Physics 570B, Spring 2011
Assignment 07
Due Tuesday, Mar. 8

1. *Baym* problem 11.7 (page 244).

2. Write an approximate ground state wavefunction for a Lithium atom. Use $\vec{r}_1$, $\vec{r}_2$ and $\vec{r}_3$ for the coordinates of the three electrons. Don't forget to include spin. Write out all the terms to make the wavefunction completely antisymmetric.
   Hint: If we didn't have to worry about antisymmetry, we could write

$$\psi(\vec{r}_1, m_1, \vec{r}_2, m_2, \vec{r}_3, m_3) = \phi_{1S}(\vec{r}_1) \uparrow_1 \phi_{1S}(\vec{r}_2) \downarrow_2 \phi_{2S}(\vec{r}_3) \uparrow_3 \tag{1}$$

   where ϕ_{1S} is the ground state hydrogenic wave function with $Z = 3$, etc. m_1 is the z component of the spin of the first electron.

3. Using the result of the previous problem, show that the spin of the two electrons in the 1S state is zero.

4. What is the spin of the first excited state of the helium atom? Explain why the results of last week's homework problems are relevant to determining this spin.

5. What are the orbital angular momentum, spin and total angular momentum of the ground state of boron? Explain your answer. (boron has atomic number 5.)

6. The electronic configuration of the ground state of silicon is

$$(1S)^2(2S)^2(2P)^6(3S)^2(3P)^2 \tag{2}$$

   What are the possible values of S, L and J (spin, orbital angular momentum, and total angular momentum) for this electronic configuration? What will S, L and J be in the ground state? Do not just quote Hund's rules. Instead, explain your answers using the concepts covered in the textbook and lecture.

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7. This problem is trivial if you understand each step

   (a) What are the possible values for the total orbital angular momentum of three particles, each with orbital angular momentum one?

   (b) For three vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$, the triple product $\vec{a} \cdot \left(\vec{b} \times \vec{c}\right)$ is the volume of the parallelepiped whose edges are $\vec{a}$, $\vec{b}$ and $\vec{c}$. Show that this expression is completely antisymmetric under exchanges of the vectors.

   (c) $\vec{a}$ is a vector. What orbital angular momentum does it correspond to? The expression above, $\vec{a} \cdot \left(\vec{b} \times \vec{c}\right)$, is a scalar. What orbital angular momentum does it correspond to?

   (d) The ground state configuration of nitrogen has three electrons in the 2P orbitals. What are the spin and orbital angular momenta of the ground state of nitrogen? What is the angular part of the wave function for these three electrons? (Best done in Cartesian coordinates)