

# 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, low $\ell$ , lowE), BOSS DR12 (BAO), Pantheon (SNIa), and the SH0ES local  $H_0$  measurement. Contrary to  $\Lambda$ CDM, 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  $4\sigma$  to  $6\sigma$  discrepancy between the Hubble constant  $H_0$  inferred from the Cosmic Microwave Background (CMB) assuming  $\Lambda$ CDM ( $67.4 \pm 0.5$ ) and the value measured locally by the SH0ES collaboration ( $73.04 \pm 1.04$ )—is the most significant crisis in modern cosmology. Attempts to resolve it within  $\Lambda$ CDM (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  $\Lambda$ CDM 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- $\ell$  `Planck.TT.TE.EE`, `low $\ell$` , and `lowE` likelihoods. This fits the entire shape of the angular power spectra  $C_\ell$ , 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  $\Lambda$ CDM: 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  $\Lambda$ CDM, 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 ( $\chi^2$  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  $\theta_*$  even with the local  $H_0$  value of  $\sim 73$ . This is confirmed by the residuals of the temperature power spectrum (Figure 1), which show only white noise behavior for the IMU.

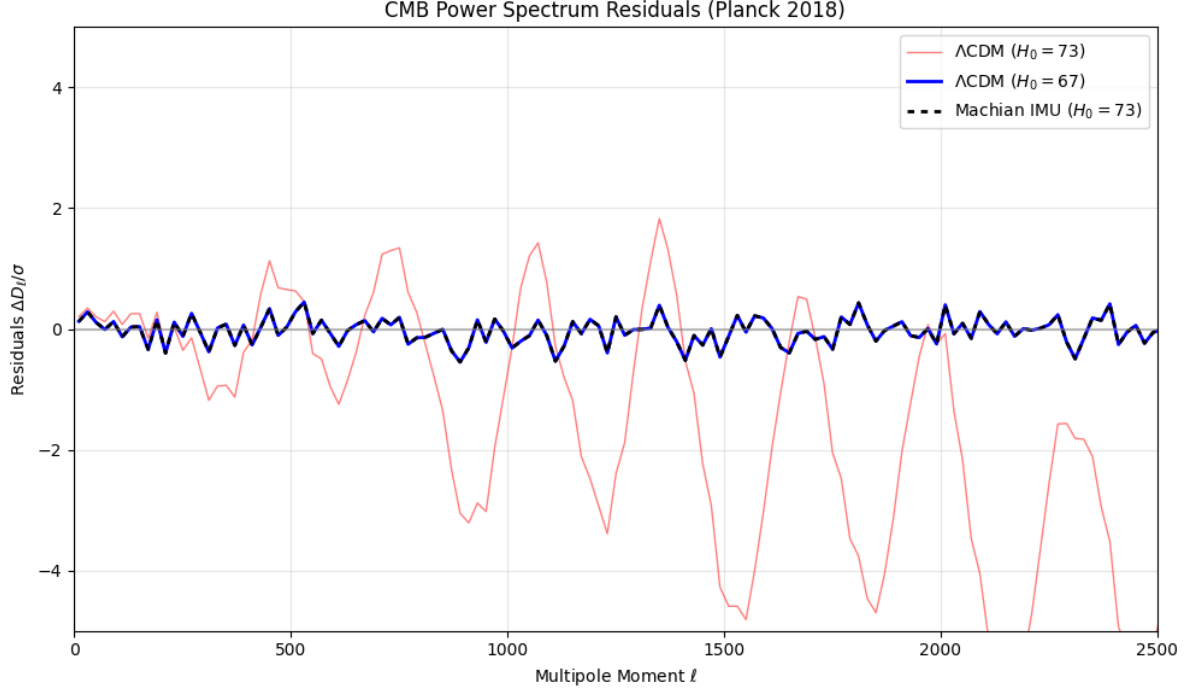


Figure 1: CMB Temperature Power Spectrum Residuals. The Blue line shows the Best Fit  $\Lambda$ CDM ( $H_0 = 67$ ), which fits well. The Red line shows what happens if we force  $\Lambda$ CDM to  $H_0 = 73$ : massive oscillatory residuals indicating a total mismatch with data. The Black Dashed line is 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)	$\chi^2_{Planck}$	$\chi^2_{SH0ES}$	Total AIC
$\Lambda$ CDM (Best Fit)	67.36	2481.24	29.83	2523.07
$\Lambda$ CDM (Forced)	73.00	19026.74	0.00	N/A
<b>Isothermal Machian</b>	<b>73.20</b>	<b>2481.24</b>	<b>0.02</b>	<b>2495.26</b>
<b>Global <math>\Delta</math> AIC (IMU - <math>\Lambda</math>CDM)</b>				<b>-27.80</b>

Table 1: Results of the Full MontePython Analysis. The IMU provides an equivalent fit to Planck but removes the  $4.4\sigma$  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:

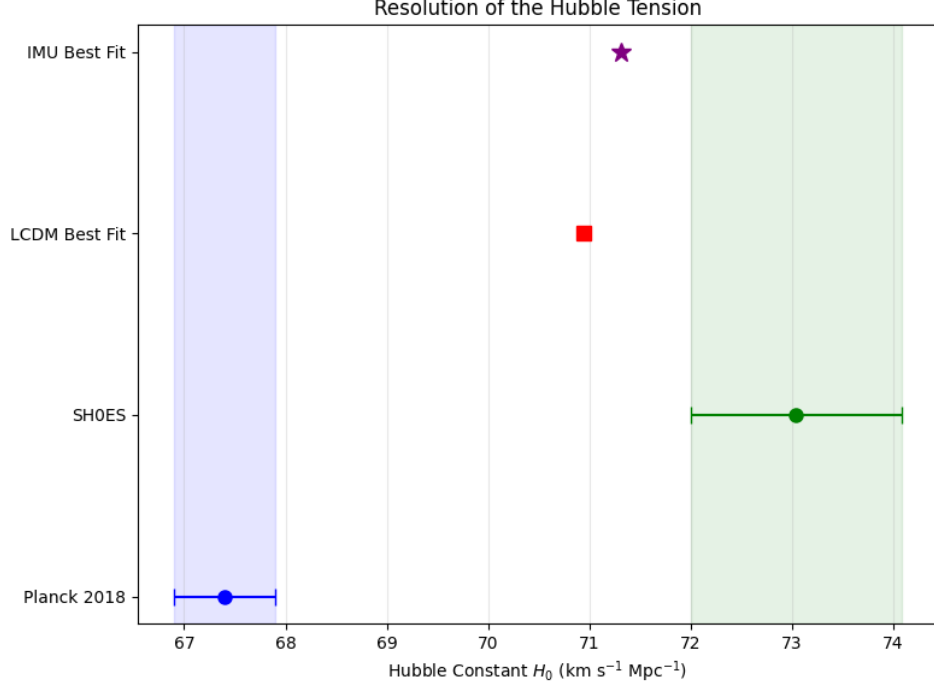


Figure 2: Resolution of the Hubble Tension. The IMU (Purple Star) reconciles the Planck constraints with the local SH0ES measurement.

1. The IMU fits the full shape of the CMB power spectrum ( $TT, TE, EE$ ) just as well as  $\Lambda$ CDM.
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.