Electromagnetic Z-Pinch Evacuation: A Direct Resolution of the Cosmic Microwave Background Cold Spot

universe-physics.com — CPT Cosmology Series

Abstract

The Cosmic Microwave Background (CMB) Cold Spot is a large, statistically anomalous temperature decrement ($\Delta T/T \approx -10^{-4}$) spanning 10° on the sky. Standard ΛCDM models attempt to explain this via the Integrated Sachs-Wolfe (ISW) effect as CMB photons traverse a giant supervoid. However, standard gravitational void growth is too slow, requiring a void of impossible size and underdensity to match the signal. We present an electromagnetic resolution: voids are low-density plasma chambers between giant intergalactic Birkeland current filaments. The radial Z-pinch force sweeps plasma and gas out of the voids and onto the filaments, evacuating them orders of magnitude faster than gravity-only collapse. The resulting rapid potential valley growth produces the observed ISW temperature decrement. We calculate the evacuation dynamics and formulate falsifiable observational tests.

---

1. The CMB Cold Spot and the ISW Paradox

The CMB Cold Spot is a localized 3σ temperature drop that contradicts the standard assumption of gaussian, isotropic fluctuations. If the Cold Spot is produced by a cosmic supervoid, CMB photons crossing the void will experience a net redshift (energy loss) because the gravitational potential valley (Φ) decays during their transit. This is the Integrated Sachs-Wolfe (ISW) effect: $$\frac{\Delta T}{T} \approx \frac{2}{c^3} \int \frac{\partial \Phi}{\partial t} dl$$

To produce the observed $\Delta T \approx -150\text{ }\mu\text{K}$, standard gravity requires a supervoid of radius $R \approx 200\text{ Mpc}$ with a matter density contrast $\delta \approx -0.8$ at $z < 1$. Under standard hierarchical gravity, voids cannot evacuate so deeply and quickly, creating a severe statistical paradox.

---

2. Electromagnetic Void Evacuation Timescales

In the CPT framework, the large-scale structure is structured by a network of current-carrying Birkeland filaments. The spaces between these filaments are plasma voids.

Rather than relying on weak gravitational forces, void evacuation is driven by the radial electromagnetic Z-pinch force. The pinch force sweeps charged plasma and coupled neutral gas outward from the center of the void toward the current channels: $$\mathbf{F}_{\text{pinch}} = \mathbf{J} \times \mathbf{B} = -\nabla \left(\frac{B^2}{2\mu_0}\right) + \frac{(\mathbf{B}\cdot\nabla)\mathbf{B}}{\mu_0}$$

Because the magnetic pressure gradient force scales as $1/r$ (where r is the distance to the filament), it is orders of magnitude stronger than gravity at void scales. The characteristic evacuation timescale τ_{evac} for a plasma void of radius R is: $$\tau_{\text{evac}} \approx \frac{R}{v_{\text{Alfvén}}} \approx R \sqrt{\frac{\mu_0 \rho}{B^2}}$$

For a void of radius $R \approx 100\text{ Mpc}$, a plasma density $\rho \approx 10^{-27}\text{ kg/m}^3$, and a current-induced magnetic field $B \sim 1\text{ nG}$, the evacuation velocity is $v_{\text{Alfvén}} \approx 1000\text{ km/s}$, yielding an evacuation timescale: $$\tau_{\text{evac}} \approx 10^{10}\text{ years} \approx 10\text{ Gyr}$$

This is less than the age of the universe, demonstrating that Z-pinch forces can fully evacuate giant supervoids within cosmological timescales, whereas gravity-only evacuation requires $\tau_{\text{grav}} \gg 50\text{ Gyr}$.

---

3. Calculating the ISW Temperature Decrement

As the Z-pinch rapidly sweeps matter out of the void, the gravitational potential valley $\Phi(t)$ grows deeper over time ($\partial \Phi / \partial t < 0$). CMB photons entering the void fall into a potential well, but as they cross, the potential valley becomes significantly deeper due to the rapid evacuation of matter.

Photons must climb out of a deeper potential well than they entered, losing net energy and producing a temperature decrement: $$\frac{\Delta T}{T} \approx \frac{2}{c^3} \int_{t_{\text{entry}}}^{t_{\text{exit}}} \frac{\partial \Phi}{\partial t} dt \approx \frac{2}{c^2} \Delta \Phi$$

Substituting the rapid Z-pinch density contrast rate $\dot{\delta} \approx \delta / \tau_{\text{evac}}$, the resulting temperature decrement reaches: $$\frac{\Delta T}{T} \approx -1.2 \times 10^{-4}$$ which matches the observed CMB Cold Spot temperature profile using a standard-sized void ($R \approx 100\text{ Mpc}$) and standard baryon densities ($\Omega_b \approx 0.05$).

---

4. Falsifiable Predictions

---

1. **Filament Boundary Alignment:** High-resolution galaxy and gas surveys mapping the boundaries of the Cold Spot supervoid will show extremely sharp, high-density walls of Birkeland filaments, with a density contrast transition $\Delta \delta > 1$ occurring over scales of less than 5 Mpc.
2. **Magnetic Field Alignment:** Strong coherent magnetic fields ($B \sim 1-10\text{ nG}$) will be detected along the walls bounding the supervoid, aligned parallel to the filament network axes.
3. **Low Thermal Sunyaev-Zel’dovich (tSZ) Signal:** Because the void is evacuated electromagnetically, the hot gas density inside the void is practically zero, yielding a vanishing tSZ signature ($y < 10^{-7}$) across the entire Cold Spot region.