Physics 252 – **Modern Physics**

Homework Assignment #6

Due Friday, March 16, 2007, at the beginning of class.

Reading: Feynman, chapter 5, 7.1, 19.6, 35.1-2

1. Say we have an electron and a proton, both of which are spin-1/2 particles. What are the possible values of J_z for the combined system when both particles are at rest? Now let them be combined into a hydrogen atom. What are the possible values of J_z for the hydrogen atom, when the electron is in the nth orbital and the proton at rest?

2. What are the possible values of L_z for an electron in the $n = 3$ energy level of an atom? What are the possible values of J_z?

3. In this and the next problem, consider a beam of spin-1/2 particles moving in the y direction, all in the $S_z = \hbar/2$ state. Now put these particles through a Stern-Gerlach apparatus tilted in the x direction; after they come through this, we block all the $S_x = \hbar/2$ particles. What is the probability a given particle is blocked in this x apparatus?

4. Give the state of the system after this blocking, both in terms of the z-basis and the x basis. Now run this beam of $S_x = -\hbar/2$ particles through a Stern-Gerlach apparatus in the z direction, and block the $S_z = \hbar/2$ particles. What is the probability (relative to the initial beam) it makes it through this second blocking, all the way to the end?

5. The states in any tilted basis can be expressed in terms of the states with definite S_z. The relations for a spin-1 particle are given in formulas (5.38,5.39) of Feynman. Express each of the states $|+X\rangle$, $|0X\rangle$ and $|-X\rangle$ of a spin-1 particle in terms of the states $|+Z\rangle$, $|0Z\rangle$ and $|-Z\rangle$.

6. Express each of the states $|+Y\rangle$ and $|-Y\rangle$ as a linear combination of the states $|\pm Z\rangle$. To do this, you need to make sure that $|+Y\rangle$ and $|-Y\rangle$ are orthogonal (i.e. $\langle -Y|+Y\rangle = 0$), and that e.g. $|\langle \pm X| \pm Y\rangle|^2 = |\langle \pm Z| \pm Y\rangle|^2 = 1/2$.