What If the Hubble Tension Were Trivial?

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A Single-Parameter Hypothesis, and Its Limits

Exploratory note — building on work concerning R_h=ct cosmologies (Melia, 2007) and the geometric framework R_H=N·l_Pl.

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1. The Problem, in One Sentence

Two independent methods measure the same constant — the rate at which the universe is expanding today, H_0 — and arrive at two incompatible values:

Method	H_0 value (km/s/Mpc)	What it probes
SH0ES (Riess et al. 2022)	73.04 ± 1.04	Local distance ladder (Cepheids + Type Ia supernovae, $z < 0.15$)
Planck (Aghanim et al. 2020)	67.4 ± 0.5	Cosmic microwave background power spectrum ($z \approx 1089$)

The discrepancy is **5σ** — statistically, the odds of this being chance are roughly one in 3.5 million. This is what is known as the "Hubble tension," one of the most widely discussed open puzzles in current cosmology.

The standard explanation invokes new physics: early dark energy, additional neutrino species, modifications to general relativity... All of these avenues remain, to this day, speculative.

This article explores a more modest hypothesis — almost disarmingly simple — and honestly examines its actual scope.

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2. A Simple Observation: These Two Measurements Do Not Look at the Same Thing in the Same Way

Let us revisit the two methods, not by their result, but by **what they actually measure**.

SH0ES measures a redshift z spectroscopically, directly, for each supernova host galaxy (between $z \approx 0.002$ and $z \approx 0.15$). The value of H_0 is then extracted as the y-intercept — in the mathematical sense — of the magnitude-redshift relation, extrapolated to $z \to 0$. This extraction depends very little on the chosen cosmological model: at these redshifts, only the deceleration parameter q_0 enters, and its effect is negligible (less than 1 km/s/Mpc, even when varied significantly).

Planck measures no individual redshift at all. It measures an angular power spectrum — the statistical texture of a single image of the sky, taken at one frozen epoch (decoupling, $z \approx 1089$). The value of H_0 is not read directly: it is **calculated** by solving

$$\theta_* = \frac{r_s(z_*)}{D_A(z_*)},\ D_A(z_*) = \frac{c}{1+z_*}\int_0^{z_*} \frac{dz}{H(z)}$$

In other words, to extract H_0 from Planck's data, one must **integrate a specific form of H(z) over the entire interval [0, 1089]**. This form — that of ΛCDM, with matter and a cosmological constant — is an assumption of the calculation, not an observation.

This is the starting point of this note: **if the form of H(z) used in this calculation is changed, the value of H_0 extracted from it changes too.** SH0ES, by contrast, would remain nearly unchanged, since it barely depends on this form at all.

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3. A Different H(z): The R_h=ct Postulate

Fulvio Melia (2007) proposed an alternative cosmological framework to ΛCDM, in which the Hubble radius grows **linearly** with cosmic time:

$$R_H(t) = ct \text{ at every epoch } t \text{ — not just today}$$

This condition imposes a scale factor $a(t) \propto t$ (instead of ΛCDM's more complex curve), with two direct consequences:

$$t(z) = \frac{t_0}{1+z} \quad H(z) = H_0(1+z)$$

This is a radically simpler law than ΛCDM's. It is not new: its mathematical structure traces back to the Milne model (1932), and it has, according to Melia, passed some twenty independent observational tests — with results sometimes better, sometimes worse than ΛCDM depending on the dataset used.

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4. The Measurement Depth D(z)

Under this framework, a single quantity carries three names:

$$D(z) \ \equiv\ R_H(z) \ \equiv\ c \cdot t(z) \ \equiv\ \frac{c}{H(z)}$$

This is the **Hubble radius at epoch z** — the "shell" that a measurement made at that redshift probes. With $H(z)=H_0(1+z)$:

$$D(z) = \frac{D(0)}{1+z},\ D(0) = \frac{c}{H_0}$$

Two regimes naturally stand out:

- **R_H,dom** ≡ D(0) — the dominant shell, at the present epoch (z=0)
- **R_H,sub** ≡ D(z_eff) — a sub-dominant shell, deeper, smaller

