

# **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

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## Abstract

We present a compact synthesis connecting Floquet time-crystal dynamics, holographic coarse-graining, and operator-level coherence constraints. The goal is not to claim a final theory but to formalize a minimal testable scaffold that separates established results from speculative bridges. We introduce an effective coherence functional and derive practical falsification hooks for numerical and experimental workflows.

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

## 1 Introduction

Time-crystal discourse often mixes distinct regimes: rigorous no-go statements in equilibrium, non-equilibrium Floquet order, and information-theoretic interpretations. This manuscript imposes a minimal common language so each claim can be attached to assumptions, observables, and failure modes.

## 2 Minimal Formal Layer

Let  $\rho_t$  denote a reduced state on a finite operator algebra. We define a periodic coherence witness over one drive period  $T$ :

$$\mathcal{C}_T = \frac{1}{T} \int_0^T \text{Tr}[\rho_t \mathcal{O}_c] dt, \quad (1)$$

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

For a stroboscopic map  $\Phi_T$ , persistence under perturbation family  $\{\epsilon\}$  is tracked by

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

A practical robustness criterion is

$$\sup_{\epsilon \in [0, \epsilon_0]} \Delta_\epsilon < \delta_*. \quad (3)$$

### 3 Holographic Interpretation Layer

We model coarse-grained reconstruction by an effective channel  $\mathcal{R}$  acting on low-energy observables. A consistency requirement between boundary witness and reconstructed bulk proxy is

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

with  $\eta$  explicitly reported as model error, not absorbed into interpretation.

### 4 Validation and Falsification Hooks

- **Numerical hook:** sweep drive-noise amplitude and test violation of the robustness bound.
- **Model hook:** replace  $\mathcal{O}_c$  by orthogonal witness families; check whether conclusions are basis-dependent.
- **Interpretation hook:** force  $\eta \rightarrow 0$  in controlled toy models; reject holographic claim if mismatch persists.

### 5 Conclusion

This paper provides a cleaner publication-ready baseline: assumptions are explicit, equations are readable, and each interpretive step is paired with a concrete failure condition.

### References (working set)

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