

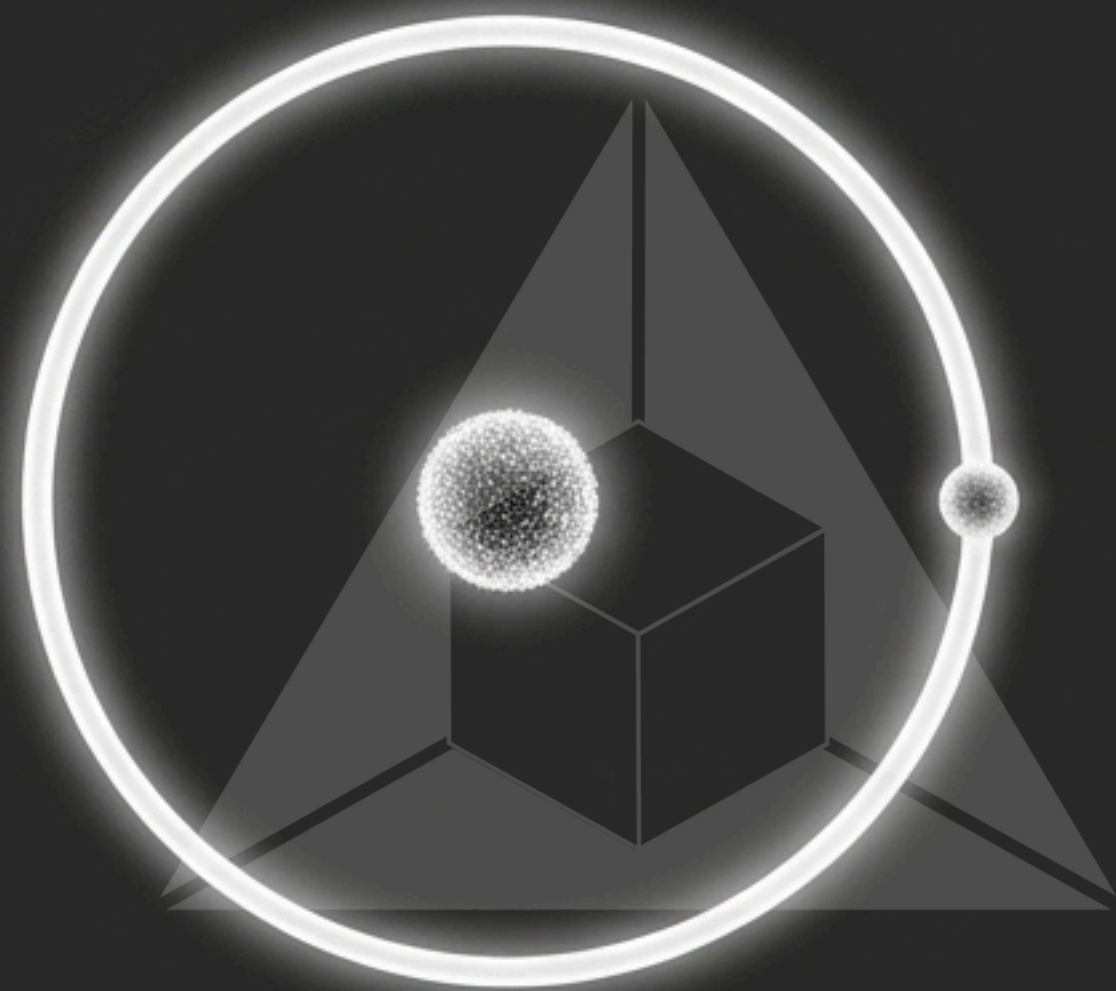
Orbitals and Quantum Numbers



$$[n, l, m_l, m_s]$$
$$E = H\psi$$

The Paradigm Shift: Orbit vs. Orbital

Orbit (The Bohr Model)



- A precise 2D circular path.
- Assumes an exact trajectory, which violates the Heisenberg Uncertainty Principle.

Orbital (The Quantum Model)



- A 3D region defining the probability of finding an electron.
- Complies with Heisenberg; deals in probabilities, not certainties.

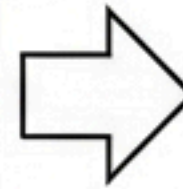
The Language of Quantum Mechanics

(The Math)

$$\psi$$

Wave Function

Mathematical abstraction. Represents the state of the electron, but carries absolutely no direct physical meaning by itself.

