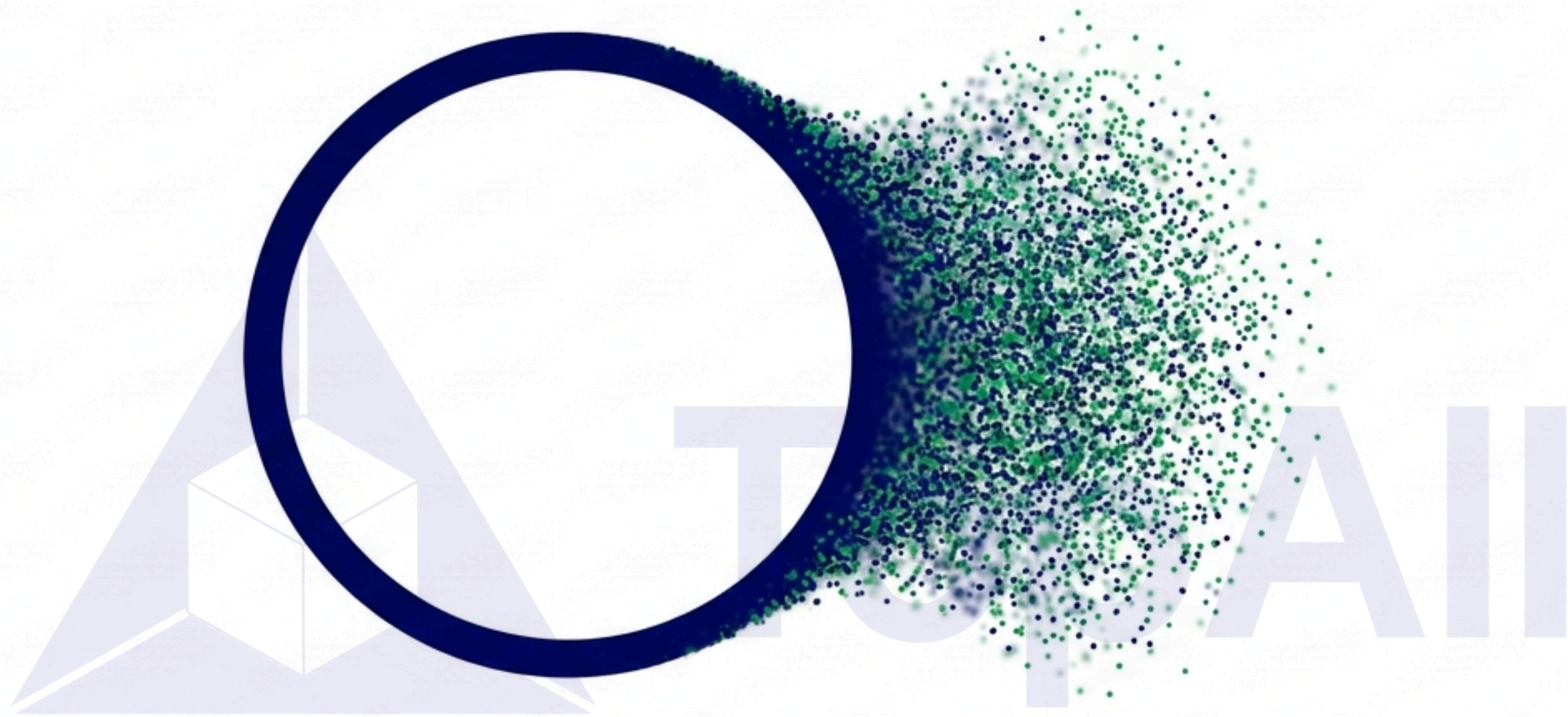




Towards Quantum Mechanical Model

The breakdown of classical mechanics and the birth of probability.

