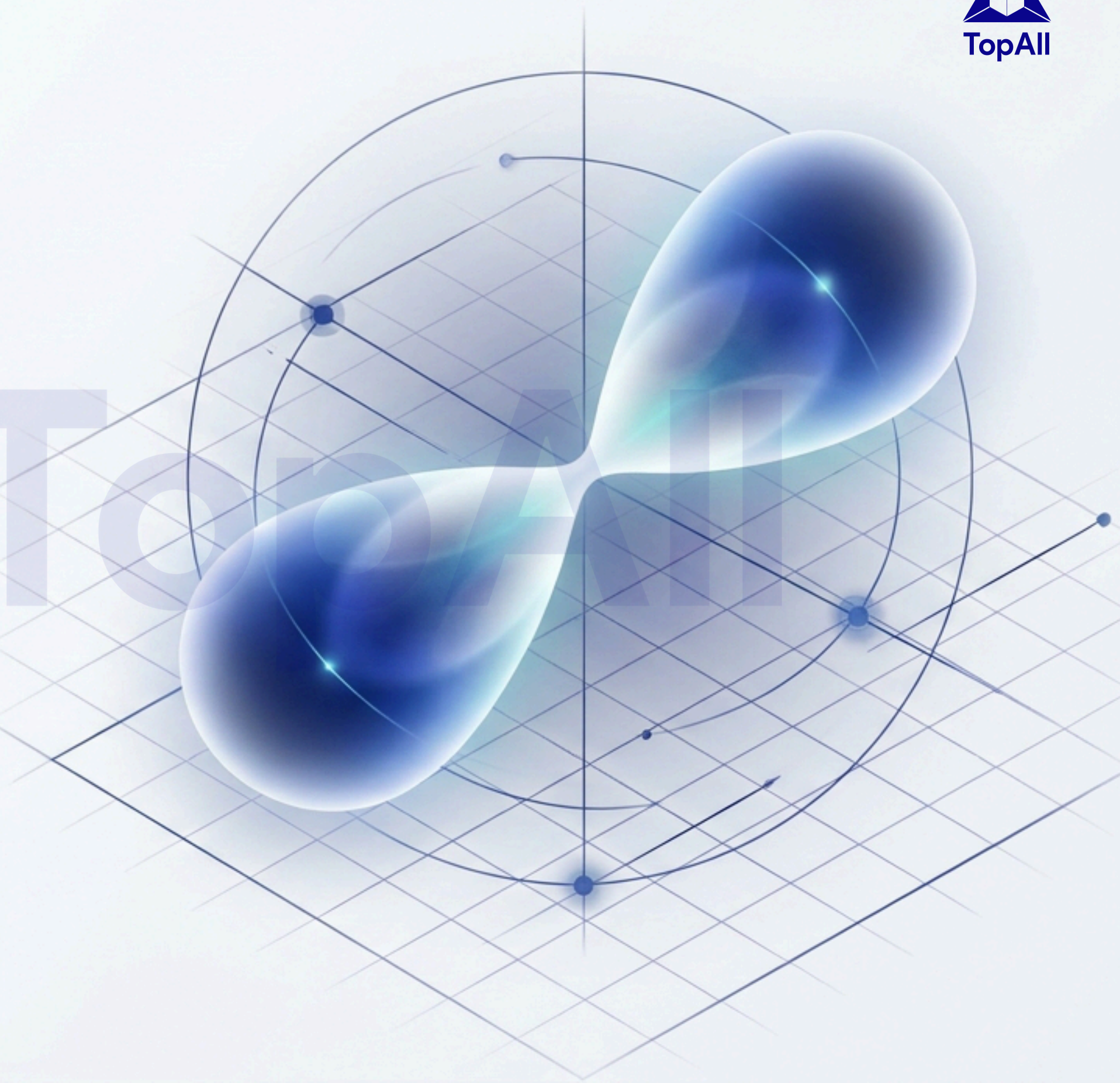


2.6 Quantum Mechanical Model of Atom

A probabilistic framework for atomic structure, replacing exact orbits with mathematical wave functions and electron probability clouds.



