Workshop module 11 - Physics 123, Spring 2013

1. A sample of atoms is prepared so they each have electrons in an excited metastable state with a lifetime of 3.7 ms. The electrons eventually drop down into the ground state and emit light in the process. How well known is the energy of the electron in the metastable state? How wide is the spectral line emitted by these atoms as the electron drops back into the ground state?

2. Estimate roughly the spread of momenta of protons bound within an atomic nucleus.

3. What is the ionization energy of the metastable state of Li++ that has the electron with a quantum number of n=2?

4. A monochromatic (all one frequency) beam of light excites hydrogen atoms in a glass tube. Light of 10 different frequencies is observed to be emitted by the gas in the tube as the hydrogen atoms fall back to the ground state. What is the energy of the photons in the incident monochromatic beam of light?

5. Consider a particle of mass m in a 1-dimensional box with $V=0$ for $0 \leq x \leq L$ and $V=\infty$ for $x<0$ and $x>L$. What is the wavefunction for the first excited state of this system? What is the difference in energy between the ground state and the first excited state of this system?

6. Consider a particle of mass m confined to a 2 dimensional box of length L in both dimensions in the xy plane. Write Schrodinger's non-relativistic time-independent equation for such a system. Do not solve this equation. However, assume the differential equation and the wavefunction solution of the equation are separable, i.e., think of the x and y solutions as independent of each other, and, using what we know about the solution to the 1-dimensional problem, write down a plausible solution for the wavefunction and the possible energies for the system. What are the quantum numbers of the three lowest energy states of the system? What is the difference in energy between the ground state and the first excited state? Is the ground state degenerate? (No, that's not a moral judgment, in spite of how it sounds.) Is the first excited state degenerate? Is the second lowest excited state degenerate?