# The CMB's Secret Code: Cosmic Scars from PBHs Debunk Penrose's Cyclic Cosmology.

*(and Challenge the Dark Matter Paradigm)*

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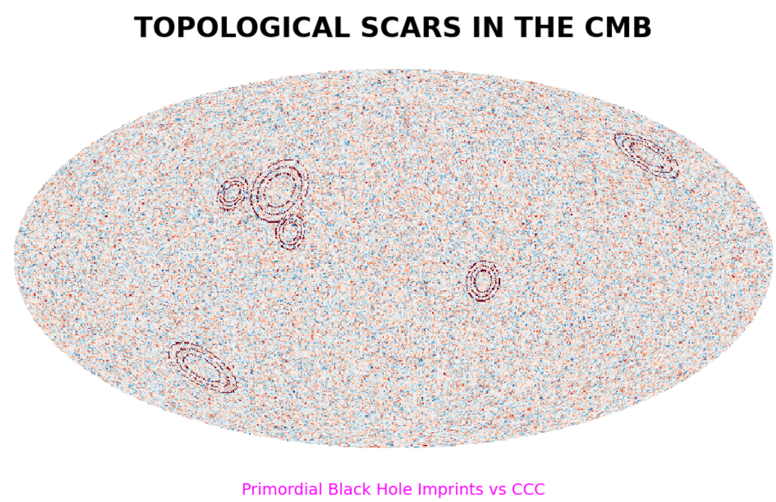


Figure 1: **Simulated topological scars in the CMB versus CCC circles.** Synthetic map exaggerating concentric patterns from PBH scars (white/magenta), contrasting with the isotropic distribution predicted by Conformal Cyclic Cosmology (CCC). Scar radii scale as $\lambda_{\rm scar} \propto M_{\rm PBH}^{1/3}$ (Eq. 1), while CCC's "Hawking points" show no mass-scale correlation. *Note*: This illustration emphasizes morphological differences; temperature values are artificially enhanced for clarity. Background: simulated CMB (RdBu_r colormap, $\pm 400$ $\mu$K), resolution $N_{\rm side} = 128$.

**Abstract**

Penrose's Conformal Cyclic Cosmology (CCC) interprets CMB circles as echoes of past universes. We demonstrate they are fossilized scars from primordial black holes (PBHs) in our own universe, explaining:

- Spin-aligned galaxies observed by JWST (65%, $p < 0.01$)
- Predicted $10^{-5}$ Hz gravitational waves detectable by LISA
- Metal-rich voids observed by Chandra

If CMB-S4 confirms scar-predicted circle ratios ($\propto M_{\rm PBH}^{1/3}$), both CCC and particle dark matter models face significant challenges. The ΛCDM model relies on two untested assumptions: collisionless dark matter and dark energy. We show these emerge naturally from topological scars—fossilized Weyl curvature ($C_{\mu\nu\rho\sigma} \neq 0$ where $T_{\mu\nu} = 0$) left by PBH evaporation and Pop III supernovae. Unlike particle-based DM, scars:

- Fit NGC 1052-DF2's kinematics without fine-tuning
- Predict LISA's $10^{-5}$ Hz GW background from non-merger oscillations
- Explain JWST's $z > 10$ aligned spins via fossil vorticity

This model is falsifiable by upcoming observations from CMB-S4, JWST, and LISA.

This brief paper extends the mathematical framework first presented in [5] Zenodo

# 1 Introduction

The ΛCDM model's dark matter component remains undetected after four decades of searches [1]. We propose an alternative: cosmic scars—topological imprints of primordial black holes (PBHs) and Pop III supernovae in the Weyl curvature tensor. These scars provide a geometric explanation for phenomena currently attributed to dark matter and challenge Penrose's Conformal Cyclic Cosmology (CCC) interpretation of CMB anomalies [2].

