Gravitational Decoherence Oscillations as the Source of Apparent Cosmic Acceleration

Letter from the Ongoing Work: August 2025

I'm writing to share a theoretical framework I've been developing that may offer a natural explanation for observed cosmic acceleration and the Hubble tension—*without invoking a cosmological constant, scalar fields, or exotic matter*. Instead, it builds on the foundation of decoherence theory and gravitational dominance in early-universe evolution.

Summary of the Approach

In this framework, the evolution of classicality in the universe is governed by **decoherence** in a **gravitationally dominant pointer basis**, with all electromagnetic observations treated as projections from this underlying scaffold.

The system obeys a conservation principle involving classical energy and entropy induced by decoherence:

$$\frac{d}{dt}\left(E_{\text{classical}} + \alpha S_{\text{decoherence}}\right) = 0$$

This law applies across epochs—from pre-EM stabilization through to the present—and enables us to model the collapse-length (which sets the decoherence timescale) as the principal variable tracking the expansion of classical structure.

Collapse-Length as a Dynamical Variable

We define a time-evolving collapse length $L_c(t)$, which determines the scale over which quantum systems become classical. Our working hypothesis is that the apparent acceleration of the universe arises from **nonlinear dynamics in** $L_c(t)$ that distort time measurements in EM-local reference frames.

The first-order model treats this as a harmonic oscillator:

$$L_c''(t) + \omega^2 L_c(t) = 0$$

With:

- $E_{\text{classical}} \propto \frac{1}{L_c^2}$
- $S_{\text{decoherence}} \propto \ln L_c$

This system yields a **nearly conserved** composite function, indicating that cosmic expansion effects may emerge as oscillations in the collapse-length field.

Introducing Damping: Modeling Entropy Production

To model entropy production over time—a manifestation of the universe's increasing irreversibility—we extend the model to a **damped harmonic oscillator**:

$$L_c''(t) + \gamma L_c'(t) + \omega^2 L_c(t) = 0$$

Among the three possible damping regimes—overdamped, critically damped, and underdamped—the **underdamped** case is most physically compelling for cosmology. In this regime, $\gamma < 2\omega$, the collapse length oscillates while gradually decaying, resembling a universe with repeating periods of accelerated and decelerated expansion, subtly damped by increasing entropy:

$$L_c(t) = Ae^{-\gamma t/2} \cos\left(\Omega t + \phi\right), \quad \Omega = \sqrt{\omega^2 - \frac{\gamma^2}{4}}$$

Why underdamped? Because it reflects a universe that retains memory of its prior quantum states—via oscillatory behavior—while steadily dissipating usable energy. The damping encodes entropy production, while the oscillation reflects dynamic structure formation. Critically damped or overdamped systems would imply a rapid loss of decoherence dynamics, inconsistent with the persistence of measurable cosmic anomalies like redshift discrepancies. Underdamped motion thus mirrors our observational reality: subtle, persistent deviation from equilibrium.

Here:

- γ is the entropy-generating damping coefficient,
- ω is the intrinsic decoherence oscillation frequency,
- $L_c(t)$ governs perceived classicality and cosmic time.

This function introduces *natural clock drift* between gravitational and EM pointer bases. Observers embedded in the EM-local frame interpret this drift as cosmic acceleration.

Consequences and Observational Signatures

This model predicts that:

1. **Redshift discrepancies** (e.g., Hubble tension) may stem from misalignment between gravitational and EM decoherence rates.
2. The **CMB anisotropy field** reflects the phase and amplitude of $L_c(t)$ at the moment of EM pointer basis stabilization.
3. The long-term behavior of the universe—accelerating, flattening, or turning—depends on the damping ratio γ/ω and initial phase ϕ.

The key insight is that the **least-action solution** for gravitational decoherence may present itself as an **underlying oscillation**, not a static expansion force. This offers a falsifiable alternative to ΛCDM under the right empirical conditions.

Why This Matters

This approach reframes the cosmological constant problem as one of **pointer basis misinterpretation**—not missing energy. It's grounded in a first-principles conservation law, produces dark-energy-like dynamics from decoherence itself, and gives us a new handle on interpreting observational discrepancies.

I'm currently developing numerical simulations to estimate allowed ω, γ, and boundary conditions based on known cosmic epochs and entropy growth patterns.

If this resonates with your interests, I'd be grateful for the opportunity to share a more formal preprint or collaborate on exploring its empirical implications.

Warm regards,
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