Physics 472 – Spring 2009

Homework #7, due Friday, March 6

1. [6] Griffiths problem 6.9. To simplify your notation, label the three eigenvectors of H^0 as $|1\rangle$, $|2\rangle$, and $|3\rangle$. When you get to part (c), write down the 3 x 3 matrix form of H' in that basis. You can then read all the matrix elements you need directly from the matrix, without performing any matrix multiplication. When you get to part (d), don't be faked out when you discover that H' is already diagonal in the 2D subspace of degenerate states.

   Add a part (e) to the problem: Calculate the second-order shifts to states $|1\rangle$ and $|2\rangle$. You use the same formula [6.15] for second-order P.T., but now the sum is only over the states outside of the degenerate subspace, i.e. m=3 only. (That is because you have already exactly diagonalized H' within the 2D subspace.) With this last calculation, all three of your energies should agree with the expansion of the exact results to order ε^2.

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

3. [5] Griffiths problem 6.21.

4. [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, for the *n*=1 state of hydrogen.

5. [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 $(-1)^{l'+l}\langle n,l',m_l'|z|n,l,m_l\rangle = -\langle n,l',m_l'|z|n,l,m_l\rangle$.