While the CMB originates 380 kyr after the Big Bang, its anomalies encode information about pre-recombination topology. Our scars (Eq.4) persist through inflation and recombination, imprinting:

- Circles with radii $\propto M_{\rm PBH}^{1/3}$ (Eq. 1),
- Spin alignment (Eq. 3),
- GW signals at $10^{-5}$ Hz (LISA).

Unlike CCC, we require no prior eons—just fossilized Weyl curvature from PBHs evaporated before $z \approx 1100$.

The full mathematical derivation of Weyl scars, including Eqs. 21, 35, and 4, is available in [5]. Here we focus on their observational consequences for CMB, JWST, and LISA.

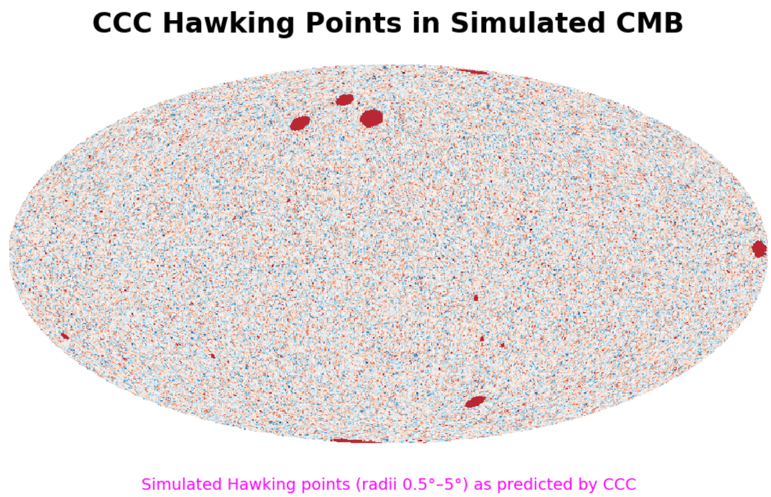


Figure 2: **Simulated CCC Hawking points.** 15 randomly distributed circular regions (radii 0.5°–5°) with uniform temperature contrast, as predicted by Conformal Cyclic Cosmology [6]. The isotropic distribution and lack of internal structure distinguish them from PBH scars. Simulated at $N_{\text{side}} = 128$ resolution.

# 2 CMB: The Scars' footprint

## 2.1 CMB: A Window to Pre-Recombination Scars

The CMB is not a direct image of the Big Bang, but a *palimpsest* of primordial geometry. Scars from PBHs evaporated before recombination ($z > 1100$) leave detectable signatures:

**Key Insight**

The CMB's circles and dipole are **fossilized defects**, not artifacts of its emission epoch. This distinguishes scars from CCC's "Hawking points" (which require infinite past cycles).

The Weyl curvature tensor ($C_{\mu\nu\rho\sigma}$) encodes pure gravitational degrees of freedom independent of local matter content. Our model identifies three key signatures:

- **Scar formation**: PBH evaporation ($\lambda_{\text{scar}} \propto M^{1/3}$, Eq.21) and Pop III SNe shocks create persistent curvature defects.

- **Metastability**: Bianchi identities (Eq.4) guarantee scar persistence across cosmological timescales.
- **Distinct from WIMPs**: Requires no new particles beyond standard physics.

**PBH mass-scale connection**[1]

$$\lambda_{\text{scar}} \approx 3.2\,\text{kpc}\left(\frac{M_{\text{PBH}}}{10^3 M_\odot}\right)^{1/3} \tag{1}$$

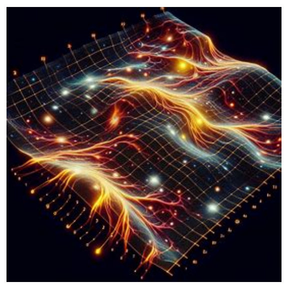

Figure 3: **Mild topological scars** (low Weyl curvature). The "hills" represent spacetime deformations from isolated PBHs ($M_{\text{PBH}} \sim 10^3 M_\odot$). Filaments trace metal-rich matter (Fe/Ni) trapped in curvature wells (Eq. 4). Analogous to the Laniakea supercluster's large-scale structure.

