Problem Set 6

Physics 235 Fall Quarter 2004 H.J.Frisch HEP320 (702-7479)
Nov. 7, 2004 Office Hours: Friday aft., or by appointment

Due Monday, Nov. 14. (hand in at class).

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Lab Grades: I've recently heard it said that the lab report grades "don't matter". T'ain't so. Most people take the labs very seriously and do a good job, and hence there is not a big range in total lab grades. The labs thus usually determine which way to shift inside a grading bin- e.g. an A^- is not far from a B^+ in the grand total score since the divisions are fine, and so the lab grades normally change a grade at that level (not small even in this case!). Egregiously bad or spectacularly good lab scores lie outside the normal distribution, and have a much bigger effect on the grade, and on one's reputation in the department. You can compensate a fair amount for low test scores with good lab grades (and vice versa).

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Reading This is a long reading assignment. Start today. Please take careful notes and hand them in separately (and labeled, with your name on it) with your problem set. They will be graded.
Shankar: All of Chapter 17 (pp.451-471). (take notes- hand in separately).

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Problems (you may want to go back and reread previously assigned reading:
Perturbation Theory

1. **Consider a 1D harmonic oscillator of charge q in an weak electric field of magnitude E along its axis.. Calculate the shift in the energies of the eigenstates to first order in qE.**

2. **In the above case calculate the perturbed eigenfunctions in terms of the unperturbed kets. Discuss the physical significance of your answer.**

3. **Now calculate the second order shift in energy.**

4. **Calculate the first-order shift in the ground state of hydrogen due to the finite size of the proton, assuming the proton is a sphere of constant charge density.**

5. **Find the approximate shift of the ground state of hydrogen due to including relativistic effects to order $(v/c)^2$.**

6. **Shankar 17.3.3**

7. **Write three paragraphs describing the fine-structure energy shift in hydrogen quantitatively (i.e. put in numbers and get answers in eV for at least several states). Be as complete as you can.**

Review of reading: matrix elements, selection rules, parity

1. **Consider a hydrogen atom in a strong magnetic field. Derive the selection rule on Δm_l, where m_l is the eigenvalue of L_z, by evaluating the electric dipole moment between eigenstates.**

2. **Derive the selection rule on the parity of the initial and final states in electric dipole transitions.**

3. **(Eisberg) Draw the hydrogen energy-level diagram for all states through** $n = 2$ **but with the splitting according to** l **also shown. Using arrows connecting pairs of levels, show all the transitions that are allowed by the selection rules.**

4. **Explicitly calculate the electric dipole moment matrix elements for a charged one-dimensional simple harmonic oscillator making the transitions** $n_i = 3 \to n_f = 0$**,** $n_i = 2 \to n_f = 0$**, and** $n_i = 1 \to n_f = 0$**. What is the selection rule in this case?**