PHYS514		**Homework 2**

PHYS514
Fall 2013

Homework 2
due ??

1. Foot 6.2…Hyperfine structure of Li mystery…don't answer the "Explain" questions and don't verify the interval rule…start at "Determine"

2. Hydrogen-Deuterium 1S—2S isotope shift:
Calculate the mass and volume shift for the 1S-2S transition in Hydrogen vs. Deuterium. Use 0.8 fm for the radius of the proton, and 2 fm for the radius of the deuteron. Use the equation for the volume shift that we wrote down in class (since it is for Hydrogenic atoms). Compare your calculation to a measurement: http://prl.aps.org/pdf/PRL/v80/i3/p468_1.

3. Zeeman effect in an alkali atom:
a. Derive the Breit-Rabi formula that we wrote down in class for the Zeeman energy of a ground-state alkali atom with nuclear spin I, nuclear g-factor g_I, and hyperfine ground state splitting ΔE_{hfs} by diagonalizing the appropriate Hamiltonian. Find expressions for the energy shift for each $|F, m_F\rangle$ state for any magnetic field strength B. Also determine how to express the each $|F, m_F\rangle$ state in the $|m_I, m_s\rangle$ basis for any B. It's OK to involve Mathematica at some point, but be sure to carefully write out how you parameterize the Hamiltonian.

b. Using the results of part **a** for the Breit-Rabi formula (or, if you can't get part **a** to work out, use what we wrote down in class), plot the energy of all m_F states for the two hyperfine ground states in ^{87}Rb vs. magnetic field for 0—2000 Gauss. You'll need to track down the ground-state hyperfine splitting (or A) for this atom, as well as g_I. Check the lecture notes on "real atoms" for some hints on where to find this info!

c. At approximately what field does the magnetic moment of the $|F = 1, m_F = -1\rangle$ vanish? What is the $|F = 1, m_F = -1\rangle$ state in the $|m_I, m_s\rangle$ basis at that field? How does this explain the behavior of the magnetic moment?