Section 5 The CUWF Mechanism of Quantum Tunneling

Standard quantum mechanics successfully predicts tunneling probabilities, but it does not specify what physically occurs when a particle is said to tunnel. Within the CUWF framework, the mechanism is made explicit and deterministic: tunneling is understood as a geometrically governed entropic process in which a collapse node becomes unstable, the underlying wave remains continuous, and a new node forms only when the entropic landscape again permits stability.

In the present paper, this mechanism is described most clearly as a three-phase process: (i) node destabilization as the incoming node encounters an unfavorable entropic ascent, (ii) wave-only propagation through the entropic peak where no stable node can exist, and (iii) node re-instantiation at the next admissible entropic minimum. This removes the paradox of a particle passing through a classically forbidden region while preserving full continuity of the underlying wave on the Fundamental Wave Basin (FWB).

5.1 Phase I — Node Destabilization

Before interacting with the barrier, the particle exists as a stable collapse node, denoted N_A, localized at an entropic minimum. The stability condition for such a node is given by:

$$dS/dx = 0,$$

$$d^2S/dx^2 > 0.$$

As the node approaches the barrier, the incoming particle wave begins to couple to the structured waveform of the barrier. This interaction progressively alters the local entropic geometry, driving the curvature toward instability:

$$d^2S\_incoming/dx^2 \longrightarrow 0^-.$$

Once the local curvature loses its positive character, the node can no longer be sustained. The key point is that this destabilization is not probabilistic. It is structurally required by the changing entropic landscape.

5.2 Transitional Subprocess — Quasi-State Collapse (QSC)

The transition from a stable node to full node extinction need not be described as an abrupt discontinuity. In CUWF, the destabilization process may pass through an extremely brief transitional configuration in which the node has lost full stability but has not yet vanished completely. This is the Quasi-State Collapse (QSC).

QSC arises when the entropic curvature approaches zero:

$$C_S(x,t) = \partial^2 S/\partial x^2 \approx 0.$$

In this regime, the node is no longer fully stable, yet a wave-only region has not been fully established. QSC should therefore be understood as a transient geometric threshold between stable node existence and complete node extinction. It does not introduce a new ontological object; it simply describes the smooth geometric passage from node-supported structure to wave-only continuity.

This transitional idea strengthens the internal continuity of the CUWF mechanism while remaining fully consistent with the broader three-phase picture. Accordingly, QSC is best treated as a sub-process within Phase I rather than as a separate phase of tunneling.

Note: More Understanding Quasi-State Collapse (QSC) as a CUWF Transitional Concept

Within the CUWF framework, the disappearance of a collapse node is not treated as an instantaneous, structureless event. CUWF instead introduces Quasi-State Collapse (QSC) as the transitional regime that arises when a stable node loses its entropic support but has not yet fully entered the wave-only state. QSC should therefore be understood explicitly as a CUWF concept: it is not an auxiliary patch added to rescue the tunneling model, but a natural consequence of the CUWF ontology in which continuity belongs to the wave, whereas discreteness belongs to the collapse node.

The need for QSC follows directly from the smoothness of the structural entropy field S(x,t). A stable node exists only when the local entropic geometry satisfies

$$\partial S/\partial x = 0, \quad \partial^2 S/\partial x^2 > 0.$$

As the node approaches the barrier, the entropic curvature cannot jump discontinuously from positive to strongly negative values without passing through a transitional regime. Instead, the local curvature evolves continuously according to

$$\partial^2 S/\partial x^2 : (+) \longrightarrow 0 \longrightarrow (-).$$

QSC denotes this narrow intermediate region in which node stability is lost, collapse has become inevitable, yet the system has not fully entered the node-free wave-only phase. In this sense, QSC is the final geometrical stage of Phase I and the immediate precursor to Phase II.

Formally, let the entropic curvature be defined as

$$C\_S(x,t) = \partial^2 S/\partial x^2.$$

Then the CUWF tunneling sequence may be partitioned into three local regimes:

$$\text{Stable node regime:} \quad C\_S(x,t) > \varepsilon$$

$$\text{QSC regime:} \quad |C\_S(x,t)| \leq \varepsilon$$

$$\text{Node-impossible regime:} \quad C\_S(x,t) < -\varepsilon$$

where ε is a small structural threshold determined by the smoothness scale of the local wave geometry. Under this definition, QSC is the regime in which the node no longer possesses full particle-like stability, yet the transition to complete node extinction has not mathematically finished.

This allows the collapse operator to be refined in CUWF form as

$$C[\Psi(x,t)] = N(x,t), \quad \text{if } C\_S(x,t) > \varepsilon$$

$$C[\Psi(x,t)] = Q(x,t), \quad \text{if } |C\_S(x,t)| \leq \varepsilon$$

$$C[\Psi(x,t)] = \emptyset, \quad \text{if } C\_S(x,t) < -\varepsilon,$$

where Q(x,t) denotes the Quasi-State Collapse configuration. In CUWF, Q(x,t) is neither a fully stable node nor an ordinary propagating wave packet. It is a transient boundary configuration with vanishing stability and no independently measurable particle identity.

