

Section 8. Relation to Quantum Tunneling and Micro-Mechanisms

Having established the entropic mechanism underlying the quantum–classical transition, it is now necessary to clarify how this regime-level description connects to specific microphysical phenomena. Among these, quantum tunneling occupies a central position. Tunneling is often treated as a purely quantum effect that should disappear in the classical limit. Within CUWF, however, tunneling is reinterpreted as a micro-mechanism whose expression depends on the surrounding entropic regime rather than as a phenomenon belonging to an entirely separate ontology.

This section therefore explains how tunneling behavior changes across entropic regimes, why tunneling weakens but does not vanish in classical contexts, how micro-mechanisms differ from regime-level behavior, and where the conceptual boundary between Paper A-4 and Paper A-6 should be drawn.

8.1 Tunneling Behavior Across Entropic Regimes

In conventional quantum mechanics, tunneling is described as a nonzero probability for a particle to traverse a classically forbidden potential barrier. That description successfully captures observed amplitudes, but it does not in itself explain why tunneling depends so strongly on environmental and structural context.

In CUWF, tunneling is interpreted as the traversal of collapse configurations through low-entropic corridors in configuration space. Whether tunneling occurs depends not only on local energetic conditions, but also on the availability of collapse pathways that remain structurally accessible.

Let C_L and C_R denote collapse configurations on opposite sides of a barrier. Tunneling is possible when a continuous collapse pathway exists such that:

$$E[C_{\text{path}}] < E_{\text{blocking}}$$

where E_{blocking} represents the entropic constraint imposed by the barrier configuration.

In low-stability quantum regimes, entropic constraints are weak, configuration space remains comparatively open, and low-entropic corridors are more readily available. As a result, tunneling occurs more easily and may carry significant amplitude.

8.2 Why Tunneling Weakens but Persists Classically

As systems transition into stabilized classical regimes, entropic constraints intensify and configuration space contracts. Many collapse pathways that previously supported tunneling become inaccessible because structural stabilization saturates the available corridor structure.

However, stabilization does not eliminate every micro-level pathway. It suppresses most of them, leaving only rare and highly constrained corridors. Tunneling probability therefore decreases sharply without becoming identically zero.

This behavior may be expressed schematically as:

$$P_{\text{tunnel}} \propto \exp(-E[\text{C}_{\text{path}}])$$

As $E[\text{C}_{\text{path}}]$ increases with stabilization, P_{tunnel} becomes exponentially small while remaining finite.

This explains why tunneling effects can still be observed in classical or semiclassical settings—such as nuclear decay or Josephson systems—without contradicting classical stability. Tunneling persists as a micro-mechanism operating beneath a stabilized regime rather than as a macroscopically dominant mode of behavior.

8.3 Micro-Mechanism versus Regime-Level Behavior

A key conceptual distinction in CUWF is the difference between micro-mechanisms and regime-level behavior. Micro-mechanisms describe local collapse dynamics and the availability of specific pathways. Regimes, by contrast, describe the broader stability structure that determines which mechanisms remain physically relevant at observable scale.

Tunneling is therefore a micro-mechanism: it describes how collapse configurations may traverse constrained regions under particular structural conditions. Classicality is a regime property: it describes whether such mechanisms retain visible impact once stabilization dominates.

In stabilized regimes, micro-mechanisms do not disappear. Rather, their effects are suppressed by structural persistence, and observable behavior becomes dominated by stabilized configurations. Failure to distinguish these levels leads to a recurring confusion—namely, the assumption that quantum effects must disappear completely in classical systems. CUWF resolves this by assigning tunneling and similar phenomena to the micro-level, while allowing regime stability to determine their macroscopic relevance.

8.4 Clarifying the Boundary Between Paper A-4 and Paper A-6

This distinction also clarifies the relationship between Paper A-4 and Paper A-6 within the CUWF series. Paper A-4 is concerned with regime formation: how entropic thresholds and stabilization give rise to classical behavior, and why quantum indeterminacy becomes suppressed at the level of observable structure.

Paper A-6, by contrast, is concerned with the detailed micro-mechanism of tunneling itself. There, tunneling is analyzed in terms of node destabilization, wave-only propagation through the barrier region, and node re-instantiation beyond the barrier. In other words, A-6 explains how tunneling proceeds as a three-phase process within the CUWF framework, whereas A-4 explains why the broader entropic regime determines whether such a micro-mechanism has significant observable impact.

The distinction may therefore be stated succinctly:

Paper A-4 asks why classical regimes emerge.

Paper A-6 asks how tunneling operates within and across such regimes.

Maintaining this separation preserves conceptual clarity and prevents regime-level explanations from being conflated with detailed micro-dynamical mechanism.

8.5 Summary: Tunneling Within Stabilized Regimes

Quantum tunneling does not contradict classical stability because it operates at a different structural level. In CUWF, tunneling reflects the availability of micro-level collapse pathways through low-entropic corridors, whereas classicality reflects regime-level stabilization that suppresses their macroscopic impact.

Tunneling therefore weakens as entropic constraints intensify, but it does not vanish. This regime-sensitive interpretation reconciles tunneling with classical persistence and provides a consistent bridge between microphysics and emergent classical behavior.

With this relationship clarified, the paper can now proceed to the broader physical and conceptual implications of regime formation.