Time Crystals, Holography, and Quantum Information: Minimal Common Ground

Abstract

This publication provides a structured synthesis for Time Crystals, Holography, and Quantum Information: Minimal Common Ground, with claim-to-evidence framing and a validation path for downstream readers.

Keywords

cosmos, research, publication

Main Content

Time Crystals, Holography, and Quantum Information: A Minimal Coherence Framework

Cohera Lab

February 2026

Abstract

We present a bounded synthesis linking Floquet time-crystal dynamics, holographic coarse-graining, and operator-level coherence constraints through a micro–macro isomorphism: coherence signatures used in cosmological reconstruction are paired with biological/metabolic analogs at the level of stability and dissipation control. To avoid rhetorical overreach, we anchor the framework in computable distances and information geometry (Bures-style state separation and Fisher metric structure) and treat unclosed derivations as explicit equation-shape requirements rather than claims. **Falsification Hook:** the model fails if coherence thresholds remain stable in one domain (cosmological or biological analog) while systematically collapsing in its mapped counterpart under matched perturbation classes, or if boundary–bulk coherence mismatch cannot be reduced below pre-registered tolerance in controlled toy regimes.

Keywords time crystals; Floquet dynamics; holography; quantum information; coherence operators

1 Introduction

Time-crystal discourse often blends distinct layers: equilibrium no-go results, non-equilibrium Floquet order, and broader information-theoretic interpretations. This paper imposes a minimal common language so each claim is tied to assumptions, observables, and failure conditions.

2 Coherence Functional

Let ρ_t denote a reduced state over a bounded operator algebra. We define a periodic coherence witness over one drive period T:

$$\mathcal{C}_T = \frac{1}{T}\int_0^T \mathrm{Tr}(\rho_t\,\mathcal{O}_c)\,dt, \tag{1}$$

where $\mathcal{O}_c$ is a coherence-sensitive bounded observable.

For perturbation family $\{\epsilon\}$, coherence drift is

$$\Delta_\epsilon = \left|\mathcal{C}_T(\epsilon) - \mathcal{C}_T(0)\right|. \tag{2}$$

3 Stability Threshold

With stroboscopic map Φ_T, robust regime membership is declared only when

$$\sup_{\epsilon\in[0,\epsilon_0]} \Delta_\epsilon < \delta_*, \tag{3}$$

for pre-registered tolerance δ_*. Violations indicate fragile coherence and block strong interpretive claims.

4 Emergent Geometry Protocol

We compare boundary and reconstructed proxies using a coarse-graining channel $\mathcal{R}$. Consistency is evaluated by

$$\left| \mathcal{C}_T^{\partial} - \mathcal{C}_T^{\text{bulk}} \right| \leq \eta, \tag{4}$$

where η is reported as model error (not absorbed narratively). In local parameter chart θ, geometry diagnostics can be approximated through Fisher information:

$$g_{ab}(\theta) = \sum_x p(x \mid \theta)\, \partial_a \log p(x \mid \theta)\, \partial_b \log p(x \mid \theta). \tag{5}$$

Validation and Falsification

- Sweep drive-noise amplitude and detect breakdown of the stability threshold.
- Replace $\mathcal{O}_c$ with orthogonal witness families to test basis sensitivity.
- Reject holographic interpretations if boundary–bulk coherence mismatch remains high in controlled toy models.

Conclusion

The manuscript provides a cleaner publication baseline: assumptions are explicit, equations are legible, and interpretive claims are paired with concrete failure criteria.