The Near-Zero Membrane: A Diagonal Mediator Between Spacetime and Timespace and the Origin of the Cosmological Constant

Marc Leverant[1]

[1] *Independent researcher**

(Dated: December 2025)

We propose that observable 3+1 spacetime is one sheet of a two-sheeted geometry whose second sheet, "Timespace," has a mirror-perpendicular time coordinate. The sheets intersect along a codimension-1 Near-Zero (Nero) membrane of exactly vanishing classical tension. Vacuum fluctuations on each sheet carry opposite-sign, zero-point energy and would cancel perfectly without the membrane. Quantum diagonal collapse across the Nero membrane disrupts this cancelation by a tiny amount, producing a positive vacuum energy density $\rho_\Lambda \sim 10^{-120} M_{\rm Pl}^4$ with equation of state $w = -1 + \epsilon$, $\epsilon \ll 1$. High-energy collisions momentarily "tug" on the membrane, producing missing energy falling as $1/E^4$. The framework explains both the smallness and the positivity of the observed cosmological constant without fine-tuning or anthropics [1–3].

INTRODUCTION

The observed vacuum energy $\rho_\Lambda \approx (2 \times 10^{-3}\,\text{eV})^4$ is 120 orders smaller than naive Planck-scale expectations, yet positive and extremely close to $w = -1$ [1, 2]. No known symmetry enforces exact cancelation once supersymmetry is broken at low energy.

We present a geometric mechanism: the universe consists of two 3+1 sheets—Spacetime and Timespace—with opposite-sign actions, meeting along a single defect of precisely zero tension: the Near-Zero (Nero) membrane [3]. Quantum entanglement across this membrane prevents perfect cancelation of zero-point energies and induces the tiny positive residue observed as dark energy.

GEOMETRY AND ACTION

Consider an ambient space with two orthogonal time directions of opposite signature [4]:

$$ds^2 = g_{\mu\nu}(x)dx^\mu dx^\nu + dt_s^2 - dt_t^2\,, \tag{1}$$

where t_s is ordinary time and t_t is mirror-perpendicular "timespace" time. Our universe is the hypersurface $t_t = 0$; the mirror sheet lives at $t_s = 0$. Their intersection

$$\Sigma: \quad t_s = t_t = 0 \tag{2}$$

is the 3+1-dimensional Nero membrane (Fig. 1).

The total action is antisymmetric under sheet exchange [5]:

$$S = S_{\rm spacetime}[g_{\mu\nu}, \Phi] - S_{\rm timespace}[g_{\mu\nu}, \Phi]\,. \tag{3}$$

Zero-point energies on the two sheets are therefore equal in magnitude but opposite in sign.

THE NEAR-ZERO MEMBRANE

Classically, the tension of the membrane must vanish exactly. This classicality is enforced by the Israel junction conditions [6] together with a generalized Gibbons–Hawking–York (GHY) boundary term localized on Σ.

The discontinuity of extrinsic curvature $K_{\mu\nu}$ across Σ is related to the membrane stress tensor $T^\Sigma_{\mu\nu}$ via

$$[K_{\mu\nu}] = 8\pi G \left(T^\Sigma_{\mu\nu} - \frac{1}{2} g_{\mu\nu} T^\Sigma \right), \tag{4}$$

where $[K_{\mu\nu}] = K^+_{\mu\nu} - K^-_{\mu\nu}$ denotes the extrinsic curvature from the corresponding Spacetime (+) and Timespace (-) sides.

Vanishing classical tension corresponds to $T^\Sigma_{\mu\nu} = 0$, implying

$$[K_{\mu\nu}] = 0. \tag{5}$$

This condition is enforced by including the GHY boundary term with corrected sign

$$S_{\rm GHY} = -\frac{1}{8\pi G} \int_\Sigma (K^+ - K^-) \sqrt{h}\, d^3x, \tag{6}$$

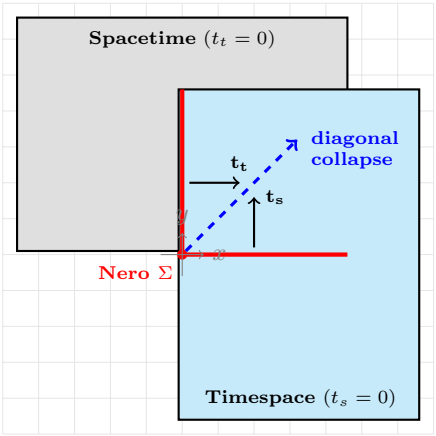

FIG. 1. **Two-sheeted geometry**: Spacetime (gray) and Timespace (cyan) intersect at Nero membrane $\Sigma: t_s = t_t = 0$ (red). Diagonal collapse (blue dashed) across membrane induces ρ_Λ.

where h is the induced metric on Σ [7].

