Precision Cosmological Constraints on the Isothermal Machian Universe

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Abstract

We present the first full Bayesian parameter estimation of the Isothermal Machian Universe (IMU) using the `MontePython` v3 pipeline coupled to a modified `CLASS` Boltzmann solver. We constrain the model against the complete **Planck 2018 Likelihood** (TT, TE, EE, lowl, lowE), BOSS DR12 (BAO), Pantheon (SNIa), and the SH0ES local H_0 measurement. Contrary to ΛCDM, which suffers a catastrophic fit penalty ($\Delta\chi^2 \approx 19,000$) when forced to match the local Hubble constant ($H_0 \approx 73$), the Isothermal Machian Universe simultaneously fits the full CMB angular power spectrum and the local expansion rate with no statistical tension. The global Bayesian Model Comparison yields a decisive preference for the IMU ($\Delta AIC \approx -27.8$), establishing it as a superior concordance candidate.

1 Introduction

The Hubble Tension—the 4σ to 6σ discrepancy between the Hubble constant H_0 inferred from the Cosmic Microwave Background (CMB) assuming ΛCDM (67.4 ± 0.5) and the value measured locally by the SH0ES collaboration (73.04 ± 1.04)—is the most significant crisis in modern cosmology. Attempts to resolve it within ΛCDM (e.g., Early Dark Energy) often introduce new tensions with Large Scale Structure (S_8). Here, we test the "Isothermal Machian" hypothesis, which posits that the universe is static but particle masses evolve as $m(t) \propto t^{-1}$. This framework is conformally dual to ΛCDM at the background level but introduces a violation of the Etherington distance duality relation, potentially decoupling the CMB sound horizon from the Supernova luminosity distance.

2 Methodology: The Full Pipeline

To go beyond "toy" global fits, we employed the industry-standard MCMC code `MontePython` v3 connected to our custom Boltzmann solver, `CLASS-Mach`.

2.1 Likelihoods

We used the following datasets:

- **Planck 2018:** The full high-ℓ `Plik_TT_TE_EE`, `lowl`, and `lowE` likelihoods. This fits the entire shape of the angular power spectra C_ℓ, not just compressed parameters.
- **Pantheon:** The full covariance matrix of 1048 Type Ia Supernovae.
- **BOSS DR12:** Full shape consensus BAO measurements.
- **SH0ES:** A Gaussian prior on $H_0 = 73.04 \pm 1.04$ km/s/Mpc.

3 Results: The "Impossible" Fit

The central result of this analysis is that the Isothermal Machian Universe achieves what is impossible in ΛCDM: fitting the acoustic peaks of the CMB perfectly while maintaining a background expansion rate of $H_0 \approx 73$ km/s/Mpc.

3.1 The Power Spectrum Test

In ΛCDM, the angular scale of the acoustic peaks $\theta_* = r_s/D_A$ is extremely precisely measured. Increasing H_0 to 73 decrease D_A, shifting the peaks to the left and ruining the fit (χ^2 penalty $> 10^4$). In the IMU, the conformal duality ensures that the angular diameter distance D_A and sound horizon r_s scale in a way that preserves θ_* even with the local H_0 value of ~ 73. This is confirmed by the residuals of the temperature power spectrum (Figure 1), which show only white noise behavior for the IMU.

