PHY2005
Atomic Physics

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(6) Multi-electron atoms: adding angular momenta

Learning goals

1. To introduce notation that distinguishes angular momenta of single electrons from the summed angular momenta that apply to multi-electron atoms as a whole.
2. To learn how to sum quantised angular momenta (using quantum numbers).

Total angular momenta in atoms

Convention:

- Use lower case letters for quantities individual to an electron
- Use upper case for total of atom (= sum over all electrons in the atom)

$$\mathbf{L} = \mathbf{l}_1 + \mathbf{l}_2$$

- Same convention for quantum numbers
- Applies to all types of angular momentum

Summation of quantised angular momenta

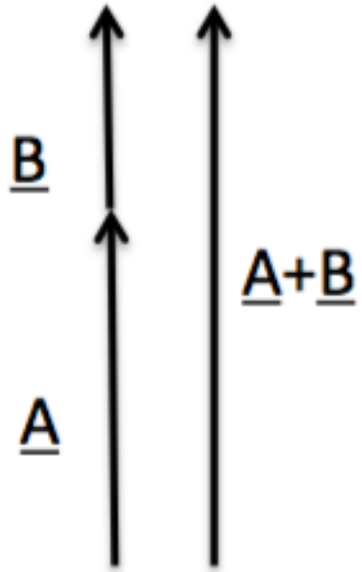
- Summation easily done with quantum numbers.
- To sum electrons with l_1 and l_2 :
  - Expect multiple allowed values of L
  - Maximum $L = l_1 + l_2.$
  - Minimum $L = |l_1 - l_2|.$
  - Integer steps between allowed:

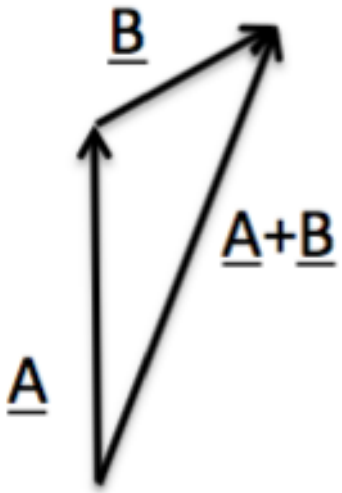
$$L = |l_1 - l_2|, |l_1 - l_2| + 1, ..., l_1 + l_2 - 1, l_1 + l_2$$

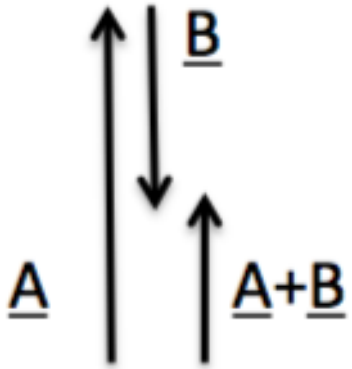
  - For each allowed L usual set of z-component QNs

$$M_L = -L, -L + 1, ..., L - 1, L$$

Reminder: vector addition







Terms in multi-electron atoms

- In spectroscopic notation of multi-electron atoms, the term gives the angular momentum QNs of the whole atom:

$$^{2S+1}L_J$$

Summary/Revision

- In multi-electron atoms, we use upper case letters for angular momenta (and associated quantum numbers) that describe the sum over all the electrons in the atom. Lower case letters are used when describing individual electrons.
- Quantised angular momentum vectors can be summed by applying a simple rule for combining the associated quantum numbers.
- It is usually the case that summing angular momenta leads to more than one possible resultant: this can be understood as a consequence of different allowed "orientations" of the vectors being summed. When finding / describing the possible states of atoms it is important to consider *all* the possibilities.
- In multi-electron atoms the spectroscopic *term* is used to identify the angular momentum quantum numbers of the whole atom.