A Physical Resolution of Wave-Particle Duality

Deriving the de Broglie Wavelength from Substrate Condensation Geometry

$$\lambda = \frac{m_p c r_p}{\pi R_0 p}$$

Based on BFUT Paper P72 | Single-Entity Hypothesis

The Ontological Divide: Complementarity vs. Physical Reality

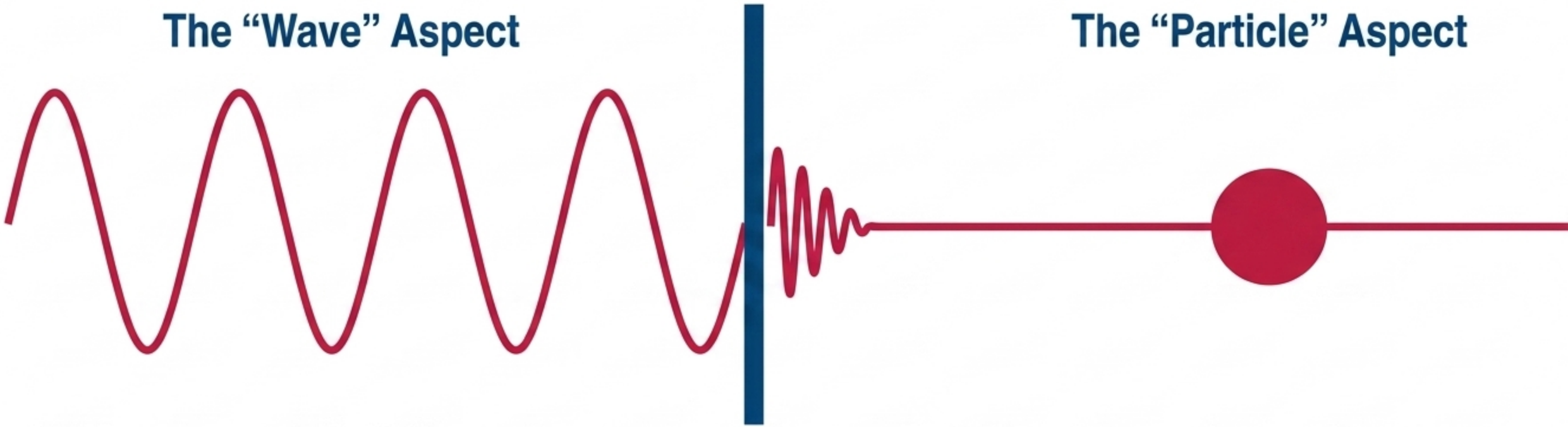
Concept	Concept	Pre-Detection State	Moment of Detection	Nature of Duality
Standard Complementarity (Bohr)	Mutually exclusive descriptions depending on experimental context.	Abstract probability wave (mathematical artifact).	Discontinuous, uncaused wave-function collapse.	A fundamental, irreducible paradox requiring dual ontologies.
BFUT Resolution	A single physical entity undergoing continuous physical processes.	Physically distributed substrate disturbance capable of interference.	Irreversible threshold coupling with macroscopic matter.	Two temporal phases (propagating vs. coupled) of the continuous physical history.

The Single-Entity Timeline

A quantum object is, at all times, an extended, propagating substrate disturbance with an internal condensation structure.