Physically, this has several important consequences. First, QSC does not restore a particle inside the barrier. The CUWF claim that no stable particle exists within the barrier remains unchanged, because QSC is not a stable node and does not carry full localization, measurable momentum, or persistent identity. Second, QSC preserves the continuity of the transition from node-based dynamics to wave-only propagation. Third, it explains why certain near-boundary transient features may appear in extremely sensitive measurements without contradicting the claim of zero stable interior detection.

The local sequence at the barrier entrance is therefore more precisely written as

$$N\_A \longrightarrow Q \longrightarrow \emptyset \longrightarrow \text{wave-only propagation} \longrightarrow N\_B.$$

This sequence clarifies the role of QSC in the CUWF mechanism. Node A does not abruptly disappear without intermediate geometric structure; rather, it passes through a short-lived transitional regime whose existence follows from differentiable entropic geometry. Once the QSC regime has been traversed, the system enters the node-free propagation domain, after which a new node may be re-instantiated at the next admissible entropic minimum beyond the barrier.

QSC should therefore be presented as an intrinsic conceptual and mathematical component of CUWF tunneling. It belongs specifically to the CUWF account of collapse-node dynamics and should be read as a theory-internal explanation of how stable nodal structure is lost continuously at the threshold of the barrier. In that sense, QSC is not an optional appendix to the mechanism, but the natural transitional bridge between node destabilization and wave-only propagation.

5.3 Phase II — Wave-Only Propagation Through the Barrier

When the barrier interior is reached, the entropic profile satisfies:

$$S_{inside} > S_{before},$$

$$d^2S_{inside}/dx^2 < 0.$$

In such a region, no collapse-node stability condition can be fulfilled. Node A therefore undergoes extinction. What disappears is the node, not the wave.

The wave remains continuous on the FWB and propagates through the barrier as a geometrically distorted, node-free structure. In the barrier region, the coupled waveform may be expressed schematically as:

$$\Psi_{coupled}(x) = \Psi_{particle}(x) \oplus \Psi_{barrier}(x).$$

Because destructive interference dominates this region, the waveform loses the sharply localized geometry required for collapse-node formation. The result is a barrier interior in which wave continuity persists but particle-like localization does not. This is why CUWF predicts no stable particle detection inside the barrier.

The apparent paradox of tunneling is therefore resolved directly: the particle does not cross the barrier as a persistent object. Only the continuous wave persists through the entropic peak.

5.4 Phase III — Node Re-instantiation Beyond the Barrier

Beyond the barrier, destructive resonance weakens and the composite wave relaxes toward a more ordered configuration:

$$S_{after} < S_{inside}.$$

If the post-barrier region contains a new entropic minimum satisfying:

$$dS_{after}/dx = 0,$$

$$d^2S_{after}/dx^2 > 0,$$

then the continuous wave may re-stabilize as a new collapse node:

N_B = collapse at the next entropic minimum.

Node B is not the same particle transported through the barrier. Rather, it is the next admissible collapse configuration of the same continuous wave. In this sense, identity is not carried by a traversing object; it is re-instantiated through the geometry of the entropic field.

This interpretation removes the need for energy borrowing, eliminates the notion of hidden passage through the barrier interior, and clarifies why tunneling-time paradoxes arise when tunneling is incorrectly interpreted as node transport.

5.5 Why the Three-Phase Mechanism Resolves the Tunneling Paradoxes

CUWF resolves the standard tunneling paradoxes in a unified way. The particle is not found inside the barrier because node stability is impossible in a region of negative entropic curvature. The particle does not pass through a wall because the node extinguishes before the barrier interior and reappears only when stability returns beyond it. Energy conservation is not violated because continuity is carried by the wave rather than by a persisting node. Likewise, tunneling time becomes conceptually non-paradoxical once it is recognized that node transport does not occur at all.

5.6 Summary of the CUWF Tunneling Mechanism

In CUWF, quantum tunneling is most coherently described as the following three-phase sequence:

Phase I: node destabilization as the incoming node encounters an unfavorable entropic ascent;

Phase II: wave-only propagation through the barrier region where no stable node can exist;

Phase III: node re-instantiation at the next admissible entropic minimum beyond the barrier.

In compact form, the mechanism may be summarized as:

$$N\_A \longrightarrow QSC \longrightarrow \emptyset \longrightarrow \text{wave-only continuity} \longrightarrow N\_B.$$

This geometric-entropic formulation restores physical meaning to tunneling and prepares the ground for Section 5, where the formal structure of entropic tunneling is developed in mathematical detail.