Diagnostic: Why Bohr's Model Failed



Spectroscopic Failure

Finer Details

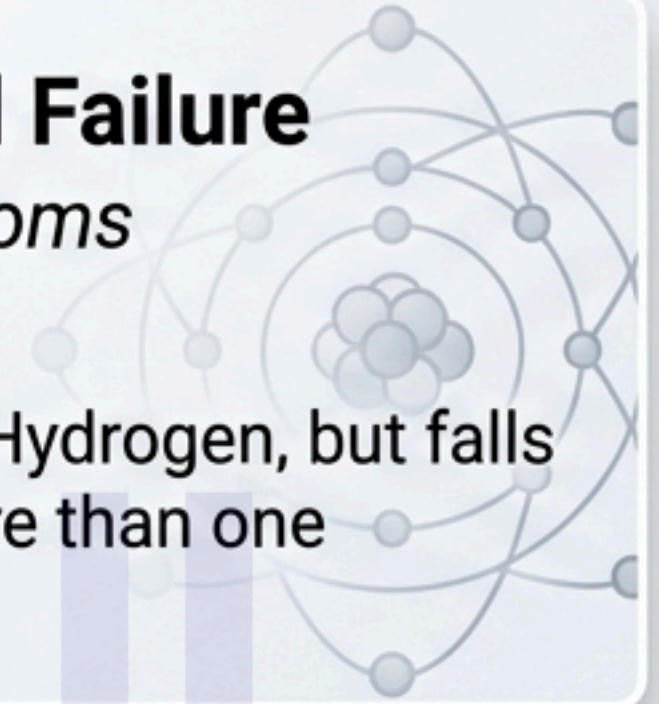
Fails to explain the fine doublets (two closely spaced lines) observed in high-resolution atomic spectra.



Compositional Failure

Multi-Electron Atoms

Mathematically elegant for Hydrogen, but falls apart for any atom with more than one electron (e.g., Helium).



Electromagnetic Failure

Field Splitting

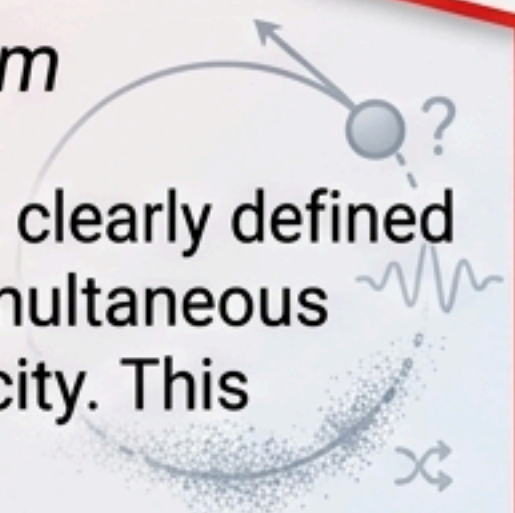
Cannot explain the splitting of spectral lines in a magnetic field (Zeeman effect) or an electric field (Stark effect).



Theoretical Failure

Classical Determinism

Assumes an electron moves in a clearly defined circular path, requiring exact simultaneous knowledge of position and velocity. This violates future quantum laws.



FATAL FLAW

Development 1: Dual Behaviour of Matter

Louis de Broglie (1924) proposed that matter, just like radiation, exhibits both particle and wave-like properties.

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

Caution: The Macroscopic Trap

Why don't everyday objects look like waves? The effect is only significant for microscopic particles.

Macro

Golf Ball

Mass = 40g, Speed = 45 m/s

$$\lambda \approx 1.46 \times 10^{-33} \text{ m}$$

Imperceptible (a trillion times smaller than an atomic nucleus).



Micro

Electron

Mass = $9.11 \times 10^{-31} \text{ kg}$

Microscopic mass results in a much larger, physically consequential wavelength, leading to observable diffraction.





