PHY140Y

Spring Term – Tutorial 22 Discussion

20 March, 2000

1. We form a beam of hydrogen atoms that start all in their ground state. We illuminate this beam with a laser beam tuned to a specific frequency, and then pass the beam through a Stern-Gerlach apparatus.

   (a) We want to populate the quantum states with $n = 2$ principal quantum number. What frequency should we tune the laser light to? Assume that we can ignore any energy-splitting due to angular momentum effects.

   (b) How many different angular momentum states can the atoms be in if we assume we have promoted all the hydrogen atoms to $n = 2$ states? What are their angular momenta? Remember that there is a selection rule that requires $\Delta l = \pm 1$ in such "optical" transitions.

   (c) Ignoring the spin of the electron, how many separate beams would you expect the hydrogen atoms to form once they pass through the magnetic field of the Stern-Gerlach apparatus?

   (d) Now remember that the electron is a spin one-half particle. How many different angular momentum states with $n = 2$ exist in the beam? How many different beams would you expect to form? Would the intensity of each beam be equal?

2. We have a number of electrons in a harmonic oscillator potential well. The natural frequency of the harmonic oscillator is ω.

   (a) If the total energy of the configuration is $6.5\hbar\omega$, how many electrons are there in the well?

   (b) What is the energy of the most energetic electron?

   (c) If we shine a laser on this system, what are the lowest two frequencies of light that would be absorbed?