Relational Mathematical Realism III: The Hubble Tension as a Discrete Spacetime Measurement Artifact

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Abstract

The 5σ discrepancy between local ($H_0 \approx 73$ km s^{-1} Mpc^{-1}) and early-universe ($H_0 \approx 67$ km s^{-1} Mpc^{-1}) measurements of the Hubble constant constitutes one of the most significant challenges to the standard ΛCDM cosmological model. We propose that this tension is not evidence of new physics beyond ΛCDM, but a systematic artifact arising from the discrete topology of spacetime within the Relational Mathematical Realism (RMR) framework.

In RMR, causal propagation is limited by a node update rate with a fundamental processing asymmetry: vacuum nodes require 4 computational ticks per update cycle while mass-coupled nodes require 5. We derive a geometric correction factor $\Gamma = (5/4)^{1/3} \approx 1.077$ representing the path-dependent latency experienced by observers calibrating distances through a 3-dimensional discrete lattice in the local, void-dominated universe.

Applied to the Planck CMB determination (67.36 ± 0.54 km s^{-1} Mpc^{-1}), this yields a predicted local measurement of $H_{\text{local}} = 72.56$ km s^{-1} Mpc^{-1}, agreeing with the SH0ES value (73.04 ± 1.04 km s^{-1} Mpc^{-1}) to within 0.46σ with zero free parameters.

Critically, this correction applies only to local path-integrated measurements (distance ladder), not to geometric bulk measurements (BAO, CMB), resolving the tension without modifying the cosmic expansion history. We classify all major H_0 measurements into "metric" (bulk geometry) and "path" (local calibration) categories, predicting that these two classes will systematically converge on different values separated by a factor of $(5/4)^{1/3}$. This framework makes specific falsifiable predictions for gravitational wave standard sirens and environment-dependent distance ladder calibrations.

If confirmed, the Hubble tension constitutes the first empirical evidence that spacetime is not a continuous manifold but a discrete relational graph.

1 Introduction

The Hubble constant H_0, which parametrizes the present-day expansion rate of the universe, has been measured with increasing precision over the past two decades. Two independent methods—one anchored in early-universe physics and one in the local distance ladder—have converged on values that are mutually inconsistent at high significance.

Measurements calibrated through the cosmic microwave background (CMB) yield $H_0 = 67.36 \pm 0.54$ km s^{-1} Mpc^{-1} from Planck [1], with consistent values from baryon acoustic oscillations (BAO) measured by DESI [2] and the full-shape galaxy clustering analysis. Local distance-ladder measurements using Cepheid-calibrated Type Ia supernovae give $H_0 = 73.04 \pm 1.04$ km s^{-1} Mpc^{-1} from the SH0ES collaboration [3]. The discrepancy, representing a ratio of 1.084 ± 0.018 between the two values, has persisted despite extensive searches for systematic errors [4, 5] and now exceeds 5σ significance.

Proposed resolutions include early dark energy [6], modified gravity [7], new light particles [8], and time-varying fundamental constants. These solutions typically require additional free parameters, may conflict with other observational constraints, and lack compelling theoretical motivation from first principles.

In this paper, we propose a qualitatively different resolution. Rather than modifying the cosmic expansion history, we identify the Hubble tension as a *measurement artifact* arising from the discrete topology of spacetime. Within the Relational Mathematical Realism (RMR) framework [9, 10], spacetime consists of a discrete relational graph in which information propagation is governed by node update cycles. A fundamental processing asymmetry between vacuum nodes (4-tick cycles) and mass-coupled nodes (5-tick cycles) introduces a systematic bias in local distance calibration that is absent from early-universe geometric measurements.

The key insight is that both Planck and SH0ES are *correct*—they are simply measuring different things. Planck and BAO measure the intrinsic (bulk) expansion rate of the universe. SH0ES measures the apparent expansion rate as inferred by observers embedded in a sparse, void-dominated local environment where the discrete processing asymmetry is maximally expressed. The discrepancy between the two is $(5/4)^{1/3} \approx 1.077$, a geometric factor derived from first principles with zero free parameters.

2 The RMR Framework

In Paper I of this series [9], we demonstrated via a Gödelian argument that any sufficiently rich logical system embedded in time cannot be self-consistent at its own boundary — a result that necessitates discrete temporal evolution rather than continuous flow. This discreteness is not a modeling choice but a logical requirement: a continuously evolving system would demand self-referential consistency at every infinitesimal interval, which Gödel's incompleteness theorems forbid. The node update cycle of the RMR framework — and with it, the 5/4 processing asymmetry that drives the present analysis — is a direct consequence of this forced discretization.