Threshold Coupling

The "Wave" Aspect



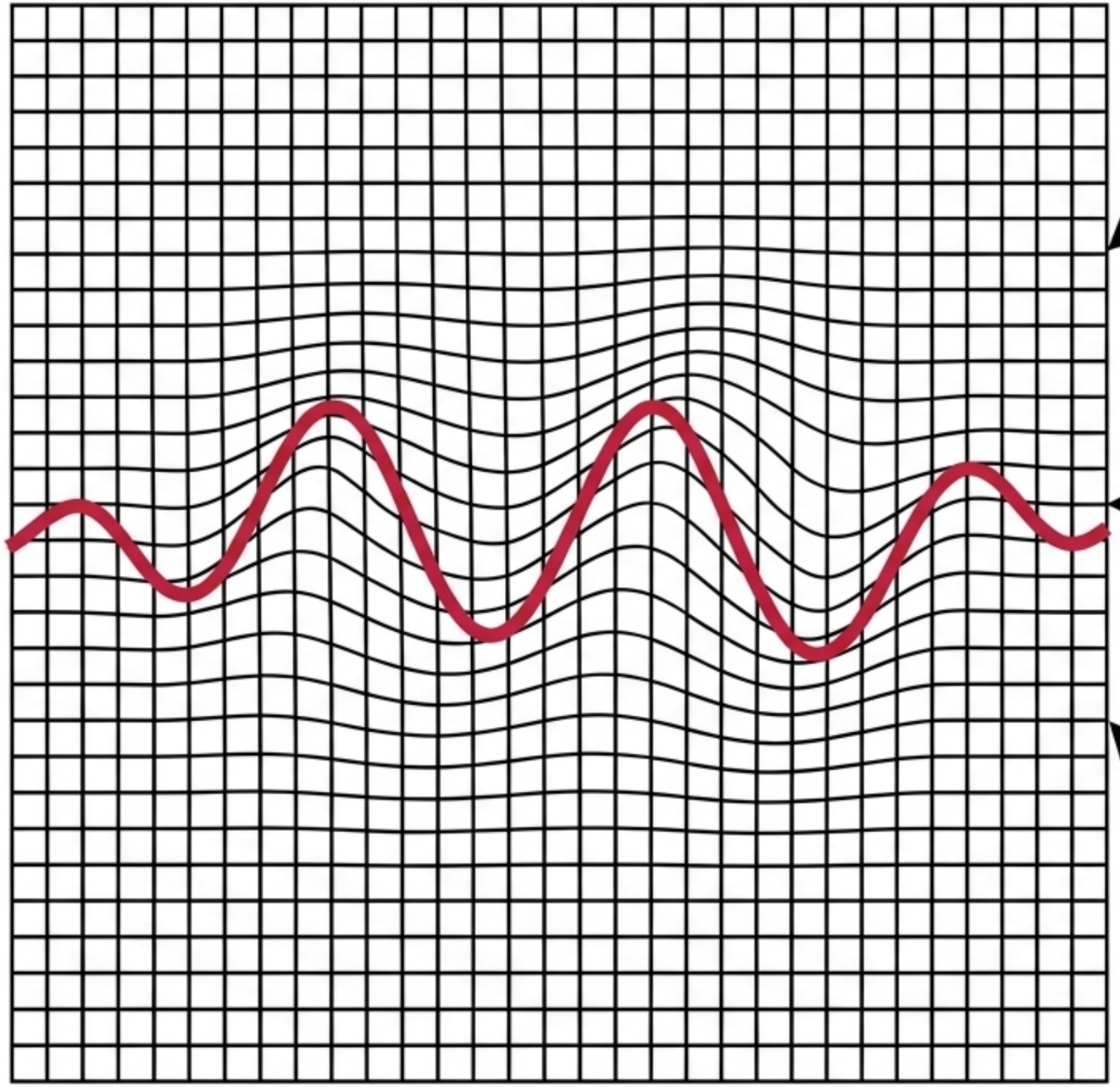
The "Particle" Aspect

Extended Substrate Disturbance
Genuinely distributed across space, driving interference phenomena.

Interaction with
persistent embedded condensation (detector).

Localized Condensation.
Structural information irreversibly absorbed.

Phase A: The Physically Real Wave



Not Statistical Ignorance

The wave function is not a bookkeeping device representing an observer's incomplete knowledge of a classical trajectory.

