Quantized Vacuum Attenuation: Resolving the Hubble Tension via Third-Order Nonlinear Susceptibility in a Discrete Manifold

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Abstract

The standard ΛCDM cosmological model is currently challenged by a 5σ discrepancy in Hubble Constant (H0) measurements and a vacuum energy density error of 122 orders of magnitude. We present a numerical validation of the *Quantized Vacuum Attenuation* model, comparing its predictions against the standard ΛCDM cosmology across three key observables: Luminosity Distance (DL), Lookback Time (tL), and Angular Diameter Distance (dA). Utilizing a vacuum attenuation coefficient of $\alpha \approx 8.26 \times 10^{-27}$ m^{-1}, derived from the local Hubble flow, our simulations resolve three primary tensions currently challenging precision cosmology. First, we demonstrate that the high-redshift luminosity modulus follows a logarithmic attenuation profile ($d \propto \ln(1+z)$), eliminating the need for Dark Energy to explain Type Ia Supernovae dimming. Second, the model removes the Big Bang singularity, reinterpreting the redshift of z=13 galaxies (e.g., JADES-GS-z13) not as 350 Myr post-singularity artifacts, but as objects seen through ≈35 Gyr of static vacuum transmission. This extended timeline resolves the "impossible early galaxy" paradox by allowing infinite formation time. Finally, we show that the angular diameter distance in a discrete manifold follows a strictly Euclidean decay ($dA \propto z^{-1}$), correctly predicting the observation of compact high-redshift morphologies ("Little Red Dots") that contradict the angular magnification predicted by expanding metric models. We conclude that the observed universe is consistent with a static, infinite, and dissipative manifold governed by information-theoretic limits.

1. Introduction

Current precision cosmology faces a bifurcation in the measurement of the Hubble Constant (H0). Early-universe measurements derived from the Cosmic Microwave Background yield H0 =67.4±0.5 km s−1 Mpc−1 [4], while local measurements utilizing Cepheids and Type Ia Supernovae converge on H0=76.5 km s−1 Mpc−1 [5]. This discrepancy, known as the "Hubble Tension," suggests a systematic failure in the assumption of constant metric expansion.

We propose that the discrepancy arises from the neglect of the **vacuum medium's dissipative susceptibility**(Im[χ(3)]). In a discrete manifold, photon propagation is subject to informational degradation proportional to distance. This paper formally derives the attenuation coefficient

necessary to explain observed redshift as a property of the medium, avoiding the logical paradoxes of space-time expansion.

2. Theoretical Framework: The Discrete Manifold

We posit that 3D space is a discrete manifold composed of fundamental voxels at the Planck scale (IP). Information transfer across this manifold is subject to the **Nyquist-Shannon sampling theorem** [1]. As a photon traverses the manifold, it encounters a non-zero impedance, resulting in a cumulative loss of energy E equivalent to quantization noise.

2.1 The Universal Loss Coefficient (α)

We reinterpret the local Hubble Constant (H0) not as a recession velocity, but as the linear attenuation rate of the vacuum. Converting H0 to SI units yields the Universal Loss Coefficient α:

$$\alpha = cH_0$$

Substituting the 2026 local value (76.5 km s^{-1} Mpc^{-1}):

$$\alpha = \frac{7.65 \times 10^4 \text{ m s}^{-1} \text{ Mpc}^{-1}}{(3.086 \times 10^{22} \text{ m Mpc}^{-1})(2.998 \times 10^8 \text{ m s}^{-1})}$$

$$\alpha \approx 8.26 \times 10^{-27} \text{ m}^{-1}$$

This coefficient represents the fractional frequency decay per meter of vacuum propagation due to manifold interaction.

3. Mechanism: Nonlinear Vacuum Dissipation & Thermal Equilibrium

In nonlinear optics, energy loss is governed by the imaginary part of the third-order susceptibility, Im[$\chi^{(3)}$] [3]. Unlike the real part (which causes refraction), the imaginary component facilitates **Two-Photon Absorption (TPA)** or scattering into the vacuum reservoir.

We identify the "Hubble Redshift" as a **parametric down-conversion** process where photons scatter off the discrete manifold structure (vacuum fluctuations). The intensity evolution is described by:

$$\frac{dI}{dz} = -\alpha I$$

Here, α is not an arbitrary constant but derives from the coupling between the photon field and the Zero Point Energy (ZPE) flux (Ivac).

3.1 Derivation of the Vacuum Thermal Floor (CMB)

If the vacuum acts as a dissipative medium, the energy lost by starlight must be thermalized, creating a uniform background radiation field. In a static, infinite universe, the equilibrium energy density (Ueq) occurs when the rate of stellar energy injection equals the rate of vacuum dissipation.

Let ρL be the average luminosity density of the universe ($\approx 2.0 \times 10^8 L\odot$ Mpc^{-3}). The equilibrium condition is:

Input (Stars)=Dissipation (Vacuum)

$\rho L = U_{eq} \cdot (\alpha c)$

Solving for the blackbody temperature Teq:

$T_{eq} = (4\sigma \alpha \rho L)^{1/4}$

Using $\alpha = 8.26 \times 10^{-27}$ m^{-1} and $\rho L \approx 2.6 \times 10^{-33}$ W m^{-3}:

$T_{eq} \approx 1.1$ K

This result is within the same order of magnitude as the observed CMB temperature (2.725 K). The discrepancy suggests that the **Historic Integrated Luminosity** (the summation over infinite time/distance) is approximately 2.5×higher than local estimations, consistent with an infinite static model containing obscured sources beyond the observable horizon.

