22. Electron Wave Interference

Centered around the nucleus, the shapes of the electron clouds are determined by their energy. Within a single atom, electron clouds *shield* each other based on their different energies and interactions with a single nucleus. When electron clouds in a single atom occupy the same space, this results in shielding. However, when two different atoms are brought together, the electron clouds (or 3D electron waves) will *overlap* and *interfere* with each other, much like classical wave interference. This interference creates new molecular orbitals (MOs) out of the initial atomic orbitals (AOs).

Shielding: Single Atom

Overlap: Two Atoms

Go to the following applet:
http://quantum.bu.edu/CDF/101/23-ElectronWaveInterference.cdf

The two buttons at the top of the applet allow you to switch between constructive (additive) and destructive (subtractive) interference. The slider at the top will now allow you to change the separation of the two waveforms until they are perfectly overlapped.

1) When two waves are in phase (shown on the image below), they constructively interfere. Using the applet, simulate this interference and draw the resulting wave on the dotted line below.

2) What happens to the amplitude of the resulting wave? What would this mean for electron density of the resulting electron wave?

3) When two waves are out of phase (shown on the image below), they destructively interfere. Using the applet, simulate this interference and draw the resulting wave on the dotted line below.

4) What happens to the amplitude of the resulting wave? What would this mean for electron density of the resulting electron wave?

We can apply this classical example of wave interference to the bonding of two atoms. During covalent bonding, the electron waves in each atom interfere as they physically overlap in space. However, there are a few problems with using this classical example with electron waves. First, when two atomic orbitals interfere, they produce two resulting molecular orbitals. (The number of AOs = the number of MOs). This is because both constructive and destructive interference occurs each time. Second, the presence of nuclei in each atom prevents complete interference of the electron waves (i.e. the two nuclei of each atom can not occupy the same space).

Go to the following applet:
http://quantum.bu.edu/CDF/101/1sMolecularOrbitals.cdf

In the applet, the red electron clouds are for those waves that are "out of phase", meaning they are opposite each other. The green electron densities are "in phase" electron waves. You can see how the electron waves interfere by the blue lines.

5) Describe what physically happens when two electron waves overlap "in phase"? What type of interference is this?

6) Describe what physically happens when two electron waves overlap "in phase"? What type of interference is this?

7) Which of the two situations above (in phase or out of phase) would result in a bond? Explain.

