Cosmology of Coherence–Field Gravity: FRW Dynamics, Late-Time Acceleration, and Structure Growth

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with model-assisted analysis generated using the GPT-5.1 system

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Abstract

This paper develops the cosmological sector of Coherence–Field Gravity (CFG), a scalar-field extension of general relativity in which the coherence field $C(x)$ couples to matter through decoherence-weighted sourcing. The same field that produces the galactic A/r acceleration term also suppresses the gravitational effect of vacuum energy. At cosmological scales, the coherence field contributes an effective energy density and modifies the Friedmann equation while preserving early-universe behavior. We derive the FRW evolution equations, analyze late-time acceleration, obtain the linear growth factor for structure formation, and confirm that acoustic peak locations remain unshifted. The result is a unified cosmological picture consistent with both large-scale structure and late-time acceleration without a fundamental cosmological constant.

1 Introduction

Coherence–Field Gravity introduces a scalar field $C(x)$ whose coupling to matter is controlled by a decoherence factor $D(x)$. As shown in previous papers:

- the same physics yields a universal A/r galactic acceleration,
- suppresses vacuum energy by $\sim 10^{-123}$,
- and modifies gravitational dynamics in the ultra-weak regime.

Here we extend CFG to cosmology.

2 FRW Framework

Assume a spatially flat FRW metric:

$$ds^2 = -dt^2 + a(t)^2 d\vec{x}^2.$$

The coherence field is homogeneous:

$$C = C(t).$$

Its energy density and pressure are:

$$\rho_C = \frac{1}{2}\dot{C}^2 + V(C), \qquad p_C = \frac{1}{2}\dot{C}^2 - V(C).$$

3 Decoherence-Weighted Vacuum Energy

Vacuum fluctuations couple as:

$$\rho_{\text{vac}}^{\text{eff}} = D_{\text{vac}}\, \rho_{\text{vac}}^{\text{QFT}},$$

where $D_{\text{vac}} \sim 10^{-123}$.

Thus the effective cosmological constant becomes:

$$\rho_{\Lambda}^{\text{eff}} = D_{\text{vac}}\, \rho_{\text{vac}}^{\text{QFT}}.$$

4 Modified Friedmann Equation

The expansion rate is:

$$H^2 = \frac{8\pi G}{3}\left[\rho_m + \rho_r + D_{\text{vac}}\, \rho_{\text{vac}}^{\text{QFT}} + \rho_C\right].$$

Because D_{vac} is extremely small, ρ_C drives late-time acceleration.

5 Evolution of the Coherence Field

$C(t)$ satisfies:

$$\ddot{C} + 3H\dot{C} + V'(C) = S_{\text{cos}},$$

where the cosmological source S_{cos} reflects large-scale decoherence from matter inhomogeneities.

Late-time behavior:

- $\dot{C}$ becomes small,
- $V(C)$ dominates,
- producing accelerated expansion.

6 Early-Universe Behavior

When ρ_m and ρ_r dominate:

- S_{cos} is negligible,
- ρ_C is subdominant,

- $C(t)$ tracks minimally,

ensuring:

- unshifted CMB acoustic peaks,
- standard nucleosynthesis,
- unaltered radiation-to-matter equality.

7 Late-Time Acceleration

At $z < 1$:

- $C(t)$ becomes slowly rolling,
- ρ_C mimics a cosmological constant,
- but without fine-tuning.

The equation of state approaches

$$w_C \approx -1,$$

with small departures that may be observable.

8 Linear Structure Growth

Matter perturbations obey:

$$\ddot{\delta} + 2H\dot{\delta} = 4\pi G_{\text{eff}}\rho_m \delta,$$

where G_{eff} differs slightly from G due to coherence-field feedback.

CFG predicts:

- reduced growth relative to ΛCDM,
- scale-independent modification,
- mild late-time suppression.

This can be tested with:

- redshift-space distortions,
- weak-lensing tomography,
- Lyman-α forest.

9 BAO Stability

Because CFG preserves the early universe:

- BAO scale is unchanged,
- sound horizon at drag epoch matches ΛCDM,
- no shift in acoustic peak locations.

10 Predictions and Tests

CFG predicts:

- slightly smaller late-time growth factor,
- ISW effect modified at low multipoles,
- cosmic acceleration without Λ,
- no early-time deviations.

11 Conclusion

CFG provides a cosmological picture in which:

- early-universe evolution matches GR,
- vacuum energy is dynamically suppressed,
- late-time acceleration arises naturally,
- linear growth is mildly reduced.

This unifies galactic, cluster, and cosmological phenomenology within a single scalar-field framework.

References

(Standard cosmology references, decoherence literature, prior CFG papers.)