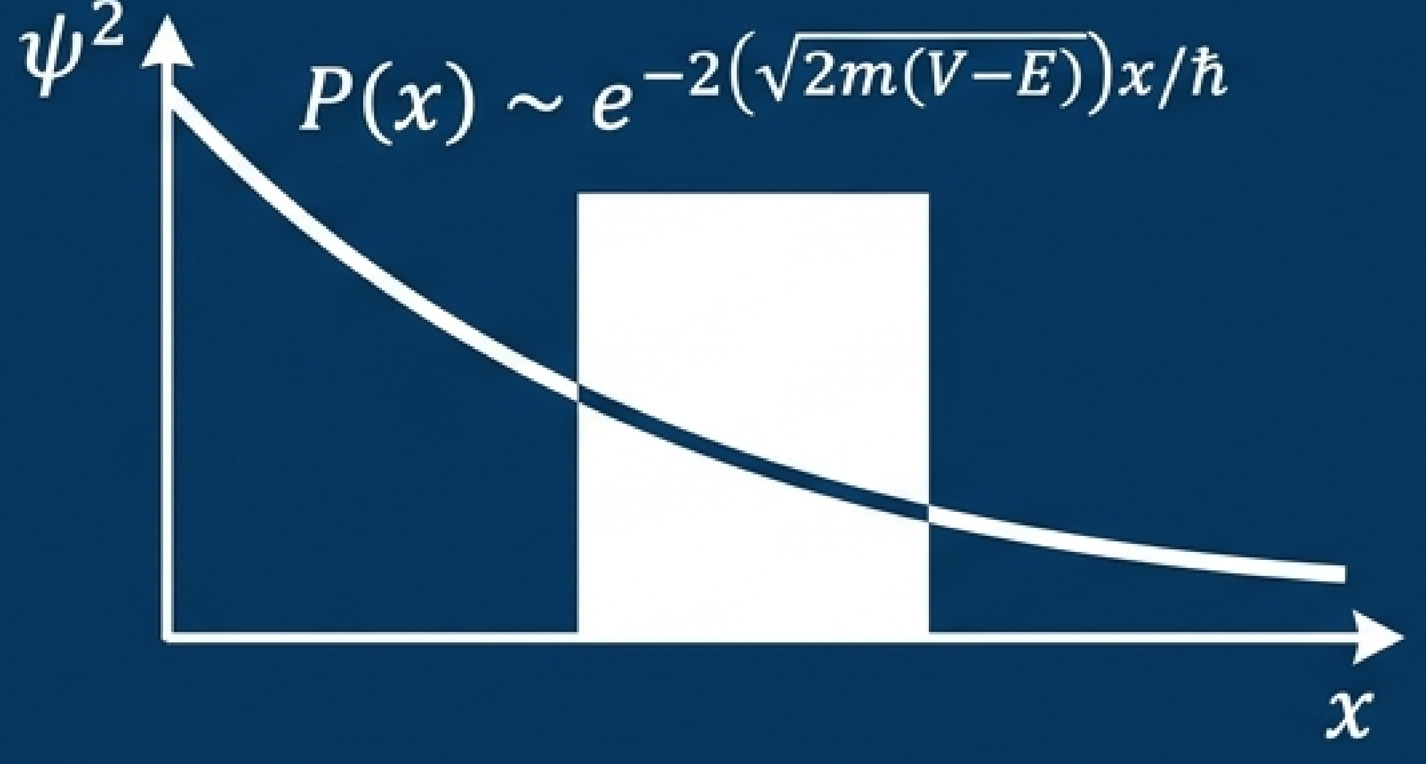
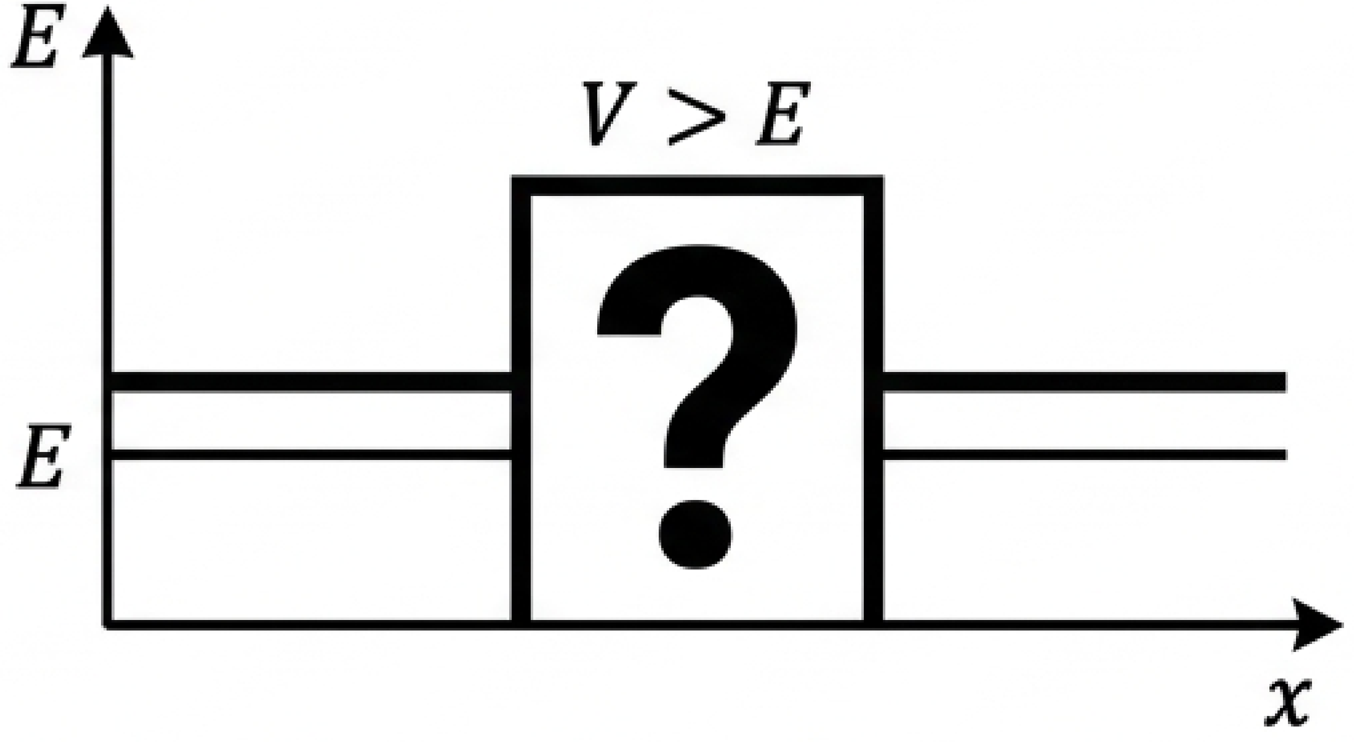
A Physical Explanation of Quantum Tunnelling

