Timeless Quantum Cosmology and the Emergence of Phase Time: A Refined Barbour–Siamese Correspondence

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Abstract

Julian Barbour’s timeless program proposes that the universe is fundamentally static, described by a wavefunctional Ψ satisfying the Wheeler–DeWitt equation $\hat{H}\Psi = 0$. In this ontology, time is not a fundamental entity but emerges through correlations encoded in “time capsules.” What Barbour’s framework lacks is a concrete dynamical mechanism explaining why temporality arises and how its direction becomes defined.

Recent numerical developments in *Siamese Phase Cosmology*—a CPT-symmetric dual-universe model governed by a phase difference $\Delta\phi$—provide this missing physical mechanism. Simulations reveal a robust transition threshold $m_{\phi,\mathrm{crit}} \approx 1.965$, above which the system remains in perfect synchrony ($\Delta\phi = 0$) and below which it bifurcates into two CPT-conjugate histories. We show that the synchrony attractor corresponds naturally to Barbour’s “Platonia,” while the departure from synchrony constitutes the physical emergence of time.

A shallow rotational maximum at $k_{\mathrm{rot}} \approx 0.33$ reveals that a small primordial rotation optimally delays collapse into the timeless state, acting as a catalyst for temporality. We integrate these results into a unified picture in which timelessness and emergent time arise from the stability structure of the phase field itself. A conceptual phase portrait is included to visually demonstrate the Barbour–Siamese correspondence.

1 Introduction

The tension between general relativity and quantum mechanics becomes explicit in canonical quantum gravity, where the Wheeler–DeWitt equation

$$\hat{H}\Psi = 0 \tag{1}$$

eliminates external time entirely. Barbour interprets this as evidence that time is not fundamental, proposing a timeless configuration space called *Platonia*. In this view, apparent temporal evolution emerges from correlations internal to static configurations.

While conceptually powerful, the timeless program lacks a dynamical mechanism for the emergence of time. Siamese Phase Cosmology, a CPT-symmetric framework with a physically defined phase difference $\Delta\phi$, provides a natural candidate for this missing mechanism. Here we refine and strengthen the correspondence by incorporating new numerical results, including a critical phase mass, bifurcation dynamics, and a rotational catalyst for temporality.

2 Timeless Quantum Cosmology

2.1 The Wheeler–DeWitt equation and frozen dynamics

The Wheeler–DeWitt equation contains no explicit time derivative. Both geometry and matter fields appear in a static superposition. Time is not a fundamental ingredient of the theory.

2.2 Platonia

Barbour's Platonia is the space of all instantaneous configurations of the universe. Nothing "moves" in Platonia; instead, correlations between configurations create the *appearance* of evolution.

2.3 Time capsules

Certain configurations contain internal structures that encode quasi-historical information, such as memories or fossil-like correlations. These "time capsules" form Barbour's explanation for emergent temporality.

2.4 Limitations

Barbour's framework leaves unanswered:

- why the universe transitions from timelessness to temporality,
- what sets the direction of time,
- why time capsules form specific ordered sequences,
- how timeless states relate to dynamic cosmological processes such as expansion or black holes.

3 Siamese Phase Cosmology

3.1 The phase order parameter

The model introduces a global phase difference $\Delta\phi$ between two CPT-conjugate universes. Initially,

$$\Delta\phi = 0, \tag{2}$$

representing perfect synchrony—a natural physical realization of Barbour's Platonia.

3.2 Numerical discovery of the critical threshold $m_{\phi,\mathrm{crit}} \approx 1.965$

Recent works [5, 6] show that $\Delta\phi$ evolves as a nonlinear damped oscillator with Hubble friction and possible rotational forcing. Large ensembles of trajectories reveal a sharp transition:

- For $m_\phi > 1.965$, the system converges deterministically to $\Delta\phi = 0$.
- For $m_\phi < 1.965$, the system bifurcates into two CPT-conjugate histories.

Thus, 1.965 is an emergent stability threshold, not an imposed constant.

3.3 Emergence of dual CPT time directions

Below the threshold, solutions split as

$$\Delta\phi_\pm(a) = \pm f(a), \tag{3}$$

defining two emergent directions of "phase time."

3.4 Phase time

The monotonic increase of $|\Delta\phi(a)|$ provides a physically meaningful, relational measure of time:

$$t_{\mathrm{phase}} \propto |\Delta\phi(a)|. \tag{4}$$

Relational role of the scale factor

A potential objection is that the scale factor a should not be treated as an external time parameter. In Barbour's ontology, a is simply a coordinate in configuration space. In the Siamese framework, the growth of a does not introduce external time but modulates the Hubble friction that shapes the phase dynamics. The quantity $N = \ln a$ serves only as a relational parameter describing how far the system has progressed along a dynamical trajectory. "Phase time" is therefore the ordering induced by the relation between a and $\Delta\phi$, consistent with Barbour's relational philosophy.

