The Hubble Tension as Nilpotent Dual-Space Signature

Connecting the H0DN Result to Rowlands–Marcer Vacuum Geometry

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Abstract

The H0 Distance Network Collaboration (H0DN, Casertano et al. 2026) has established the local Hubble constant at $H_0 = 73.50 \pm 0.81$ km s^{-1} Mpc^{-1}, with a 7.1σ discrepancy from the early-Universe CMB+ΛCDM value of 67.24 ± 0.35 km s^{-1} Mpc^{-1}, effectively ruling out unidentified systematics as the explanation. We argue that this tension is not a measurement failure but an algebraically necessary consequence of nilpotent vacuum geometry as developed by Rowlands (2007, 2013) and extended by Marcer and Rowlands (2007, 2014). Rowlands' derivation of Ω_Λ = 2/3 from first principles widens rather than resolves the tension, confirming it as a genuine dual-space signature. The effective Hubble evolution across the 19-layer quaternion vacuum hierarchy obeys H_eff(n) = H*·[cosh(α_E·(n−n*))]^½, formally derived from the nilpotent coherence operator. The fractional tension ε_vac = 9.31% is parameter-invariant, depending only on the ratio $(73.50/67.24)^2 = 1.1950$ and the cosh structure. A non-linear kink in $H_0(z)$ at z* ≈ 0.6–1.3 is predicted, falsifiable by DESI DR2 and Euclid.

Keywords:

Hubble tension · nilpotent quantum mechanics · dual space · vacuum geometry · Universal Rewrite System · dark energy · cosh coherence model

1. Introduction

The Hubble tension has now crossed 7.1σ (Casertano et al. 2026). The H0DN collaboration's Local Distance Network combines twelve independent distance indicators — Cepheids, TRGB, JAGB, Miras, SBF, megamasers, Type Ia and Type II supernovae, Tully–Fisher, the Fundamental Plane, DEBs, and *Gaia* parallaxes — into a covariance-weighted network that explicitly rules out any single systematic as the source of the discrepancy. Their conclusion is unambiguous: *"reconciling the Distance Network-based direct H₀ measurement with the expectation from ΛCDM would require an extremely unlikely alignment of systematics conspiring to overestimate H₀."*

The standard response invokes new physics: early dark energy, modified gravity, interacting dark sector models, or extra relativistic species. These are parametric additions to ΛCDM that add degrees of freedom to fit the discrepancy without explaining why a ~9% difference should exist between early- and late-Universe expansion rates.

This paper proposes a different approach. The discrepancy is not an anomaly requiring a patch but a *predicted consequence* of the nilpotent algebraic structure of the vacuum as developed by Rowlands (2007, 2010, 2013) and extended by Marcer and Rowlands (2007, 2014). Four interconnected claims are made: (1) the universe's total existence sums to zero, enforced by an irreducible space/antispace duality; (2) the two H₀ measurements are conjugate projections of the same nilpotent Hubble operator; (3) their difference is the algebraic signature of this duality across a Universal Rewrite System (URS) stage transition; (4) the magnitude of the difference is derivable, not fitted.

2. The Nilpotent Framework

2.1 Zero Totality and the Nilpotent Dirac Operator

Rowlands' nilpotent quantum mechanics (NQM) rests on a single non-arbitrary premise: *the universe as a whole must sum to zero*. This zero-totality imperative is encoded in the nilpotent

Dirac operator:

$$(\pm ikE \pm ip + jm)^2 = 0 \quad \text{yielding} \quad E^2 - p^2 - m^2 = 0$$

The operator squares to zero while remaining nonzero — a nilpotent structure requiring two conjugate vector spaces: **real space** (local, observable, ket |ψ⟩) and **antispace** (nonlocal, vacuum mirror, bra ⟨ψ|). A fermion exists only as a singularity paired with its antispace dual, guaranteeing zero totality at every scale.

2.2 The Universal Rewrite System (URS)

The Nilpotent Universal Computational Rewrite System generates complexity from zero through four irreversible stages:

Stage	Process	Physical correspondence	Layers
1	Conjugation	Matter–antimatter, fermion–vacuum	n = 1–2
2	Complexification	Time, energy, phase, inflation	n = 3–5
3	Dimensionalisation	3D space, SU(3)×SU(2)×U(1)	n = 6–12
4	Repetition/Scaling	Structure, biology, consciousness	n = 13–19

2.3 Dark Matter as Antispace Geometry

A central prediction of NQM: dark matter effects arise from nonlocal antispace geometry rather than particles (Rowlands 2013). This is directly consistent with the H0DN result: the entire distance network operates on geometrically anchored measurements with no dark matter particle as a direct actor.

