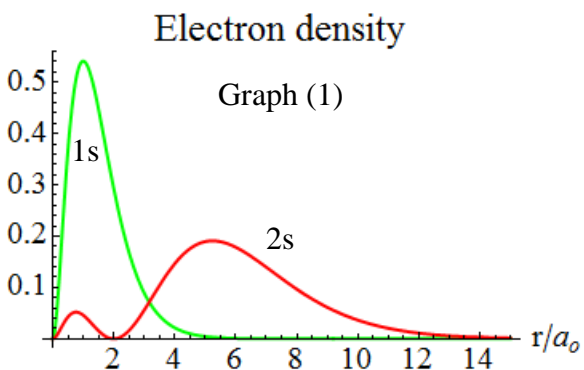


18. Shielding: Electron Waves in a Single Atom

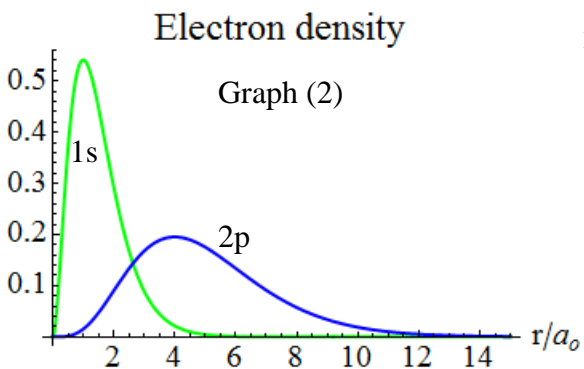
Single electron atoms (H, He^+ , Li^{2+}) are a fundamental way to understand how electron waves form energy states in an atom. For a single electron atom with a nuclear charge greater than one, the increased attraction between the nucleus and the electron changes the energy of the electron cloud. As a result, the ionization energy for Li^{+2} is greater than for H because of the increase in attractive force (three protons in Li^{+2} instead of one proton in H).

For multi-electron atoms, however, electrons will repel each other, again changing the energy of each electron cloud. When additional electrons are added to an atom, the electron clouds overlap around the nucleus. When they overlap, the electron density that is closer to the nucleus blocks some of the attractive force of the nucleus. This effect is called “shielding”. Think of it like a lampshade around a light bulb. While the lampshade does not change the intensity of the light bulb, it shields the brightness from the person on the outside. The shielding of one electron on another seemingly decreases the attractive strength of the nucleus, changing the effect of the nuclear charge on the outer electron. The resulting strength of the nucleus on these electron clouds is called the effective nuclear charge (Z_{eff}) such that the effective nuclear charge is less than the nuclear charge ($Z_{\text{eff}} < Z$).

To better understand shielding, it is helpful to look at two electron density graphs on the same set of axes. The images below show the electron densities of the 1s and 2s electron clouds, and the 1s and 2p electron clouds. These graphs represent the distance from the nucleus where the electron clouds overlap. At various distances away from the nucleus (r), the shielding of the two clouds changes. These changes determine the overall shielding of the electron clouds.



- 1) Based on graph (1): notice that the inner loop of 2s (on the left near the nucleus) is in the same approximate location as the 1s electron cloud. Describe how the 1s electron cloud affects the effective nuclear charge on the 2s electron cloud.



- 2) Conversely, look at the location of the 1s electron cloud in relation to the 2p electron cloud (Graph 2). Based on graph (2), describe how the 1s electron cloud affects the effective nuclear charge on the 2p electron cloud.

3) Compare how the 1s electron cloud shields the 2s and 2p clouds. (*Hint: Which of these electrons are more greatly shielded?*)

4) Is one of the electrons completely shielded by the other in either example above? Explain.

You will notice that the electron being shielded, and the electron cloud doing the shielding, changes based on the distance away from the nucleus. This overlap and difference in shape is why the higher energy electron clouds are only partially shielded in an atom.