We briefly summarize the elements of Relational Mathematical Realism relevant to the present analysis; full development is given in Papers I and II of this series [9, 10].

2.1 Discrete Spacetime Structure

RMR posits that physical reality consists of a discrete relational graph—a network of nodes connected by mathematically consistent relations. Observable spacetime emerges from this graph structure, with each node carrying a 137-element information registry partitioned as

$$137 = 81_{\text{spatial}} + 40_{\text{surface}} + 16_{\text{gravitational}} , \tag{1}$$

where $81 = 3^4$ encodes three spatial dimensions, $40 = \binom{10}{4}$ encodes the surface sector, and $16 = 2^4$ encodes the gravitational sector.

2.2 The 5/4 Processing Asymmetry

A central result of the RMR framework is that the node update cycle differs between vacuum and mass-coupled nodes. Each update cycle requires sequential operations—READ, PROCESS, WRITE, ADVANCE—that must be performed serially due to information causality (simultaneous read/write is forbidden).

For **vacuum nodes**, the cycle involves 4 spacetime dimensions:

$$\tau_{\text{vacuum}} = 4 \times t_{\text{tick}} \,. \tag{2}$$

For **mass-coupled nodes**, the gauge sector introduces an additional serial processing step that cannot be parallelized:

$$\tau_{\text{mass}} = 5 \times t_{\text{tick}} \,. \tag{3}$$

The ratio of propagation rates is therefore

$$\frac{c_{\text{vacuum}}}{c_{\text{mass}}} = \frac{1/\tau_{\text{vacuum}}}{1/\tau_{\text{mass}}} = \frac{5}{4} = 1.25 \,. \tag{4}$$

This ratio is not an empirical fit; it is a logical necessity of discrete time, serial processing, and gauge sector complexity. The 5/4 ratio has been independently validated in analyses of pulsar glitch timing and gravitational wave phase intervals [11].

3 Metric vs. Path Measurements

The central argument of this paper rests on a distinction between two fundamentally different classes of H_0 measurement, which we term *metric* and *path* measurements.

3.1 Metric Measurements (Bulk Geometry)

Metric measurements probe the large-scale geometry of the universe without integrating photon paths through the local discrete lattice. Examples include:

CMB acoustic peaks: The angular scale of the sound horizon at recombination ($z \approx 1100$) depends on the ratio $r_d/D_A(z_*)$, where both quantities are geometric properties of the homogeneous bulk. At $z \sim 1100$, the universe was sufficiently dense that the 5/4 processing distinction was *saturated*—effectively all nodes were mass-coupled, producing a uniform processing rate with no differential lag.

BAO: The angular and radial scales of the baryon acoustic feature measure the sound horizon r_d imprinted in the matter distribution. This is a geometric ruler frozen at the drag epoch and transported by the bulk expansion. BAO measurements at $z = 0.3$–2.3 probe the intrinsic metric expansion, not local photon propagation.

CMB lensing: Gravitational lensing of the CMB probes the integrated matter distribution, a bulk geometric quantity.

Table 1: Classification of H_0 measurements into metric (bulk geometry) and path (local calibration) categories. RMR predicts metric measurements converge on $H_{0,\text{intrinsic}} \approx 67.4$ km s^{-1} Mpc^{-1} and path measurements converge on $H_{0,\text{local}} = 67.4 \times (5/4)^{1/3} \approx 72.6$ km s^{-1} Mpc^{-1}, with intermediate values for calibrators in lower-density environments.

Measurement	Type	H_0 (km s^{-1} Mpc^{-1})	RMR prediction	Deviation
Metric measurements (bulk geometry)				
Planck CMB (2018)	Metric	67.36 ± 0.54	67.36 (input)	—
DESI BAO + BBN (2024)	Metric	68.52 ± 0.62	~ 67–68	$< 2\sigma$
ACT CMB (2020)	Metric	67.6 ± 1.1	~ 67–68	$< 1\sigma$
DES BAO + BBN (2022)	Metric	$67.4^{+1.1}_{-0.9}$	~ 67–68	$< 1\sigma$
Path measurements (local calibration)				
SH0ES Cepheids (2022)	Path (disk)	73.04 ± 1.04	72.56	0.46σ
H0LiCOW lensing (2020)	Path (lens)	$73.3^{+1.7}_{-1.8}$	~ 72–73	$< 1\sigma$
Megamaser (2020)	Path (local)	73.9 ± 3.0	72.56	0.45σ
Intermediate measurements (lower-density calibration environments)				
CCHP TRGB (2021)	Path (halo)	69.8 ± 1.7	~ 69–71	$< 1\sigma$
CCHP JAGB (2024)	Path (halo)	67.96 ± 1.85	~ 69–71	$\sim 1\sigma$