Deriving Barrier Penetration from Substrate Condensation Geometry

Vijay Shankar Sharma
DOI: 10.5281/zenodo.21303246
Keywords: quantum tunnelling, barrier penetration, decay constant, condensation topology, physical substrate.

The Interpretive Gap in Interpretive Gap in Standard Quantum Quantum Mechanics

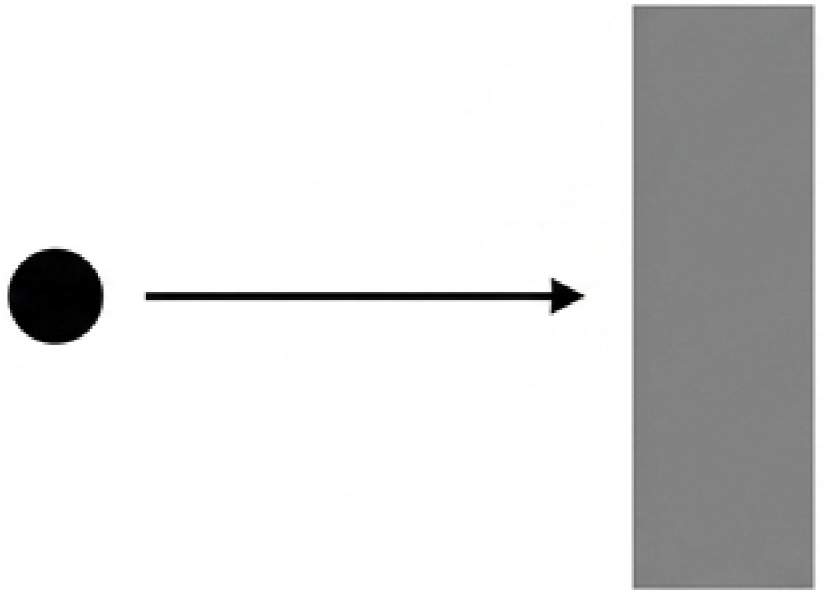




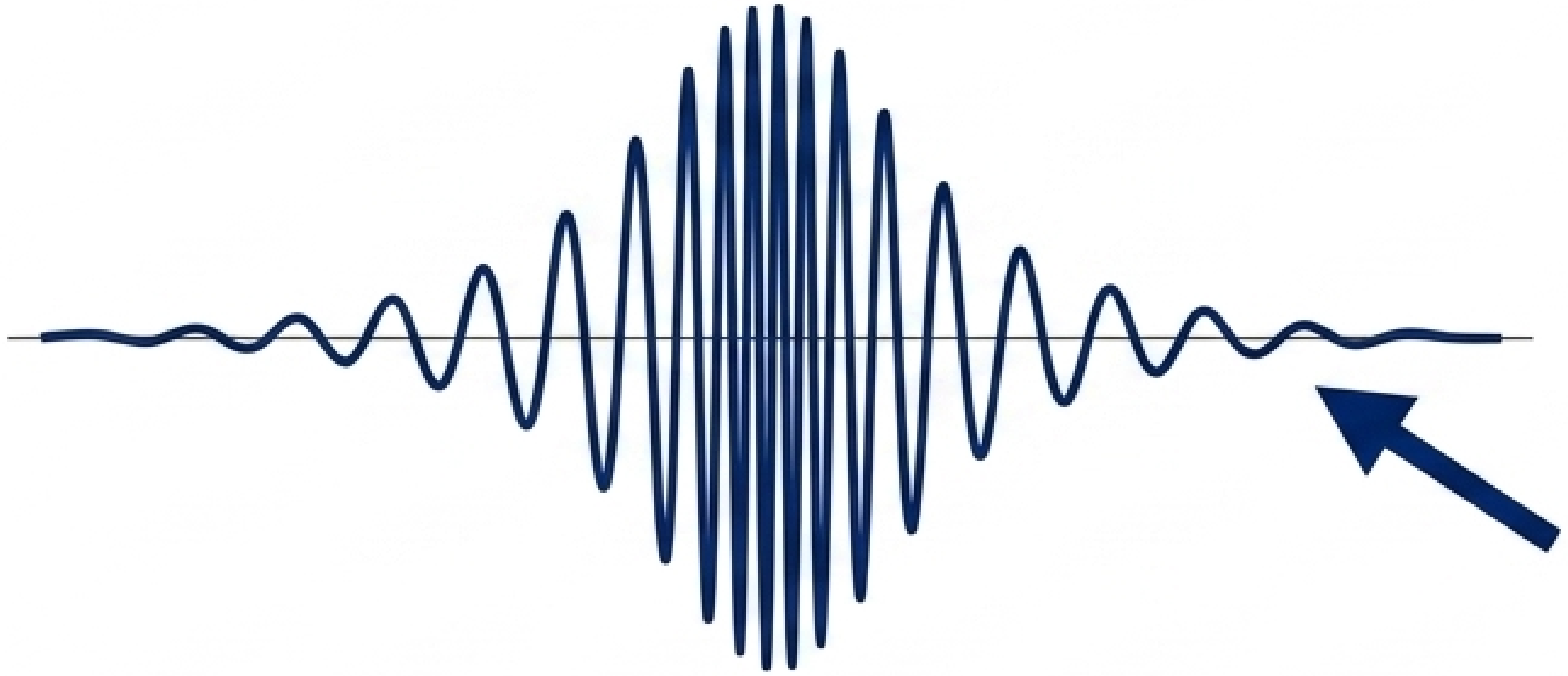
Mathematical Triumph. The Schrödinger equation predicts barrier transmission probability with total accuracy, underlying essential technologies like STM and tunnel diodes.