Focus: The 5 Fundamental Features

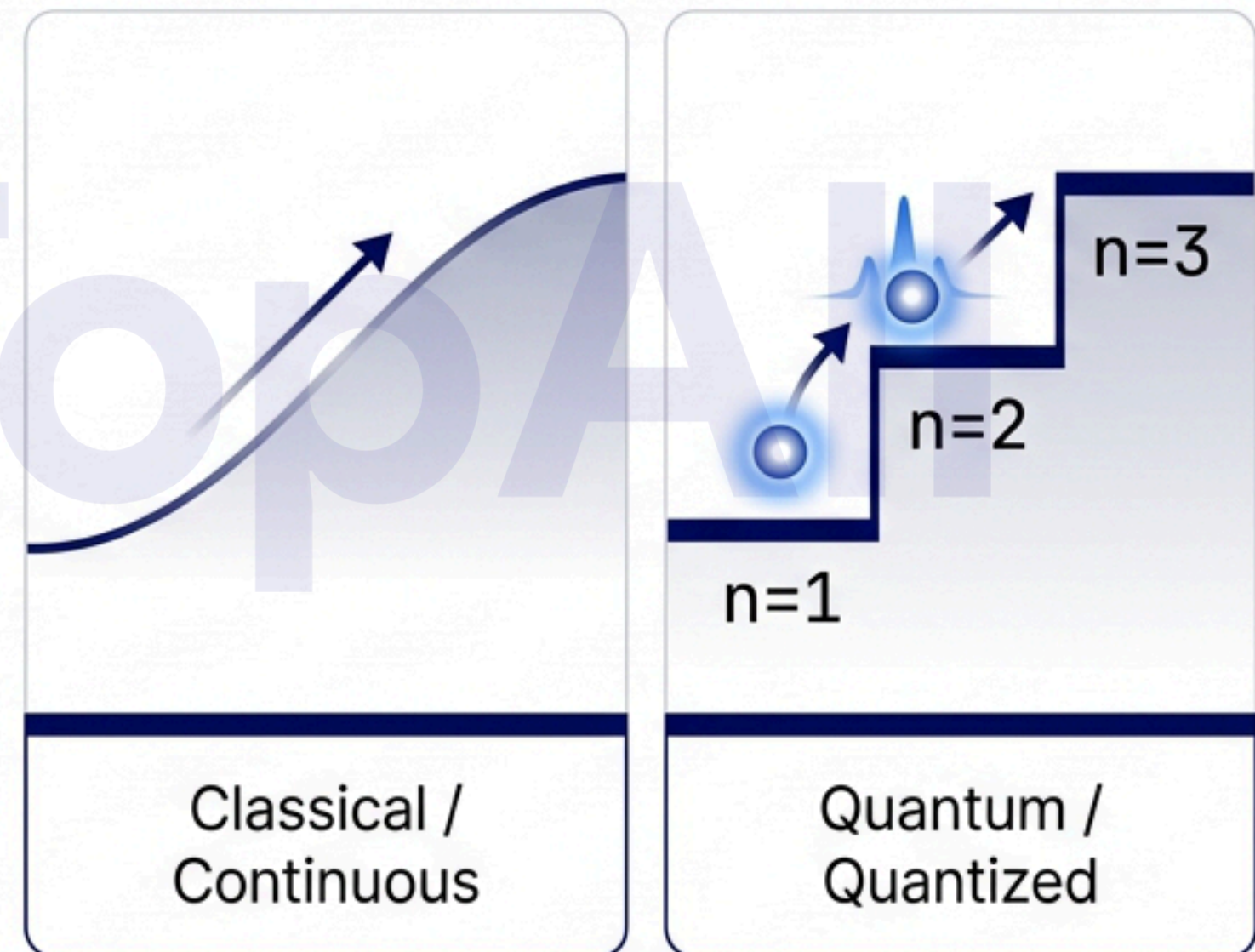


Quantized Electronic Energies

Energy is Discrete, Not Continuous

Electrons bound to a nucleus can only possess specific, allowed energy values. They cannot exist “between” these defined states.

Think of it like standing on a staircase—you can stand on a specific step, but you cannot hover in the air between them.



Wave Equation and Allowed Solutions

Schrödinger Equation (1926)

$$\hat{H}\psi = E\psi$$

The Origin

The existence of quantized energy levels is a direct mathematical result of the wave-like properties of electrons.

The Solution

Only certain specific 'waves' (wave functions) are allowed to exist without collapsing, dictating the permitted energy states of the atom.



