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The Hubble Parameter and the Past/Future Ages of the Universe

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The Hubble-Lemaître (redshift-distance) law is a cornerstone of modern cosmology that describes the expanding Universe at present. Hubble-Lemaître discovered a rough proportionality between z redshift of a nearby galaxy[1], and D is its distance to the Earth. This proportionality can be expressed as follows

$$z = H_0D/c$$

where c ($\approx 3 \times 10^8$ m) is the speed of light and H_0 [= 72 km sec^{-1} $(Mpc)^{-1}$][2] is the Hubble constant defining the rate of the expansion of the current Universe. However, this rate changes with time, and therefore the Hubble constant may have been different in the past. Expressed as a function of cosmological time (or cosmic time) the Hubble constant is named more appropriately as the Hubble parameter.

The inverse of the Hubble parameter measures the age of the Universe A_U (or the Hubble time). For the above Hubble constant H_0, the age of the Universe now A_U (t = 0) is around 13.8 Gy.

According to current thinking, the Universe similar to today's was formed about 12.8 Gy or one billion years after the Big Bang. If the Hubble-Lemaître law is valid from that time, then the Hubble parameter at cosmological time t is

$$H_t = 1/A_U \quad \dots (1)$$

where A_U is the age of the Universe at time t. Of course, the age of a galaxy $A_G = A_U$ at that time. According to this equation, if $H_t \rightarrow 0$ then $A_U \rightarrow \infty$, and *vice versa*, if $A_U \rightarrow 0$ then $H_t \rightarrow \infty$.

A question now arises: how is A_U back in time is different from today's A_U (t = 0) = 13.8 Gy? Table 1 gives the values of H_t and z_U for different values of A_U.

Table 1. The values of H_t[a] and z_U[b] for selected values of A_U

[1] We define nearby galaxies as those whose redshift z is from 0.001 to 0.1 (or $0.001 \leq z \leq 0.1$) and distant galaxies with z > 0.1 [1]. Of course, there is no sharp line between nearby and distant galaxies.
[2] This value is given by the current measurements.

A_U (Gy)	H_t (Gy^{-1})	z_U
13.8	0.0725	0
12.8	0.078	0.09
11.8	0.085	0.17
10.8	0.093	0.26
9.8	0.102	0.36
8.8	0.114	0.48
7.8	0.128	0.61
6.8	0.147	0.77
5.8	0.172	0.96
4.8	0.208	1.20
4.5*	0.223	1.29
4.1	0.244	1.40
3.8	0.263	1.52
2.8	0.357	2.00
2.1**	0.476	2.52
1.8	0.556	2.82

[a]Calculated using using (1). [b]Calculated using using (3).
*The age of the Earth. **The age of the quasar APM 08279-5255 (see below).

Carmeli et al. [2] derived a simple formula that relates the redshift of light z emitted at cosmological time t since the Big Bang, as Earth's observer measures now. This formula is

$$t = 2H_0^{-1}/[1 + (1 + z)^2] \quad \ldots (2).$$

Let us assume that a galaxy emitted the light at a cosmological time that corresponds to the age of the Universe or at $t = A_U$. Denote the redshift of this light measured by Earth's observer at the present time as z_U. Introducing $2H_0^{-1} \approx 28$ Gy into eqn. (2) [2], and also A_U and z_U instead of t and z we get

$$A_U(Gy) \approx 28/[1 + (1 + z_U)^2] \quad \ldots (3).$$

First, we will consider the five prominent "megamaser" galaxies whose experimentally measured redshift $z = z_U$ is known and to have negligible peculiar velocity, Table 2. All of them were formed after the birth of the Earth [3].

Table 2. Selected "megamaser" galaxies* and their z_u, A_U and H_t[a].