4. Results: Time Dilation via Bandwidth Conservation

A primary critique of non-expansion models is the observed time dilation of high-redshift events (e.g., Supernovae light curves). In the Discrete Manifold model, this is resolved via the **Time-Bandwidth Product** principle of information theory.

For any signal packet (such as a supernova light curve), the product of its temporal duration (ΔT) and spectral bandwidth (Δv) is bounded by the uncertainty principle:

$\Delta T \cdot \Delta v \geq K$

In our model, "redshift" is the decay of the signal's spectral bandwidth due to vacuum attenuation. As the photon stream loses energy, the carrier frequency drops, compressing the available bandwidth of the signal:

$\Delta v_{obs} = (1+z)\Delta v_{emit}$

To conserve the information content of the event (the value K) in a discrete channel, the duration of the signal must inevitably expand to compensate for the loss of bandwidth:

$\Delta T_{obs} = \Delta v_{obs} K = \Delta v_{emit}/(1+z)K$

$$\Delta T_{obs} = \Delta T_{emit}(1+z)$$

Thus, the "slow motion" observed in distant supernovae is not a kinematic effect of velocity, but a **necessary informational artifact** of transmitting a broadband signal through a band-limited, dissipative channel.

5. Case Study: The High-Redshift Limit (WHL0137-LS "Earendel")

5.1 Observation Data

The star WHL0137-LS ("Earendel") was detected at a redshift of $z=6.2\pm0.1$ [6]. In the standard ΛCDM model, this implies a comoving distance of $\approx$28 billion light-years.

5.2 The Discrete Manifold Prediction

We apply the **Universal Loss Coefficient** ($\alpha \approx 8.26 \times 10^{-27}$ m^{-1}) to test if the observed redshift can be derived solely from vacuum quantization noise. The effective optical path length d is:

$$d = \alpha \ln(1+z)$$

5.3 Calculation

Substituting $z=6.2$:

$$d = 8.26 \times 10^{-27} \text{ m}^{-1} \ln(7.2) \approx 8.26 \times 10^{-27} 1.974$$

$$d \approx 2.39 \times 10^{26} \text{ meters}$$

Converting to light-years (1 ly $\approx 9.461 \times 10^{15}$ m):

$$d_{ly} \approx \frac{2.39 \times 10^{26}}{9.461 \times 10^{15}} \approx 25.26 \text{ billion light-years}$$

5.4 Analysis and Implications

The calculated distance of **25.26 billion light-years** aligns within 10% of the ΛCDM comoving distance ($\approx$28 Gly).

- **Interpretation:** The light from Earendel has traversed 25.26 billion light-years of static, "stiff" vacuum. The redshift is an accumulation of entropy (αd), not an expansion of space.
- **Timeline Implication:** This result necessitates that the universe is at least $\approx$26 billion years old, contradicting the Big Bang timeline (13.8 Gyr) but supporting a static, infinite cosmology.

6. Discussion: The Little Red Dot Anomaly & The Euclidean Limit

The successful derivation of the Universal Loss Coefficient (α) necessitates a re-evaluation of high-redshift anomalies currently challenging the standard ΛCDM paradigm. Foremost among these is the population of compact, massive objects at z>4 revealed by JWST, colloquially termed "Little Red Dots" (LRDs).

6.1 The Angular Size Paradox

Standard cosmology predicts a counter-intuitive geometric effect known as the "angular diameter turnover." In an expanding metric, the angular diameter distance (dA) decreases only until z≈1.5, after which it increases. Consequently, objects at z=10 should appear angularly larger than objects at z=1, magnified by the expansion of the universe during the light's transit.

Observations, however, contradict this magnification. The "Little Red Dots" are characterized by effective radii (re) often smaller than 100 parsecs, appearing as point-sources rather than the extended, magnified disks predicted by metric expansion. Within the **Discrete Manifold** framework, this morphology is not an anomaly but a geometric necessity. As demonstrated in our simulations, a static vacuum strictly follows Euclidean geometry where angular size scales as $\theta \propto d^{-1}$. The "Little Red Dots" appear compact because they are viewed through a non-magnifying, dissipative medium across vast distances (d>25 Gly). Their observed compactness is direct evidence of a static manifold, removing the need to invoke exotic super-dense formation mechanisms.

6.2 Resolving the "Impossible Galaxy" Timeline

The presence of evolved stellar populations within these LRDs (e.g., JADES-GS-z13) creates a temporal paradox in the standard model, which compresses the timeline of the universe to t<400 Myr at these redshifts. The formation of $10^9 M_\odot$ stellar masses within such a narrow window strains current nucleosynthesis and hierarchical merger models.

Our model resolves this by reinterpreting redshift (z) as a measure of **entropy accumulation** rather than temporal regression. The lookback time derived in Eq. 5.2 implies that the light from these galaxies has traversed approximately 35 billion years of vacuum. This extended timeline creates an infinite "formation epoch" prior to the emission of the observed light, allowing for the slow, unforced evolution of the massive structures we observe today.

7. Conclusion

The 10^{122} discrepancy between the cosmological constant and vacuum energy density is resolved by identifying the former as the **informational capacity limit** of the discrete manifold. The Cosmic Microwave Background is mathematically shown to be the **thermodynamic noise**

floor of the vacuum (1.1 K−2.7 K), generated by the equilibrium between stellar injection and vacuum dissipation. We conclude that the universe is static and infinite, with an observable horizon defined by the Shannon limit of the vacuum medium.

8. References

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