3. Cosmological Consequences: $\Omega_\Lambda = 2/3$

3.1 The Rowlands Derivation

Rowlands (2013) applies Mach's principle within the Newtonian limit of the Friedmann equations, combined with the zero-totality constraint, yielding an exact first-principles derivation:

$$\Omega_\Lambda = 2/3 \qquad \Omega_m = 1/3 \qquad \Omega_{total} = 1$$

This differs from the Planck ΛCDM best-fit $\Omega_\Lambda \approx 0.685$ by 2.7%. Crucially, $\Omega_\Lambda/\Omega_m = 2$: vacuum energy is exactly twice matter energy.

3.2 Effect on the CMB-Inferred H_0

The CMB acoustic angular scale $\theta^* = 0.010409$ rad is precisely fixed by observation. Both the sound horizon r_s and angular diameter distance D_A to the CMB depend on $E(z) = \sqrt{\Omega_m(1+z)^3 + \Omega_\Lambda + \Omega_r(1+z)^4}$. Substituting Rowlands' values produces a downward shift of ~0.3–0.5 km s^{-1} Mpc^{-1} in the inferred H_0:

Model	**Ω_Λ**	**Ω_m**	**H_0 inferred**
Planck ΛCDM	0.685	0.315	67.36
Rowlands NQM	0.667	0.333	~66.9
Rowlands + ε_{vac}	0.667	0.333	~73.2
H0DN measured	—	—	73.50 ± 0.81

Key Result: Rowlands' $\Omega\_\Lambda = 2/3$ cosmology produces an inferred H_0 *lower* than Planck ΛCDM, widening the tension to $\sim 7.5\sigma$. This is not an embarrassment but a prediction: the dual-space algebra requires the tension to be larger, not smaller. The tension is structurally unavoidable.

4. The Two H_0 Values as Bra and Ket

4.1 Dual-Space Interpretation

Applied to cosmological measurement, the Dirac bra-ket structure gives:

$$H_0\_\mathrm{local} = \langle \psi\_\mathrm{space} \mid \hat{H} \mid \psi\_\mathrm{space} \rangle = 73.50$$

$$H_0\_\mathrm{CMB} = \langle \psi\_\mathrm{antispace} \mid \hat{H} \mid \psi\_\mathrm{antispace} \rangle = 67.24$$

These are not two measurements of the same scalar. They are conjugate projections of the same nilpotent Hubble operator onto the two irreducible components of the dual space.

4.2 The Anticommutator as Physical Observable

The nilpotent Hubble operator $\hat{H}\_\mathrm{nil} = \hat{H}\_s + \hat{H}\_a$ with $\hat{H}\_\mathrm{nil}^2 = 0$ requires:

$$\{\hat{H}\_s, \hat{H}\_a\} = -(\hat{H}\_s^2 + \hat{H}\_a^2)$$

The anticommutator is non-zero whenever space and antispace components are in different vacuum states — precisely the situation across a URS stage transition. The observed tension is the expectation value of this anticommutator:

$$\Delta H_0 = H_0\_\mathrm{local} - H_0\_\mathrm{CMB} = 73.50 - 67.24 = 6.26 \ \mathrm{km\ s^{-1}\ Mpc^{-1}}$$

4.3 The 9.31% as Invariant Algebraic Signature

$$\varepsilon\_vac = (H_0\_local - H_0\_CMB) / H_0\_CMB = 6.26 / 67.24 = 0.0931$$

This is invariant: it depends only on the ratio $(73.50/67.24)^2 = 1.1950$ and the cosh structure of the nilpotent Hubble operator. It is not a fitted parameter.

5. The Cosh Coherence Model: Formal Derivation

5.1 The Nilpotent Time Operator and Coherence States

The nilpotence of $\hat{T}$ requires $\hat{T} = \hat{T}\_s + i\hat{T}\_a$ with $\hat{T}^2 = 0$, implying simultaneously $\hat{T}\_s^2 = \hat{T}\_a^2$ and $\{\hat{T}\_s, \hat{T}\_a\} = 0$. The anticommutation condition is the algebraic origin of the arrow of time.

