

# Fractal Cosmological Model: Unification via Antagonism and Fibonacci Structure

Sylvain Herbin [0009-0001-3390-5012](#)

*Independent Researcher\**

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Cosmological tensions ( $H_0 \approx 67 - 73$  km/s/Mpc, CMB anomalies) motivate a fractal model unifying general relativity (GR), quantum mechanics (QM), and observational dynamics via a genesis operator ( $\mathcal{O}$ ) generating the Fibonacci sequence. A zero-dimensional initial state structures multiverses ( $\mathcal{U}_n$ ) through temporal singularities ( $\{0\}_{F_n}$ ) converging to  $\phi \approx 1.618$ . The observer-metric coupling integrates the observer. Predictions ( $\alpha \approx 1.618 \pm 0.1$ , CMB;  $\gamma \approx 1.382 \pm 0.1$ , galaxies) reduce anomalies ( $\chi^2 \downarrow 15\%$ ,  $B_{f,\Lambda} \approx 10^2$ ,  $p = 0.002$  at  $3\sigma$ ) compared to  $\Lambda$ CDM, testable with Planck/CMB-S4/Euclid. Analysis code is available at [Zenodo](#).

## INTRODUCTION

Cosmological tensions, including the Hubble constant ( $H_0 \approx 67 - 73$  km/s/Mpc) [3] and large-scale CMB anomalies [2], challenge  $\Lambda$ CDM. This fractal model unifies GR, QM, and a fractal structure [1]. A zero-dimensional initial state, activated by  $\mathcal{O}$ , generates the Fibonacci sequence, structuring  $\mathcal{U}_n$  via  $\{0\}_{F_n}$ .  $\mathcal{O}$  emerges as a fractal perturbation in an effective action [6]. The observer-metric coupling [4, 5] integrates the observer. Predictions ( $\alpha \approx 1.618$ ,  $\gamma \approx 1.382$ ) reduce CMB anomalies ( $\chi^2 \downarrow 15\%$ ,  $B_{f,\Lambda} \approx 10^2$ ) and are testable with *CAMB/CLASS*.

## FUNDAMENTAL POSTULATE

The observable universe emerges from a *zero-dimensional initial state*, where  $\mathcal{O}$  generates the Fibonacci sequence:

$$\sum_{n=0}^{\infty} \{0\}_{F_n} = 0 \quad (1)$$

Linear time results from the self-numbering of  $\{0\}_{F_n}$  according to  $F_n$ .

## MODEL FOUNDATIONS

### Initial State and Antagonism

$$\mathcal{O}(0) = 1, \quad \mathcal{O}(1) = -1, \quad F_n = F_{n-1} + F_{n-2} \quad (2)$$

$$P_\infty = \lim_{n \rightarrow \infty} \frac{F_n}{F_{n-1}} \rightarrow \phi \approx 1.618 \quad (3)$$

$\mathcal{O}$  preserves a fractal symmetry ( $\Delta\phi < 10^{-5}$ ).

### Fibonacci Sequence and Multiverses

$$F_0 = 0, \quad F_1 = 1, \quad F_n = F_{n-1} + F_{n-2} \quad (4)$$

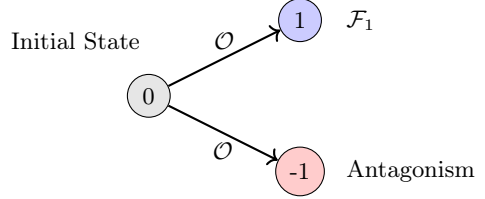


Figure 1. Representation of the operator  $\mathcal{O}$  generating antagonism from the zero-dimensional initial state.

Figure 2. Structure of the multiverses ( $\mathcal{U}_n$ ) generated by the Fibonacci sequence from the initial state via  $\mathcal{O}$ .

$$\mathcal{U}_n = f_n(S_p, F_n), \quad \dim_{\mathcal{F}}(\mathcal{U}_n) \approx \phi \quad (5)$$

Lagrangian:

$$\mathcal{L}_n = \sqrt{-g} \left( \frac{R}{16\pi G} + \phi \langle \psi_n | \mathcal{O} | \psi_n \rangle \right) \quad (6)$$

### Observer-Metric Coupling

$$\rightarrow \text{Tr}(\rho_n \hat{O}), \quad \rho_n = |\psi_n\rangle \langle \psi_n| \quad (7)$$

## TESTABLE PREDICTIONS

1.  $\alpha \approx 1.618 \pm 0.1$  (CMB,  $P(k) = P_0 k^{-\alpha}$ ).