Physical Void. The standard formulation offers no physical picture of what a particle is doing while traversing a classically forbidden region, reducing the phenomenon to an unexplained postulate of wave mechanics.

Redefining the Particle: From Point Object to Substrate Condensation



Classical/Standard QM: A point object requiring sufficient kinetic energy (E > V) to traverse a spatial boundary.

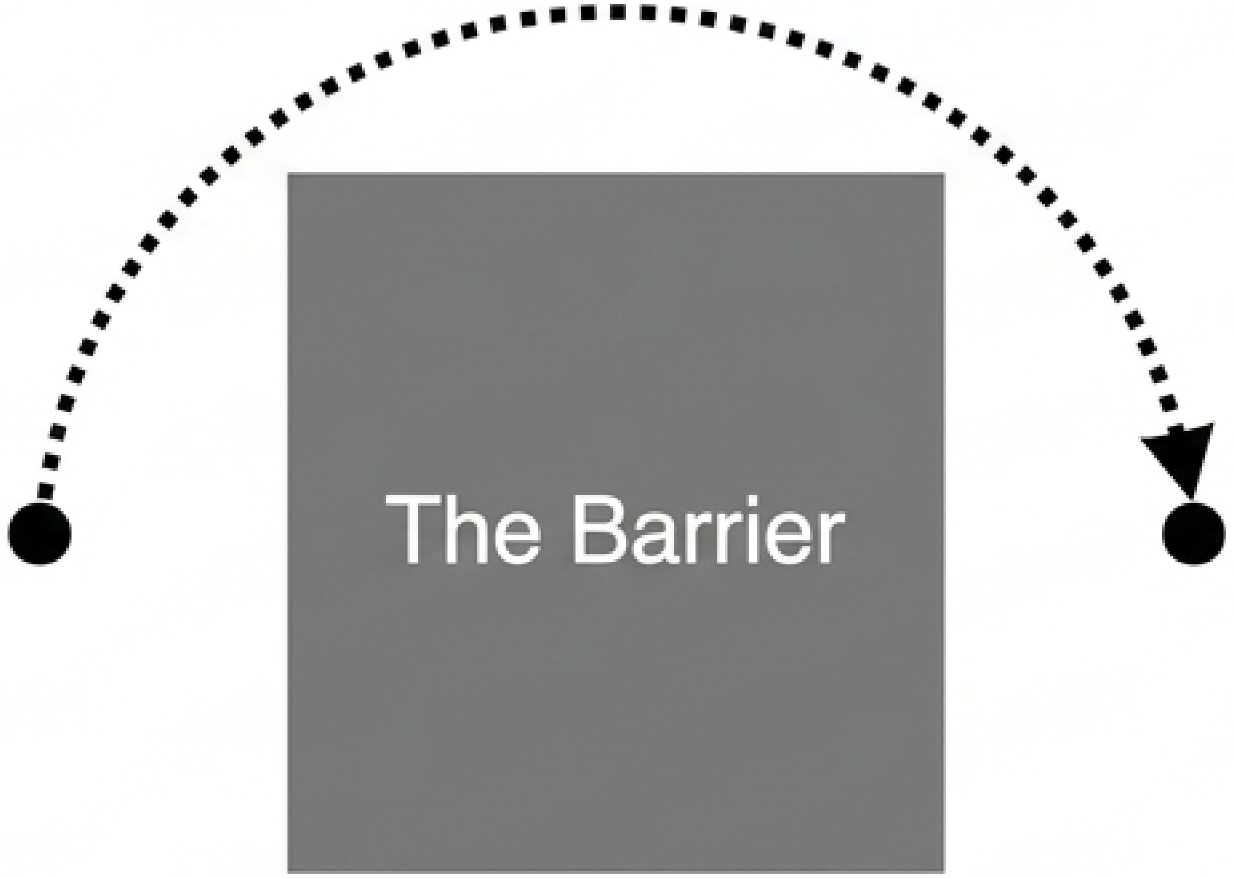


BFUT Postulate: A particle is an extended substrate deformation.

