PHY403 Atomic and Molecular Physics Aug-Dec 2019: Tutorial 5

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1. Calculate the Clebsch-Gordan table of coefficients for coupling a spin-1 particle with a spin-1/2 particle. Do not just write out the table entries, but work out each entry and its justification and the CG properties you used to arrive at the number.

2. For the one-electron case the spin-orbit term in the Hamiltonian is given by

$$H_{SO} = \frac{1}{2m_e^2c^2}\frac{Ze^2}{4\pi\epsilon_0 r^3}(\vec{l}.\vec{s})$$

   Find the energy of the splitting due to the spin-orbit interaction for the case when the valence electron of the sodium atom (atomic number 11) is excited to the $5p$ level.

3. Consider the $j-j$ coupling scheme instead of the $L-S$ coupling scheme, where the ususal angular momentum and spin quantisation rules apply. For a two-electron system show that the number of terms in the $L-S$ and $j-j$ coupling schemes is the same.

4. Draw a level diagram after including the $L.S$ coupling for the carbon atom in its ground state. Show the schematic level splitting and label each level using its term symbol.

5. Work out the fine structure of the $1s2p$ configuration of the Helium atom.