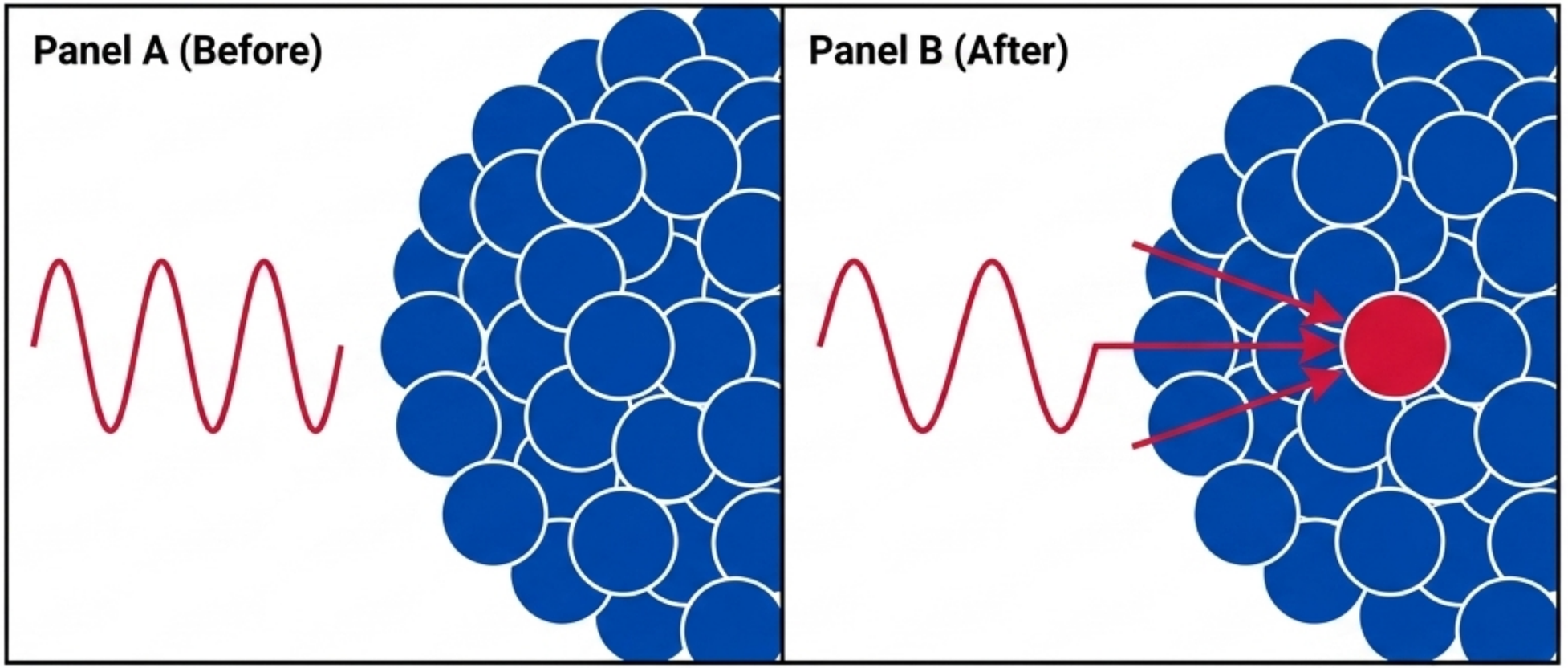
Spatially Extended

It is an extended, physically distributed configuration of the Spaticle substrate ($\rho_s = 5.9 \times 10^{-27}$ kg/m^3).

Interference Capable

Double-slit interference occurs because the substrate disturbance is genuinely distributed across space and interacts with its own structural geometry.

Phase B: Threshold Coupling (The ‘Particle’ Event)



The Physical Mechanism

Measurement is the irreversible physical coupling of a distributed disturbance to an already-condensed substrate structure.

No Observer Required

Any sufficiently persistent, highly organized embedded condensation crosses the physical threshold of irreversibility.

Result

The disturbance’s spatial extent becomes localized precisely where the coupling occurs. The wave does not “collapse” by magic; it is structurally absorbed.

The Geometric Origin of Quantum Action

Standard Postulate

$$\hbar = 1.054571 \times 10^{-34}\ \mathrm{J{\cdot}s}$$

Status: Unexplained empirical constant. Treated as a fundamental postulate with no link to a physical substrate.

BFUT Geometric Origin

$$\hbar = \frac{m_p \cdot c \cdot r_p}{\pi \cdot R_0}$$

Status: The action per radian of the smallest stable substrate condensation circulation.

Data Callout: Yields 0.0007% numerical agreement using independently measured proton charge radius ($r_p = 0.8414$ fm).

Deconstructing the BFUT de Broglie Wavelength

Proton Mass
The fundamental condensation anchoring mass.

The Wave Aspect
Wavelength governing physical interference phenomena.

Proton Charge Radius
The spatial anchor of the substrate geometry (0.8414 fm).

