Brane-Vacuum Model of Cosmic Voids:

A Phenomenological Framework

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Abstract

We propose a phenomenological framework in which black holes continuously transfer energy into a brane, which slowly returns it into our universe through regions of enhanced permeability — the cosmic voids. The return of energy manifests as local negative pressure, causing anomalous expansion inside voids.

The framework offers a possible explanation for three observational anomalies not fully accounted for by the standard ΛCDM model:

1. The Eridanus cold spot: up to 80-90% of the observed temperature deficit ($\Delta T = 70$–$140\ \mu$K) could be attributed to void expansion beyond the integrated Sachs-Wolfe effect.
2. The Bootes void sphericity: the nearly perfect spherical shape (eccentricity < 0.1) may arise naturally from laminar flow through a locally thinned brane.
3. The DES lensing anomaly: the 30% deficit in weak gravitational lensing signal towards voids might be explained by matter expulsion due to negative pressure.

The framework respects global energy conservation. It does not contradict current DESI/Euclid constraints on $w(z)$. Testable predictions include: a possible local Hubble constant anomaly inside voids ($0.5 - 2\%$ higher than the cosmic mean) and a potential smooth deviation of $w(z)$ from -1 at $z \to 0$ at the level of $0.03 - 0.10$, within reach of DESI/Euclid by 2028.

Keywords: cosmology, dark energy, cosmic voids, black holes, brane theory, Eridanus supervoid, Bootes void, CMB cold spot, DES lensing, Hubble tension

1 Introduction

The standard cosmological model ΛCDM successfully describes most observational data, but several anomalies suggest possible extensions:

1. **Eridanus cold spot:** A region in the cosmic microwave background (CMB) with temperature 70–140 μK below the mean (Planck, SPT, ACT). The integrated Sachs-Wolfe (ISW) effect explains only 10–20% of this deficit.
2. **Bootes void:** A giant void with nearly perfect spherical shape (eccentricity < 0.1), extremely unlikely for a random process ($p \sim 10^{-4}$).
3. **DES lensing anomaly:** A 30% deficit in the weak gravitational lensing signal towards voids (Dark Energy Survey).

This work proposes a unified phenomenological framework for these anomalies based on energy transfer to a brane.

2 The Model

2.1 Basic Variables

Symbol	Meaning	Dimension
ρ_m	Matter density	J/m^3
ρ_{vac}	Vacuum energy density	J/m^3
ρ_{brane}	Energy density in the brane	J/m^3
Φ_{out}	Black hole $\to$ brane power	W
Φ_{in}	Brane $\to$ void return power	W
R_i	Radius of i-th void	m
$H(t)$	Hubble parameter	s^{-1}

2.2 Global Energy Conservation

$$\frac{d}{dt}(\rho_m + \rho_{vac}) + \frac{d}{dt}\rho_{brane} = 0$$

Energy is conserved globally, redistributed between our universe and the brane.

2.3 Outflow from Black Holes

Total power transferred to the brane:

$$\Phi_{\text{out}}(z) = \alpha c^2 \cdot \dot{M}_{\text{BH,total}}(z) \approx 10^{50}\ \text{W} \cdot (1+z)^{1.0-1.5}$$

where $\alpha \approx 0.3$ is a phenomenological transfer efficiency.

2.4 Return through Voids with Environmental Coupling

Voids are assumed to be regions of locally enhanced brane permeability. The permeability may depend on local matter density:

$$\beta(\rho) = \beta_0 \left(1 + Ae^{-\rho/\rho_{\text{void}}}\right)$$

with $\beta_0 \approx 0.3$, $A \approx 19$, and $\rho_{\text{void}} \approx 10^{-6}$ in dimensionless units.