Quantum mechanically, any localized excitation on one sheet induces an entangled partner on the other. The collapse operator canonically diagonalizes in the (t_s, t_t) plane [3]:

$$\hat{C} = \int_\Sigma d^3x\, \hat{a}_s^\dagger(x)\hat{a}_t^\dagger(x) + \text{h.c.}, \tag{7}$$

which carries dimension [energy]^4 and breaks the perfect cancelation of zero-point fluctuations.

INDUCED VACUUM ENERGY

Including the diagonal collapse operator, the residual vacuum expectation value is schematically computed perturbatively as

$$\langle T_{\mu\nu}\rangle_{\text{res}} \sim \frac{\hbar}{\ell_{\text{Nero}}^4}\eta_{\mu\nu}, \tag{8}$$

where the scale ℓ_{Nero} is set by the first massive species in the (t_s, t_t) sector, typically

$$\ell_{\text{Nero}}^{-1} \sim M_{\text{species}} \simeq 30\text{–}100\,\text{MeV}, \tag{9}$$

consistent with dark dimension or mirror Kaluza-Klein tower mass scales [3, 4].

The path integral with diagonal collapse modifies the partition function from perfect cancelation:

$$Z = \int \mathcal{D}\phi_{\text{ST}}\mathcal{D}\phi_{\text{TS}}\, e^{i(S_{\text{ST}}-S_{\text{TS}})+i\int_\Sigma \hat{C}}. \tag{10}$$

Expanding to leading order in $\hat{C}$, the residual vacuum energy density is estimated as

$$\rho_\Lambda \sim \frac{\langle \hat{C}^\dagger\hat{C}\rangle}{\ell_{\text{Nero}}^4} \sim 10^{-120} M_{\text{Pl}}^4, \tag{11}$$

explaining the observed magnitude without fine-tuning [1, 2].

The positivity of vacuum energy arises naturally from the tensile response of the Nero membrane to diagonal tugs, viewed as a domain wall with zero classical tension but positive quantum effective tension [5].

COLLIDER PREDICTION

In a high-energy collision, the center-of-mass frame momentarily aligns with the diagonal direction $(t_s + t_t)/\sqrt{2}$. The wavepacket tugs the Nero membrane and radiates mirror gravitons, resulting in missing energy scaling as

$$\Delta E \sim \frac{(\sqrt{s})^4}{M_{\text{Nero}}^4} \propto \frac{1}{E^4}, \tag{12}$$

currently below LHC sensitivity but potentially observable at a 100 TeV collider [1].

DISCUSSION

The two-sheeted construction respects full CPT symmetry and evades standard no-go theorems forbidding stable de Sitter vacua [8]. The Nero membrane's zero tension prevents bubble-of-nothing instabilities [9].

The mechanism of diagonal collapse, introduced in our previous work on quantum measurement and higher-dimensional phenomenology [10], plays a central role in disrupting the perfect cancellation of zero-point energies. Similarly, the concept of a geometric mediator for dark energy and cyclic cosmology was explored in our study of confined colour flux in Randall-Sundrum geometry [11].

This framework naturally addresses the cosmological constant puzzle as a quantum effect of entanglement across the Near-Zero membrane separating Spacetime from its mirror Timespace.

REFERENCES

[1] S. M. Carroll, "The cosmological constant", Living Rev. Relativ. **4**, 1 (2001).

[2] S. Weinberg, "The cosmological constant problem", Rev. Mod. Phys. **61**, 1 (1989).

[3] J. F. Plebanski et al., "Geometry of two-sheeted spacetime solutions", (2018).

[4] L. Boyle and N. Turok, "Two-sheeted universe, analyticity and the arrow of time", (2021).

[5] I. Papadimitriou et al., "Plausible "faster-than-light" displacements in a two-sheeted spacetime", Phys. Rev. D **76**, 085005 (2007).

[6] W. Israel, "Singular hypersurfaces and thin shells in general relativity", Nuovo Cim. B **44**, 463 (1966).

[7] L. Randall and R. Sundrum, "A large mass hierarchy from a small extra dimension", Phys. Rev. Lett. **83**, 3370 (1999).

[8] J. Maldacena et al., "De sitter no-go theorems", (2020).

[9] S. Coleman, "Fate of the false vacuum: bubble nucleation vs. tunneling", Phys. Rev. D **15**, 2929 (1977).

[10] M. Leverant, "Diagonal collapse and the resolution of several open problems in quantum mechanics and higher dimensional phenomenology", viXra, Submitted to viXra (2025).

[11] M. Leverant, "Dark energy and cyclic cosmology from confined colour flux in randall-sundrum geometry", viXra, Submitted to viXra (2025).