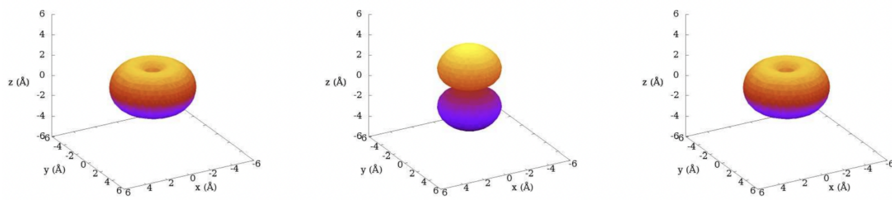
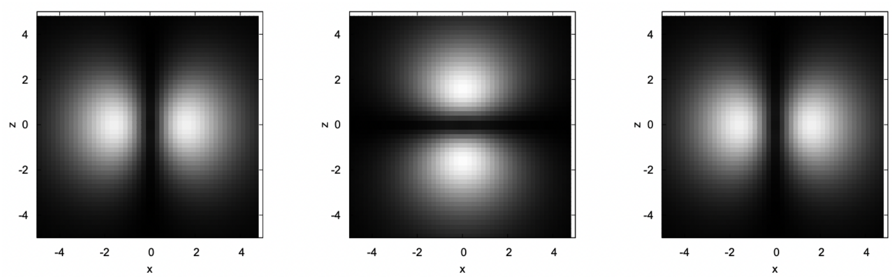
14.3.2: p Orbitals

Orbitals with total angular momentum quantum number $l = 1$ are called p orbitals. Remember that l must always be less than n. As such, the first shell has no p orbitals; it only has s orbitals. This means that you can only put two electrons (with opposite spin) in the first shell. In the second shell, you can put eight total electrons. You can put two electrons in the 2s orbital, and six in the 2p orbital. Why six? For $l = 1$, there are three possible values for m, the quantum number that indexes the z component of angular momentum: $m = 1$, $m = 0$, and $m = -1$. Below is three plots showing what the $2p$ orbitals look like.



$m = +1$ $m = 0$ $m = -1$

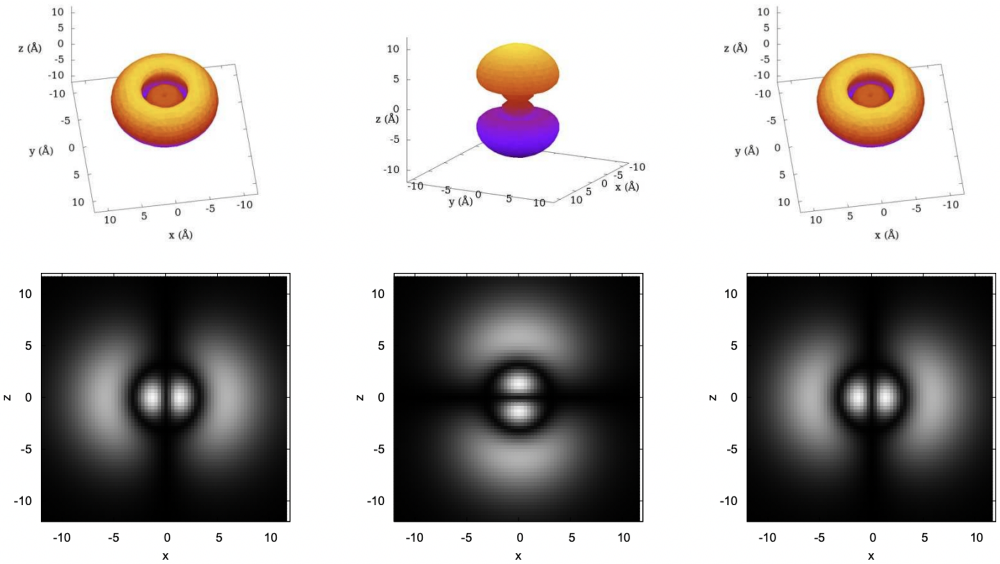
What we've drawn here is a surface of constant probability. In reality, the p-orbitals aren't hard shells, as this picture would seem to indicate. Rather, just as with the s-orbitals, they're fuzzy, with higher probability towards the "center" of the distribution which may not be at the origin!) and less probability away from it. As a way of visualizing this, the plots below show a cut in the $x - z$ plane of the three orbitals depicted above:



$m = +1$ $m = 0$ $m = -1$

Notice that the $m = +1$ and $m = -1$ $2p$ orbitals look identical. If you imagine rotating the plot around a vertical axis through the center of the plot, both of those orbitals look like two lobes, one over the other. The $m = 0$ orbital looks different, however. If you imagine rotating it around a vertical axis, you get an orbital that looks like a thick donut.

The p orbitals for higher values of n get more interesting. Just as the s orbitals become versions of themselves nested inside each other, the same thing happens with the p orbitals. Below are the three $3p$ orbitals:



$m = +1$ $m = 0$ $m = -1$
