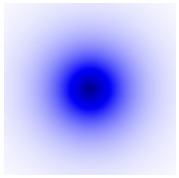
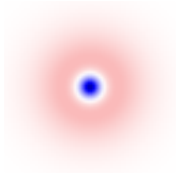
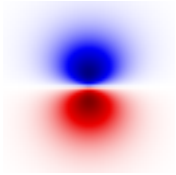
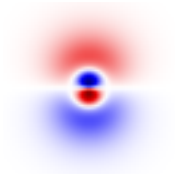
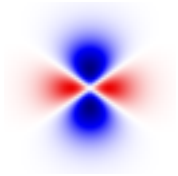
Visualizing Atomic Orbitals

We call the space in which an electron in a hydrogen atom moves an atomic oribtial. The equations—or wave functions—that describe an electron are complex, but we can visualize the equations in several ways. The table below shows slices—or wo-dimensional cross-sections—through selected atomic orbitals in the xy plane as a function of the quantum numbers n and l.

	$l = 0$	$l = 1$	$l = 2$
$n = 1$			
$n = 2$			
$n = 3$			

The quantum number n is called the principal quantum number. What are the allowed values for n?

The images above are not shown to scale, but for our purposes we may assume that the central blue circle for the atomic orbitals in the first column ($l = 0$) are of approximately equal size. What does this imply about the relationship between n and the size of an atomic orbital?

Just as a sine wave has positive and negative amplitudes, the wave function that describes an electron also have positive and negative values: in these pictures, blue indicates a positive value and red indicates a negative value. The wave functions have nodes where the color is white. What is a node? What is the value of the amplitude at a node? What does this imply about the probability of finding an electron at a node?

What is the relationship between n and the number of nodes?

The quantum number l is called the angular quantum number. What are the allowed values for l?

Examine the bottom row of the table above, which shows the atomic orbitals for different values of l when $n = 3$. What property of atomic orbitals is affected by l?

A two-dimensional cross-section provides a limited view of atomic orbitals. Shown below are three-dimensional space-filling atomic orbitals for $2p$ atomic orbitals and for $3d$ atomic orbitals.

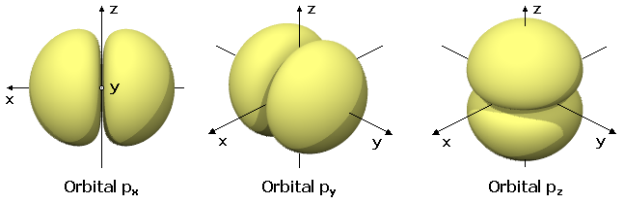


Figure 1: 2p atomic orbitals

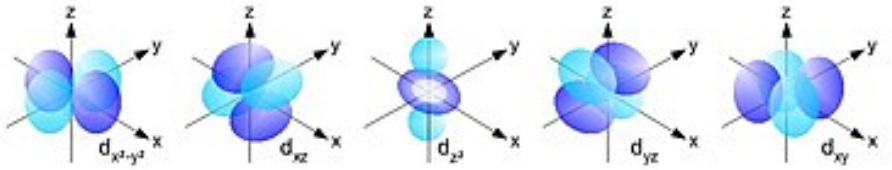


Figure 2: 3d atomic orbitals

The quantum number m_l is called the magnetic quantum number. What are its allowed values?

What is the relationship between m_l and the number of orbitals shown above?

If n determines an atomic orbital's size and l determines an atomic orbitals shape, what does m_l determine about an atomic orbital?

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