3.2 Path Measurements (Local Calibration)

Path measurements infer H_0 by calibrating distances using standard candles or rulers in the local universe, then extrapolating to the Hubble flow. These measurements are sensitive to the discrete processing environment along the calibration chain:

Cepheid-calibrated SNe Ia (SH0ES): The distance ladder proceeds from geometric parallaxes ($d < 10$ kpc) through Cepheid period–luminosity relations in nearby galaxies ($d \sim 10$–40 Mpc) to Type Ia supernovae in the Hubble flow. Each rung of this ladder is calibrated in the local, void-dominated universe where the 5/4 processing asymmetry is maximally expressed.

TRGB-calibrated SNe Ia: The tip of the red giant branch provides an alternative distance indicator. Critically, TRGB stars reside predominantly in galactic halos—lower-density environments than the disk-embedded Cepheids used by SH0ES.

Surface brightness fluctuations, Tully–Fisher, and other local calibrators: All local distance indicators are calibrated in the sparse $z \approx 0$ environment.

3.3 Classification of Major H_0 Measurements

Table 1 classifies major H_0 measurements by type and compares them to the RMR prediction.

The pattern is striking: metric measurements cluster near 67–68, path measurements near 73, and halo-based calibrators fall in between. RMR provides a natural explanation for this three-tier structure.

4 The Geometric Lag Factor

We now derive the correction factor relating intrinsic and locally observed expansion rates.

4.1 From Volumetric Processing to Linear Propagation

The 5/4 asymmetry (Eq. 4) represents a difference in the *computational density* of the spacetime medium. In RMR, a node is not merely a point on a line; it is a volumetric element of space—a "voxel" whose update cycle governs the state of an entire local 3D neighborhood. The processing overhead

$$\Omega = \frac{\tau_{\text{mass}}}{\tau_{\text{vacuum}}} = \frac{5}{4} = 1.25 \tag{5}$$

is therefore a *volumetric* quantity: it describes the ratio of computational cost per unit volume between mass-coupled and vacuum regions.

However, the Hubble constant H_0 is a *linear* quantity: it measures expansion rate per unit length ($\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$). When we measure H_0 using the distance ladder, we integrate photon paths along one-dimensional geodesics through a three-dimensional medium.

Because the graph is isotropic—a consequence of the symmetric $81 = 3^4$ spatial sector, which encodes three equivalent spatial dimensions—the volumetric processing cost Ω is distributed equipartitioned across the three spatial axes. The effective linear propagation speed v_{eff} along any geodesic is related to the volumetric processing rate by the standard dimensional scaling:

$$v_{\text{eff}} \propto \Omega^{-1/3} \,. \tag{6}$$

The effective path-integrated latency factor Γ is therefore the cube root of the volumetric processing ratio:

$$\Gamma = \Omega^{1/3} = \left(\frac{5}{4}\right)^{1/3} \,. \tag{7}$$

This is the same relationship that governs any volumetric-to-linear dimensional reduction: if a cube's volume increases by a factor V, each edge grows by $V^{1/3}$. Here, the "volume" is the computational cost per node, and the "edge" is the observable delay along a single spatial dimension.

4.2 Numerical Result

Evaluating Eq. 7:

$$\Gamma = \left(\frac{5}{4}\right)^{1/3} = 1.25^{0.\bar{3}} = 1.07722 \,. \tag{8}$$

The predicted locally observed Hubble constant is

$$\boxed{H_{0,\text{local}} = H_{0,\text{CMB}} \times \Gamma = 67.36 \times 1.07722 = 72.56 \text{ km}\,\text{s}^{-1}\,\text{Mpc}^{-1} \,.} \tag{9}$$

This agrees with the SH0ES measurement of 73.04 ± 1.04 $\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$ to within 0.46σ.

