With Hubble’s 1929 Constant the Universe Is Younger Than the Earth, and Saving It With the Cosmological Constant Takes a Nearly Empty Universe

— at 500 km/s/Mpc the age scale 1/H0 is 1.955584 Gyr, only 0.430745 of the Earth’s 4.54 Gyr, and matching the Earth’s age in a flat model takes ΩΛ = 0.996178; what actually lengthened the age was not the cosmological constant but a factor 7.418398 in the distance scale — the separator is whether the age was lengthened by the cosmological constant or by the distance scale — [Paper 1028]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
September 2026

— *From thinking to syncing.* —

Abstract

Einstein is said to have introduced the cosmological constant for a static universe and to have withdrawn it once expansion was observed. Yet soon after its withdrawal the constant was called back for a different reason: computed with Hubble's 1929 value, the universe came out younger than the Earth.This paper counts the size of that age contradiction, the share of cosmological constant needed to remove it, and what in fact removed it.No new theorem or law is claimed, nor any observed value of the cosmological constant. First, and this is the core. With the 1929 value the universe is younger than the Earth——at H0 = 500 km/s/Mpc the age scale 1/H0 is 1.955584 Gyr and the age of a flat matter-only universe (Einstein-de Sitter), 2/(3H0), is 1.303723 Gyr: only 0.430745 and 0.287164 of the Earth's representative age of 4.54 Gyr (Section 2). **Second, saving it with the cosmological constant takes a nearly empty universe——in a flat matter-plus-constant model, reaching 4.54 Gyr takes ΩΛ = 0.996178 (matter share 0.003822). At ΩΛ = 0.3, 0.7, 0.9 and 0.99 the age is 1.464151, 1.885378, 2.498990 and 3.921993 Gyr, still younger than the Earth even at 0.99** (Section 3). **Third, the age formula agrees by two routes——the closed form (2/(3H0))·asinh(√(ΩΛ/Ωm))/√ΩΛ and numerical integration agree within 10^{-8} Gyr at five values of ΩΛ, and the formula returns to 2/(3H0) as ΩΛ → 0** (Section 3). **Fourth, with today's values there is no contradiction, and putting today's constant into the 1929 value leaves it——at H0 = 67.4 and ΩΛ = 0.685 the age is 13.796235 Gyr (0.950985 of 1/H0 = 14.507303 Gyr). Putting ΩΛ = 0.685 into the 1929 H0 gives 1.859732 Gyr, still younger than the Earth** (Section 4). **Fifth, what removed the contradiction was the distance scale, not the constant——the ratio from 500 to 67.4 is 7.418398, the factor by which the cosmic distance scale stretched. As Paper 297 showed, distances are measured on a ladder, and once its rungs were corrected the age lengthened without any cosmological constant** (Section 4). **Sixth, the separator is whether the age was lengthened by the cosmological constant or by the distance scale——lengthening it with the constant takes an empty universe of ΩΛ = 0.996178; lengthening it with the distance scale took a correction of 7.418398. The latter is what happened, and the constant came back for a different reason (Paper 1013)** (Section 5). **Keywords**: Hubble constant, age of the universe, cosmological constant, distance ladder, Einstein-de Sitter universe, age of the Earth.

Scope of this paper (scope note): **No new theorem or law is claimed——Hubble's relation between distance and velocity (1929), the age formula of a flat matter-plus-constant universe, the Einstein-de Sitter age 2/(3H0), and the age of the Earth of 4.54 Gyr from meteorite dating (Dalrymple 2001) are all known.The values are representative——500 km/s/Mpc is the representative value cited as Hubble's 1929 result; the details of the coefficient in the original (per nebula and per group) are not entered. 4.54 Gyr, 67.4 km/s/Mpc and ΩΛ = 0.685 are values for comparison and no precision is claimed.Radiation and curvature are left out——the age formula is for flat matter plus constant only, without the radiation share or spatial curvature.No observed cosmological constant is claimed——ΩΛ = 0.996178 is a value moved inside the age formula, not a value of the real universe; this stands on the same side as the scope note of Paper 1013, which does not compare with the observed Λ.Historical detail is not entered——how Lemaître or Eddington used the constant is not judged from sources; only the numbers of the age formula are seen.Relation to earlier papers**: **Paper 297 showed that cosmic distance is a ladder of seven rungs of which only the first is measured directly——here it is counted that what removed the 1929 age contradiction was the correction of that ladder (a factor 7.418398).Paper 1013 showed that acceleration begins at a higher redshift than the one where matter and the constant have equal density——here it is counted that the constant was first called back not for acceleration but for age.Paper 779 showed that distance is speed times time only where space does not stretch while the light travels——the 1/H0 used here is the scale valid at that nearness.**What is added is **giving the size of the 1929 age contradiction**, **obtaining by bisection the ΩΛ needed to remove it**, **matching the age formula by two routes**, and **giving as a ratio that the distance scale is what removed the contradiction**.

1. Notation and the Question

Setting: **for a universe with Hubble constant H_0, let $1/H_0$ be the age scale, $2/(3H_0)$ the age of a flat matter-only universe, and**

$$t = \frac{2}{3H_0}\,\frac{\operatorname{asinh}\sqrt{\Omega_\Lambda/\Omega_m}}{\sqrt{\Omega_\Lambda}}, \qquad \Omega_m + \Omega_\Lambda = 1$$

the age of a flat universe of matter plus cosmological constant.The 1929 value $H_0 = 500$ km/s/Mpc, today's 67.4, and the Earth's age 4.54 Gyr are used as representative values.

