Physics 684  Quantum Optics and Laser Physics  Fall 2004

Instructor:  Hailin Wang
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Office hour:  Wed. and Fri. 11:00-12:00

TA:  None available this term.

Supplementary text:  Elements of Quantum Optics, Meystre & Sargent

References:

Optical resonance and two-level atoms, L. Allen and J.H. Eberly (Dover, 1987)
Optical coherence and quantum optics, L. Mandel and E. Wolf (Cambridge, 1995)

Grading:

Home work:  25%
Mid-term:  30%
Final:  40%
Term paper:  5%
Course topics: In this term, we will focus on the semi-classical description of light-matter interactions. After the introduction of the basic theoretical framework, we will explore a variety of fascinating optical phenomena.

I) Basic theory
1) Atom-field interactions for a two level system
   Interaction Hamiltonian
   Fermi’s golden rule
   Rotating wave approximation
   Rabi oscillation
2) Density matrix for a two-level system
   Equation of motion
   Level damping
   Bloch vectors and optical Bloch equations
3) Maxwell-Bloch equations
   Polarization and susceptibility
   Slowly varying field
   Absorption and dispersion
   Steady state solution
   Rate equation approximation
   Power broadening
   Semi-classical picture of stimulated emission and absorption

II) Special topics:
1) Semi-classical laser theory
   Population inversion and optical amplification
   The laser self-consistency equations
   Steady state amplitude and frequency
2) Coherent transient phenomena
   Photon echo
   Pulse propagation and area theorem
   Self-induced transparency
3) Atomic coherence in a three level system
   Coherent population trapping and dark states
   Electromagnetically-induced transparency
   Slow light
4) Mechanical effects of light
   Radiation pressure
   Laser cooling
   Doppler cooling limit and recoil cooling limit
   Sympathetic cooling
5) Pump-probe spectroscopy
   Spectral hole burning
   Optical stark splitting and Mollow spectrum