4.3 Why the Correction Applies Only Locally

The geometric lag factor Γ affects local distance calibration but not BAO or CMB measurements for three reasons:

(1) Calibration environment. The distance ladder is anchored in the $z \approx 0$ universe, which is dominated by cosmic voids. In this sparse environment, photon paths traverse a heterogeneous mix of vacuum (4-tick) and mass-coupled (5-tick) nodes. The processing asymmetry induces a systematic offset in the inferred distance scale. BAO, by contrast, measures a geometric feature that was frozen at $z \sim 1060$ when the universe was homogeneously dense and the 5/4 distinction was saturated.

(2) Observable type. BAO measures an *angular size*—the angle subtended by a known physical scale. This is a ratio of two bulk geometric quantities (r_d/D_A) and is insensitive to local processing rates. The distance ladder measures *apparent brightness*, which depends on the luminosity distance d_L—an integral over the photon path through the discrete lattice.

(3) Redshift dependence. At high redshift, the universe is dense and the vacuum/mass distinction is negligible (all nodes are mass-coupled). The processing is uniform, and both metric and path measurements agree. As $z \to 0$, voids dominate, the heterogeneity increases, and path measurements diverge from metric measurements by the factor Γ.

This explains a key observational fact: the Hubble tension is a *low-redshift phenomenon*. It appears only when comparing early-universe (metric) and late-universe (path) determinations of H_0.

5 Environment-Dependent Calibration Bias

A distinctive prediction of the RMR framework is that the magnitude of the calibration bias should depend on the local matter density of the calibration environment. The full bias of $\Gamma = (5/4)^{1/3}$ applies when the calibrator resides in a typical void-dominated, disk-embedded environment. In lower-density environments (e.g., galactic halos), the effective lag is reduced because a larger fraction of nodes along the calibration path are vacuum-type.

5.1 The TRGB–Cepheid Discrepancy

This prediction naturally explains the discrepancy between Cepheid-based and TRGB-based H_0 measurements.

Cepheid variables are young, massive stars found in galactic disks—dense, star-forming environments with a high fraction of mass-coupled nodes. The SH0ES measurement ($H_0 = 73.04 \pm 1.04$) uses Cepheid calibration and experiences the full Γ factor.

TRGB stars, by contrast, are old red giants found predominantly in galactic halos—diffuse environments with lower matter density and a higher fraction of vacuum nodes. The CCHP measurement ($H_0 = 69.8 \pm 1.7$) using TRGB calibration should therefore experience a *reduced* lag factor:

$$\Gamma_{\mathrm{TRGB}} = \Gamma^{f_{\mathrm{halo}}/f_{\mathrm{disk}}} < \Gamma, \tag{10}$$

where $f_{\mathrm{halo}} < f_{\mathrm{disk}}$ represents the effective mass-coupling fraction in halo vs. disk environments.

The observed TRGB value of ~ 69.8 sits between the Planck value (67.4) and the full-lag prediction (72.6), consistent with a reduced but nonzero discrete correction. No other proposed resolution of the Hubble tension naturally accounts for this intermediate value.

5.2 Quantitative Estimate

If we parametrize the effective lag as $\Gamma_{\text{eff}} = (5/4)^{f_m/3}$ where f_m is the mass-coupling fraction along the calibration path, then the observed H_0 values imply:

For SH0ES (Cepheids, disk): $f_m \approx 1.0$ (full lag), predicting $H_0 = 72.56$.

For TRGB (halo): $H_0 = 69.8$ implies $\Gamma_{\text{eff}} = 69.8/67.36 = 1.0362$, giving $f_m \approx 0.47$.

We note that $f_m \approx 0.5$ is physically plausible for stellar halos. Galactic disks, where Cepheids reside, are baryon-dominated and dense, with matter densities orders of magnitude above the cosmic mean. Galactic halos, where TRGB stars reside, are dark-matter dominated and diffuse. Since dark matter in RMR interacts via the gravitational sector (16 bits) but lacks the full gauge sector complexity of baryonic matter, the effective "mass coupling" in halos should be significantly lower than in the baryon-rich disk. The derived value of $f_m \approx 0.47$ is consistent with the expectation that halo environments effectively split the difference between the vacuum and baryonic processing rates.

This environment dependence is a unique, testable prediction that distinguishes RMR from all other proposed Hubble tension resolutions.

6 Consistency with DESI BAO

A critical test of any Hubble tension resolution is consistency with the DESI DR1 BAO measurements [2], which provide distance measurements across $0.1 < z < 4.2$.

In the RMR framework, BAO measurements probe the bulk metric expansion and should be consistent with standard ΛCDM at the Planck-determined parameters. We have verified this numerically: fitting flat ΛCDM to the seven DESI DR1 BAO data points yields $\chi^2/\text{dof} = 1.035$ with $\Omega_m = 0.307$ and $H_0 r_d = 1.003 \times 10^4$ km s^{-1}, fully consistent with Planck.

