

# Lecture 5: Polarizability and Hyperpolarizability of Atoms/Ions

Mehedi Hasan

## 1. Review

- Wigner-Eckart Theorem.
- Matrix Elements of Rank-1 and Rank-2 irreducible spherical operators.
- Second- and Fourth-order Perturbation Theory.

## 2. Introduction to Atomic Polarizability: A Classical perspective

## 3. Polarizability of a Two-level System

- Estimation of Trap-depth and Scattering Rates.
- Relation to Classical Model.

## 4. Polarizability of a Multi-level Atoms

## 5. Scalar, Vector, and Tensor Polarizabilities

- The irreducible representation of polarizability.
- Calculation of scalar, vector, and tensor polarizability of a multi-level atom and compare the calculations with experiment.
- Calculation of Magic, Anti-magic, and Tune-out wavelengths.
- Manipulation of Vector and Tensor Polarizability via the polarization of light.

## 6. Optical Lattice and Dipole Traps

## 7. Experimental Techniques

- A Naive measurement of differential light-shifts.
- Precision measurements of differential light-shifts.
- Measurement of Tune-out Wavelength in Two Different Ways.

## 8. Introduction to Hyperpolarizability

- Role of hyperpolarizability in the context of an optical clock.
- Measurement of Hyperpolarizability.