Question: **how much younger is the universe with the 1929 value, what does saving it with the constant take, and what in fact removed the contradiction?**

2. The 1929 Value and the Age of the Earth

Computation 2.1: **at $H_0 = 500$ km/s/Mpc, $1/H_0 = 1.955584$ Gyr and $2/(3H_0) = 1.303723$ Gyr. Their ratios to the Earth's 4.54 Gyr are 0.430745 and 0.287164.At today's 67.4, $1/H_0 = 14.507303$ Gyr and $2/(3H_0) = 9.671535$ Gyr,**

and $500/67.4 = 7.418398$.

> **Observation 2.2**
>
> this is the core. With the 1929 value the universe is younger than the Earth.The expansion traced backward takes less time than the rocks underfoot have existed——the cosmological constant was called back as a tool to lengthen it.

3. Saving It With the Constant

Computation 3.1: the closed form of the age and the numerical integration of $da/(aH)$ (2×10^5 points) were compared at five values of Ω_Λ ($H_0 = 500$).

Ω_Λ	closed form (Gyr)	numerical (Gyr)	difference (Gyr)
0.000001	1.303723	1.303723	4.09×10^{-9}
0.3	1.464151	1.464151	4.89×10^{-9}
0.7	1.885378	1.885378	7.47×10^{-9}
0.9	2.498990	2.498990	1.29×10^{-8}
0.99	3.921993	3.921993	4.09×10^{-8}

As $\Omega_\Lambda \to 0$ the formula returns to $2/(3H_0)$. Bisection for the Ω_Λ that gives 4.54 Gyr yields 0.996178 ($\Omega_m = 0.003822$), at which the age is 4.540000 Gyr.

> **Observation 3.2**
>
> saving it with the constant takes a nearly empty universe.Even at $\Omega_\Lambda = 0.99$ the age is 3.921993 Gyr, still younger than the Earth——only when matter is reduced to four parts in a thousand does the age catch up with the rocks.

4. Today's Values, and What Removed the Contradiction

Computation 4.1: at $H_0 = 67.4$ and $\Omega_\Lambda = 0.685$ the age is 13.796235 Gyr, 0.950985 of $1/H_0$. Putting $\Omega_\Lambda = 0.685$ into the 1929 H_0 gives 1.859732 Gyr.

> **Observation 4.2**
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> what removed the contradiction was the distance scale, not the constant.Putting today's constant into the 1929 value leaves the contradiction, and only when H_0 fell by a factor 7.418398 did the age lengthen——as Paper 297 showed, distances are measured on a ladder, and correcting its rungs lengthened the age. The constant came back for the acceleration that Paper 1013 counted, a different reason.

5. The Separator and What Is Not Said

> **Observation 5.1**
>
> the separator is whether the age was lengthened by the cosmological constant or by the distance scale.Lengthening it with the constant takes $\Omega_\Lambda = 0.996178$; lengthening it with the distance scale took a correction of 7.418398——in the words of Paper 779, $1/H_0$ is the scale at the nearness where space does not stretch, and what enters it is the distance scale.

> **Observation 5.2**
>
> what is not said.No observed value of the constant is claimed, and radiation and curvature are left out——500 and 4.54 are representative values, and how Lemaître or Eddington used the constant is not judged from sources.

6. Census and Closing

1. $1/H_0$ = **1.955584** Gyr, $2/(3H_0)$ = **1.303723** Gyr, ratios to the Earth **0.430745** and **0.287164** (Computation 2.1): **the core.**
2. **required Ω_Λ = 0.996178, Ω_m = 0.003822** (Computation 3.1): **an empty universe.**
3. **ages at Ω_Λ = 0.3 to 0.99: 1.464151, 1.885378, 2.498990, 3.921993 Gyr** (Computation 3.1): **still young at 0.99.**

4. **today's age 13.796235 Gyr, ratio 0.950985, 1929 value with today's constant 1.859732 Gyr** (Computation 4.1): **the contradiction remains.**
5. **distance-scale ratio 7.418398** (Computation 2.1): **this is what removed it.**
6. **constant or distance scale** (Observation 5.1): **the separator; Papers 297, 1013 and 779.**

Closing: **With Hubble's 1929 constant the universe is younger than the Earth, and saving it with the cosmological constant takes a nearly empty universe.At 500 km/s/Mpc, 1/H0 is 1.955584 Gyr, only 0.430745 of the Earth's 4.54 Gyr, and matching the Earth's age in a flat model takes ΩΛ = 0.996178. Even today's constant gives 1.859732 Gyr; what lengthened the age was the factor 7.418398 in the distance scale——the constant was called back for age, the age contradiction was removed without it, and the constant returned for acceleration.The separator is whether the age was lengthened by the cosmological constant or by the distance scale.Placed among the earlier papers——Paper 297 showed that distance is a ladder of seven rungs, Paper 1013 the redshift at which acceleration begins, and Paper 779 that 1/H0 is a scale valid only nearby. Here it was counted as a ratio that correcting the ladder removed the age contradiction.To be honest——every value is representative, and the details of the original coefficient have not been entered.**

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Yuuki YAMAGISHI (山岸 勇輝)

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