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[TP] What electron cloud has 3 radial loops and 1 nodal plane?

10% 1. 1s
 10% 2. 2s
 10% 3. 2p
 10% 4. 3s
 10% 5. 3p
 10% 6. 3d
 10% 7. 4s
 10% 8. 4p
 10% 9. 4d
 10% 10. None of the above

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 Friday, November 17, 2017

For today ...

- Hydrogen atom electron clouds: <http://goo.gl/XPkcxv>

Next lecture: H atom energy diagrams; H, He⁺, Li²⁺, etc., photon energies; Ionization (photoelectric effect)

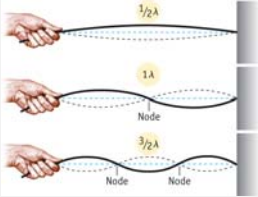
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Hydrogen atom electron clouds

1D electron cloud:

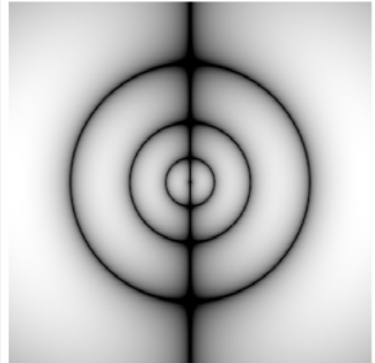
1D example of a standing wave
 Major Lesson: lowest energy has 1 loop (0 nodes)
 Major Lesson: more loops, more energy



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Extend to 3D electron cloud: <http://goo.gl/XPkcxv>

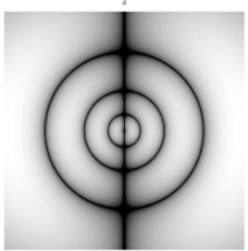


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Hydrogen atom family album: <http://goo.gl/XPkcxv>

1D electron cloud:
 1D example of a standing wave
 Major Lesson: lowest energy has 1 loop (0 nodes)
 Major Lesson: more loops, more energy



Extend to 3D electron cloud:
 Atoms are spheres!! (not wires)
 Two types of loops: **radial** and **angular**

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Clouds and probability

The density of an electron cloud is a measure of the **fraction of the electron** in that region.

For this reason, clouds are sometimes referred to in terms of **probability density**.

It is crucial to understand that **the cloud is the electron**, and **not a time exposure** of a point particle.

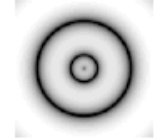
Probability density is due to **spatial extent** rather than **motion**.

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Radial loops

Concentric rings around nucleus
 (distance from the nucleus)



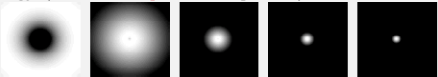
$j = \# \text{ radial loops}$

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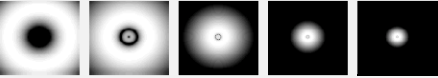
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Radial loops only (known as "s")

Lowest Energy (1 radial loop, 0 nodal planes):



2nd Lowest Energy (2 radial loops, 0 nodal planes):



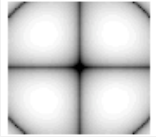
Etc.

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Nodal planes

- Will look like planes (lines) of **zero probability**



$l = \# \text{ of nodal planes}$


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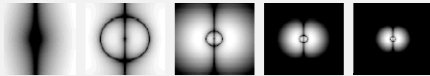
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Radial + 1 nodal plane (known as "p")

Lowest Energy (1 radial loop, 1 nodal plane):



2nd Lowest Energy (2 radial loops, 1 nodal plane):



Etc.

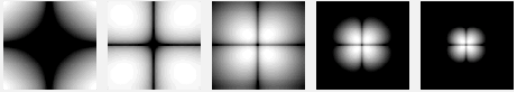
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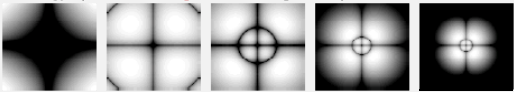
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Radial + 2 nodal planes (known as "d")

Lowest Energy (1 radial loop, 2 nodal planes):



2nd Lowest Energy (2 radial loops, 2 nodal planes):



Etc.

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Loops, planes, and quantum number n

Electron wave	Radial loops	Nodal planes	$n = \text{loops} + \text{planes}$
1s	1	0	$1 = 1 + 0$
2s			
2p			
3s			
3p			
3d			

$E_n = -13.6 \text{ eV}/n^2 \rightarrow E_1 = -13.6 \text{ eV}$

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eV (electron volt) energy unit

The electron volt, eV, is the energy of one units of electron charge in a field of one volt, $1 \text{ V} = 1 \text{ J/C}$.

energy = "charge" \times "voltage"

"charge" = electron charge $e = 1.6021766 \times 10^{-19} \text{ C}$

"voltage" = $1 \text{ V} = 1 \text{ J/C}$

$e\text{V} = e \times 1 \text{ J/C} = 1.6021766 \times 10^{-19} \text{ J}$

$R_y = 2.17987 \times 10^{-18} \text{ J} \times \frac{1 \text{ eV}}{1.6021766 \times 10^{-19} \text{ J}} = 13.6 \text{ eV}$



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Ry (Rydberg) unit of energy

The Rydberg unit of energy, Ry, is the ionization energy of one H atom.

$$R_y = 2.17987 \times 10^{-18} \text{ J} \times \frac{1 \text{ eV}}{1.6021766 \times 10^{-19} \text{ J}} = 13.6 \text{ eV}$$

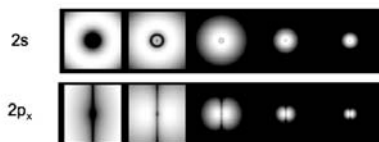


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Principal quantum number $n = 2$



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Loops, planes, and quantum number n

Electron wave	Radial loops	Nodal planes	$n = \text{loops} + \text{planes}$
1s	1	0	$1 = 1 + 0$
2s	2	0	$2 = 2 + 0$
2p	1	1	$2 = 1 + 1$
3s			
3p			
3d			

$$E_n = -13.6 \text{ eV}/n^2 \rightarrow E_2 = -13.6/4 \text{ eV}$$



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Principal quantum number $n = 3$

3s

3p_x

3d_{xy}

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Loops, planes, and quantum number n

Electron wave	Radial loops	Nodal planes	$n = \text{loops} + \text{planes}$
1s	1	0	$1 = 1 + 0$
2s	2	0	$2 = 2 + 0$
2p	1	1	$2 = 1 + 1$
3s	3	0	$3 = 3 + 0$
3p	2	1	$3 = 2 + 1$
3d	1	2	$3 = 1 + 2$

$E_n = -13.6 \text{ eV}/n^2 \rightarrow E_3 = -13.6/9 \text{ eV}$

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Principal quantum number $n = 4$

4s

4p_x

4d_{xy}

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[TP] What electron cloud has 3 radial loops and 1 nodal plane?

10% 1. 1s

10% 2. 2s

10% 3. 2p

10% 4. 3s

10% 5. 3p

10% 6. 3d

10% 7. 4s

10% 8. 4p

10% 9. 4d

10% 10. None of the above

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