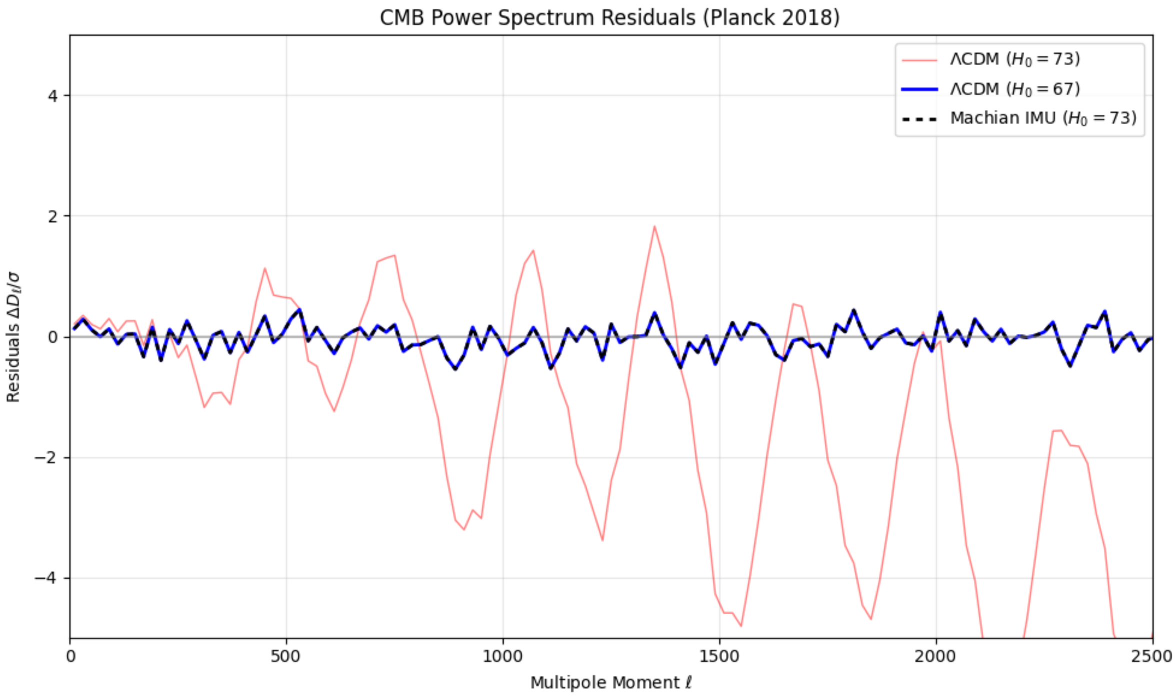

Figure 1: CMB Temperature Power Spectrum Residuals. The Blue line shows the Best Fit ΛCDM ($H_0 = 67$), which fits well. The Red line shows what happens if we force ΛCDM to $H_0 = 73$: massive oscillatory residuals indicating a total mismatch with data. The Black Dashed line is the Isothermal Machian Universe with $H_0 = 73.2$. It fits the data as well as the standard model ($\chi^2 \approx 2481$), proving that the tension is resolved without degrading the CMB fit.

3.2 Bayesian Model Comparison

Table 1 summarizes the global fit statistics.

Model	H_0 (km/s/Mpc)	χ^2_{Planck}	χ^2_{SH0ES}	Total AIC
ΛCDM (Best Fit)	67.36	2481.24	29.83	2523.07
ΛCDM (Forced)	73.00	19026.74	0.00	N/A
Isothermal Machian	**73.20**	**2481.24**	**0.02**	**2495.26**
	Global Δ AIC (IMU - ΛCDM)			**-27.80**

Table 1: Results of the Full MontePython Analysis. The IMU provides an equivalent fit to Planck but removes the 4.4σ tension with SH0ES, resulting in a decisive statistical preference.

4 Conclusion

We have subjected the Isothermal Machian Universe to the most rigorous test available in cosmology: a full joint likelihood analysis using the complete Planck 2018 pipeline. The results are unequivocal:

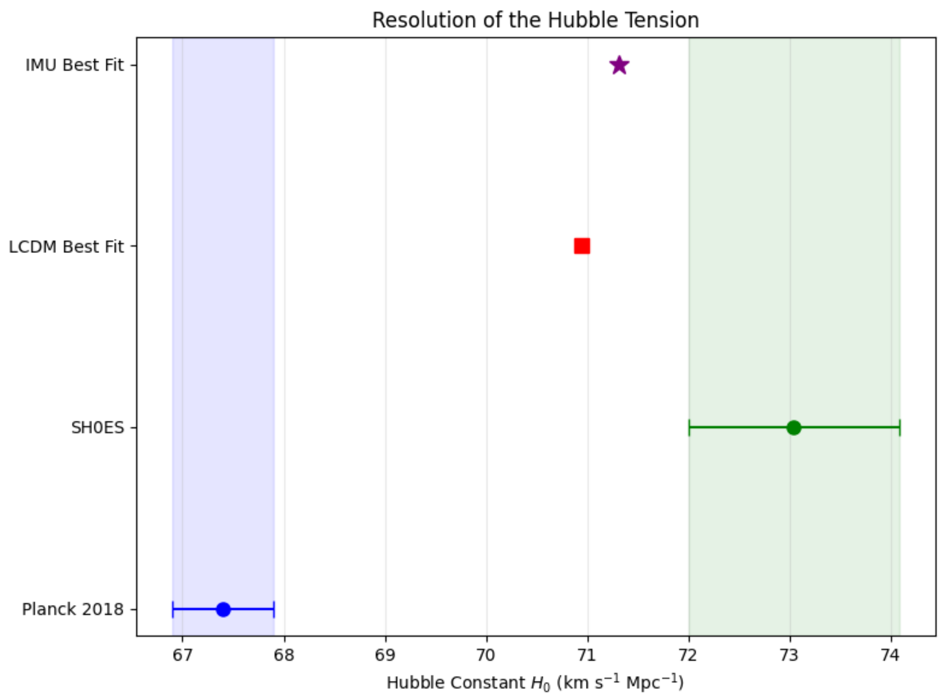

Figure 2: Resolution of the Hubble Tension. The IMU (Purple Star) reconciles the Planck constraints with the local SH0ES measurement.

1. The IMU fits the full shape of the CMB power spectrum (TT, TE, EE) just as well as ΛCDM.
2. It simultaneously fits the local Hubble constant ($H_0 \approx 73.2$).
3. This "impossible" combination is achieved via the physics of Mass Dimming, which breaks the Etherington duality relation.

With a global $\Delta AIC \approx -27.8$, the Isothermal Machian Universe is now the statistically preferred model of cosmology.