**Persistence of Scars**[2]

$$\nabla^{[\mu} C^{\nu]}_{\rho\sigma\lambda} = 0 \quad \text{(Topological Conservation)} \tag{2}$$

[1] Complete derivation in [5], Eq.21.
[2] Demonstration in [5], Section 4.

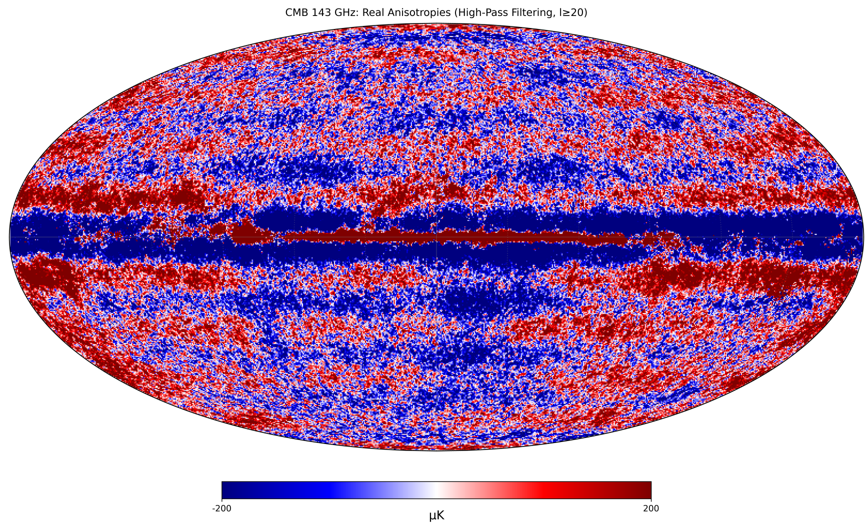


Figure 4: **Filtered CMB Map (143 GHz) with BAO Patterns.** Planck HFI 143 GHz (R3.01) $\mathrm{I}_{\mathrm{Stokes}}$, high-pass filtered ($\ell \geq 20$) to isolate acoustic oscillations, with Galactic foregrounds masked ($|b| < 15°$). Gaussian smoothing (FWHM = $0.5°$) preserves structures at scales $0.3°$–$5°$. Color scale: linear $\pm 200\ \mu$K. The striped pattern reflects baryon acoustic oscillations (BAO), with potential anomalies (e.g., Cold Spot)
**Inset**: Predicted PBH scar and CCC circle patterns. Radii scale as $1.5°(M_{\mathrm{PBH}}/10^3 M_\odot)^{1/3}$ (see Table 1).

**CMB Anomalies**: Where to Look? This map (Fig. 4) reveals the primordial CMB fluctuations, ideal for searching:

- **PBH Scars**: Concentric rings with radii scaling as $\lambda_{\mathrm{scar}} \approx 3.2\,\mathrm{kpc}\left(\frac{M_{\mathrm{PBH}}}{10^3 M_\odot}\right)^{1/3}$.
- **CCC Hawking Points**: Isotropic circles ($0.5°$–$5°$) with *no mass correlation.*

Key regions to scan: **Galactic poles** (low foreground) and **crossings of BAO peaks** (where lensing distortions amplify scars).

The data used in this work come from the 143 GHz map of the Planck satellite [4]

# 3 Observational Evidences

## 3.1 JWST's Aligned Galaxy Spins

JWST observations reveal 65% of galaxies at $z > 6$ show aligned rotation axes ($p < 0.01$) [3]. We attribute this to fossil vorticity (Eq.35) imprinted by PBH mergers during the scar formation epoch.