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$$E=mc^2$$



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Key Highlights

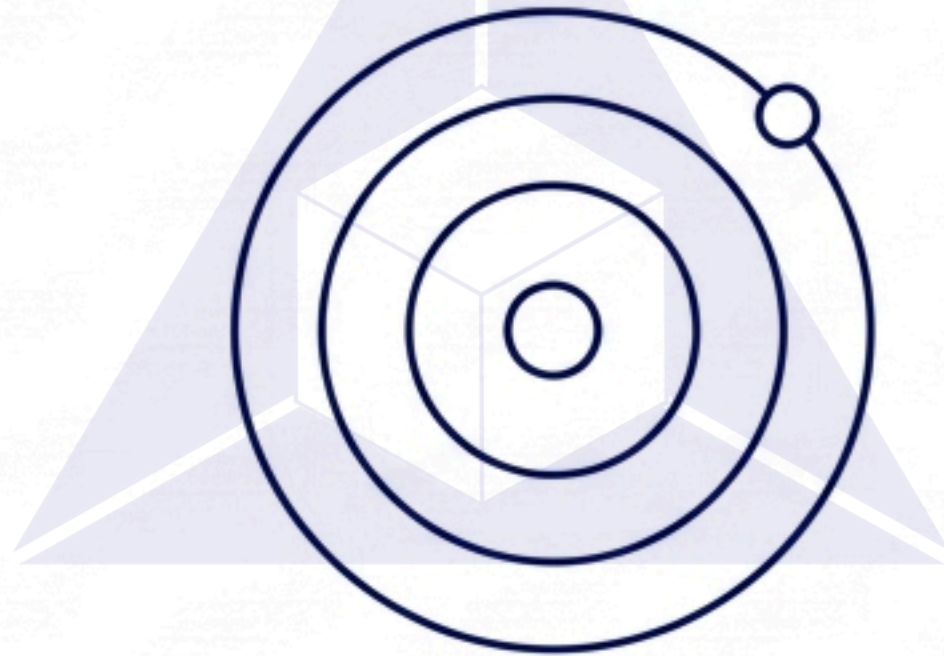
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Probability Replaces Exact Path

✗ Disproven

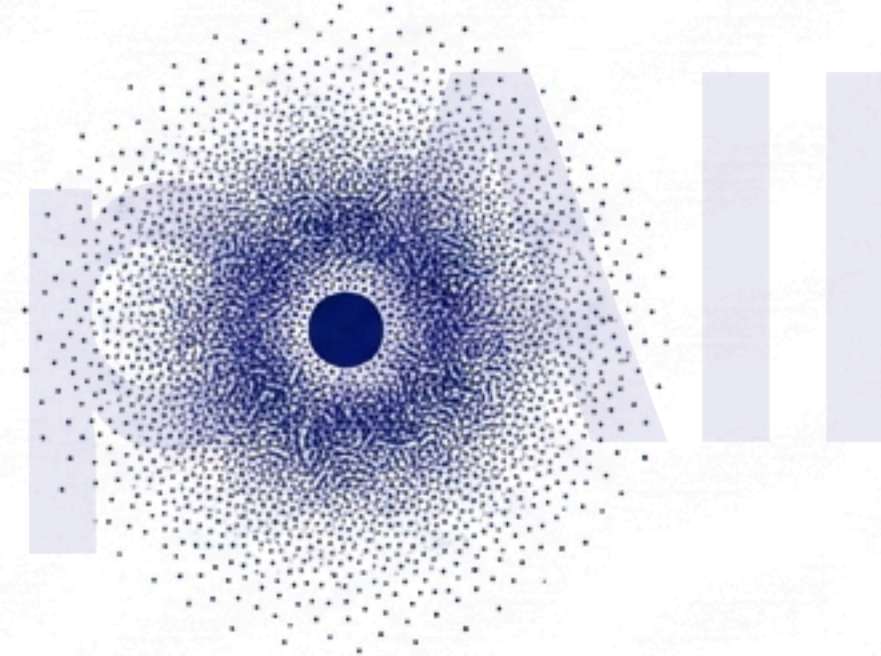
The Exact Path (Failed Model)



Assumed we could know exact position and velocity simultaneously.

✓ Accepted

The Probability Cloud



Heisenberg Uncertainty proves we cannot know both position and velocity. Trajectories do not exist.

We can only predict the probability of finding an electron at different points.

Atomic Orbital as Wave Function

An atomic orbital is entirely defined by the wave function ψ for an electron in an atom. It is not a physical box or boundary, but a mathematical description storing all information about the electron.

The Anatomy of an Orbital

n

Principal

Determines Size
& Energy

l

Azimuthal

Determines Shape
(s, p, d, f)

m_l

Magnetic

Determines
Spatial Orientation

Key-Takeaway Box: An orbital cannot contain more than two electrons. In a multi-electron atom, electrons fill orbitals in order of increasing energy.

