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](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 $\Delta E_{hfs}$ by diagonalizing the appropriate Hamiltonian. Derive the energy shift for each $|F, m_F\rangle$ state for any magnetic field strength $B$. Also determine how to express 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 $^{87}\text{Rb}$ 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 alkali 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?