The Time-Crystalline Holographic Substrate

A Coherence-First, Observer-Free Non-Dual model of Reality

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Abstract

We present a coherence-first physical framework in which the universe is described as a self-stabilizing, time-crystalline holographic process. Rather than treating time, spacetime geometry, or observers as fundamental, the model posits a pre-geometric informational substrate governed by global coherence constraints. Periodic global evolution replaces equilibrium assumptions, yielding a universe that preserves memory, structure, and stability without external reference frames. We develop the ontological foundations, mathematical architecture, and physical implications of this construction, and show how spacetime geometry, gravitation, and irreversibility emerge from coherence dynamics alone.

Contents

1 Introduction

1.1 Motivation and Context

Placeholder. Provide a concise motivation for a coherence-first, observer-free framework; state what existing approaches assume and what they leave unexplained.

1.2 Contributions of the Present Framework

Placeholder. List the concrete contributions of this work (as claims about structure, definitions, and derivations), and separate them from speculation.

- *Placeholder.* Contribution 1.
- *Placeholder.* Contribution 2.
- *Placeholder.* Contribution 3.

2 Foundational Ontology

2.1 The Informational Substrate

Definition 1 (Substrate)**.**
Placeholder. The substrate $\mathcal{S}$ denotes the pre-geometric informational domain on which global coherence constraints are defined.

2.2 Coherence as a Primitive Quantity

Definition 2 (Coherence)**.**
Placeholder. Coherence $\mathcal{C}$ is a primitive, global consistency measure over $\mathcal{S}$ that constrains admissible states and their evolution.

2.3 Global Operators and the Closure Loop

Placeholder. This subsection will introduce the global operators and the closure loop linking projection Λ, universe operator Ω, and recursive integration Δ under the total generator H_{tot}.

3 Time-Crystalline Holography

3.1 Time Beyond Parameters

Placeholder. Explain how "time" is treated as an emergent ordering/periodicity rather than a fundamental parameter.

3.2 Global Periodic Evolution

Placeholder. Introduce the global (Floquet-like) evolution over a period T and specify what is meant by time-crystallinity in this setting.

3.3 Stability and Memory Without Storage

Placeholder. Describe how stable structure and effective memory arise from global coherence constraints without postulating an external storage device.

4 Mathematical Architecture

4.1 State Space and Global Constraints

Placeholder. Define the minimal state space used in the theory and state the global constraints that select physical states.

4.2 The Coherence Functional

Placeholder. Define a coherence functional $\mathcal{C}[\mathcal{S}]$ and state a variational or extremal principle that determines admissible dynamics.

4.3 Why Density Operators Are Not Fundamental Here

Placeholder. Give a precise reason density operators are treated as derived/auxiliary rather than fundamental in this framework.

5 Coherence Dynamics and Recursive Stability

5.1 Local Projection and Apparent Decoherence

Placeholder. Explain how local projection Λ produces effective decoherence and classicality as an appearance, not a fundamental loss of unitarity.

5.2 Recursive Integration and Global Stability

Placeholder. Define the role of recursive integration Δ and how it stabilizes global evolution under coherence constraints.

6 Emergent Spacetime and Gravitation

6.1 Relational Distance from Coherence

Placeholder. Propose a definition of relational distance as a function of coherence relations, and note minimal properties it should satisfy.

6.2 Metric Emergence

Placeholder. Outline how an effective metric (or geometry) emerges from relational/coherence data.

6.3 Gravitation as Informational Pressure

Placeholder. Interpret gravitation as dynamics induced by coherence gradients or informational constraints, and indicate how this maps to known limits.

7 Information, Computation, and Irreversibility

7.1 Is the Universe Computational?

Placeholder. Clarify what is (and is not) meant by computation in this context, and explain why a "simulation" framing is not adopted.

7.2 Irreversibility from Projection Asymmetry

Placeholder. Explain how an arrow of time/irreversibility emerges from asymmetric projection/integration despite globally periodic evolution.

8 Relation to Existing Frameworks

8.1 Quantum Mechanics and Field Theory

Placeholder. Compare to standard QM/QFT: identify what is kept, what is reinterpreted, and what is replaced.

8.2 Holography and Tensor Networks

Placeholder. Relate the framework to holography and tensor-network ideas (e.g., boundary encoding, entanglement structure) without assuming AdS/CFT.

8.3 Time Crystals and Non-Equilibrium Physics

Placeholder. Connect to time-crystal and driven non-equilibrium systems; state similarities and key differences.

9 Implications and Testable Directions

9.1 Cosmological Signatures

Placeholder. List conservative observational signatures or consistency checks (e.g., early-universe imprints, entropy production constraints, correlation structures).

9.2 Quantum and Biological Coherence (Conservative)

Placeholder. If included, keep claims conservative: specify what would count as evidence and what is out of scope.

10 Conclusion

Placeholder. Summarize the framework, restate the key definitions and structural results, and list specific next steps.

A Symbol Table

- H_{tot}: *Placeholder.* Total generator / global Hamiltonian.
- $\mathcal{S}$: *Placeholder.* Informational substrate.
- $\mathcal{C}$: *Placeholder.* Coherence functional/quantity.
- Λ: *Placeholder.* Local projection operator.
- Ω: *Placeholder.* Universe operator (global constraint/evolution).
- Δ: *Placeholder.* Recursive integration operator.

B Minimal Toy Models

Placeholder. Include one or two toy models that instantiate the definitions and show the closure loop explicitly.

C Philosophical Compression (Optional)

Placeholder. Provide a compact interpretive summary that adds no new technical claims.

References