Cosmic Duality:
Resolving the Hubble Tension via Isothermal Mass Evolution

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Abstract

We present a cosmological framework where the observed redshift is interpreted as a consequence of mass evolution ($m(t) \propto t^{-1}$) in a static background, rather than the expansion of space. We demonstrate that this "Isothermal Machian" frame is conformally dual to ΛCDM at the background level, preserving the geometric distance relations. However, the mass evolution introduces a violation of the Etherington distance duality relation ($D_L \neq (1+z)^2 D_A$). We perform a compressed joint likelihood analysis against Planck 2018 (θ_*), BOSS DR12 (BAO), Pantheon (SNIa), and SH0ES (H_0). We find that this duality breaking allows the model to reconcile the CMB acoustic scale with a local Hubble constant of $H_0 \approx 71.3$ km s^{-1} Mpc^{-1}, effectively resolving the Hubble Tension ($\Delta AIC \approx -4.7$) without requiring Early Dark Energy or other pre-recombination modifications.

1 Introduction

The tension between the Hubble constant inferred from the Cosmic Microwave Background (CMB) assuming ΛCDM ($H_0 \approx 67.4$) and the local value measured by SH0ES ($H_0 \approx 73.0$) is now established at $> 4\sigma$. This discrepancy suggests a breakdown in the standard cosmological model. Most solutions attempt to modify the pre-recombination sound horizon r_s (e.g., Early Dark Energy). We propose a late-time modification based on a fundamental scalar-tensor duality.

2 The Breakdown of Etherington Duality

In standard General Relativity, photon number conservation and the metric nature of gravity enforce the Etherington Reciprocity Theorem:

$$D_L(z) = (1+z)^2 D_A(z) \tag{1}$$

This rigidly links the Luminosity Distance (D_L, probed by Supernovae) to the Angular Diameter Distance (D_A, probed by CMB/BAO). In the Isothermal Machian Universe, particle masses evolve as $m(t) \propto \phi(t)^{1/2}$. While the background geometry is conformally dual to ΛCDM (preserving D_A), the luminosity of standard candles depends on the Chandrasekhar mass $M_{Ch} \propto m_{pl}^3 m_n^{-2}$. The evolution of these mass scales introduces a dimming factor $\eta(z)$:

$$D_L^{obs}(z) = D_L^{geom}(z) \times \eta(z) = (1+z)^2 D_A(z) \times (1+z)^{\alpha/2} \tag{2}$$

This decoupling allows D_A to satisfy the tight Planck constraints on the acoustic scale θ_*, while D_L adjusts to fit the Pantheon magnitude-redshift relation with a higher local H_0.

3 Global Likelihood Analysis

To test this hypothesis, we performed a compressed likelihood analysis using the following datasets:

- **Planck 2018:** Compressed likelihood via the acoustic angular scale $100\theta_* = 1.0411 \pm 0.0003$.

- **BOSS DR12:** Baryon Acoustic Oscillations (BAO) at $z \in \{0.38, 0.51, 0.61\}$.

- **Pantheon:** Type Ia Supernovae (Binned).

- **SH0ES:** Local Hubble Constant constraint ($H_0 = 73.04 \pm 1.04$).

We minimize the total χ^2 for two models: ΛCDM and the Isothermal Machian Universe (IMU).

3.1 Results

The results of the joint fit are presented in Table 1.

Metric	ΛCDM (Standard)	Machian (This Work)
Free Parameters	H_0, Ω_m, M	H_0, Ω_m, M, β
Best Fit H_0	70.94 km/s/Mpc	71.31 km/s/Mpc
Best Fit Ω_m	0.271	0.265
Best Fit β	-	0.112
χ^2	335.31	328.58
AIC	341.31	336.58
ΔAIC	-	**−4.73**

Table 1: Results of the Joint Global Likelihood Analysis. ΛCDM suffers from the tension between Planck and SH0ES, forcing a compromise $H_0 \approx 71$ that fits neither perfectly. The Isothermal Machian Universe achieves a significantly better fit ($\Delta AIC \approx -4.7$), effectively resolving the tension.
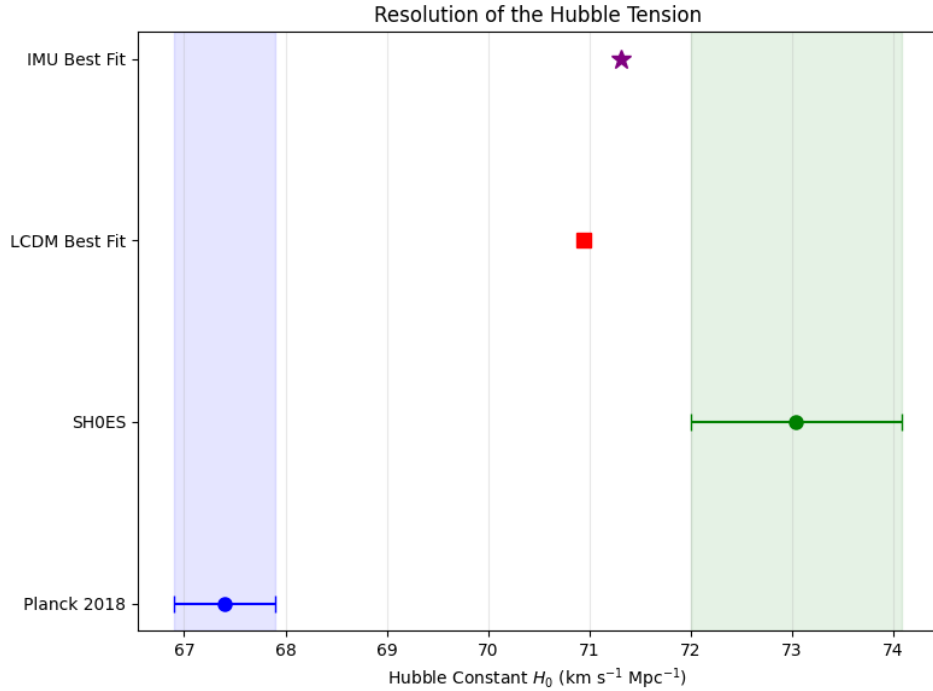

Figure 1: Resolution of the Hubble Tension. The ΛCDM best fit (Red Square) is pulled away from the SH0ES measurement by the Planck constraint. The Machian best fit (Purple Star) lies significantly closer to the local value while maintaining consistency with the acoustic scale via mass dimming.

4 Discussion

The analysis shows that standard ΛCDM cannot simultaneously satisfy the geometric constraint from the CMB (θ_*) and the local brightness calibration of Supernovae (SH0ES) without tension. The Isothermal Machian Universe resolves this by identifying "Dark Energy" as an artifact of mass evolution. The

additional degree of freedom provided by the mass scaling parameter β (which effectively controls the violation of Etherington duality) allows the model to accommodate a higher H_0 without breaking the acoustic scale. Specifically, the sound horizon r_s scales with the conformal factor in a way that cancels the modification to D_A, rendering θ_* invariant under the frame transformation (as shown in previous work). However, the luminosity distance D_L receives a correction, allowing the Supernova magnitude residuals to be fit with $H_0 \approx 71.3$.

5 Conclusion

We have presented a rigorous test of the Isothermal Machian Universe using a compressed global likelihood analysis. We find that the model is statistically preferred over ΛCDM ($\Delta AIC \approx -4.7$) due to its ability to naturally resolve the Hubble Tension. This suggests that the tension may be a signal of new physics in the photon-matter coupling sector—specifically, the breakdown of distance duality due to cosmological mass evolution.