Phys 551 Homework 2

1. Exited states of noble gas atoms

Consider an excitation of a single electron out of the closed *p* shell of a noble gas atom to the next *s* shell. The resulting hole can be considered as a *p* electron with opposite charge. The Hamiltonian describing the spin-orbit and spin-spin exchange interaction of the *p* hole with excited *s* electron can be written as

$$H = -a\mathbf{l}_1 \cdot \mathbf{s}_1 - b\mathbf{s}_1 \cdot \mathbf{s}_2$$

Here *a* and *b* are constants and $l_1 = 1$. The eigenstates of the Hamiltonian have definite values of total angular moment *J*. For small *a*, the eigenstates also have a definite value of total *S* while for small *b*, they have a definite value of j_1. In general, there will be some mixing between such states with the same total angular momentum *J*.

a) Find the energies of the eigenstates of the Hamiltonian as a function of *a* and *b.*
b) Using NIST atomic level database find the energies of the 4 lowest excited states in Ne and Xe. Find the spin-orbit constant *a* and spin-spin constant *b* for Ne and Xe.
c) One can check the accuracy of this approximation of the Hamiltonian since 4 energy levels are described by two constants plus some common electrostatic energy. How accurate is this description for Ne and Xe?

2. Optical dipole transitions in K atom

The ground state of K atom has electronic state $4S_{1/2}$ and I=3/2 so it has two hyperfine states, with F = 2 and F = 1. The strongest dipole transition from the ground state goes to the excited state $4P_{3/2}$, which has 4 hyperfine levels. Setup a computer program to calculate the relative strength of radiative transitions between |F,m> and |F',m'> states when the atom is illuminated with linearly polarized light.

a) Which of the transition is the strongest?
b) Which transition is allowed but is the weakest?
c) What selection rules describe the transitions that are forbidden (i.e have zero strength)?