Name of galaxy	z_U	A_U (Gy)	H_t $(Gy)^{-1}$
NGC 1052	0.004930	13.9	0.0719
UGC 3789	0.010679	13.9	0.0719
NGC 6323	0.02592	13.6	0.0735
NGC 5765B	0.02754	13.6	0.0735
NGC 6264	0.03384	13.5	0.0741

*For details see Table 1 in [3]. [a]Calculated using eqn. (1).

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In Table 3 are given the values of z_U, A_U and H_t for selected distant galaxies.

Table 3. Selected distant galaxies* and their z_u and A_u[a].

Name of galaxy	z_U	A_U (Gy)
GN-z11	11.09	0.2
MACS0647-JD	10.7	0.2
GRB 090423	8.26	0.3
EGS-zs8-1	7.73	0.4
Cosmos Redshift 7	6.60	0.5
APM 08279+5255	3.91	1.1
A1689B11	2.54	2
53W091	1.55	3.7
53W069	1.43	4
3C 65	1.175	5

*For details see Table 1 in [4]. [a]Calculated using eqn. (3).

Any galaxy with a redshift greater than 1.4 is currently moving away from us faster than the speed of light. For $z_U \geq 1.4$, using eqn. (3), we find $A_U \leq 4$ Gy. Then using eqn. (1), we estimate that $H_t \geq 0.245$ $(\text{Gy})^{-1}$.

The age of the quasar APM 08279-5255 of 2.1 Gy was also obtained by measuring the F_e(iron)/O(oxygen) abundance ratio [5, and references therein]. This value is higher for 1 Gy than its calculated value of $A_U = A_G$ (Table 3). At first sight, this discrepancy is huge. However, both the above determination of the age of the Universe A_U (or the age of a galaxy A_G) using eqn. (3) as well as the measurement of the Fe/O abundance ratio including the assumptions having some limitations.

We know that $1 + z_U$ represents the overall expansion of the Universe, i. e.

$$1 + z_U = R(0)/R(Au)$$

where R(0) and $R(A_U)$ are the scale factor values at the time A_U when the light was emitted and 0 at the time when it was received.

Premović [6] proposed that the speed of light emitted from a galaxy is $c_G = c/(1+ z_G)$ and that the maximum redshift of light emitted from the distant galaxies in the observed Universe is z = 136. Therefore, the minimum speed of that light is $c_G = c/(1 + 136)$ (= c/137). Including z =136 in equation (3), we get that the A_G of that galaxy is 0.0015 Gy or 150 Mly after the Big Bang event. In other words, that galaxy is almost as old as the Universe itself.

Carmeli, Hartnett and Oliviera [2] pointed out "*it is hoped that the formula*, [eqn. (2) or better eqn. (3)], *will be useful for identifying objects at the early Universe so we can go back in time*…" But not only in the past but also we can go forward in the future. Indeed, eqn. (3) could be useful for calculating the redshift of a distant galaxy in the future. For example, when the Earth was born the Universe (or the

Milky Way galaxy) was about 9.3 Gy old. From today, after 4.5 Gy, these two would be about 18.3 Gy old and $2H_0^{-1} \approx 36.6$ Gly. Applying the eqn. (3), it can be calculated that the redshift of a distant galaxy, whose then age is 13.8 Gy, would be $z_u \approx 0.3$.

References

[1] P. I. Premović, *Nearby and distant galaxies: a brief note*. The General Science Journal, August 2024.
[2] M. Carmeli, J. G. Hartnett, F. J. Oliveira, *The cosmic time in terms of the redshift*. Found. Phys. Lett., 19, 277/283 (2006).
[3] P. I. Premović, *The age of the "megamaser" galaxies in the Big Bang Universe*. The General Science Journal, March 2022.
[4] P. I. Premović, *The redshift and age of nearby and distant galaxies*. The General Science Journal, June 2021.
[5] Y.-H. Sanejouand, *A simple Hubble-like law in lieu of dark energy*. arXiv:1401.2919[astro-ph.CO]. (2015).
[6] [1] P. I. Premović, *The Speed of light and the Principle of energy conservation.* The General Science Journal, April 2022.