PHYSICS 565 – SPRING 2006

TΘ 11:20 - 12:40 QUANTUM ELECTRONICS
Room: TBA

Text: See handouts
will be devoted to
Prof. H. Metcalf

ATOMIC PHYSICS

I. LIGHT AND ATOMS
   A. Classical oscillating dipole - Radiation reaction
   B. Radiative Transitions - Classical Field
      1. Time-dependent perturbation theory, dipole and rotating wave approximations
         a) Oscillator strength, selection rules, stimulated emission, misc.
         b) Molecular transitions, Franck-Condon factor, symmetry
      2. Relaxation of approximations of item 1 (above)
         a) Higher order perturbation theory - 2 photon, Raman
         b) Quadrupole and higher order transitions
         c) Rotating wave approximation
      3. Removal of the perturbation approximation
         a) Rabi oscillations, two level atoms
         b) Dressed states, light shifts
         c) Bloch vector and Bloch sphere
   C. The Density Matrix
      1. Basic concepts - pure case
      2. The optical Bloch equations
      3. Power broadening and saturation
   D. Special Examples - superradiance, optical pumping, quantum beats, Hanle effect
   E. Quantized Field
      1. Spontaneous emission, Einstein A & B coefficients
      2. Alternate Theories of Jaynes, Boyer, Series

II. ATOMIC STRUCTURE
   A. One electron atom - Hydrogen
      1. Alkali atoms - quantum defect theory - Rydberg spectroscopy
      2. Fine and hyperfine structure,
      3. Zeeman and Stark effects, weak and strong fields
   B. Two electron atoms - single particle model, symmetry, perturbation methods
   C. Many electron atoms - shells and allowed states - Pauli exclusion principle
   D. Molecular Structure
      1. Vibrational and rotational Hamiltonian, structure, spectra.
      2. Electronic energy levels, symmetry, band spectra
      3. Splittings - fine structure, hfs, lambda doubling, Zeeman effect, etc.

III. LASERS AND SPECTROSCOPY
   A. Criteria for laser action, laser output, gain and loss
      1. Population inversion, Einstein coefficients, multilevel lasers
      2. Optical cavity, dielectric mirrors, cavity modes, Doppler width
      3. Laser spectra, Lamb dip, stabilization, saturation spectroscopy.
   B. Tunable lasers
      1. Modes, multiple laser lines, dye molecules
      2. Dye laser pumping, relaxation and spectra
      3. Tuning and stabilizing pulsed and CW dye lasers, bandwidth
      4. Introduction to diode lasers
   C. Laser Techniques
      1. Mode locking, ultra-short pulses
      2. The 2005 Nobel Prizes for the frequency comb
      3. Frequency multiplication, phase matching and ultraviolet production

IV. MOTION OF ATOMS IN LASER LIGHT - LASER COOLING AND TRAPPING
   A. Laser slowing of atomic beams - radiative forces on atoms
   B. The origin and nature of optical forces on atoms
   C. Ultra-low temperatures (µK, nK) - experiment and theory
   D. Optical, magnetic, and magneto-optic traps
   E. Bose-Einstein condensation