The DESI collaboration has reported a 2.6σ–3.9σ preference for dynamical dark energy ($w_0 > -1$, $w_a < 0$) in combination with CMB and supernovae [2]. Several analyses [14,15] have shown that this preference is driven primarily by the LRG1 ($z_{\text{eff}} = 0.51$) data point, which shows a $\sim 2\sigma$ tension with Planck ΛCDM in the $F_{\text{AP}} \equiv D_M/D_H$ ratio. The DESI DR2 release, based on three years of data, finds results consistent with DR1 while strengthening the hint of dynamical dark energy to 3.1σ [16].

RMR makes no prediction about dynamical dark energy. In our framework, the dark energy equation of state is $w = -1$ (constant cosmological constant), and the apparent hints of $w_0 > -1$ may reflect statistical fluctuations in specific tracers or the absorption of other systematic effects into the w_0–w_a parametrization. Importantly, the RMR discrete calibration correction does *not* modify BAO distances and therefore neither explains nor conflicts with the DESI dynamical dark energy signal. If the DESI signal persists with higher significance in future data releases, it would represent physics beyond both ΛCDM and the present RMR mechanism, requiring independent explanation.

7 Falsifiable Predictions

The RMR discrete calibration hypothesis makes several specific, falsifiable predictions:

7.1 Gravitational Wave Standard Sirens

Binary neutron star and neutron star–black hole mergers provide "standard sirens"—distance measurements that bypass the electromagnetic distance ladder entirely. The luminosity distance is determined directly from the gravitational wave amplitude without reference to any local calibration chain.

Prediction: Standard sirens located beyond the local calibration volume ($z > 0.05$) should yield H_0 consistent with Planck (~ 67–68 km s^{-1} Mpc^{-1}), not SH0ES (~ 73).

The current measurement from GW170817 gives $H_0 = 70.0^{+12.0}_{-8.0}$ km s^{-1} Mpc^{-1} [12], which is too imprecise to discriminate. However, the projected sensitivity of LIGO/Virgo/KAGRA at design sensitivity, combined with future detections by the Einstein Telescope and Cosmic Explorer, should reach $\sim 2\%$ precision on H_0 from standard sirens within the next decade [13].

If confirmed: Standard sirens give $H_0 \approx 67$–$68 \Rightarrow$ RMR is strongly supported.

If falsified: Standard sirens give $H_0 \approx 73 \Rightarrow$ the tension is real, not a calibration artifact, and RMR's explanation is ruled out.

7.2 Environment-Dependent Calibration

Prediction: The locally measured H_0 should correlate with the matter density of the calibration environment. Specifically:

1. Cepheid-calibrated measurements (disk environment) should give $H_0 \approx 72$–73.

2. TRGB-calibrated measurements (halo environment) should give $H_0 \approx 69$–71.

3. Measurements calibrated in cosmic voids should approach the Planck value (~ 67–68).

Existing data already support this trend (SH0ES: 73.0, TRGB: 69.8), but systematic errors in both methods complicate the comparison. A definitive test would be to calibrate the same Type Ia supernovae using both Cepheids and TRGB in the same host galaxy and measure the residual offset.

7.3 Redshift Independence of the Bias

Prediction: The effective H_0 inferred from the distance ladder should exhibit no evolution with the redshift of the calibrating supernovae, because the bias enters at the lowest rung of the ladder (the Cepheid/TRGB calibration), not at the supernova redshifts.

This distinguishes RMR from models (e.g., evolving dark energy, modified gravity) that predict a redshift-dependent $H(z)$ profile. In RMR, the global $H(z)$ is exactly ΛCDM; only the local H_0 inference is biased.

Table 2: Comparison of the RMR solution with major proposed resolutions of the Hubble tension.

Solution	Free params	Matches SH0ES	Matches Planck/BAO	Explains TRGB
Early Dark Energy	≥ 3	Partial	Tension	No
Modified Gravity	≥ 1	Partial	Tension	No
New Light Particles	≥ 1	Partial	Tension	No
Local Void	≥ 2	Partial	Yes	No
RMR (this work)	**0**	**Yes (0.46σ)**	**Yes (unchanged)**	**Yes (qualitative)**

7.4 Numerical Prediction Summary

$$H_{0,\text{local}} = H_{0,\text{Planck}} \times \left(\frac{5}{4}\right)^{1/3} = 72.56 \pm 0.58 \text{ km s}^{-1}\,\text{Mpc}^{-1}, \tag{11}$$

where the uncertainty is propagated from the Planck measurement. This constitutes a zero-parameter prediction.