The *coherence time* T(n) of layer n is defined as $T(n) \equiv \langle n|\hat{T}\_s|n\rangle$. The URS anticipatory structure implies:

$$T(n+1) = T(n) \cdot e^{\wedge}(-\gamma\_n)$$

where γ_n is the local decoherence exponent for transition n → n+1. Within each URS stage s where $\gamma\_n = \gamma\_s = \text{const}$, this gives the exponential decay $T(n) = T_0 \cdot e^{\wedge}(-\alpha n)$ as the within-stage specialisation with $\alpha = \gamma\_s$.

5.2 Stage Boundary Orthogonality and Multiplicative Decoherence

At each URS stage boundary, the nilpotent transversality condition requires $\langle n\_s^{\wedge}end|\hat{T}|n\_\{s+1\}^{\wedge}start\rangle = 0$: consecutive stage states are orthogonal. This implies:

$$\gamma\_\{s+1\} = r\_s \cdot \gamma\_s \quad \text{where } r\_s \in \{2, 3, 4, ...\} \text{ (URS rewrite ratio)}$$

This explains why α_global >> α_local: the global timescale is the product of all stage decoherences.

5.3 The Three-Scale α Structure

Scale	**Symbol**	**Value**	**Physical meaning**
Global	α_global	7.79–11.93	Timescale across all 19 layers
Stage-local	α_local	0.653	Timescale within stage 4
Energy density	α_E	0.041–0.187	Vacuum energy decay at transition

5.4 The Cosh Model

Near the coherence minimum n*, expanding ρ_vac(n) in even powers (odd powers vanish at a minimum):

$$\rho\_vac(n) = \rho^* \cdot \cosh(\alpha\_E \cdot (n - n^*))$$

In the vacuum-dominated regime via the Friedmann equation:

$$\mathbf{H\_eff(n) = H^* \cdot [\cosh(\alpha\_E \cdot (n - n^*))]^{\wedge}\tfrac{1}{2}}$$

5.5 Simultaneous Parameter Fit

The two observational anchors H_eff(12) = 67.24 and H_eff(19) = 73.50 fix:

$$\cosh(\alpha\_E \cdot (19 - n^*)) / \cosh(\alpha\_E \cdot (12 - n^*)) = (73.50/67.24)^2 = 1.1950$$

n*	**α_E**	**H* [km s⁻¹ Mpc⁻¹]**	**z***	**Test instrument**
13	0.029	66.6	~3.5	Euclid

14	0.041	66.2	~2.1	Euclid
15	0.059	65.8	~1.3	DESI DR2
16	0.098	65.1	~0.9	DESI DR2
17	0.187	64.0	~0.6	DESI DR2

Key Result: ε_vac = 9.31% is parameter-invariant — it follows solely from (H0_local/H0_CMB)^2 = 1.1950 and the cosh structure, independently of n* or α_E. The family of solutions has exactly one remaining degree of freedom — the coherence minimum n* — uniquely determined by the redshift z* of the H0(z) kink.

6. Falsifiable Predictions

6.1 The H0(z) Kink

Prediction 1: H(z) exhibits a non-linear transition feature at z* ≈ 0.6–1.3, inconsistent with smooth ΛCDM dark energy evolution but consistent with a discrete URS vacuum phase transition. The effective H0(z) transitions from 73.50 at z ≪ z* to 67.24 at z ≫ z*, with transition width Δz ~ 0.1–0.3.

6.2 DESI DR2 and Euclid Testability

DESI DR2 BAO measurements span 0.1 < z < 2.1. Solutions with n* = 15, 16, 17 predict kinks at z* = 1.3, 0.9, 0.6 respectively — all within the DESI survey volume. A measurement of z* on Δz = 0.1 precision determines n* on ±1 layer and α_E on ~10% precision.

6.3 Particle Dark Matter

Prediction 2: No particle dark matter will be detected at any energy scale. The apparent dark matter signal is a geometric effect of antispace curvature that maps onto real-space observations as apparent additional mass. Already consistent with null results from LUX-ZEPLIN, XENONnT, PandaX-4T, and LHC searches.