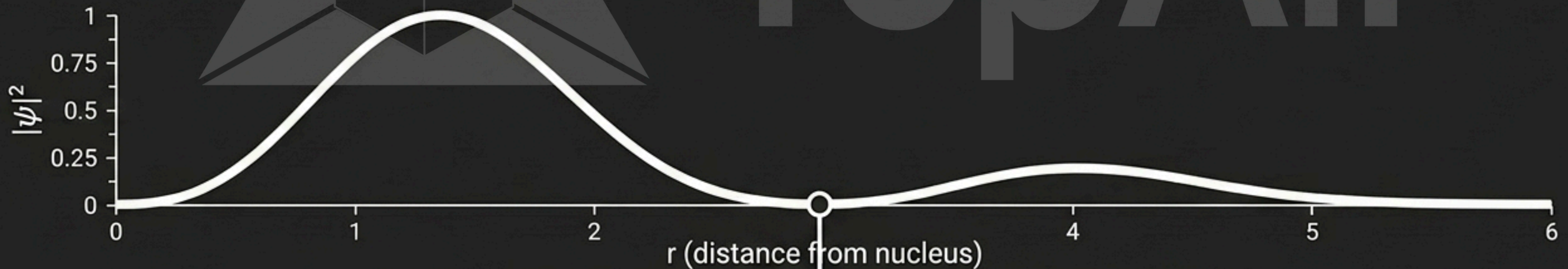


(The Reality)

$$|\psi|^2$$

Probability Density

Physical reality. The probability of finding an electron in a specific tiny volume. It is always a positive value.



Node: Region where probability density reduces to zero.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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n

The Shell

Principal Quantum Number

Determines the Size and the Energy of the orbital.

As n increases, the electron is located further away from the nucleus and the energy increases.

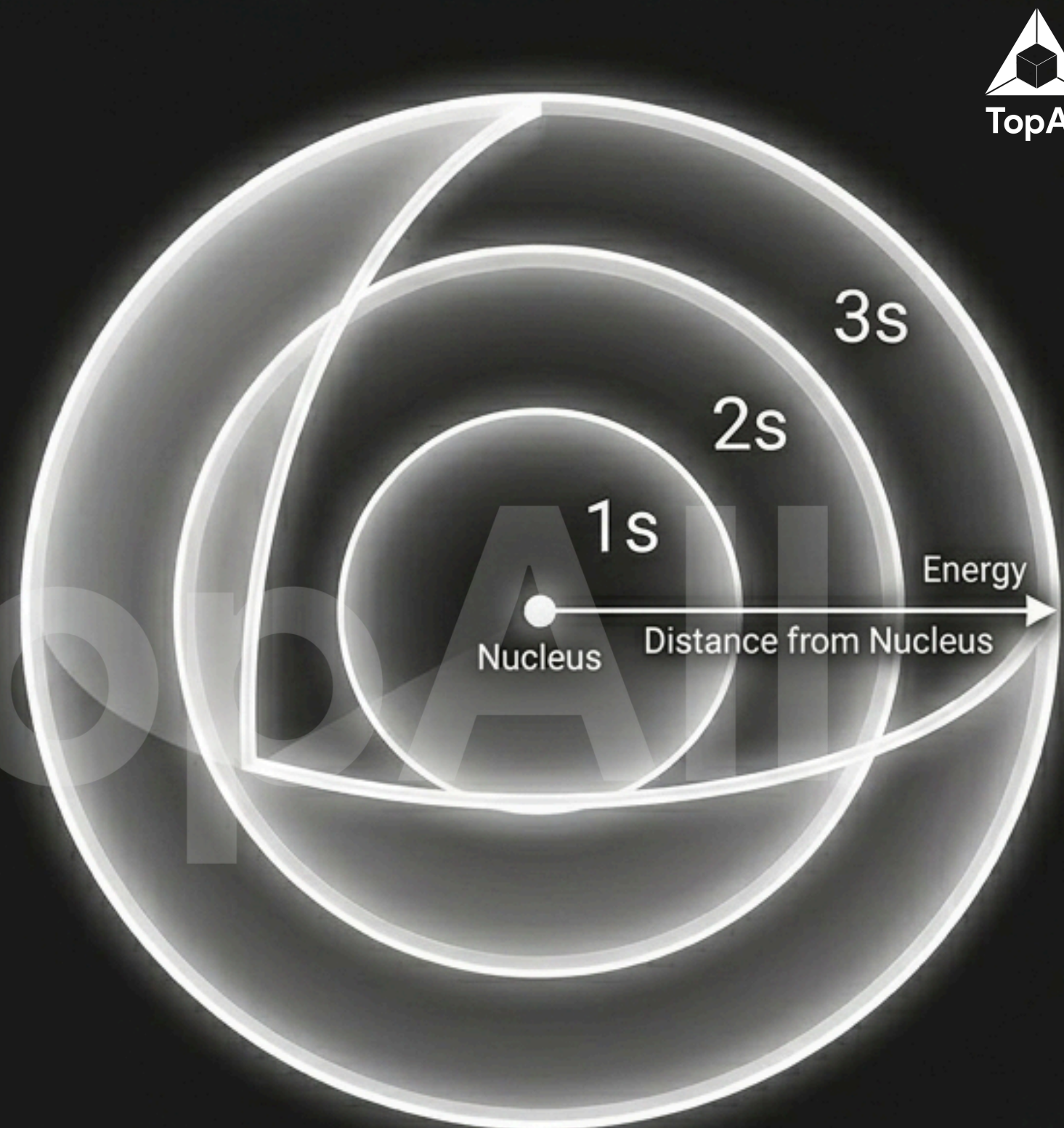
Identifies the main Shell (K, L, M, N).

