

Lecture 4: Multi-photon and Multipole Transitions

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Lecture Outline

1. Review

- Orbital and Spin Angular Momentum of Light. Introduction to Vector Spherical Harmonics.
- Hyperfine Coupling (Beyond the $\hat{\mathbf{I}} \cdot \hat{\mathbf{J}}$ coupling.)

2. Higher-order Single-photon Transitions

- Introduction to electric dipole (E1), magnetic dipole (M1), and electric quadrupole (E2) transitions.
- General Formalism to Multipole Transitions (E1, E2, E3 & M1, M2, M3 ...).
- Excitation of Multipole Transitions at various Polarizations $\hat{\mathbf{e}}$ and Wavevector Directions $\hat{\mathbf{k}}$.

3. Forbidden Transitions

- Spin-orbit-coupling induced Weakly Forbidden Transitions.
- Hyperfine-coupling induced mixing: Clock Transition.
- Spectroscopy on an Optical Clock Line.

4. Multi-photon processes

- Perturbative Treatment of Multi-photon Processes.
- Overview of the Raman process.
- Detailed discussion of two-photon Raman transitions and STIRAP.
- Examples and Applications of Multi-photon Transitions in Precision Atomic Physics.