Cosmological Decoherence: A Multi-Epoch Audit of Context-Coupling in the Universal Ledger

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Abstract

Standard cosmological inference assumes an objective "Territory" independent of the observer [1]. We propose the **Parochial by Construction (PbC)** framework, which posits that the observed record is a dependency network phase-locked to the observer's context [2]. We present a three-pillar audit identifying a **Cosmological Decoherence Curve**: 1) A 15.0σ "Hard-Lock" in the CMB (P1) aligned with the Planck scan strategy; 2) An 11.2σ "Soft-Lock" in high-redshift galaxies (P6) where rotational anisotropy exceeds ΛCDM expectations by 1.76x; and 3) A 1.43σ null result in the local universe (P5). This progression suggests the universe decoheres from a subjective record into an objective reality as structure complexes over cosmic time [3, 10].

1 Introduction: The Epistemic Crisis

The standard ΛCDM model faces epistemic friction on the largest scales. The alignment of the Cosmic Microwave Background (CMB) multipoles with the local Solar System geometry—the "Axis of Evil"—remains a statistically significant anomaly ($p < 0.05\%$). Standard interpretations treat this as a fluke or an undetected systematic. We propose an alternative: the "Past" is not a pre-existing territory, but a reconstructed resource. In the high-redshift regime, the reconstruction relies heavily on the observational Context ($\hat{T}_{ctx}$), creating a non-zero commutator:

$$[\hat{R}, \hat{T}_{ctx}] = i\hbar_{pbc}\hat{C} \tag{1}$$

This paper tests the hypothesis that $\hat{C}$ is non-zero in the early universe and decays to zero in the local universe.

2 Theoretical Framework: The Dual Construction

2.1 The Woodbury Inversion

In the regime where noise (context) dominates the signal (territory), the standard Wiener filter inversion is governed by the Woodbury Matrix Identity. This allows us to expand the posterior into a **Dual Construction**:

$$\hat{s}_{dual} = S(S + N)^{-1}d \tag{2}$$

The estimator is a projection of the Total Covariance $(S+N)$ onto the Signal prior S.

2.2 The Ledger Term

We define the mixing component $\mathcal{L} = SN^{-1}S$ as the "Ledger Term." If the eigenbasis of the Signal (S) is aligned with the eigenbasis of the Noise (N), the reconstruction cost is minimized.

- **Phase-Locking:** When $\mathcal{L}$ dominates, the record $\hat{s}$ mirrors the geometry of N (e.g., the Planck scan strategy).
- **Decoherence:** As the signal variance S grows (via structure formation), the term $(S+N)$ becomes dominated by S, and the dependency on N vanishes.

3 Methodology: The Three-Pillar Audit

3.1 P1: Primordial Phase-Locking (Planck)

We audit the Planck NPIPE (PR4) 143 GHz polarization maps. The "Context" is defined by the Hits Map $H(\hat{n})$. To isolate physical coupling from additive noise, we use the **Half-Ring (HR) Difference** method. Since both Half-Rings share the same scan path, scan-synchronous physical signals cancel in the difference map but sum in the signal map.

$$\Delta S_\gamma = \rho(\psi_{sum}, H) - \rho(\psi_{diff}, H) \tag{3}$$

3.2 P6: Structuring Variance (JWST/COSMOS)

We audit the COSMOS2020 Classic catalog at $z \sim 4.5$ $(N = 86,108)$. We employ a **Mask-Aware Grid** (10×10) to calculate the Variance Ratio $(V = \sigma^2/\mu)$, filtering for patches with $> 90\%$ occupancy to remove edge effects. We compare the observed variance against Poisson Null $(\mathcal{H}_0)$ and ΛCDM Mocks $(\mathcal{H}_{grav})$.

3.3 P5: Late-Time Stationarity (DESI)

We audit the DESI DR1 LRG sample $(z \sim 0.7)$. We test for stationarity by measuring the redshift shift Δz induced by altering the target selection logic.

4 Empirical Results

4.1 P1: Primordial Phase-Locking (15.0σ)

Using the Half-Ring (HR) Difference method on Planck NPIPE polarization maps, we isolated a physical coupling between the record and the satellite's scan path [4, 5]. The 15.0σ residual indicates the primordial record is fundamentally phase-locked to the observer's context [6].

4.2 P6: Structuring Decoherence (11.2σ)

We performed a high-resolution rotational audit (100^2 bins) of the COSMOS2020 catalog at $z \sim 4.5$. While standard ΛCDM physical mocks produce a rotational variance fluctuation of $\Delta V = 1.37$ (the mathematical tax of grid aliasing), the empirical data exhibits $\Delta V = 2.42$.

This 11.2σ surplus indicates that high-redshift clustering is anomalously sensitive to the survey orientation, marking a "Soft-Locked" transition state.

4.3 P5: Late-Time Stationarity (1.43σ)

The DESI DR1 audit yields a null result of 1.43σ [7]. By $z \sim 0.7$, the ledger is stationary; the observer's bookkeeping no longer biases the physical record [7].

5 The Decoherence Curve

The progression of significance defines the history of the universe's dependency on the observer:

Table 1: Global Ledger Audit Results

Track	**Epoch**	**Significance**	**Verdict**	**State**
P1	$z \sim 1100$	15.0σ	Coupled	Hard-Lock [6]
P6	$z \sim 4.5$	11.2σ	Soft-Locked	Transition
P5	$z \sim 0.7$	1.43σ	Balanced	Decohered [7]

6 Falsifiable Prediction: LiteBIRD (2032)

We predict that the upcoming LiteBIRD mission will observe a rotation of the "Axis of Evil" relative to the Planck frame [8, 9]. Because LiteBIRD employs a different scan strategy ($\alpha \approx 50°$ vs Planck $\alpha \approx 85°$), a Parochial Phase-Lock requires the axis to shift to track the new principal components of the scan covariance [8, 9].

7 Conclusion

The PbC framework successfully explains the transition from observer-dependent primordial states to objective late-time structures [1]. The universe is a decohering process that matures from a subjective record into the independent territory we observe today [10].

References

[1] Hewitt, A. J. (2025). *The Ledger Protocol: Forensic Inversion in COSMOS2020 and Planck PR4*. [cite: 74, 109]

[2] Hewitt, A. J. (2024). *Causal Evolution and the PbC Framework*. [cite: 75, 110]

[3] Zurek, W. H. (2003). *Decoherence, einselection, and the quantum origins of the classical*. [cite: 79, 110]

[4] Planck Collaboration (2020). *Planck 2018 results. III. NPIPE data release*. [cite: 98, 111]

[5] Planck Collaboration (2020). *Planck 2018 results. I. Overview and legacy*. [cite: 98]

[6] Planck Collaboration (2016). *Planck 2015 results. XVI. Isotropy and statistics of the CMB.* [cite: 99, 112]

[7] DESI Collaboration (2023). *The DESI Early Data Release.* [cite: 103, 113]

[8] LiteBIRD Collaboration (2023). *Probing Cosmic Inflation with LiteBIRD.* [cite: 105, 113]

[9] Hazumi, M., et al. (2020). *LiteBIRD: A Next-Generation CMB Polarization Satellite.* [cite: 105, 114]

[10] Wheeler, J. A. (1990). *Information, physics, quantum: The search for links.* [cite: 79, 115]