Permitted
Values:
 $n = 1, 2, 3...$

Max electrons
per shell:
 $2n^2$

Total orbitals
per shell:
 n^2

Formula Strip



l

The Subshell

Azimuthal Quantum Number

Determines the 3D Shape of the orbital.

Identifies the Subshell.

Dictates the number of angular nodes (which equals l).

Permitted Values: $l = 0, 1, 2 \dots (n-1)$

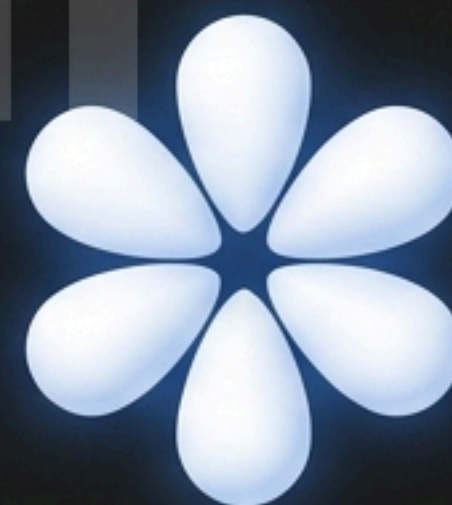
$l = 0 \rightarrow s$



$l = 1 \rightarrow p$



$l = 2 \rightarrow d$



m_l

The Orbital

Magnetic Quantum Number



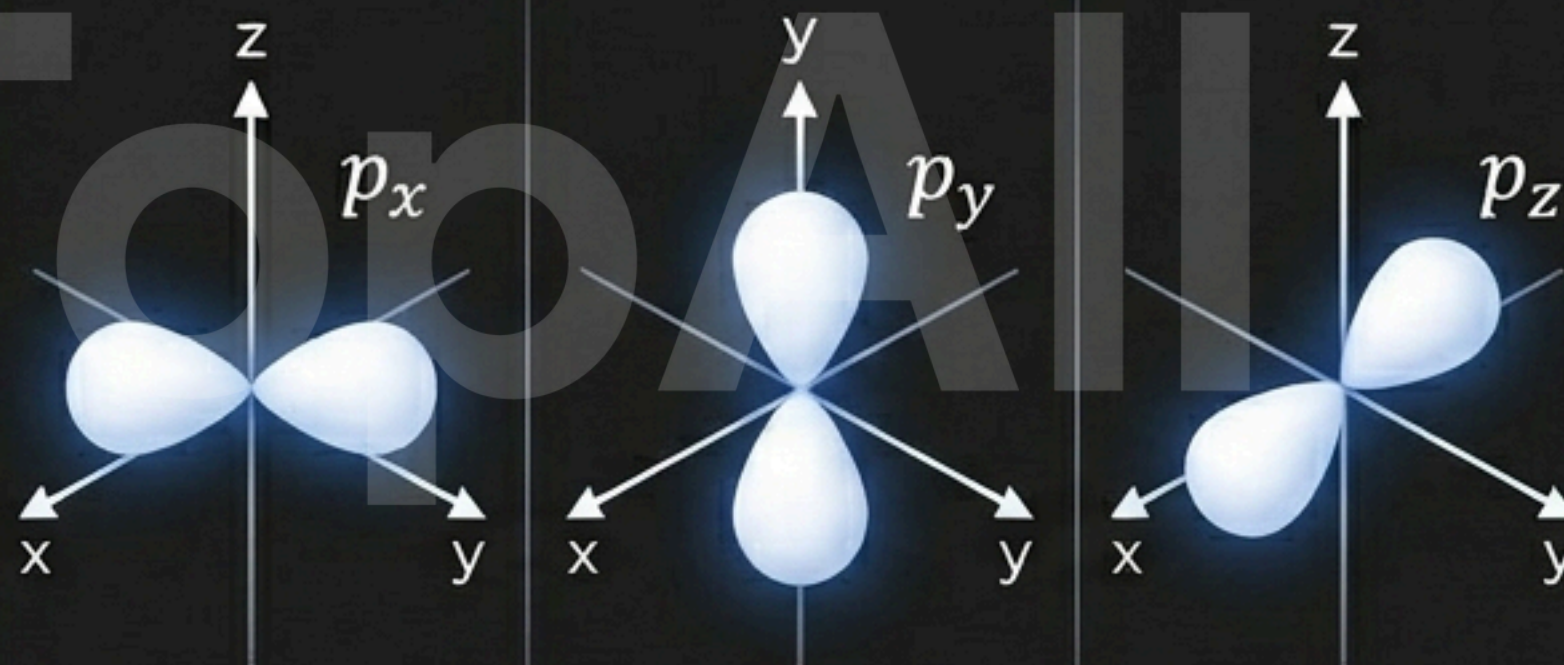
Determines the Spatial Orientation of the orbital with respect to a standard set of coordinate axes.

