Physics 472 – Spring 2010

Homework #7, due Friday, March 5

1. [2] Griffiths problem 6.11, part (a) only. (Part (b) of this problem is a joke.)

2. [5] Griffiths problem 6.21. We did some of this in class. To organize your answer, I suggest you construct a table with the following columns: j, l, g_J, m_j, $m_j g_J$. Note that the last column of that table tells you the slopes of the lines on your plot of energy vs. $\mu_B B_{ext}$, for weak magnetic fields.

3. [2] We have two different procedures for calculating the Zeeman energy of the hydrogen atom, depending on whether the magnetic field is "weak" or "strong." Calculate the magnetic field strength (in Tesla) for which the Zeeman energy is equal to the fine structure energy shift for the n=1 state of hydrogen.

4. [5] Griffiths problem 6.36. We did most of this problem in class, but we didn't calculate the one nonzero matrix element. I want you to repeat the whole problem to make sure you understand it. We used two symmetries to figure out which matrix elements of the form $\langle n,l',m_l'|z|n,l,m_l\rangle$ are zero. The first was rotational symmetry: $[\hat{z},\hat{L}_z]=0$ implies $(m_l'-m_l)\langle n,l',m_l'|z|n,l,m_l\rangle = 0$. The second was parity: $\hat{\Pi}\hat{z}\hat{\Pi} = -\hat{z}$ implies $(-1)^{l'+l}\langle n,l',m_l'|z|n,l,m_l\rangle = -\langle n,l',m_l'|z|n,l,m_l\rangle$. Note that we can ignore spin in this problem, since the electric field does not couple to spin.

5. [6] Griffiths problem 6.37. Follow the same strategy you used to solve the previous problem, i.e. use symmetries to figure out which matrix elements of the form $\langle n,l',m_l'|z|n,l,m_l\rangle$ are zero.

   First, show which elements of the 9×9 matrix are zero. Then calculate the first non-zero matrix element, $\langle 3,0,0|z|3,1,0\rangle$, using Tables 4.3 and 4.7 in Griffiths. Use Mathematica to do the radial integration. You can take the values of the other nonzero matrix elements from Griffiths. Construct the 9×9 matrix representation of $\hat{z}$. If you choose the order of the 9 states carefully, then the matrix should break into a 3×3 block, two 2×2 blocks, and two trivial 1×1 blocks. Calculate the eigenvalues and their degeneracies. Don't forget to multiply the eigenvalues by eE_{ext} to get the energies.