

Physical Chemistry II – Chem 542

Short lecture syllabus for Spring 2016

1. Electrodynamics
 - Maxwell's equations
 - Wave equations
 - Electromagnetic energy
 - Plane waves in a box
 - Charged particle interaction energy
2. Multipole couplings and external fields in the Hamiltonian
 - Multipole fields
 - Electrostatic and magnetostatic multipole interactions
 - Dipole-dipole couplings, Fermi contact, quadrupole couplings, Zeeman and Stark effects
3. Time dependent quantum mechanics
 - Schrödinger and Heisenberg formulations
 - Time dependent perturbation theory
 - Golden Rule
 - Absorption of an electromagnetic pulse
 - Spectral correlation functions
 - Wave packet propagation
4. Density matrices
 - Density matrices from wavefunctions
 - Time evolution
 - Incoherence by superposition and by reduction
 - Application: decoherence of a two level system coupled to a harmonic oscillator
5. Quantum-classical treatment of the two-level system
 - Bloch equations and connection to full quantum treatment
 - Applications: NMR pulse sequences, photon echoes
 - Einstein coefficients
6. n-level systems, lasers and optics
 - Refraction, reflection, and polarization
 - Gaussian and ray optics: eikonal equation
 - 3- and 4-level systems, lasing
7. Full quantum-classical treatment of molecule light interactions
 - Polarizability and susceptibility
 - Simple theory for the refractive index and absorption coefficient
 - Applications: scattering experiments DFWM, CARS, SEP and LIGS
 - Density matrix derivation of the molecular susceptibility
 - Correlation functions
 - Higher order susceptibility
 - Feynman diagrams
8. Second quantization: molecule-radiation interaction
 - Quantum field theory and photons
 - Transition moments
 - Applications: stimulated and spontaneous emission, absorption by randomly oriented molecules, Raman scattering