Is The Hubble Tension Dismissed?

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Abstract

Measurements of the rate of expansion of the universe, the Hubble constant, differ way beyond their errors. One value is based on the ΛCDM model of the universe, using the Planck satellite data. The Riess team at John Hopkins University measured the Hubble contant using distant supernovae calibrated with Galactic Cepheids. They produced a value for the Hubble constant significantly larger than the ΛCDM value, initiating the Hubble Tension. The Riess team checked the Cepheid calibration using Hubble photometry to derive a photometric parallax. The photometric parallax was checked against the parallax data of the Gaia satellite. The two parallaxes do not agree. The Riess team achieve agreement in the Riess et al 2021 paper by subtracting ten micro arcseconds from each of the Cepheid Gaia parallaxes. The Gaia team errors of about one or two micro arcseconds are widely accepted. The Riess team abandoned their ten micro arcsecond correction in Riess et al (2022) to produce a second parallax calibration using photometry of Cepheids in clusters and an earlier release of Gaia data based on the mean parallax of clusters of stars containing Cepheids. These two parallaxes agree within their significantly inferior errors and are claimed to support the larger value of the Hubble constant, maintaining the Hubble Tension. Mathematical analysis is used to show that a ten micro arcsecond correction is equivalent to a tiny wavelength independent extinction. If the Gaia parallaxes are correct to one or two micro arcseconds the conflict between the two parallaxes indicates a tiny wavelength independent extinction of light in the visible wavelengths across the galaxy. The tiny extinction corrects the Riess team absolute magnitude of the Cepheids and removes the Tension.

Full Text

Preamble

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Abstract

Measurements of the universe’ s expansion rate—the Hubble constant—differ significantly beyond their stated uncertainties. One value derives from the ΛCDM cosmological model using Planck satellite data, while the Riess team at Johns Hopkins University measured the Hubble constant using distant supernovae calibrated against Galactic Cepheids. Their result is substantially higher than the ΛCDM value, creating the “Hubble tension.” The Riess team validated their Cepheid calibration using Hubble photometry to derive photometric parallaxes, which they compared against Gaia satellite parallax data for the same stars. The two parallax measurements disagree.

In Riess et al. (2021), the team achieved agreement by subtracting ten microarcseconds from each Cepheid’ s Gaia parallax. However, the Gaia team’ s parallax errors of about one to two microarcseconds are widely accepted. In Riess et al. (2022), the team abandoned this ten microarcsecond correction and instead developed a second calibration using photometry of Cepheids in clusters with an earlier Gaia data release, employing mean parallaxes of star clusters containing Cepheids. These two parallaxes agree within their considerably larger uncertainties, which the Riess team claims supports the higher Hubble constant value and maintains the Hubble tension.

Mathematical analysis demonstrates that a ten microarcsecond correction is equivalent to a tiny wavelength-independent extinction. If Gaia parallaxes are accurate to one or two microarcseconds, the parallax conflict indicates a minute wavelength-independent extinction of visible light across the galaxy. This tiny extinction corrects the Riess team’s Cepheid absolute magnitudes and eliminates the tension.

1.0 Introduction

The Hubble tension rests primarily on the Hubble constant value measured by the SHoES group led by Adam Riess (Riess et al. 2018, 2021, 2022). They calibrate supernovae in distant galaxies against the absolute magnitudes of Cepheid variable stars in our galaxy. Their Hubble constant value disagrees with the early-universe value derived from the widely accepted ΛCDM model.

This paper focuses on the calibration of Cepheid absolute magnitudes in the Milky Way. Riess et al. (2021) employs the best available Hubble photometry combined with parallaxes for the same Cepheids from Gaia’s Early Data Release 3. The Riess team argues that the Gaia data suffer from a zero-point offset and reduces all Gaia parallaxes by ten microarcseconds to achieve agreement. This adjustment yields Cepheid absolute magnitudes that support their Hubble constant value and sustain the Hubble tension. The Gaia team (Lindegren et al. 2021a, 2021b) has corrected its data, and most of the community—including the SHoES team in Riess et al. (2022)—accepts that Gaia parallaxes are accurate to one or two microarcseconds. These precise Gaia parallaxes do not agree with the photometric parallaxes derived from Hubble photometry in Riess et al. (2021).

The mathematical analysis in Baruch (2025a) shows two possible explanations for this disagreement: either a ten microarcsecond zero-point error exists in the Gaia parallaxes, or a tiny wavelength-independent extinction of a few percent per kiloparsec affects light crossing our galaxy.

The Riess team' s procedure of reducing Gaia parallaxes by ten microarcseconds is problematic. As clearly shown in Baruch (2025a) Section 1.1.2, "Questions around the ten microarcsecond reduction in the Gaia parallax,"the Gaia parallax of each Cepheid is reduced by this fixed amount. The Riess team justifies this approach by plotting the two parallax measurements against each other. As parallax increases, any tiny distance-dependent extinction becomes negligible. However, when distances are plotted against each other, a tiny extinction grows with distance and becomes conspicuous, as shown in Figure 1 [Figure 1: see original paper], which reveals a 6% per kiloparsec extinction.