Isolates the exact orbital within a given subshell.

Permitted Values:
 $m_l = -l$ to $+l$

Total orbitals
in subshell:
 $2l + 1$

Formula Strip



m_s

The Electron

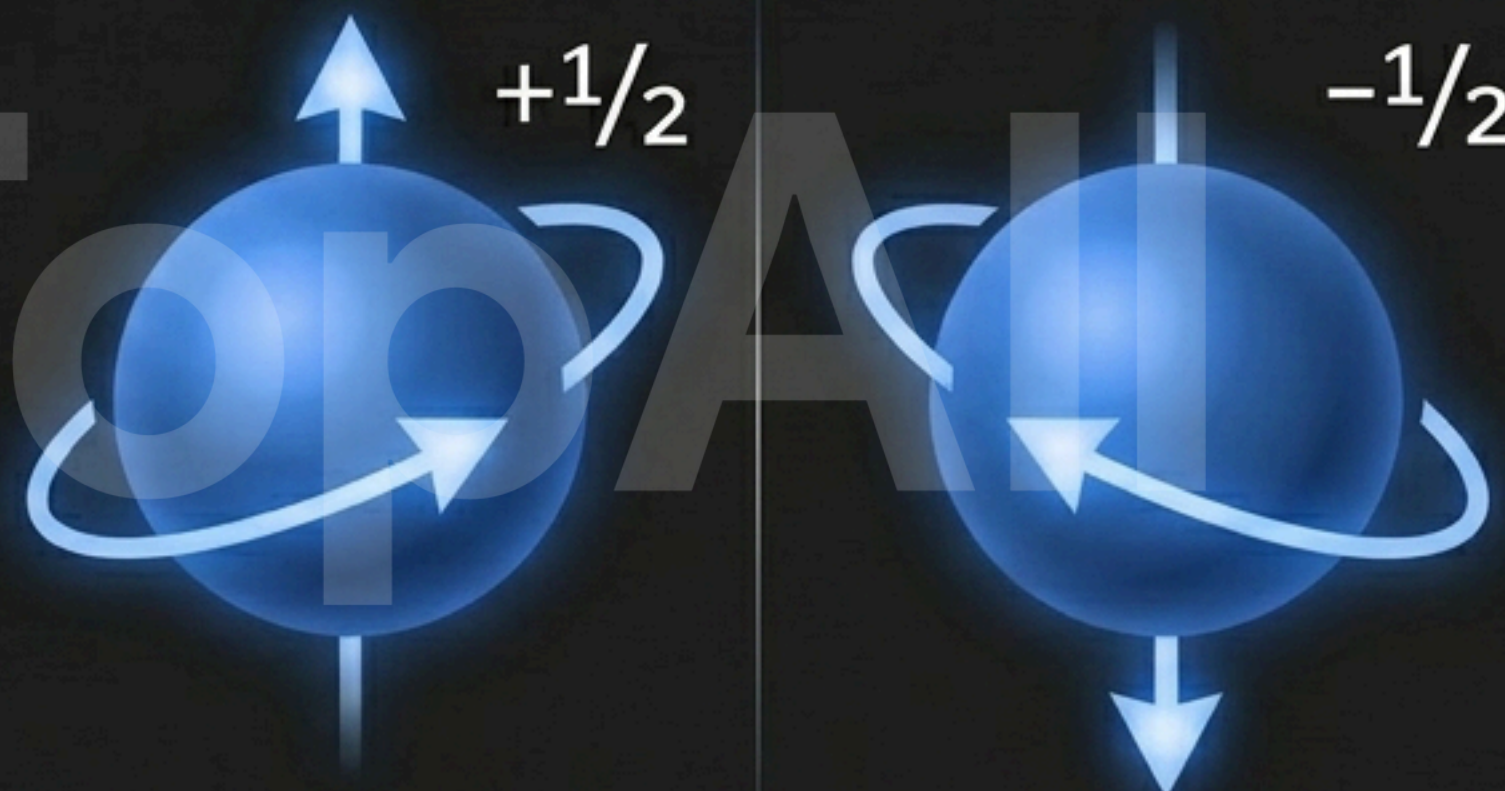
Spin Quantum Number



Determines the Spin Orientation of the electron.

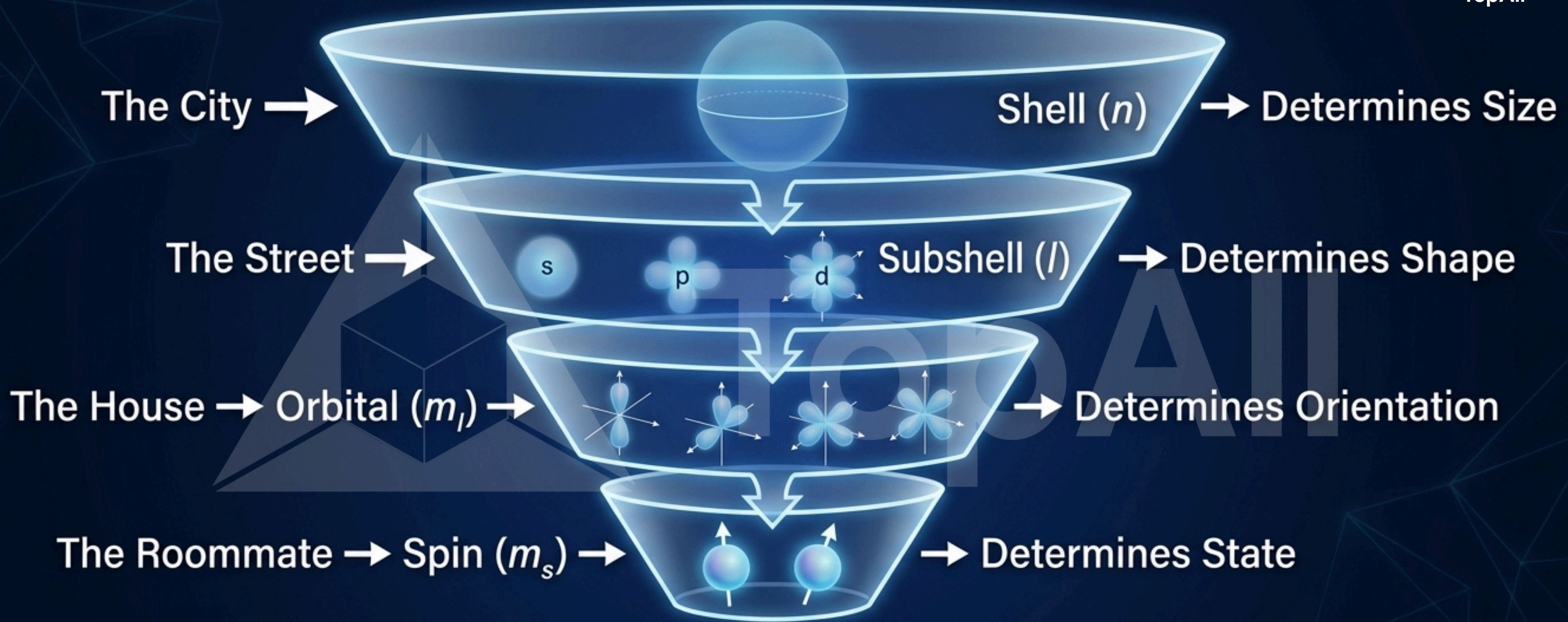
Spin angular momentum can only have two orientations relative to the chosen axis.

Permitted Values: $+1/2$ ($\uparrow$) or $-1/2$ ($\downarrow$)



Pauli Exclusion Principle: An orbital cannot hold more than two electrons, and these two electrons **must have opposite spins**.

The Electron Address System



No two electrons in an atom can have the same set of four quantum numbers (Pauli Exclusion Principle). Every electron has a unique mathematical address.



You've Learned the Theory.

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