



IISER Mohali

[August 2024 Session]

PHY 403 (Atomic and molecular physics)

Assignment-1

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2024-09-01 15:56:26+05:30

1. Read the article *The spectrum of atomic Hydrogen* uploaded on the moodle.
2. Due to finite nuclear mass effect, the spectral lines of the deuterium ${}_1H^2$ is shifted compared to hydrogen. Estimate the shift for H_α line.
3. Provide an order of magnitude comparison of corrections (in eV) to the hydrogen atom spectrum due to fine structure, Lamb shift and hyperfine structure. Take $\alpha \sim \frac{1}{137}$.
4. *Spectral shift due to finite nuclear size*: Problem 5.9 in B&J.
5. Analyze Zeeman effect for the case when the strength of the external magnetic field is such that the spin-orbit coupling term can be treated as a perturbation.
6. Estimate the typical electric field strength inside atoms by taking the example of Hydrogen atom in the ground state.
7. Discuss the splitting of $n = 3$ energy levels in presence of an external Electric field $\mathcal{E}_{\text{ext}} = \mathcal{E}_0 \hat{z}$.
8. Consider an electron at rest in a uniform magnetic field $\mathbf{B} = B_z \hat{z}$.
 - (a) Write down the Hamiltonian H_0 for this system, and calculate the eigenvalues and eigenstates.
 - (b) Compute the first nonzero correction to the ground state energy of the system in perturbation theory when a small uniform magnetic field B_x is turned on along x direction.
 - (c) Taking $\chi = \cos\phi \chi_1 + \sin\phi \chi_2$ as the trial wave function, find the bound on ground state energy using the variational method. $\chi_{1,2}$ are eigenstates of H_0 , and ϕ is an adjustable parameter.