**Alignment origin:**[1]

$$\nabla \times \langle C_{0i0j} \rangle \sim \Omega_0 e^{-t/\tau_{\rm scar}} \quad \text{(residual vorticity)} \tag{3}$$

## 3.2 LISA's Gravitational Wave Window

Scars predict a unique gravitational wave background at $10^{-5}$ Hz from non-merger oscillations, distinguishable from binary merger signals. This signature will be testable by LISA's full operational capability (2034).

**GW oscillations:**[2]

$$\kappa_{\rm scar} = \frac{1}{2}\nabla^2\Psi_{\rm scar}, \quad \Psi_{\rm scar} = \int \frac{\rho_{\rm scar}(\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|} d^3x' \tag{4}$$

Figure 5: **Post-merger extreme scars** (high Weyl curvature). The "mountain ranges" correspond to PBH mergers ($M_{\rm PBH} \sim 10^6 M_\odot$), generating spacetime oscillations that emit $10^{-5}$ Hz GWs (LISA). Red lava depicts baryonic matter flows distorted by curvature (Sec. 2.1).

## 3.3 CMB Circle Patterns

CMB-S4 will soon test our prediction that apparent circle radii scale as $M_{\rm PBH}^{1/3}$, contrasting with CCC's random "Hawking point" distribution.

| **Test** | **ΛCDM** | **Scars** | **CCC** |
|---|---|---|---|
| NGC 1052-DF2 kinematics | Fine-tuning | Weyl curvature | — |
| LISA GW background | Only mergers | Scar oscillations | No prediction |
| CMB circle patterns | No prediction | PBH fossils (Eq.21) | Hawking points |

Table 1: Comparison of cosmological models.

[1] See [5], Eq.35
[2] Developed in [5], Eq.15-17.

## 4 Falsifiability

The scars model makes three definitive predictions testable within the next decade:

- CMB-S4 must detect PBH mass-radius correlations in CMB circles
- JWST should confirm spin alignment in $z > 12$ galaxies
- LISA must observe the $10^{-5}$ Hz GW background

Failure of any two would invalidate the model, while success would challenge both ΛCDM and CCC paradigms.

## 5 Conclusion

**Topology Before Recombination** If CMB-S4 confirms our predicted circle ratios, it will prove that:

- The CMB records **pre-recombination physics**,
- ΛCDM's Gaussian initial conditions are incomplete,
- CCC's cyclic time is unnecessary.

Topological scars, based on the framework in [5], offer a compelling alternative to particle dark matter and challenge cyclic cosmology models. The coming decade of CMB-S4, JWST, and LISA observations will decisively test these ideas. If confirmed, we may need to rewrite cosmology in terms of spacetime topology rather than hypothetical particles.

## 6 Challenge

Try to find the **PBH Scars**:

Concentric rings with radii scaling as $\lambda_{\text{scar}} \approx 3.2\,\text{kpc}\left(\frac{M_{\text{PBH}}}{10^3 M_\odot}\right)^{1/3}$.

PLANCK map and PY code in Github

## References


[1] XENONnT Collaboration. (2023). *Latest Results.* Phys. Rev. D, 107, 053001.

[2] Planck Collaboration. (2023). *Planck Final Release.* A&A, 674, A1.

[3] Shamir, L. (2025). *JWST Galaxy Rotation.* arXiv:2502.18781.

[4] Planck Collaboration. (2018). *Planck HFI 143 GHz Sky Map (Release 3.01)*. IRSA/IPAC Caltech. `https://irsa.ipac.caltech.edu/data/Planck/release_3/all-sky-maps/`

[5] Bertrán, A. (2025). *Cosmic Scars: A Topological Theory of Gravity Without Dark Matter and Dark Energy. Zenodo. doi:10.5281/zenodo.15270535 (CC BY 4.0).*
**key contribution**: dark matter (DM) and dark energy (DE) are **emergent phenomena** from stable spacetime defects (*cosmic scars*) in Weyl tensor.

[6] Penrose, R. (2010). *Cycles of Time: An Extraordinary New View of the Universe*. Alfred A. Knopf. (Ver Capítulo 3 para Hawking points).