

## 16. Electron Waves: Nodal Planes

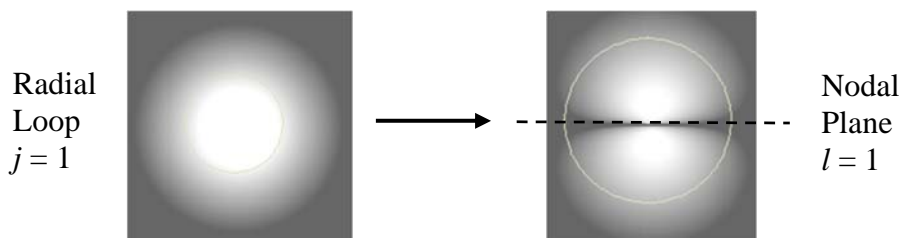
In addition to having multiple radial loops, many electron clouds are broken up by nodal planes. Much like a node in a standing wave (where the energy is zero and the wave has no effect in that space), nodal planes will result in two-dimensional areas where the electron density of an orbital is zero. The following activity is designed to help you recognize and count the number of nodal planes in an electron cloud. Nodal planes are indicated using the letter “ $l$ ”.

Go to the following applet: (you will have to enable java for this applet)

<http://www.bu.edu/dbin/quantumconcepts/Hybridization/explorers.html>

Select the “**Hydrogen Explorer**”, “**3D**”, “**Density**” and “**View All Orbitals**” radio buttons at the top left of the screen.

1) Select the 1s electron orbital. Now, imagine that a nodal plane bisects this orbital. The resulting shape can be seen below ( $l = 1$ , and  $j = 1$ ). This results in a 2p orbital. Select the 2p orbital and compare the shapes.



2) If a 1s electron orbital is cut by two perpendicular nodal planes, the resulting shape is a 3d orbital. Select the  $3d_{x^2-y^2}$  orbital and sketch the shape. Indicate on your drawing where the nodal planes are located.

3) Select the 2s electron orbital. Predict what the shape will look like when it is bisected by a nodal plane. Sketch this below and check your work by selecting the 3p orbital.

4) Select the 3s electron orbital. Predict what the shape will look like when it is bisected by two nodal planes. Sketch this prediction below. What electron orbital does this represent?

Now that you know how to recognize the number of nodal planes, we will talk about the shapes that these planes create. The specific shapes are labeled based on the  $l$  value of the electron orbital. You will notice these letters on the energy diagram in your applet.

$l =$	0	1	2	3
	s	p	d	f

The 1s orbital has an  $l$  value of 0, meaning there are no nodal planes in this orbital where as the 3d orbitals have an  $l$  value of 2, meaning that there are two nodal planes in each of these orbitals.

You will also notice that each electron orbital is labeled with a number. This number is known as the principle energy level, or “ $n$ ”. The electron orbital, 2s, therefore has  $n = 2$ , and  $l = 0$ .

5) The principle quantum number is related to the number of radial loops ( $j$ ) and the number of radial planes ( $l$ ). See if you can determine the equation for  $n$ .

6) Based on this equation, can you have an electron cloud that is 1p or 2d? Explain.