$$\lambda = \frac{m_p c r_p}{\pi R_0 p}$$

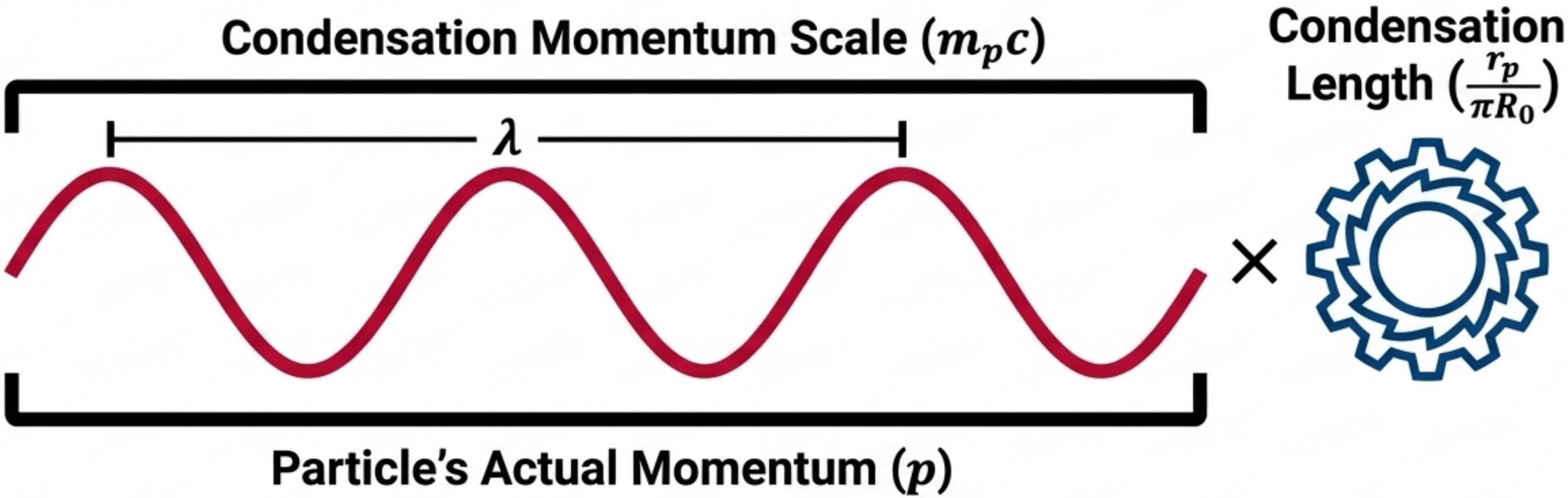
Dimensionless Minimum
The geometric minimum of the condensation free-energy functional (1.27348).

The Particle Aspect
The object's actual localized momentum.

The standard de Broglie relation ($\lambda = \hbar/p$) is not an arbitrary postulate connecting two distinct ontologies, but a direct expression of Spaticle condensation geometry.

The Geometric Signature of Duality

The De Broglie Geometric Signature



Wave-particle duality is physically defined as the ratio of the fundamental condensation momentum scale to the particle's actual momentum, modulated by the condensation length. Validated to 0.14% precision for a 100 eV electron.

Deriving the Schrödinger Kinetic Operator

$$i\hbar \frac{\partial \Psi}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \Psi + V\Psi$$

$$i\left(\frac{m_p c r_p}{\pi R_0}\right) \frac{\partial \Psi}{\partial t} = -\frac{(m_p c r_p)^2}{\pi^2 R_0^2 m} \nabla^2 \Psi + V\Psi$$

Mathematical Invariance

No quantum mechanical postulate is altered. The equation is fully preserved.

