Physics 137B Discussion 2

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These are notes taken from discussion sections for UC Berekley's Physics 137B class in the Sprng 2024 semester.

Contents

1 January 29 - Perturbation Theory

Today:

- Non-degenerate Stark Effect
- Degenerate Star Effect
- Etc.

The Hamiltonian for the Hydrogen atom is

$$H_0 = \frac{P^2}{2\mu} - \frac{e^2}{r}$$

where μ is the reduced mass.

The solutions for this Hamiltonian are

$$\psi_{nlm}$$

and they have energies

$$E_{nlm}$$

The ***Stark Effect*** happens when we add a perturbation of the form

$$H_1 = eE\hat{z}$$

Now, what is the ***First Order correction*** to the energy?

$$\begin{aligned} E^{(1)}_{nlm} &= \langle nlm \,|eEz|\, nlm\rangle \\ &= \int \underbrace{|\psi|^2}_{even} \underbrace{z}_{odd} d^3r \\ &= 0 \end{aligned}$$

Shit! Our first order corrections are zero. We're gonna have to go higher to get a more accurate answer. Let's find the ***second order correction***

$$E^{(2)}_{100} = e^3E^2 \sum_{nlm\neq(0,0,0)} \frac{|\langle nlm \,|z|\, 100\rangle|^2}{E^{(0)}_1 - E^{(0)}_n}$$

Now,

$$\langle nlm \,|z|\, 100\rangle = \int d^3r R^*_{nl}(r) Y^*_{lm}(\theta,\phi)[r\cos(\theta)] R_{10} Y_{00}$$