Finite localisation cost (A/R^2) means the deformation field retains non-zero amplitude at all distances from its formation center.

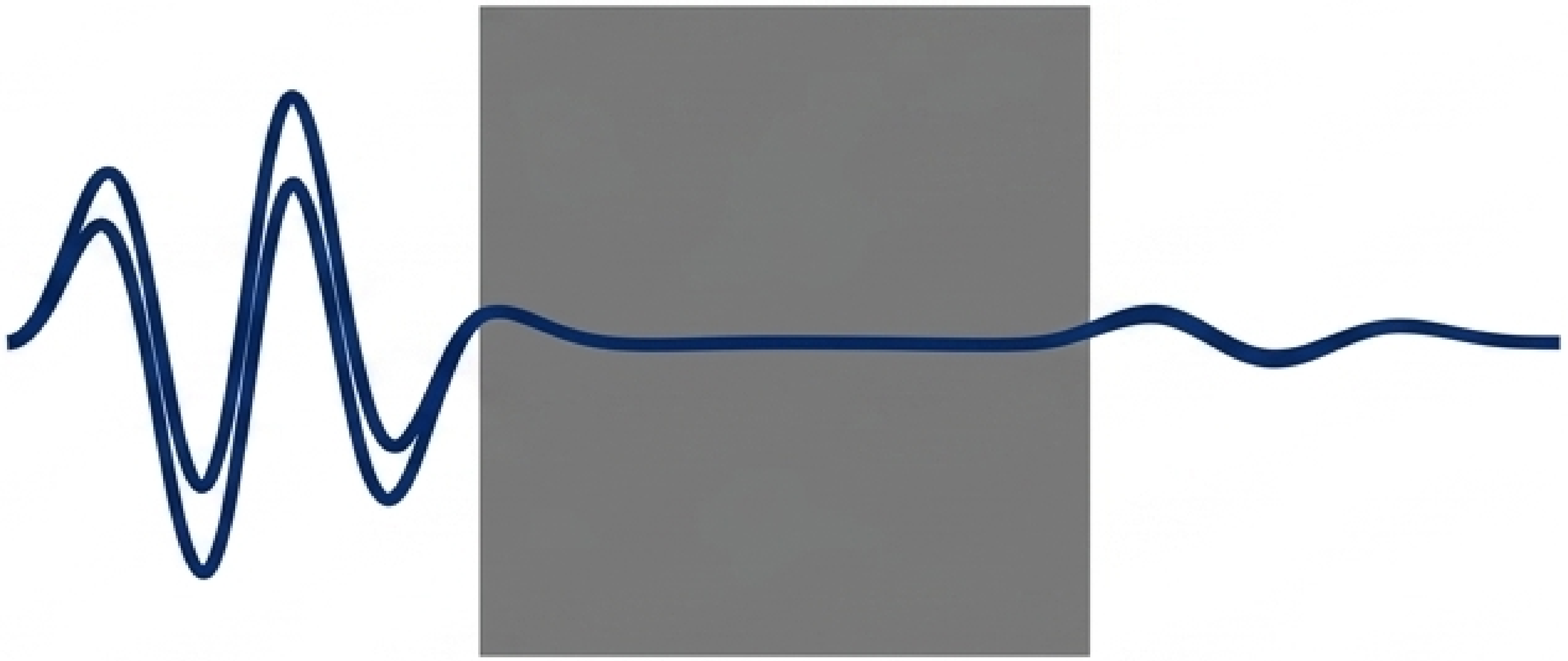
Tunnelling as Condensation Boundary Leakage

Standard View



Standard Intuition: The particle "borrows" energy or jumps the gap.

BFUT Mechanism



Because the particle was never a point, its physical field is already present on the far side of the barrier.

Because the particle was never a point, its physical field is already present on the far side of the barrier. Tunnelling is the physical continuity of this extended deformation field across a region of elevated substrate energy.

