

Coherence, Time, and Ontological Substitution

A Critique of Circularity in Emergent Time Theories

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Abstract

This paper critiques a prevalent trend in foundational physics: the attempt to derive time from “coherence” or “information geometry.” We argue that such theories do not eliminate time but obscure it through ontological substitution. By treating coherence as a primitive scalar field, these frameworks smuggle in pre-existing relational structures—space, order, and metric—that effectively encode the very temporal dynamics they claim to derive. We demonstrate that coherence is a derived statistic, not a fundamental generator, and that treating it as foundational results in a tautology where time is simply renamed rather than explained.

1. The Promise of Emergence

The ambition to eliminate time from the fundamental ontology of the universe is understandable. The “Problem of Time” in quantum gravity—the incompatibility between the mutable time of General Relativity and the fixed background time of Quantum Mechanics—suggests that time might be an emergent property rather than a fundamental one.

Recent theoretical approaches often propose that time emerges as a parameterization of relational change. The narrative is seductive:

- Posit a timeless state space (a “coherence space” or “information manifold”).
- Define a scalar field (coherence C) across this manifold.

- Define “physical time” as the arc-length along a trajectory of changing coherence.
- Derive entropy, causality, and time dilation as consequences of the geometry of C .

At first glance, this framework appears modest and elegant. It suggests that the universe is a static geometry, and that “time” is merely the gradient of correlations within it.

2. The Ontological Substitution

What makes these theories feel both elegant and dishonest is not a mathematical flaw, but an ontological substitution: several conceptually independent structures are collapsed into a single privileged object called “coherence.”

These theories do not derive time from space in a neutral sense. They derive time from a space that has already been redefined as coherence.

Formally, let us assume a domain Ω (the state space) and a coherence function $C(\psi)$. The theory claims that the “flow” of time τ is given by the gradient descent of C :

$$d\tau \propto -\nabla C$$

From this definition, familiar temporal phenomena—halting (where $\nabla C = 0$), redshift, and entropy growth—are presented as derived consequences.

The Error

The derivations themselves are mathematically consistent. The error lies in what is assumed while being presented as minimal.

Coherence is not ontologically primitive. It is a relational property. It is defined only relative to:

- A set of degrees of freedom (the “things” being coherent),
- A manifold across which variation is measured (a spatial context),
- A metric by which alignment or order is evaluated.

To say “State A is more coherent than State B” requires a pre-existing metric of order. Coherence therefore presupposes relation and space; it does not precede them.

3. Case Studies in Circularity

This error is not hypothetical. It appears in several leading “timeless” frameworks where the generator of time is simply a hidden clock described in different language.

3.1 The Thermal Time Hypothesis (Connes & Rovelli)

The Claim: Time is not fundamental. It is a statistical artifact determined by the state of the system. The “flow” of time is defined by the Tomita–Takesaki modular flow associated with a thermal (KMS) state.

The Substitution: The theory assumes a von Neumann algebra of observables from the outset. Such an algebra inherently encodes the system’s dynamical structure. Selecting a specific state to generate flow is not deriving time from nothing; it is choosing a particular perspective on an already dynamical framework. The thermal state functions as a proxy for the Hamiltonian—the operator of time evolution itself.

Verdict: Time is not derived; it is encoded in the algebraic relations of the observables.

3.2 Shape Dynamics (Barbour)

The Claim: Time does not exist; only “Nows” exist. The universe is a heap of instantaneous three-dimensional geometries in a configuration space called Platonia. “Time” is merely the path of best matching between these shapes.

The Substitution: Determining the “best match” requires minimizing incongruence between configurations. This minimization presupposes a metric of similarity—an ordering principle. By imposing a rule that sequences static instants, time has not been eliminated but renamed.

Verdict: The best-matching algorithm functions exactly as a time evolution operator.

3.3 Entropic and Information-Based Gravity

The Claim: Gravity and time emerge from entanglement entropy or information processing among microscopic degrees of freedom.

The Substitution: Information is treated as a physical substance, yet information requires a reference frame or reader. Concepts such as processing, erasure, or computation presuppose state change. An operation necessarily involves a “before” and “after.”

Verdict: Processing is a temporal verb. Treating information processing as the generator of time is tautological.

4. The Loss of Neutrality

Treating coherence—or thermal states, or best matching—as the generator of time already assumes relational structure, spatial differentiation, and an ordering principle.

Once these are in place, a time-like parameter is already encoded. What is presented as derivation is instead a concentration of independent structures into a single scalar field.

Monotonicity (the arrow of time) is not derived from coherence; it is built into the requirement that coherence decay or entropy increase. Causality is not emergent from geometry; it is imposed as a constraint on allowable trajectories. Space is not eliminated; it reappears as “coherence space” under another label.

5. Conclusion

Minimalism is claimed, but neutrality is lost. Time is not eliminated from the ontology; it is renamed and embedded.

Entropy is encoded as coherence decay. Dynamics are encoded as geometric gradients. Time is encoded as relation.

Coherence cannot ground time without already presupposing relation and space. It is therefore not a foundation, but a derived statistic elevated to ontology. The problem with these theories is not incorrect mathematics, but ontological non-independence.

We must stop pretending that renaming the clock “coherence” breaks it.