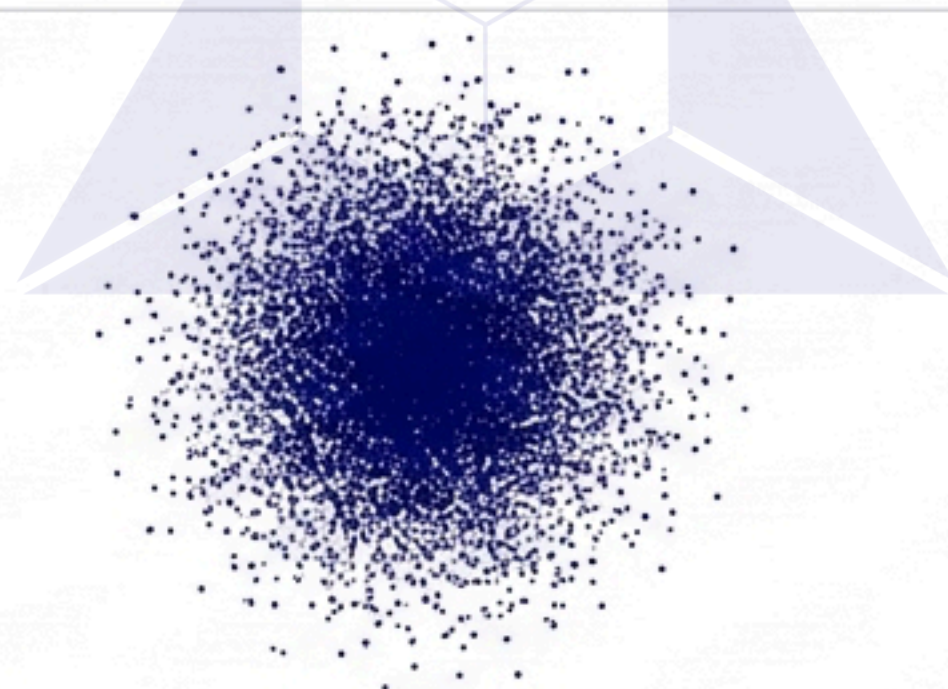
Probability Density $|\psi|^2$

Formula Highlight Card

$$\text{Probability Density} \propto |\psi|^2$$

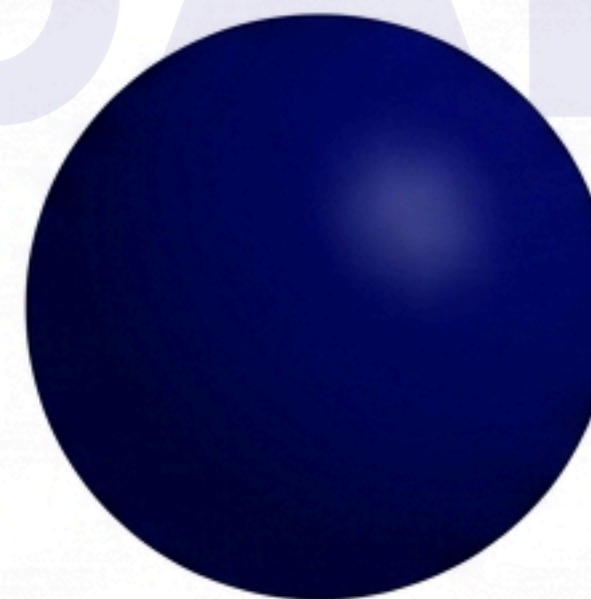
While ψ itself has no physical meaning, its square represents the probability of finding an electron at a specific point in space. It is always positive.

Electron Cloud / Dot Plot



Density of dots represents probability. Thickest near the nucleus.

Boundary Surface Diagram



A boundary drawn to enclose a volume with ~90% probability of finding the electron.

The Atom as a Probability-Based System

Feature Number	Core Concept	Key Takeaway
Feature 1	Energies	Are quantized and discrete.
Feature 2	Wave-Particle	Quantization is a direct result of wave properties and Schrödinger solutions.
Feature 3	Heisenberg	Exact paths are replaced by probability clouds due to uncertainty.
Feature 4	Orbitals	Described mathematically by the wave function (ψ).
Feature 5	Density	Visualized in physical space by the boundary surface of $ \psi ^2$.

Together, these 5 features form the complete basis of the modern electronic structure of atoms.



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