Diagnostic Matrix: Standard Formulation vs. BFUT Substrate

	Standard Formulation	BFUT Substrate Formulation
Nature of Particle	0D Point mass / Abstract probability wave	Extended physical Spaticle substrate deformation
Nature of Tunnelling	Probabilistic violation of classical boundaries	Physical continuity of the deformation boundary leakage
Role of Planck Constant ($\hbar$)	Unexplained fundamental empirical constant	Derived geometric expression of condensation scale
Mathematical Output	Predicts exact transmission rates	Reproduces standard rates identically via physical geometry

SECTION 3: FORMALISM - The Standard Decay Constant

Classical momentum deficit inside the forbidden region

$$\kappa = \frac{\sqrt{2m(V-E)}}{\hbar}$$

Reduced Planck Constant (Treated as an irreducible empirical input)

Decay Constant (Determines exponential suppression in the barrier)

Unlocking $\hbar$: The Geometric Condensation Origin

Proton Rest Mass

Speed of Light
(Substrate propagation limit)

Proton Charge Radius
(Measured physical dimension)

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

Geometric Condensation Constant (R_0 = 1.27348)

Substituting the unexplained constant for a derived expression of substrate condensation geometry allows us to rewrite the rules of tunnelling.

The Geometric Decay Constant

Inverse of the Condensation Length Scale (ℓ_{model})

Ratio of the barrier energy scale to the proton momentum scale

$$\kappa = \frac{\pi R_0 \sqrt{2m(V-E)}}{m_p c r_p}$$

The decay constant is no longer dependent on a mysterious fundamental constant. It is expressed entirely in terms of independently measured condensation-geometry quantities.

Universal Transmission Probability

Barrier Width

$$T = \exp\left(-2\pi R_0 d \frac{\sqrt{2m(V-E)}}{m_p c r_p}\right)$$

Exponential suppression is simply the physical decay of the already-present, extended field amplitude.

This equation does not modify numerical predictions. It reveals that transmission probability is dictated by the physical length scale of the condensation itself.

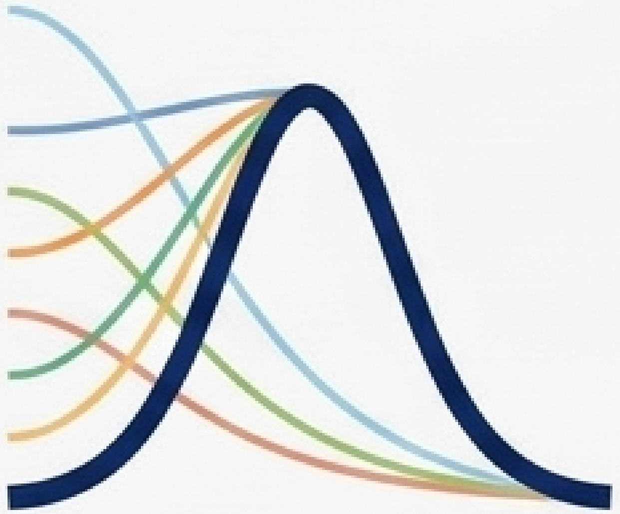
Quantitative Verification: The 1 eV Electron Barrier

Test Case: Electron ($m_{\text{eff}} = 5.317 \times 10^{-28}$ kg) encountering a 1 eV potential barrier.

	Standard QM (via empirical $\hbar$)	BFUT Geometric Derivation	Discrepancy
Penetration Depth ($1/\kappa$)	8.080 pm	**8.091 pm**	0.14%

The 0.14% discrepancy is strictly consistent with the precision limits of the underlying proton charge radius (r_p) measurement used in the derivation. The geometry reproduces empirical reality.

Falsifiable Predictions & Empirical Tests

1 

Universal Functional Collapse

Tunnelling probability curves across different material systems (e.g., Josephson junctions), when expressed in terms of the shared condensation length scale $\ell_{\text{model}} = r_{\text{p}}/(\pi R_0)$, will collapse onto a common functional form.

2 

Precision Tracking

As independent measurements of the proton charge radius (r_{p}) improve in precision, the predicted tunnelling penetration depth will track the corresponding refinement in $\hbar$ to the exact same precision.

3 

Mathematical Consistency

No confirmed tunnelling measurement will show a transmission probability inconsistent with the derived geometric formula (Eq 2), as the physical ontology reproduces the Schrödinger mathematics precisely.