ADVANCED QUANTUM OPTICS

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Atom-field interactions.

Introduction. Classical theory of the atom-field interactions. Lorentz model. Classical image of spontaneous emission. Stimulated emission and absorption.

Semiclassical atom-field interactions. Overview: Quantum state, density matrix, pictures (Schrödinger, Heisenberg, interaction), Wigner distribution. Two-level atoms: Rabi flopping, dressed states, Bloch sphere, Bloch equations, consistency with other models, resonant fluorescence, mechanical effects of light on TLA. Three-level atoms: stimulated Raman transitions, coherent population trapping.

Quantum light-matter interactions. Quantization of the electromagnetic field. Atomic interaction with the quantized field. Cavity QED and the Jaynes-Cummings model.

Early atomic physics: Introduction; Spectrum of atomic hydrogen; Bohr's theory; Relativistic effects; Moseley and the atomic number; Radiative decay; Einstein A and B coefficients; The Zeeman effect.

The interaction of atoms with radiation: Perturbation by an oscillating electric field; rotating-wave approximation; Einstein B coefficients; Interaction with monochromatic radiation; concepts of π-pulses and π/2-pulses; Bloch vector and Bloch sphere; Ramsey fringes; Radiative damping; damping of a classical dipole; optical Bloch equations; optical absorption cross-section; Cross-section for pure radiative broadening; saturation intensity; Power broadening; a.c. Stark effect or lightshift.

Laser cooling and trapping: scattering force; Slowing an atomic beam; The optical molasses technique; The Doppler cooling limit; magneto-optical trap; The dipole force; Optical lattices; Sisyphus cooling; Raman transitions; Velocity selection by Raman transitions; Raman cooling; Atomic fountains.