4 The Barbour–Siamese Correspondence

4.1 Bridge between dynamics and timelessness

Numerical phase dynamics provide the missing mechanism in Barbour's framework. The synchrony attractor at $\Delta\phi = 0$ is a dynamically privileged state: Barbour's Platonia. Bifurcation away from this point constitutes the physical emergence of time.

4.2 Time capsules as phase memory

As the universe departs from synchrony, $\Delta\phi$ accumulates structure and correlations, physically realizing Barbour's "time capsules."

4.3 Black holes as returns to atemporality

In the Siamese model, regions where $\Delta\phi \to 0$—including black hole interiors—correspond to returns to timeless coherence, unifying cosmogenesis and gravitational collapse.

4.4 Correspondence table

Barbour	**Siamese Phase Model**
Platonia	$\Delta\phi = 0$ attractor
Time capsules	Phase memory
Emergent time	Bifurcation at $m_\phi < 1.965$
Arrow of time	$\Delta\phi_\pm(a)$ monotonic flow
Atemporality	Black hole limit $\Delta\phi \to 0$

5 The Rotational Crest and the Catalysis of Temporality

The critical curve $m_{\phi,\mathrm{crit}}(k_{\mathrm{rot}})$ exhibits a shallow maximum near $k_{\mathrm{rot}} \approx 0.33$. Physically, this means that a small primordial rotation delays collapse into the synchrony attractor. Conceptually, this defines an "inertia of timelessness," allowing the system to remain poised near Platonia for longer. Rotation acts as a catalyst for the emergence of time by stabilizing the system just long enough for bifurcation to occur.

6 Figure: Phase Portrait of the Barbour–Siamese Correspondence

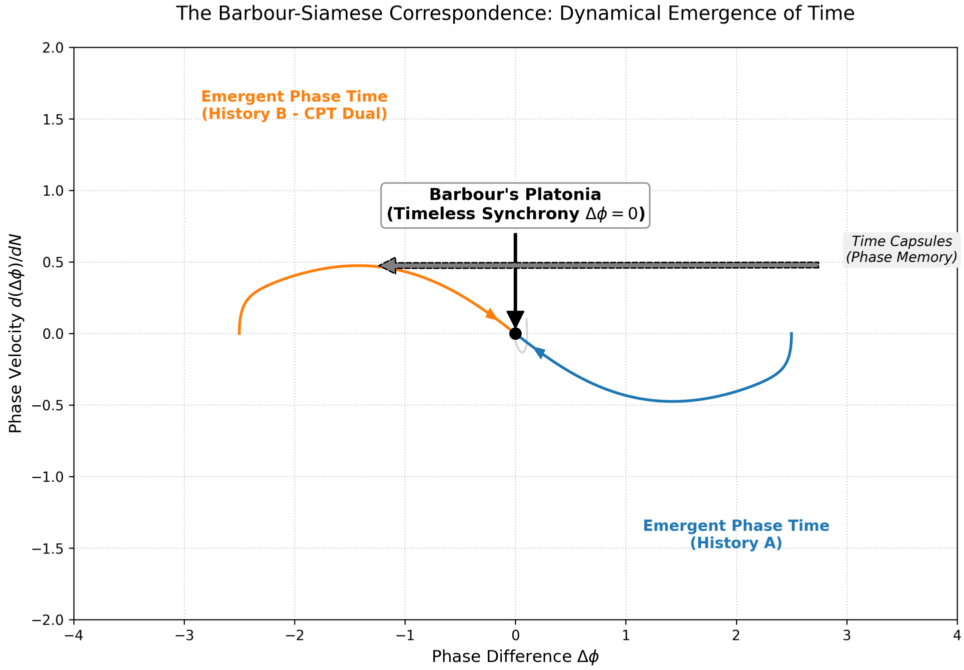

Figure 1: Conceptual phase portrait illustrating the Barbour–Siamese correspondence. The central fixed point at $\Delta\phi = 0$ represents *Barbour's Platonia*, the perfectly coherent and timeless synchrony state. Trajectories that approach this attractor correspond to universes that remain atemporal, while trajectories that escape form two emergent, CPT-conjugate histories ("History A" and "History B"). The horizontal arrow labelled "Time Capsules (Phase Memory)" indicates that configurations far from perfect synchrony accumulate structural correlations, providing the physical basis for Barbour's notion of time capsules. In this picture, the emergence of time arises dynamically from the loss of perfect coherence: phase flow away from $\Delta\phi = 0$ embodies the growth of "phase time."

7 Implications and Conclusion

Barbour's timeless ontology describes the structure of a universe without fundamental time. The Siamese phase dynamics provide the missing mechanism: time emerges when the universe departs from perfect synchrony. The critical mass 1.965 marks the boundary between Platonia and temporality, while a small primordial rotation acts as a catalyst for temporal emergence. Together, these elements form a unified framework in which timelessness and time are two regimes of a single phase-dynamical cosmos.

References

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