

# **Cosmos v5: Coherence Operators and Emergent Geometry**

## **Abstract**

This publication provides a structured synthesis for Cosmos v5: Coherence Operators and Emergent Geometry, with claim-to-evidence framing and a validation path for downstream readers.

## **Keywords**

cosmos, research, publication

## **Main Content**

# Cosmos v5: Coherence Operators and Emergent Geometry

Cohera Lab

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## Abstract

This paper consolidates the Cosmos v5 formal layer into a publishable baseline. We define a computable coherence functional, introduce an operator-norm compatibility criterion for projected stability, and outline a geometry reconstruction protocol from state distinguishability. The focus is methodological clarity: each equation maps to an observable quantity and each interpretive claim carries an explicit falsification path.

**Keywords** coherence operators; projection stability; emergent geometry; Bures distance; Fisher information metric

## 1 Introduction

Cosmos v5 studies how coherent operator structure can be tracked across projected sectors without collapsing interpretability into heuristic narrative. Earlier drafts mixed useful equations with pipeline metadata and implementation notes. This version removes non-academic artifacts and presents the formal core in a clean sequence: coherence functional, stability threshold, and geometry protocol.

## 2 Coherence Functional

Let  $\rho_{\text{loc}}$  be the localized density operator in a fixed basis. We define off-diagonal coherence by

$$\mathcal{C}(\rho_{\text{loc}}) = \sum_{i \neq j} |\rho_{ij}|. \quad (1)$$

Selection dynamics are controlled by an energy-coherence tradeoff

$$\mathcal{F}_n = E_n - \kappa \mathcal{C}_n, \quad (2)$$

where  $\kappa > 0$  weights coherence preservation against energetic cost over recurrence windows.

## 3 Stability Threshold

Let  $\Pi$  denote the projection operator onto the selected coherent sector and  $\mathcal{F}_{\text{loc}}$  the local flow operator. Compatibility mismatch is

$$\varepsilon = \|\Pi\mathcal{F} - \mathcal{F}_{\text{loc}}\Pi\|_{\text{op}}. \quad (3)$$

A stable coherent sector is declared only when

$$\varepsilon < \delta_{\text{coh}}, \quad (4)$$

with  $\delta_{\text{coh}}$  fixed before evaluation. Exceeding this threshold signals representation drift and loss of projected-sector coherence.

## 4 Emergent Geometry Protocol

Geometry is reconstructed from distinguishability between projected states  $\{\rho_i\}$ .

First, define pairwise Bures distance:

$$D_B(\rho_i, \rho_j) = \sqrt{2\left(1 - \sqrt{F(\rho_i, \rho_j)}\right)}, \quad (5)$$

where fidelity is

$$F(\rho_i, \rho_j) = \left[ \text{Tr} \left( \sqrt{\sqrt{\rho_i} \rho_j \sqrt{\rho_i}} \right) \right]^2. \quad (6)$$

Second, in a local chart  $\theta$ , estimate an information metric by Fisher form

$$g_{ab}(\theta) = \sum_x p(x | \theta) \partial_a \log p(x | \theta) \partial_b \log p(x | \theta). \quad (7)$$

Third, construct a weighted graph from  $D_B$  (or local Fisher approximation), embed it, and estimate curvature from the induced metric tensor. Geometry is interpreted as an emergent descriptor of coherence organization, not a primitive axiom.

## Validation and Falsification

- Sweep  $\kappa$  and report phase boundaries for  $\delta_{\text{coh}}$ .
- Replace coherence witnesses and test qualitative invariance.
- Reject geometric conclusions if curvature signatures are unstable under mild perturbations.

## Conclusion

The sanitized Cosmos v5 manuscript now provides a coherent formal spine suitable for publication review: no pipeline noise, legible mathematics, and explicit failure criteria.