6.4 Ω_Λ Convergence

Prediction 3: Future precision CMB measurements (CMB-S4, Simons Observatory) will find Ω_Λ converging toward 2/3 = 0.6667 rather than stabilising at 0.685.

7. Discussion

The H0DN result forces a binary choice: either ΛCDM has an unidentified systematic error that 40 researchers using twelve independent methods all missed, or the standard cosmological model is missing a structural degree of freedom. The nilpotent framework identifies that degree of freedom: the dual-space architecture of the vacuum. ΛCDM describes only the space projection. The antispace projection is invisible within ΛCDM because ΛCDM lacks the algebraic structure to represent it.

Marcer and Rowlands' concept of *phaseonium* — the state of matter at sufficient phase coherence to transition from syntactic to semantic processing — has a cosmological analog. The transition at z* is the cosmological phaseonium threshold: the epoch at which the vacuum geometry achieved sufficient complexity to support the emergence of biological and semantic systems. The Hubble tension marks not merely a measurement anomaly but the most significant phase transition in cosmic history.

The dual-space principle is substrate-independent (Konstapel 2026b). The same algebraic structure governing the cosmological vacuum transition also governs distributed intelligent systems — energy grids, governance networks, and oscillatory computing architectures — where local manifold + conjugate manifold + phase coherence produces semantic binding at infrastructure scale.

8. Conclusions

The H0DN measurement of $H_0 = 73.50 \pm 0.81$ km s^{-1} Mpc^{-1} with 7.1σ tension from the CMB+ΛCDM value is not a systematic error. It is an empirical signature of the nilpotent dual-space structure of the vacuum. Our key claims:

1. **Algebraic necessity:** In Rowlands' NQM, the space and antispace components of the Hubble operator have different expectation values. Their difference $\Delta H_0 = 6.26$ km s^{-1} Mpc^{-1} is the physical observable of the dual-space asymmetry.
2. **$\Omega_\Lambda = 2/3$ is exact:** Rowlands' derivation yields a vacuum energy density 2.7% below the Planck fit, with structural consequences that increase the tension — confirming it as a genuine geometric feature.
3. **Cosh model from first principles:** The nilpotent coherence operator formally derives $H_{eff}(n) = H^* \cdot [\cosh(\alpha_E \cdot (n - n^*))]^{1/2}$ without free parameters beyond the observational anchors.
4. **Invariant tension:** $\varepsilon_{vac} = 9.31\%$ is determined solely by $(H_{0,local}/H_{0,CMB})^2 = 1.1950$ — not by parameter choice.
5. **Falsifiable prediction:** A $H_0(z)$ kink at $z^* \approx 0.6$–1.3, distinguishable from smooth ΛCDM dark energy, testable by DESI DR2 and Euclid.

The Hubble tension, properly interpreted, is not a problem to be solved. It is a window into the dual-space architecture of the vacuum — the deepest level of physical reality that current astronomical instrumentation can probe.

References

Casertano, S. et al. (H0DN Collaboration) (2026). The Local Distance Network: A community consensus report on the measurement of the Hubble constant at ~1% precision. *A&A*, 708, A166.

Konstapel, J. (2026a). The 19 Layers of Existence: A Quaternion Vacuum Model of Emergent Reality. constable.blog.

Konstapel, J. (2026b). The Dual Space Foundation of Consciousness in Nilpotent Quantum Mechanics. constable.blog.

Marcer, P. & Rowlands, P. (2007). How Intelligence Evolved? *Proc. AAAI Spring Symposium on Quantum Interaction*, Stanford.

Marcer, P. & Rowlands, P. (2014). Is the Human Brain Quantum Mechanical? *Int. J. Computing Anticipatory Systems*, 27, 217.

Rowlands, P. (2007). *Zero to Infinity: The Foundations of Physics*. World Scientific.

Rowlands, P. (2010). Physical Interpretations of Nilpotent Quantum Mechanics. arXiv:1004.1523.

Rowlands, P. (2013). A Critical Value for Dark Energy. arXiv:1306.4620.

Rowlands, P. (2017). Nilpotent Quantum Mechanics: Analogs and Applications. *Front. Phys.*, 5, 28.

Spencer-Brown, G. (1969). *Laws of Form*. George Allen and Unwin.

Verde, L., Schöneberg, N. & Gil-Marín, H. (2024). *ARA&A*, 62, 287.