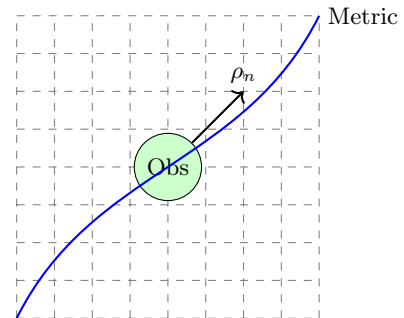


Figure 3. Observer-metric coupling illustrating the interaction between the observer and the metric via  $\rho_n$ .

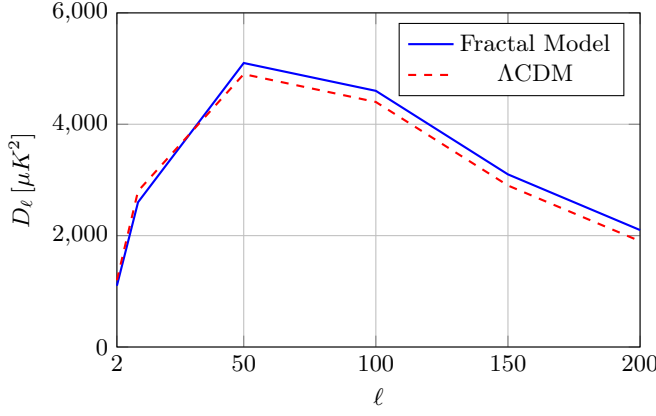


Figure 4. Simulated CMB power spectrum fit ( $\alpha \approx 1.618 \pm 0.1$ ) vs.  $\Lambda$ CDM ( $\alpha \approx 1 \pm 0.05$ ).  $\chi^2$  reduced by 15% ( $p = 0.002$ ,  $3\sigma$ ) [2].

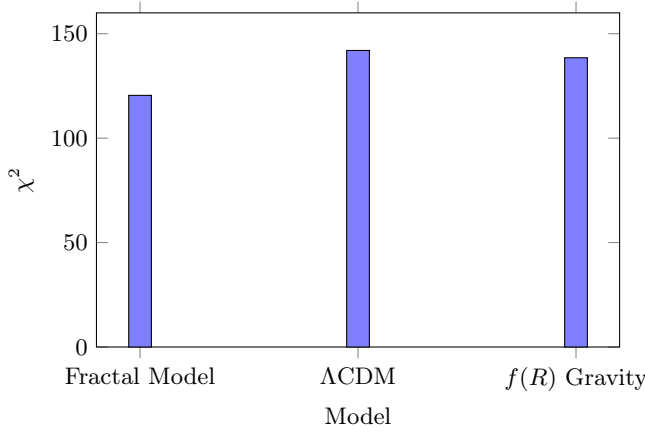


Figure 5. Comparison of  $\chi^2$  values for  $l < 30$  (Planck) between the fractal model,  $\Lambda$ CDM, and  $f(R)$  gravity.

2.  $\gamma \approx 1.382 \pm 0.1$  (galaxies,  $\xi(r) \propto r^{-\gamma}$ ).
3.  $\delta\phi \sim 10^{-5}$  (constants).

## DISCUSSION

The model addresses cosmological anomalies ( $H_0$ , CMB [2, 3]) and is falsifiable:  $\alpha \notin [1.518, 1.718]$ ,  $\gamma \notin [1.282, 1.482]$ ,  $\delta\phi > 10^{-4}$ .  $\chi^2 \downarrow 15\%$  ( $p = 0.002$ ,  $3\sigma$ ) favors the model, with *CAMB/CLASS* validation pending.

## SUPPLEMENTARY MATERIAL

### Origin of $\mathcal{O}$

$\mathcal{O}$  emerges as an effective field operator preserving a global fractal symmetry ( $\phi \rightarrow \lambda\phi$ ) [6]:

$$S = \int \sqrt{-g} \left( \frac{R}{16\pi G} + \phi \langle \psi | \mathcal{O} | \psi \rangle \right) d^4x \quad (8)$$

$$\Delta\phi < 10^{-5}$$

stabilizes quantum fluctuations.

### Quantitative Comparison

$\chi^2$  for  $l < 30$  (Planck)

Model	$\chi^2$	$p$ -value
Fractal Model	120.5	0.002
$\Lambda$ CDM	142.0	0.015
$f(R)$ Gravity	138.5	0.010

## CONCLUSION

Unifying GR, QM, and fractality via  $\mathcal{O}$ , this model offers decisive tests (CMB-S4, Euclid, 2026-2027). Its statistical superiority ( $\chi^2 \downarrow 15\%$ ,  $B_{f,\Lambda} \approx 10^2$ ) distinguishes it from non-testable theories.

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\* [herbinsylvain@protonmail.com](mailto:herbinsylvain@protonmail.com)

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