Fractal Causality: A Bounce–Holographic–Conformal Cosmology

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Version: v3.3

DOI: 10.5281/zenodo.17221015

Abstract

Fractal Causality proposes that the universe is a self-similar, cyclical process in which local collapses seed new expansions. Black holes act as transformation chambers where holographically stored information undergoes a loop-quantum-gravity style bounce and a conformal flip, re-expressing compressed two-dimensional data as new three-dimensional initial conditions. Version 3.3 presents a minimal mathematical model, stability criteria, and falsifiable predictions across the CMB, large-scale structure, gravitational waves, and 21 cm cosmology.

Author’s Note

This work is offered as an open hypothesis — a bridge between physics, mathematics, and meaning. It was developed outside traditional institutions, using unorthodox methods, but guided by a conviction that ideas should stand or fall on their own merit. The Fractal Causality framework grew out of years of questioning and observation, refined through persistence and the tools available in our time. Its origins may be unconventional, but its predictions are concrete and testable. This paper does not lean on biography or credentials — it leans on mathematics, consistency, and evidence. The invitation is simple: engage with the model, test its claims, and challenge its implications.

Part I — The Core Model

1. Bounce + Conformal Flip Model

Interior metric with LQC correction:

```
ds^2 = -N(tau)^2 dtau^2 + a(tau)^2 [ dr^2/(1 - k r^2) + r^2 dOmega^2 ]
```

Effective LQC dynamics (modified Friedmann):

```
H^2 = (8 pi G / 3) rho (1 - rho/rho_c) with H = a_dot / a
```

Conformal transformation across the flip (bounce hypersurface Sigma where rho = rho_c):

```
g'_{mu nu} = Omega(tau)^2 g_{mu nu}
```

Minimal assumptions (finite curvature):

- Choose Omega(tau) = (rho_c / rho(tau))^(1/6) near the bounce.

- Ricci scalar stays finite: R' = Omega^-2 [R - 6 Box(Omega)/Omega].

- Weyl tensor transforms conformally: C'_{mu nu rho sigma} = Omega^-2 C_{mu nu rho sigma}.

2. Horizon Data -> Initial Conditions Mapping

Holographic boundary correlator (theta = angular separation on pre-flip horizon):

```
C_Sigma(theta) = A0 * theta^(-alpha) for small theta
```

Bulk two-point function post-flip (AdS/CFT-inspired):

```
G'(x,x') = int C_Sigma(theta) K(x,theta) K(x',theta) dtheta
```

Power spectrum derivation:

For alpha = 2 (scale-invariant boundary): P(k) propto k^(-1) => n_s = 1.

Near scale-invariance: alpha = 2 + epsilon => n_s approx 1 - epsilon.

3. Mass–Spectrum Relations

Horizon area–mass:

```
A = 16 pi G^2 M^2 / c^4
```

Microstate count (Bekenstein–Hawking):

```
S(A) = A / (4 l_P^2) = 4 pi G^2 M^2 / (hbar c^3)
```

Progenitor distribution -> perturbation spectrum (k_M is characteristic scale ~ M^-1):

```
A_s(k) propto int p(M) S(M) exp(-k/k_M) dM
Spectral tilt: n_s - 1 = d ln A_s / d ln k approx < d ln p / d ln M >
```

4. Stability Conditions

Conformal factor constraints (avoid ghosts/gradients):

```
(Omega_dot / Omega) < H ; w_eff = -1 - 2 H_dot / (3 H^2) > -1
```

Near the bounce: w_eff approx (rho_c - rho) / (rho_c + rho) transitions from -1 to +1.