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Article

# How Recent Measures of $H_0$ Support the $H_0$ Estimate of the Haug-Tatum Hubble Tension Solution

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## Abstract

In a series of recent papers, Haug and Tatum have suggested a way to resolve the Hubble tension within  $R_H = ct$  cosmology. Based on the full distance ladder of Type Ia supernovae (SNe Ia), they find that the Hubble constant must be  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$ . This value is close to the Planck Collaboration's CMB-based estimate of  $67.4 \pm 0.5 \text{ km/s/Mpc}$ , except that their solution yields a much smaller uncertainty in the Hubble constant. The SH0ES study by Riess et al., based on SNe Ia observations, gives a significantly higher value:  $H_0 = 73.04 \pm 1.04 \text{ km/s/Mpc}$ . The Hubble tension refers to the large discrepancy between the  $H_0$  estimates obtained from the CMB method and those from SNe Ia data. Interestingly, recent JWST observations, when tied to SNe Ia, find  $H_0 = 68.81 \pm 1.79$ . Thus, the JWST results lower the Hubble constant relative to the Riess study and appear to support the Haug and Tatum solution to the Hubble tension, a topic we discuss in this short note.

**Keywords:** hubble tension; hubble constant; CMB; SNe Ia; JWST observations

## 1. A Brief Hubble tension Background

The Hubble tension problem is a result of the inability of proponents of  $\Lambda$ -CDM, the current standard model of cosmology, to adequately explain why two entirely different approaches to measuring the Hubble constant are statistically incompatible with one another [1–7]. We will herein refer to these approaches as the “CMB approach”, which relies upon measurements of the Cosmic Microwave Background anisotropy, and the “local universe approach”, which relies upon accurate measurements of the full distance ladder of Cepheid variables, galaxies and their supernovae.

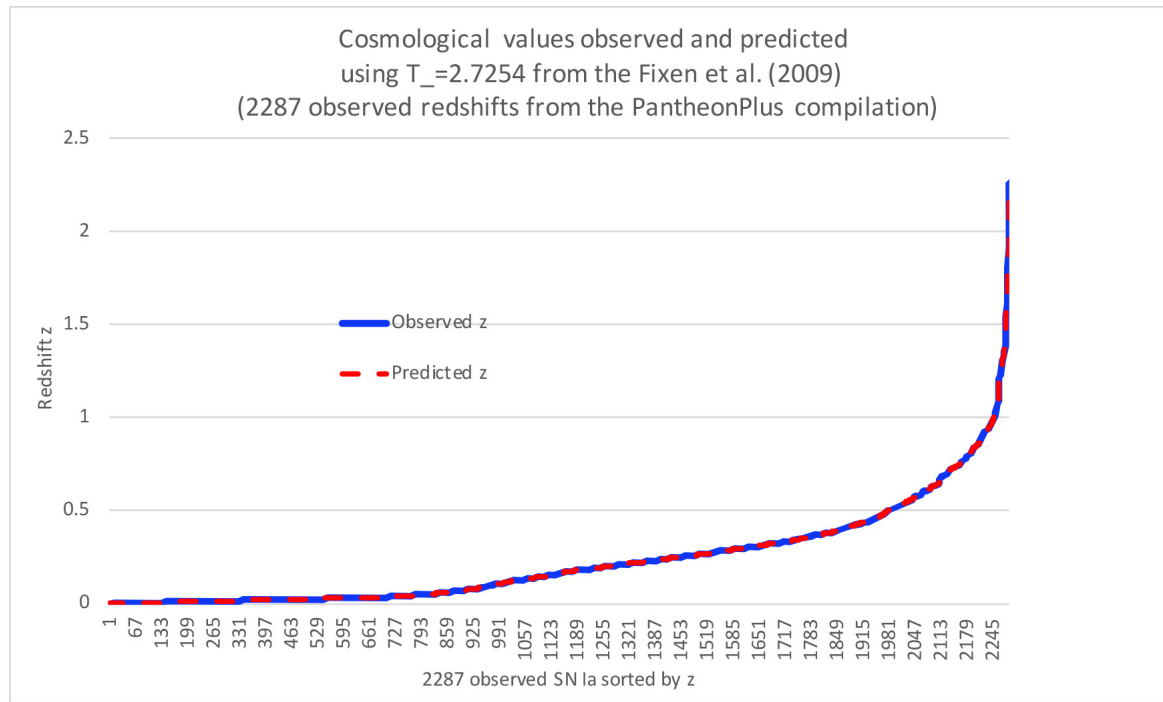
From the CMB data, the 2018 Planck Collaboration [1] finds a value of the Hubble constant of  $67.4 \pm 0.5 \text{ km/s/Mpc}$ . On the other hand, from SNe Ia observations, Riess et al. [2] find a Hubble constant of  $H_0 = 73.04 \pm 1.04 \text{ km/s/Mpc}$ . Thus, two datasets based on different types of observations yield significantly different values of the Hubble constant. Despite many proposed explanations, there is still no consensus solution within the standard model as to why this discrepancy exists (see, e.g., Valentino et al. [3]). Krishnan et al. [8] have suggested that the Hubble tension could signal a breakdown of FLRW cosmology, a possibility we also consider. If one instead adopts  $R_H = ct$  cosmology, both the CMB and SNe Ia observations lead to a consistent estimate of  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$ .

