

Section 4. Entropic Structure and Regime Formation

The failure of measurement-driven and probability-based accounts of classical emergence points toward a deeper requirement: a structural principle capable of distinguishing physical regimes independently of observation. Within CUWF, that principle is provided by entropy—not as a statistical measure of ignorance, but as a structural constraint governing collapse configuration space.

This section reformulates entropy as an organizing structure that shapes collapse pathways, couples configurations, and defines regime boundaries. Quantum and classical behaviors are shown to arise not from competing laws, but from distinct entropic regimes determined by stabilization conditions. In this way, the traditional quantum–classical dichotomy is replaced by a regime-based ontology grounded in structural entropy.

4.1 Entropy as a Structural Constraint, Not a Statistical Artifact

In conventional physics, entropy is most often interpreted as a statistical quantity: a measure of microstate multiplicity or informational uncertainty. That interpretation is powerful in thermodynamics, but it becomes insufficient when the question concerns the quantum–classical transition. Statistical entropy describes distributions over states; it does not by itself specify how physical configurations acquire or lose structural stability.

CUWF therefore adopts a different interpretation. Entropy is treated as a structural constraint acting directly on collapse configuration space. Rather than counting microstates, entropy limits the degrees of freedom available to collapse pathways and determines which configurations can persist.

Let C denote a collapse configuration in configuration space \mathcal{C} . Define an entropic constraint functional $E[C]$ by:

$$E[C] = -\log \Omega(C)$$

where $\Omega(C)$ represents the effective configuration volume accessible to C under collapse dynamics.

High $E[C]$ corresponds to strong constraint and reduced configurational freedom, whereas low $E[C]$ corresponds to weak constraint and high accessibility. Structural stability requires collapse evolution to become confined to a restricted region of configuration space:

$$d\Omega(C)/dt \rightarrow 0$$

This condition is independent of statistical ensembles or observer knowledge. Entropy, in this formulation, is not primarily a property of description but a property of configuration accessibility. It acts as a geometrical limiter on collapse evolution and thereby shapes the structural possibilities of physical reality.

4.2 Entropic Coupling Among Collapse Configurations

Collapse configurations do not evolve in isolation. In CUWF, configurations are coupled through shared entropic constraints, forming a relational network rather than a collection of independent trajectories. This coupling is not mediated by conventional forces or signal exchange. It is generated by entropic compatibility among configurations.

Let $\{C_i\}$ denote a set of collapse configurations. Define an entropic coupling kernel K_E such that:

$$K_E(C_i, C_j) \neq 0$$

whenever configurations C_i and C_j share overlapping constrained configuration space.

Entropic coupling implies that stabilization of one configuration can restrict the accessible pathways of neighboring configurations. Conversely, instability in one region of configuration space can propagate destabilization across coupled configurations. In this way, collective behavior can emerge without invoking classical interaction mechanisms at the foundational level.

In low-constraint regimes, entropic coupling remains weak:

$$K_E \rightarrow 0$$

and collapse configurations evolve largely independently, leading to widespread pathway competition and indeterminacy. As constraints intensify, coupling strengthens, enabling collective stabilization and

coordinated collapse behavior. Entropic coupling therefore functions as a pre-geometric relational structure, binding configurations together before spacetime, fields, or forces emerge in effective description.

4.3 Definition of Physical Regimes in CUWF

Once entropy is defined as both a structural constraint and a coupling mechanism, CUWF can define physical regimes in terms of stability classes rather than in terms of separate dynamical laws. A regime is characterized by whether collapse configurations can achieve persistence under the prevailing entropic constraints.

Let $\Pi[C]$ denote the persistence functional introduced earlier, and let $E[C]$ denote the entropic constraint strength. A physical regime R is defined by the condition:

$$R = \{ C \mid \Pi[C] \geq \Pi_{\min}(E[C]) \}$$

In quantum regimes:

$$\Pi[C] \rightarrow 0$$

$$E[C] < E_{\text{critical}}$$

Collapse configurations remain unstable, entropic coupling is weak, and indeterminacy dominates.

In classical regimes:

$$\Pi[C] > 0$$

$$E[C] \geq E_{\text{critical}}$$

Collapse configurations stabilize, entropic coupling consolidates pathways, and persistence emerges.

Crucially, regimes are not defined by scale, mass, or macroscopicity alone. A small system can exhibit classical behavior if entropic constraints are sufficient, and a large system can retain quantum behavior if such constraints remain weak. Regime membership is therefore structural rather than merely dimensional.

4.4 Why Regimes Replace the Quantum–Classical Dichotomy

Traditional physics often treats quantum and classical descriptions as fundamentally distinct frameworks, connected only through correspondence rules, limiting approximations, or interpretive patchwork. CUWF replaces this dichotomy with a continuous but non-linear regime structure.

Quantum and classical behaviors are not governed by separate laws. They are manifestations of collapse dynamics operating under different entropic conditions. The apparent discontinuity between quantum indeterminacy and classical determinism arises because stability thresholds introduce bifurcation points in configuration space.

This regime-based view resolves several longstanding tensions at once. It explains why quantum mechanics can remain universally valid while classical behavior appears robust. It removes the need for special measurement postulates or observer-dependent transitions. And it unifies microphysical and macrophysical behavior under one structural principle rather than under two incompatible ontologies.

In CUWF, “quantum” and “classical” are therefore not competing descriptions of two different worlds. They are labels applied to different regions of the same entropic landscape. What distinguishes them is not the nature of reality itself, but the degree of structural stabilization achieved by collapse configurations.

4.5 Summary: Entropic Regimes as the Basis of Physical Reality

Entropy, when understood as a structural constraint rather than a statistical artifact, provides the missing foundation for regime formation in CUWF. Entropic coupling binds collapse configurations into relational structures, while entropic thresholds determine whether those structures remain indeterminate or stabilize into persistent forms.

Physical regimes emerge naturally from these constraints. Quantum behavior corresponds to low-stability, weakly coupled regimes, whereas classical behavior corresponds to stabilized, strongly constrained regimes. The quantum–classical transition is therefore not a change of laws, but a change of regime.



With the entropic basis of regime formation now established, the paper can proceed to formalize how specific thresholds arise and how stabilization produces the observable features of classical reality.