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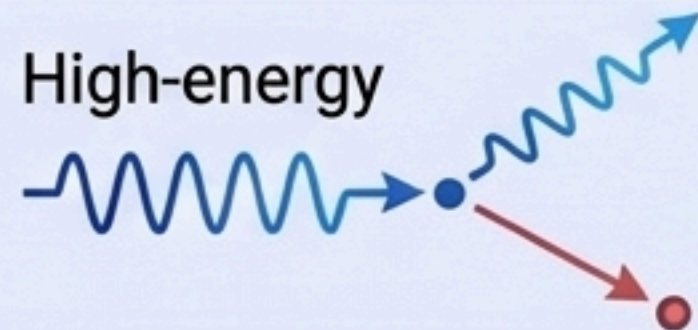
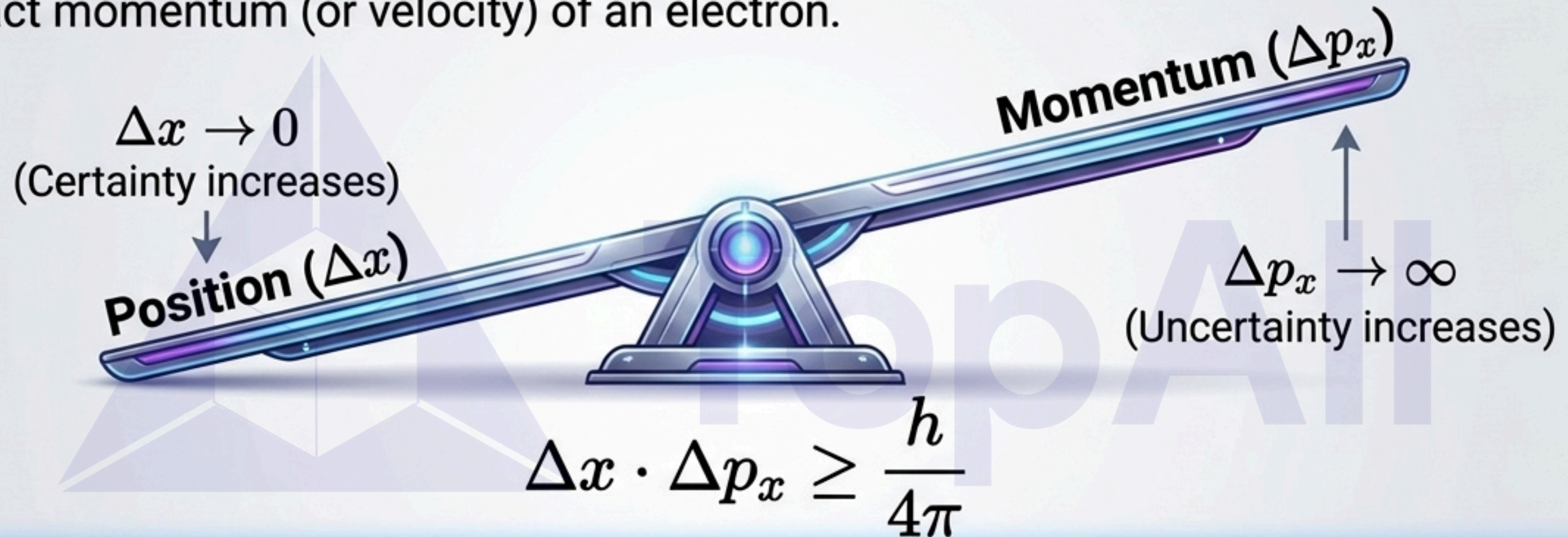
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Development 2: Heisenberg Uncertainty Principle

It is impossible to determine simultaneously the exact position and exact momentum (or velocity) of an electron.

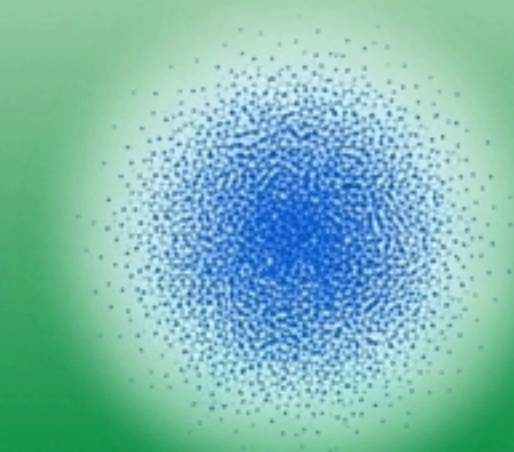


The Microscope Effect

To observe an electron's exact position, we must illuminate it with a high-momentum photon. The collision changes the electron's velocity unpredictably. The act of measurement alters the system.

Implication: Definite paths or 'trajectories' for sub-atomic particles are physically impossible.

Key Takeaways: The Orbit to Orbital Shift

	Bohr Model (Classical)	Quantum Mechanical Model (Modern)
The Path	Orbit (A well-defined, exact circular 2D trajectory).	Orbital (A 3D mathematical region of space where finding an electron is most probable).
Nature of Matter	Pure particle.	Wave-particle duality (de Broglie).
Certainty	Exact position & momentum known simultaneously.	Subject to the Uncertainty Principle ($\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$).
The Core Metric	Absolute precision.	Probability Density ($ \psi ^2$). The universe is fundamentally fuzzy at the atomic level. 



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