It is now widely accepted that Gaia parallax errors of one or two microarcseconds are correct. This precision is based on approximately one million quasars with zero parallax, a similar number of binary stars in the Milky Way, and stars in the Large Magellanic Cloud, which comprehensively address Gaia' s parallax brightness and color issues. The SHoES team accepts the Gaia precision (Riess et al. 2022), as discussed in detail in Baruch (2025a). In their second paper, using much lower-quality data from an earlier Gaia release and employing mean parallaxes of clusters containing Cepheids, the errors are larger and no parallax disagreement appears within those uncertainties, which the Riess team interprets as maintaining the Hubble tension.

Most photometric support for the Riess value must be discarded because it is corrupted by this tiny wavelength-independent extinction. Baruch (2025a) examines in detail the photometric evidence compiled by Riess et al. (2021). The Zinn et al. (2019, 2021) photometry of 2000 first-ascent red giant stars with asteroseismically derived distances would be corrupted by a tiny wavelength-independent extinction across the galaxy. Similarly affected are the detached eclipsing binaries (DEBs) studied by Stassun and Torres (2021) and Pietrzyński et al. (2019). Mira variables, which are asymptotic giant branch stars existing in oxygen- and carbon-rich subclasses, are also used for distance determination. The oxygen-rich Miras exhibit a tight period-luminosity relation in the near-infrared. Huang et al. (2018, 2019) calibrated Mira distances in the Large Magellanic Cloud, which had already been photometrically calibrated using Cepheids that were themselves photometrically calibrated in the Milky Way and would therefore be subject to a tiny wavelength-independent extinction.

Water masers present more complexity, and Efstathiou (2020) calls for revisiting the NGC 4258 water masers. Yang Huang et al. (2020, 2021) studied effective parallaxes of primary red clump stars, showing that LAMOST-derived parallaxes are not fully compatible with Gaia Early Data Release 3 parallaxes, with their corrected values slightly supporting a tiny wavelength-independent extinction. Details are discussed in Baruch (2025a).

Strong-lensing support exists for the Riess Hubble constant value, but this complex process requires angular-diameter distance derivation that likely depends on photometric galaxy modeling. Thus, support for the Riess (2018, 2021, 2022) Hubble constant value is, at best, inconsistent.

Independent parallax measurements have questioned the Hubble tension. Groenewegen (2021) analyzed the Riess et al. (2021) photometric parallax conflict, aiming to investigate the zero-point offset of Gaia EDR3 independently. Using a completely different set of quasars and physical binaries, he applied his data to the Cepheid sample from Riess et al. (2021) and compared his results with those of the Gaia team (Lindegren et al. 2021a). Groenewegen suggested that the Riess photometric parallaxes were underestimated by 5%, precisely what would be expected from a tiny wavelength-independent extinction. His work also supports the one-to-two microarcsecond error estimate for Gaia parallaxes.

The Gaia team evaluated their own data (Andrae et al. 2023). Using Data Release 3, they showed that Gaia parallax distances of clusters are significantly smaller than published photometric distances (Cantat-Gaudin et al. 2020), which is what would be expected from a tiny wavelength-independent extinction. The Gaia team noted this disparity without explanation or comment. Efstathiou (2020) reviewed evidence for the Hubble tension using Riess (2018) data and the ΛCDM model, including the Carnegie-Chicago Hubble Program value from Freedman et al. (2019), concluding that differences in Hubble constant values were due to a "systematic calibration effect," though for different reasons than proposed here. Efstathiou concluded that without a compelling theoretical solution to the Hubble tension, "the alternative is that the SHoES result is biased by systematic errors that are not included in their error estimates." This is precisely the case made here for a tiny wavelength-independent extinction, which Baruch (2025a) shows mathematically is the only possible solution if Gaia errors are only one or two microarcseconds.

5.0 The Hubble Constant Is Derived From The Real Absolute Magnitudes Of The Cepheids

Riess et al. (2021) demonstrates how the Hubble constant value is derived from Cepheid absolute magnitudes, showing the derived Hubble constant from measured Cepheid absolute magnitudes or luminosities (Figure 4 [Figure 4: see original paper] of Riess et al. 2021). In this paper, Figure 2 [Figure 2: see original paper] presents the Cepheid absolute magnitudes and derived Hubble constant values. Baruch (2025a) Appendix 3 calculates the true absolute magnitude for the Riess et al. (2021) Cepheids, accounting for a tiny wavelength-independent extinction.

