QUANTUM MECHANICS III

PHYS 518

Problem Set # 2

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Due: Oct. 8, 2010

The magnetic interaction between the spin dipole moment of the electron and that of the proton in the hydrogen atom is given by the Fermi contact term in the Hamiltonian:

$$\mathcal{H}_{\text{Fermi contact}} = \frac{8\pi}{3}(g_e\mu_B)(g_p\mu_N)\mathbf{s}_e\cdot\mathbf{i}_p\delta(\mathbf{r}) \tag{1}$$

In this expression $\mathbf{s}_e$ is the electron spin angular momentum and $\mathbf{i}_p$ is the proton spin angular momentum; $\mu_B = e\hbar/2m_ec$ is the Bohr magneton, $g_e = 2$ is the "gyromagnetic moment" of the electron, g_p is the corresponding moment for the proton, $\frac{8\pi}{3}$ is a usual geometric factor, and the delta function tells us that there is no interaction (via this term, at least) unless the electron is sitting on the proton (hence, "contact" interaction).

1. For an electron in its spacial ground state, what are the values of L, S, J, I, F? As usual, $\mathbf{l}$ is the electron orbital angular momentum, $\mathbf{s}$ is its spin angular momentum, $\mathbf{j}$ is the total electron angular momentum, $\mathbf{i}$ is the nuclear spin angular momentum, and $\mathbf{f}$ is the total atomic angular momentum. Compute the energy difference between the $F = 0$ and $F = 1$ states. Give this value in terms of eV, frequency (in MHz), and wavelength (in cm). Does the wavelength ring a bell (so to speak)?

2. Compute the spin-flip transition energies (and their wavelengths) when deuterium and tritium nuclei replace the proton.

3. Ditto for $p^+\mu^-$.