This is the central hypothesis of this note, stated simply: **what if SH0ES and Planck are not measuring the same thing because each probes a different R_H shell of one and the same cosmic history?**

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5. The Calculation

If the two reported values are interpreted as H(z_S) and H(z_P) for two different depths of a single underlying cosmology H_0,true:

$$\frac{H_{SH0ES}}{H_{Planck}} = \frac{1+z_S}{1+z_P} = \frac{73.04}{67.4} = 1.0837$$

HPlanckHSH0ES=1+zP1+zS=67.473.04=1.0837

Setting z_P = 0 (Planck probes the dominant shell):

$$z_S = 0.0837$$

zS=0.0837

Translated into a physical Hubble radius:

z	D(z) (Mpc)	D(z)/D(0)
0 (Planck)	4448	100%
0.0837 (required)	**4105**	**92.3%**
0.15 (upper bound of SH0ES sample)	3868	87.0%

Striking observation: the depth required to reconcile the two measurements (z=0.084) falls precisely within the redshift range of the sample used by SH0ES itself (0.023 to 0.15, with ⟨z⟩=0.055 in Riess et al.'s analysis). This is not an arbitrary number — it lands exactly where one would expect it to, if the intuition were correct.

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6. What This Calculation Explains — And What It Does Not Yet Explain

Honesty about the scope of this result is essential, because this is precisely where most "alternative" explanations of the Hubble tension fail to convince.

What has been done

A single free parameter (z_eff) was **fitted** to reproduce a single observed ratio (73.04/67.4). By construction, this fit always succeeds — whatever the gap to be explained, a z_eff always exists that reproduces it exactly. This is not, in itself, proof of anything.

What makes the result *interesting* nonetheless

The z_eff obtained is not just any value: it falls naturally within the physically relevant range (SH0ES's actual sample), without having been forced to land there. This is a non-trivial order-of-magnitude agreement — the kind of coincidence that deserves further investigation, not dismissal.

What is missing for this to become a genuine explanation

A mechanism is needed that **predicts** z_eff *before* knowing the ratio 73.04/67.4 — not a parameter fitted after the fact. Two avenues stand out:

1. **Redo the fit of the raw CMB power spectrum** by substituting $H(z)=H_0(1+z)$ for the ΛCDM form in the calculation of D_A(z*). This is the only rigorous path for Planck: since its H_0 value depends explicitly on the form of H(z) integrated over [0, 1089], changing that form would potentially change the extracted value — without any manual "depth" adjustment being necessary. This calculation was not performed here; it lies beyond the scope of this note and would require reprocessing Planck's raw data.
2. **Test a third independent determination of H_0** — time-delay gravitational lensing, gravitational-wave standard sirens, the TRGB method — and check whether its effective depth z_eff, predicted *before* knowing its result, falls where the R_H,sub framework requires. This is the decisive test that is still missing.

Without either of these, R_H,sub remains a coherent and suggestive reformulation of the problem, not its resolution.

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7. Conclusion: Trivial or Not?

The honest answer is: **we do not yet know — and that is precisely what makes the question interesting.**

What can be affirmed:

- The structure $D(z)=R\_H(z)=c/H(z)$ is mathematically clean and unambiguous under the $R\_H=ct$ postulate.
- The methodological imbalance between SH0ES (quasi model-independent) and Planck (strongly dependent on the form of $H(z)$ integrated) is real and documented — this is not an invention of this note.
- The numerical agreement obtained (z_eff falling within SH0ES's sample range) is suggestive, not demonstrative.

What cannot yet be affirmed:

- That this mechanism actually *predicts*, rather than merely *reproduces after the fact*, the observed gap.
- That redoing the CMB analysis under $H(z)=H_0(1+z)$ would actually yield a value close to 73 rather than remaining close to 67.

The Hubble tension may not be trivial. But the question of whether two measurements of H_0 genuinely probe the same cosmological "depth" — rather than being silently assumed to do so — deserves to be asked before invoking new physics. That, modestly, is the only thing this note claims to establish.

This note is exploratory in nature and does not claim to settle the debate. The calculations presented are reproducible from the values published by Riess et al. (2022) and Aghanim et al. (2020, Plan