structure. Isotope shift and isotope separation.

Week 7: Many electron atoms. Electron configuration and electron states. Hund's rule, the "aufbau" principle. The periodic table. LS and JJ coupling. Alkali atoms. (Beiser)

Week 8: The Helium Atom. Many electron system

Week 9: Atoms in magnetic Field, normal Zeeman Effect, anomalous Zeeman effect, Paschen-Back effect. Atoms in electric field.

Week 10: The Hydrogen molecule, covalent bonds, spins and bonding and anti- bonding states. Molecular bonds. Hybrid orbitals. (Beiser), Rotation of molecules, rotational spectra rigid and non-rigid rotor, centrifugal distortion. Rotational transitions in molecule.

Week 11: Molecular Vibration, parabolic approximation, vibrational energy levels. Non- linear effects, vibrational transitions. Vibrational-rotational spectra. The electronic structure of diatomic molecule, the Born-Oppenheimer approximation. Separation of nuclear motion, separation of vibration and rotation. The notation of electronic states.

Week 12: The energy level and potential function diagrams. Frank-Condon principle and Frank-Condon factor.

Week 13: Special Topics: lasers, Optical pumping, Bose Einstein-condensation, Muonic atoms

Week 15: Very high resolution (two photon spectroscopy), Atomic beam experiments.