Ontological Shift

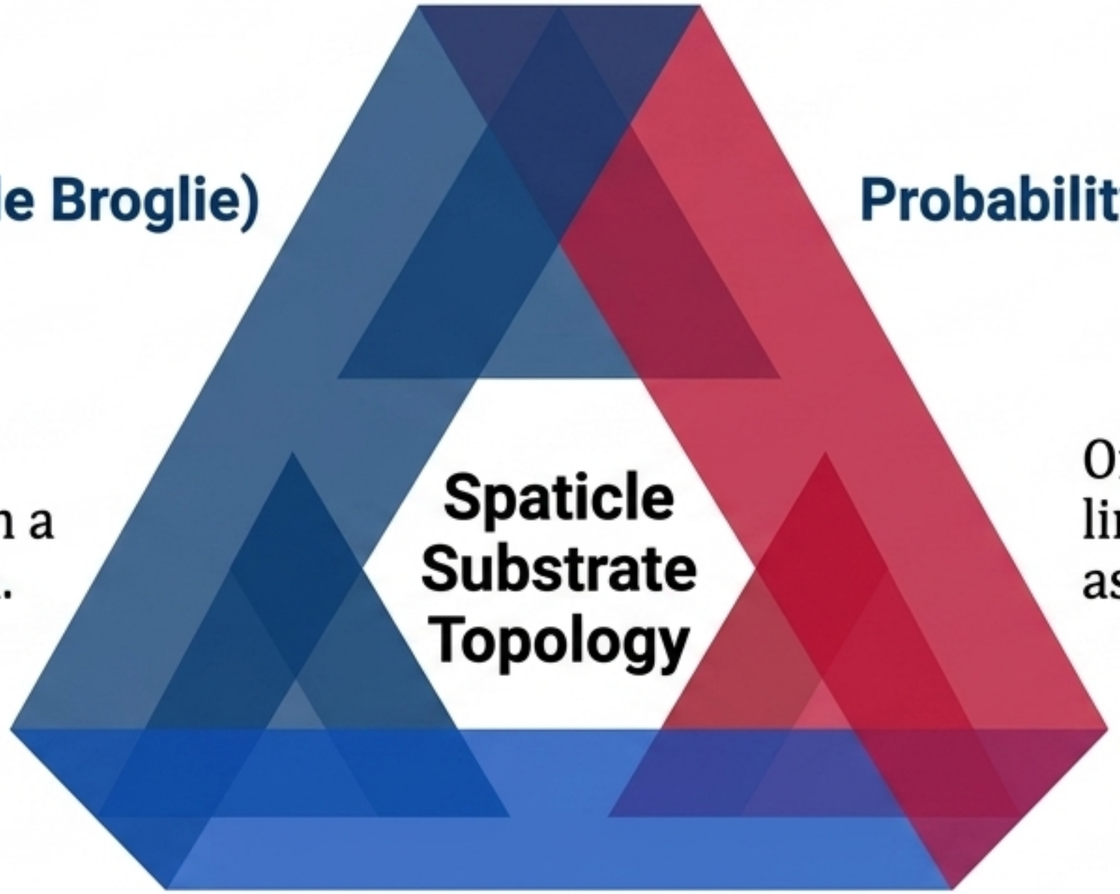
The entire Schrödinger equation is now expressed exclusively in terms of condensation geometry geometry (m_p, r_p, R_0), particle mass (m), and potential (V).

The Geometric Unity of Quantum Mechanics

Wave-Particle Duality (de Broglie)

$$\lambda = \frac{m_p c r_p}{\pi R_0 p}$$

Origin: Ratio of momentum scales in a continuous medium.



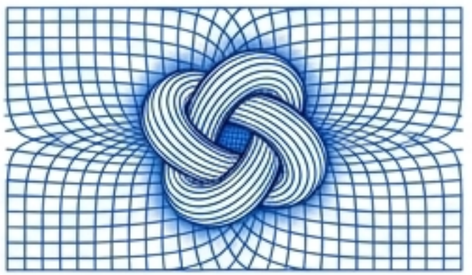
Probability (Born Rule)

$$P(x) \propto |\psi(x)|^2$$

Origin: Energy density in a linear wave system scaling as squared amplitude.

Spin-Statistics (Fermions vs Bosons)

Origin: 720° phase restoration requirement for embedded condensations vs. 360° for freely propagating waves.



These are not separate quantum postulates. All three are emergent mathematical consequences of the exact same geometric substrate topology.

Falsifiable Predictions

1. **Geometric Tracking:** As the measurement of the proton charge radius (r_p) is independently refined experimentally, the predicted de Broglie wavelength for any given particle will track this refinement to the exact same precision.

2. **Graded Decoherence:** Decoherence manifests as a continuous, graded suppression of interference visibility governed by coupling strength—not an abrupt, binary transition.

3. **Detector-Dependent Thresholds:** Systematically different detector technologies, engineered with varying degrees of structural persistence, will exhibit measurably different effective collapse thresholds under weak measurement protocols.

4. **Observer Independence:** No experimental protocol will ever demonstrate that conscious observation plays a causal role in collapse distinct from physical coupling.

Summary: Mathematical Precision, Ontological Clarity

The Entity

A quantum object is a single physical entity—an extended, propagating substrate disturbance with an internal condensation structure.

The Math

Standard QM predictions (de Broglie relation, Schrödinger equation) are reproduced with extreme precision (e.g., 0.14% for low-energy electrons) without modifying the established formalism.

The Problem Solved

Wave-particle duality is not an irreducible paradox requiring 'complementarity'. It is the natural consequence of viewing one entity across two temporal phases: pre-detection extension and post-detection coupling.

Conclusion

The mathematics of quantum mechanics are correct; what was missing was the physical substrate (The Spaticle Field) that dictates their values.