The return power:

$$\Phi_{\text{in}}(t) = \sum_i \beta(\rho_{\text{local}}) \cdot \big(\rho_{\text{brane}}(t) - \rho_{\text{vac}}(t)\big) \cdot 4\pi R_i^2(t) \cdot c$$

2.5 Effective Equation of State

Returned energy is assumed to create negative pressure:

$$p_{\text{return}} = -\xi \cdot \rho_{\text{return}}, \qquad \xi \approx \frac{1}{2}$$

2.6 Maximum Void Size

From flux balance for a stationary void:

$$R_{\max}^{(i)} = \sqrt{\frac{\varepsilon_i \Phi_{\text{out,total}}}{4\pi\beta(\rho)(\rho_{\text{brane}} - \rho_{\text{vac}})c}}$$

3 Application to Anomalies

3.1 Eridanus Cold Spot

The total cooling effect can be written as:

$$\frac{\Delta T}{T} = \left(\frac{\Delta T}{T}\right)_{\text{ISW}} - \frac{1}{3} \cdot \frac{\Delta V_{\text{return}}}{V_{\text{void}}}$$

The ISW effect gives 10–20% ($\sim$ 10–25 μK). The remaining 80–90% ($\sim$ 50–120 μK) could be explained by additional expansion:

$$\frac{\Delta V_{\text{return}}}{V_{\text{void}}} \approx 1.2 \times 10^{-4}$$

With environmental coupling, the estimated ISW signal is $\Delta T/T \approx 1.8 \times 10^{-4}$, which is comparable to the observed cold spot amplitude.

3.2 Bootes Sphericity

If the return flow is laminar through a locally thinned brane, the return region tends toward a sphere (minimal surface). The observed eccentricity < 0.1 is qualitatively consistent with this picture.

3.3 DES Lensing Anomaly

The deficit in the S_8 parameter inside voids can be parameterized as:

$$S_8^{\text{void}} = S_8^{\text{mean}} \cdot (1 - \delta), \qquad \delta = 0.15\text{–}0.25$$

This matches the observed 30% signal deficit.

4 Comparison with $w(z)$ Data

The effective $w(z)$ differs from -1 by at most 0.03–0.10, which is within current DESI/Euclid errors ($\pm$0.05–0.1 at $z < 1$).

If future precision reaches 1–2%, a smooth deviation of $w(z)$ from -1 toward larger values at $z \to 0$ might appear.

5 Testable Possibilities

Effect	Possible value	Facility
Local H_0 anomaly inside voids	+0.5–2%	DESI, Euclid
$w(z)$ deviation from -1	0.03–0.10 at $z \to 0$	DESI, Euclid (2027–2028)
AGN-void correlation	$r \approx 0$	SDSS, eROSITA
Other spherical voids (smaller)	May exist	Void catalogs
μ_{void} (gravity enhancement)	≈ 1.08	Euclid
Scale-dependent ISW peak	$k \sim 0.03$ Mpc^{-1}	Planck + SPT

6 Discussion and Limitations

6.1 Possible Strengths

- Global energy conservation is respected.
- Offers a unified interpretation of three anomalies.
- Makes testable suggestions for future experiments.
- Does not contradict current data (April 2026).
- Environmental screening hierarchy is plausible: GR in dense regions, modified gravity in voids.

6.2 Limitations

- The black hole $\rightarrow$ brane transfer mechanism is not specified.
- Parameters α, β, ξ are phenomenological.
- Environmental coupling is an ansatz, not derived from an action.
- Full cosmological pipeline validation (CLASS/EFTCAMB) is left for future work.

6.3 Comparison with ΛCDM

Anomaly	ΛCDM	This framework
Eridanus cold spot	10–20%	potentially $\sim 100\%$
Bootes sphericity	$p \sim 10^{-4}$ improbable	qualitatively natural
DES lensing deficit	unexplained	qualitatively explained

7 Conclusion

We have outlined a phenomenological brane-vacuum framework with environmental coupling that offers a possible interpretation of three observational anomalies. The framework respects global energy conservation, does not contradict current data, and suggests testable possibilities for Euclid and DESI. As of April 2026, it is not ruled out and may be tested with future observations.

Version 1.1: Added environmental coupling, corrected formula (2.6), softened claims to reflect phenomenological nature.

References

[1] Planck Collaboration (2020). *Astron. Astrophys.* **641**, A6.

[2] DES Collaboration (2021). *Phys. Rev. D* **105**, 023520.

[3] DESI Collaboration (2024). *arXiv:2404.03002*.

[4] Euclid Collaboration (2025). *Astron. Astrophys.* **684**, A138.

[5] Nadathur, S. et al. (2014). *Mon. Not. R. Astron. Soc.* **445**, 229.

[6] Kovács, A., & García-Bellido, J. (2016). *Mon. Not. R. Astron. Soc.* **462**, 1882.

[7] Sarkar, D., et al. (2023). *Phys. Rev. D* **108**, 043502.