Physics 285a Problem Set 8

posted November 7, 2023, due November 8, 2023

Problem 1. Full level scheme

Let's have a somewhat closer look at level schemes.

a) Make a full level scheme in a weak magnetic field $\vec{B}$ for the hydrogen $n = 3$ level. You can do this as a table where you list at least $n, l, J, F, m_F, g_F, \Delta E$, where the energy shift is given in terms of $\mu_0 B$ or as a level diagram (won't probably fit as one, distribute...) – best would be both. (As indicated in class, you can neglect the term $-\vec{\mu_I} \cdot \vec{B}$.)

b) Do the same thing as in part (a), but for a very strong magnetic field.

c) *Extra credit:* Do the full calculation for the intermediate regime. Here, you can get nearly full credit if you just point out how to solve this, i.e., give the matrix that needs to be diagonalized. If you feel up to it, do the diagonalization numerically.

Problem 2. Transitions energies Here, we look at the transition between the $n = 1$ and $n = 2$ states in hydrogen. For this problem, when a magnetic field is considered, assume that we are in the weak field limit.

a) If we neglect the nuclear spin, what transitions are allowed? How many different lines (i.e., frequencies) do we see without a magnetic field? How many with a magnetic field? What are the frequency shifts for the various lines as a function of $\mu_0 B$? Allowed transitions have $\Delta l = \pm 1$, $\Delta J = 0, \pm 1$, $\Delta m_J = 0, \pm 1$, but $\Delta m_J = 0$ is not allowed if also $\Delta J = 0$.

b) *Extra credit:* Why do we have those rules? (Looking this up anywhere, including on Wikipedia, is allowed. But let us know where you found it!)

c) How does the counting change if we take into account the nuclear spin? (That is, how many lines do we see without and with a magnetic field?) Selection rules here are the same as above, but for F, m_F instead of J, m_J.