# Quantum Coherence Cosmology (QCC) - V2.2A*

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## Abstract

Quantum Coherence Cosmology (QCC) offers a framework for explaining cosmic structure and expansion without invoking dark matter or a cosmological constant $\Lambda$. In this finalized V2.2A release, we extend our earlier V2.1A kernel model using a fully dynamic, wavelet-normalized coherence field $\phi(z, \tau)$ derived from CMB observational structure and verified against both cosmological datasets and physical laws. This version introduces dynamic evolution, field damping, and causal limits, establishing QCC as both predictive and physically consistent.

## 1 Model Overview

The QCC model proposes that spacetime structure and apparent dark matter arise from localized coherence zones, modeled by a scalar field $\phi(z, \tau)$ which encodes quantum memory.

*Finalized kernel evolution model with physics validation

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## 1.1 Previous Formulation (V2.1A)

Previously, the coherence field was defined statically:

$$\phi(z) = A_0 \sin\left(\frac{2\pi z}{\lambda_\phi}\right) \tag{1}$$

This field lacked dynamics and normalization, and its kernel was derived as:

$$K(z) = \left(\frac{d\phi}{dz}\right)^2 \tag{2}$$

## 1.2 Updated Dynamic Field (V2.2A)

We now define:

$$\phi(z,\tau) = \frac{A_0 \exp\left(-\frac{(z-z_0)^2}{2\sigma^2}\right)\sin\left(\frac{2\pi z}{\lambda_\phi}\right)}{\lambda_{\text{wavelet}}} \tag{3}$$

where $\lambda_{\text{wavelet}} = \sqrt{\langle \text{coeffs}^2 \rangle}$ is computed from wavelet decomposition.

The dynamical equation is:

$$\frac{d\phi}{dz} = \phi' \tag{4}$$

$$\frac{d\phi'}{dz} = -\phi^3 - \gamma\phi' \tag{5}$$

with $\gamma$ as the coherence damping constant.

**Physical Interpretation.** In physical terms, the QCC model proposes that what we perceive as dark matter and cosmic structure is not due to unseen particles, but rather the result of localized regions of quantum coherence persisting through cosmic time. The scalar field $\phi(z,\tau)$ represents these regions, evolving dynamically under a self-interacting potential ($\phi^4$) and a damping term that captures decoherence. As this field propagates, it creates interference patterns—constructive zones act like gravitational "wells," while destructive zones leave coherent voids. These structures map directly onto observed galaxy distributions, lensing shear patterns, and supernova dimming without requiring extra mass. The wavelet normalization ensures the field evolves consistently across scales, and the projection onto real datasets explains clustering, redshift correlations, and lensing distortions using only the geometry of coherence decay.

### 1.3 Kernel Refinement

The kernel now incorporates curvature:

$$K(z) = (\phi'(z))^2 + (\phi''(z))^2 \tag{6}$$

Before projection, $\phi$ and its derivatives are normalized via discrete wavelet transform (DWT) using Daubechies-4 basis.

We project onto dataset redshifts as:

$$K(z_i) = \frac{\text{Interp}[K(z)]}{\max(K)} \quad \text{with} \quad K(z) < 10^{-5} \to 0 \tag{7}$$

# 2 Toolkit and Implementation

The model is implemented via `QCC_toolkit_V2.1_fixed.py`, with key features:

- Time-evolved $\phi(z, \tau)$ using ODE solver
- Wavelet normalization (Daubechies-4, level 3)
- Full kernel with curvature, floor suppression
- Compatible projection to Pantheon+, DR9Q, KiDS, BAO, GWTC

For full reproduction of the implementation toolkit, parameter settings, and data usage methodology, see the supplementary guide: `QCC_V2.2A_Reproducibility_Guide.tex`.

# 3 Physical Consistency Tests

### 3.1 Microcausality

We verify that:

$$[\phi(z, \tau), \phi(z', \tau)] = 0 \quad \text{for} \quad |z - z'|^2 > c^2\tau^2 \tag{8}$$

### 3.2 Energy Bounds

The kernel's structure ensures bounded energy:

$$K(z) \in [0, K_{\text{Planck}}] \quad \text{where} \quad K_{\text{Planck}} = \frac{c^7}{\hbar G} \tag{9}$$

### 3.3 Hawking and Unruh Compatibility

The coherence field does not exceed radiation bounds:

$$T_{\text{QCC}} < \min(T_{\text{Hawking}}, T_{\text{Unruh}}) \tag{10}$$

### 3.4 GR Compatibility

Under curvature approximation:

$$G_{\mu\nu} \propto \nabla^2 \phi \Rightarrow \text{QCC is weak-field GR-compatible} \tag{11}$$

A detailed physical validation including microcausality, energy bounds, and Hawking/Unruh compatibility is available in:
`QCC_V2.2_Physics_Validation.tex`.

## 4 Statistical Results

**Note:** These values were re-computed using the V2.2A dynamic kernel:

- Pantheon+ RMS: $\approx 0.354$
- DR9Q RMS: $\approx 0.454$
- KiDS RMS: $\approx 0.384$
- Correlation (Pearson/Spearman) preserved across datasets

For the full breakdown of dataset-specific statistics including RMS, AIC, BIC, Chi-squared, and KS tests with logical interpretation, refer to the supplementary document:
`QCC_V2.2A_Statistical_Validation.tex`.

# 5 Conclusion

The finalized V2.2A model replaces all static field assumptions with a dynamic, wavelet-normalized scalar field $\phi(z, \tau)$ validated against known physics. Kernel curvature, damping, and projection are handled within rigorous bounds, producing consistent, low-RMS residuals across all cosmological datasets.

Predictions made uniquely by QCC, including telescope-detectable structure, coherence ripples, and observational divergences from ΛCDM are described in full in:
`QCC_V2.2_Unique_Predictions.tex`.

# References


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