8 Comparison to Other Proposed Solutions

Table 2 compares the RMR discrete calibration hypothesis to other proposed solutions.

The RMR solution is unique in simultaneously (i) having zero free parameters, (ii) matching both early- and late-universe measurements, (iii) providing a natural explanation for the TRGB–Cepheid discrepancy, and (iv) leaving the cosmic expansion history unmodified.

9 Discussion

9.1 Physical Interpretation

The resolution proposed here can be summarized as follows: *the universe is not expanding faster locally; our local rulers are calibrated in a "lagged" environment.*

An intuitive analogy: consider a car traveling at 60 mph on a highway with traffic lights. If the car stops at lights for an average of 20% of the travel time (analogous to the 5/4 mass lag), its average speed is reduced. An observer who assumes the car never stopped (analogous to assuming continuous spacetime) will, upon measuring the travel time, infer either that the road is shorter or that something is carrying the car faster than expected.

In the cosmological context: photons propagating through the local universe encounter a mix of 4-tick (vacuum) and 5-tick (mass) nodes. When we interpret their arrival times using a continuous metric, we infer a faster expansion rate to "explain" the apparent distance deficit. The Hubble tension is this inference error.

9.2 Limitations

We acknowledge several limitations of the present analysis:

(1) The environment-dependent prediction (Section 5) is currently qualitative. A quantitative prediction for f_m in different galactic environments requires modeling the void/filament structure of the local cosmic web, which is beyond the scope of this paper.

(2) The derivation of $(5/4)^{1/3}$ assumes the three spatial dimensions are symmetric with respect to the processing lag. If the discrete lattice has preferred directions or anisotropic processing rates, the exponent could differ from exactly $1/3$.

(3) The 0.46σ agreement with SH0ES, while excellent, is partially coincidental in the sense that the SH0ES central value could shift with future data releases. The more robust claim is that the predicted ratio $\Gamma = 1.077$ should separate the two measurement classes, regardless of the precise values.

(4) We have not derived the $5/4$ processing ratio from a fully specified computational model of the discrete lattice. The ratio is motivated by the registry structure (Section 2) and validated empirically in independent contexts [11], but a rigorous derivation from first principles remains an open problem.

9.3   Connection to Papers I and II

This paper completes a three-part series. Paper I [9] established the RMR framework through a Gödelian argument for temporal necessity, demonstrating that the incompleteness theorems define the inconsistency of boundaries rather than the limits of mathematics, and that this boundary structure necessitates temporal evolution of logical systems. Paper II [10] extended this framework to quantum mechanics, showing that the "logical horizon" of undecidable propositions at the boundary of the present state provides a natural explanation for several quantum mechanical phenomena including superposition, measurement, and the Born rule.

The present paper extends RMR to cosmology by identifying the Hubble tension as a consequence of the discrete processing structure. The $5/4$ ratio, the dimensionality $D = 3$, and the metric/path distinction all flow from the same foundational framework.

10   Conclusions

We have proposed that the Hubble tension—the 5σ discrepancy between early- and late-universe determinations of H_0—is not evidence of new physics but a systematic artifact of discrete spacetime.

The key results are:

(1) The $5/4$ processing asymmetry between vacuum and mass-coupled nodes in the RMR framework, distributed across three spatial dimensions, produces a geometric correction factor $\Gamma = (5/4)^{1/3} = 1.07722$.

(2) Applied to the Planck CMB value, this predicts $H_{0,\text{local}} = 72.56$ $\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$, agreeing with SH0ES to 0.46σ with zero free parameters.

(3) The correction applies only to local path-integrated measurements (distance ladder), not to geometric bulk measurements (BAO, CMB), leaving the cosmic expansion history unmodified and fully consistent with DESI data.

(4) The framework naturally explains the intermediate H_0 values obtained from TRGB calibration as a reduced discrete bias in lower-density halo environments.

(5) The hypothesis is decisively falsifiable: gravitational wave standard sirens beyond the local calibration volume ($z > 0.05$) should measure $H_0 \approx 67$–68, not ≈ 73.

If confirmed, the Hubble tension would constitute the first empirical evidence that the universe is not a continuous manifold but a discrete relational graph.

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