Let M_1 be the Riess et al. (2021) Cepheid absolute magnitude value reflected in their Hubble constant determination. This assumes zero wavelength-independent extinction coefficient and a true mean distance $D_1 = 4.06$ kpc (4060 parsecs) for their Cycle 22 Cepheids. Let M_2 be the derived Cepheid absolute magnitude reflecting the revised true mean distance due to measured extinction. This revised true mean distance is calculated in Baruch (2025a) Appendix 3 as R_1 through a scanning process that digitally solves the product-logarithmic relations between magnitude and distance, where extinction is folded into the inverse-square law intensity reduction.

For absolute magnitude:

$$M_1 = m - 5\log(D_1/10)$$

where m is the measured magnitude, the logarithm is base 10, and D_1 is the distance in parsecs.

To find the absolute magnitude correction due to wavelength-independent extinction using the revised true mean distance D_2:

$$M_1 - M_2 = 5(\log(D_2/10) - \log(4060/10)) \tag{2}$$

Riess et al. (2021) assumed no wavelength-independent extinction and that their derived absolute magnitude was correct. Equation (2) shows the correction required when extinction is present.

Apart from the SHoES subtraction of ten microarcseconds from the Gaia parallaxes, the data are also consistent with a small zero-point correction corresponding to a true extinction of 4.55% per kiloparsec. This true extinction appears as an observed extinction of 6% per kiloparsec. Such extinction reduces the true mean distance of the Cepheids to 3.773 kpc (i.e., D_2), decreasing their absolute magnitude by the value calculated using equation (2) above:

$$M_1 - M_2 = 5(\log(3773/10) - \log(4060/10)) = -0.1592$$

The absolute magnitude M_1 used by Riess et al. (2021) is -5.915. Subtracting 0.1592 yields an absolute magnitude of -6.074. This is derived from the data in Riess et al. (2021) Figure 4, "Cepheid Luminosity," which are plotted in Figure 2 of this paper. Applying the linear equation from Figure 2 produces a Hubble constant value of 67.8 km $\mathrm{s}^{-1}\mathrm{Mpc}^{-1}$. Within the uncertainties, this is compatible with the Planck team' s cosmic microwave background measurement of 67.27 ± 0.60 km $\mathrm{s}^{-1}\mathrm{Mpc}^{-1}$. The Hubble tension evaporates. The derived absolute magnitudes and Hubble constant values are shown in Appendix C Table C1 of Baruch (2025a).

5.1 The Impact Of The Wavelength Independent Extinction On The Luminosity of Cepheids and The Hubble Tension

The SHoES data from Riess et al. (2018) were used by Riess et al. (2021) to confirm a Hubble constant 8.8% higher than the Ade et al. (2014) Planck value. Applying the observed 6% wavelength-independent extinction rate (from Gaia data) to the SHoES Cepheids' mean distance of 2.3 kpc produces a 14% intensity loss (±2%). This corresponds to a Hubble constant difference from Planck of approximately +7% (±1%), which strongly supports the hypothesis that wavelength-independent extinction causes the SHoES Hubble constant value to differ from Planck. Within current uncertainties, this also removes the Hubble tension.

6.0 Conclusions

The conflict between photometrically derived parallaxes and Gaia parallaxes for Cepheids (as evaluated by the SHoES group, Riess et al. 2021) and for red clump stars (as evaluated by Khan et al. 2023) can be attributed to two causes. One explanation posits a variable zero-point error in Gaia parallaxes, with Riess et al. (2021) subtracting ten microarcseconds from Cepheid parallaxes and Khan et al. subtracting varying amounts depending on distance for red clump stars. This is widely supported despite the Gaia team calculating that their latest data release is accurate to "a few microarcseconds."

Riess et al. (2022) abandoned the ten microarcsecond subtraction, but their data remain questionable. The Riess and Khan reductions of Gaia parallaxes ensure that the Hubble tension persists.

This paper demonstrates that a tiny wavelength-independent extinction observed across the Milky Way of about 6% per kiloparsec is mathematically equivalent to Riess' s claimed ten microarcsecond zero-point error and fully explains the results of Khan et al. (2023). Thus, support for the Hubble tension rests on subtracting a ten microarcsecond zero-point correction from Gaia data. An equally valid mathematical interpretation is a galactic wavelength-independent extinction of 4.55% per kiloparsec, observed as 6% per kiloparsec. Such extinction also eliminates all photometric support for the Hubble tension. Notably, the true mean distance of 3.773 kpc for the SHoES Cepheids yields a Hubble constant value that, within uncertainties, is identical to the Planck value, supporting the case that wavelength-independent extinction causes the Hubble tension. Analysis of Cepheid luminosities accounting for a tiny wavelength-independent extinction (observed as 6% per kiloparsec) similarly dismisses the Hubble tension.

A wavelength-independent extinction in visible wavebands is not predicted by known physics. If confirmed by further analysis of Gaia parallaxes and their conflict with photometric parallaxes, particularly with support from Gaia Data Release 4, this would clearly indicate new physics.

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