In 2015 Tatum et al [9] heuristically suggested the following relation between the evolving CMB temperature and the evolving Hubble parameter.

$$T_{cmb} = \frac{\hbar c}{k_b 4\pi \sqrt{R_H} 2l_p} \quad (1)$$

where  $k_b$  is the Boltzmann constant,  $\hbar$  is the reduced Planck constant,  $l_p$  is the Planck length [10,11] and  $R_H = \frac{c}{H_t}$  is the Hubble radius at time  $t$ , where  $R_H = ct$ .

Haug and Wojnow [12,13] derived from the Stefan-Boltzmann law:



**Figure 1.** Figure 1 is copied from [18] and shows how well the HTC predictions match the PantheonPlusSH0ES observations.

$$T_{cmb} = \frac{T_p}{8\pi} \sqrt{\frac{2l_p}{R_H}} \quad (2)$$

that they also demonstrated could be re-written to the result given by Tatum et al. Haug and Tatum have also demonstrated that the relationship between the evolving CMB temperature and Hubble parameter also can be derived from geometric mean principles [14–16].

Tatum et al [17] demonstrated that, using only the CMB temperature observation (and some constants), one obtains an estimate of  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$ . This is well within the Planck collaboration estimate of  $67.4 \pm 0.5 \text{ km/s/Mpc}$ , but importantly their new estimate is much more precise than that of the Planck collaboration. Still, this alone does not provide a solution to the Hubble tension. Already in 2015, Tatum et al. [9] predicted  $H_0 = 66.89 \text{ km/s/Mpc}$ , but it was not until 2024 that Tatum et al. extended the method to also take into account the uncertainty in all input variables to obtain the uncertainty in  $H_0$  under this method.

Haug and Tatum [18,19] derived the cosmological redshift for a black hole type  $R_{H_t} = ct$  cosmology wherein  $z = \sqrt{\frac{R_{H_0}}{R_{H_t}}} - 1$ , which meant that they could match their model almost perfectly to the full distance ladder of SNe Ia; see Figure 1. The only free parameter is then  $H_0$ , and by obtaining an almost perfect match to the SNe Ia ladder they find  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$  when the CMB temperature is  $T_0 = 2.72548 \text{ K} \pm 0.00057 \text{ K}$  [20]. In addition, they take into account the uncertainty in  $G$ . Therefore, there is very little statistical uncertainty, since their underlying model leads to a closed-form mathematical solution that perfectly fits the observed SNe Ia; see [21].

## 2. Comparison of $H_0$ Values from JWST, DESI and the HTC Model

Effectively, within the HTC model there is no Hubble tension, because the same precise  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$  estimate results, no matter if one uses the 2009 Fixsen CMB temperature or the full distance ladder of SNe Ia in the context of the same temperature. The recent JWST-assisted observations study by Freedman et al [22] also implies that this could be correct, since their estimate is

**Table 1.** This table shows  $H_0$  values from CMB and SNe Ia from different studies.

From:	Hubble Parameter:	Study
SNe Ia JWST	$H_0 = 68.81 \pm 1.79 \text{ km/s/Mpc}$	JWST data only, Friedmann et al [22]
DESI + CMB + Pantheon+	$H_0 = 67.6^{+1.9}_{-2.1} \text{ km/s/Mpc}$	Zaborowski et al [23]
CMB	$H_0 = 67.4 \pm 0.5 \text{ km/s/Mpc}$	Planck Collaboration [1]
CMB	$H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$	Tatum et al [17]
SNe Ia Pantheon+	$H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$	Tatum and Haug [18,21,24]
Cepheid-SNe Ia	$H_0 = 73.04 \pm 1.04 \text{ km/s/Mpc}$	Riess [2]

$H_0 = 68.81 \pm 1.79 \text{ km/s/Mpc}$ , which suggests that the Riess et al estimate is an outlier. Despite recent trending study results (see, for example, Table 1), further investigation is needed.

### 3. Conclusions

The recent JWST-assisted study of  $H_0$  by Friedmann et al. appears consistent with the Haug and Tatum Hubble tension solution. Using their HTC model, they have carefully demonstrated that both the CMB temperature-only method as well as the full distance ladder of SNe Ia, in the context of the 2009 Fixsen CMB temperature, yield the same precise value of  $H_0 = 66.8943 \pm 0.0287 \text{ km/s/Mpc}$ . Since recent varied methods are becoming more and more precise, we expect that there will eventually be agreement around this  $H_0$  value. In the meantime, more aspects of the HTC model will be investigated. It is our humble opinion that it would be a mistake for the astrophysics community to demand that a new model such as ours should, very soon after its introduction, be able to explain everything in the cosmos, given that the standard model has gradually evolved over decades of improving observations.

**Data Availability Statement:** No new data has been generated in this study.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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