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The Age of the "Megamaser" Galaxies in the Big Bang Universe

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The Big Bang theory is widely regarded as the leading explanation for the origin of the Universe. According to this theory, all the matter and energy in the current Universe emerged from a singularity. The Universe then expanded rapidly to the present version and this expansion of space itself (or better of space-time itself) is still occurring.

Hubble's law states that the recession speed υ_G of distant galaxies is proportional to their distance D_G from the Earth. This law can be expressed as follows

$$\upsilon_G = cz_G = H_0 D_G \ldots (1)$$

where c ($\approx 3 \times 10^8$ m sec^{-1}) is the speed of light, z_G is galaxy's redshift and H_0 (= 72 km sec^{-1} (Mpc)$^{-1}$ = 7×10^{-11} y^{-1}) is the Hubble constant. According to cosmology, H_0 represents the constant rate of cosmic expansion. The above formula is valid for distant galaxies with $z_G \leq 0.1$. For $z_G > 0.1$ this law is no longer relevant and depends on the particular cosmological model.

Most cosmologists consider that when the Big Bang occurred, time began. The time scale for the age of the Universe and its galaxies is set by the Hubble time $1/H_0$. For a Hubble constant H_0 of 72 km sec^{-1} (Mpc)$^{-1}$, as given by current measurements, the Hubble time $1/H_0$ is around 13.65 Gy. However, the true value of the Hubble constant is still debatable and its estimate varies between 50 km sec^{-1} (Mpc)$^{-1}$ to 100 km sec^{-1} (Mpc)$^{-1}$. Thus, the Hubble time varies between 10-20 Gy and hence the beginning or zero time of the Universe.

The best estimate of the age of the Earth (and the rest of the Solar system) is 4.55 ± 0.05 Gyr**.** (This value is derived from several different lines of evidence). Therefore, it appears that Earth's formation is a more reliable zero-time standard for the expanding Universe and the non-expanding Universe than the Hubble zero-time. In other words, the birth of the Earth can be considered as "coordinated astronomical time"[1] (CAT) for each of the universes. This would imply that each of them is "geocentric in time".

Most of the distant galaxies were formed before Earth's creation. For this type of galaxies, we will use the term before the Earth and label it: BE. This is a rough analogy to the historical term before Christ or BC. For example, the (active-type) galaxy APM 08279+5255 was formed at about 7 Gy BE. The age of this galaxy (~ 2.1 Gy) was determined by measuring the Fe/O ratio [1 and references therein].

[1] In rough analogy with the world standard "zero" time: coordinated universal time (UTC).

A much smaller number of distant galaxies were formed after the birth of the Earth. For this type of galaxy, we will use the term after the Earth and label it: AE. This is a rough analogy to the historical term Anno Domini (in the year of the Lord) or AD.

In what follows, we will only consider the galaxies whose peculiar motion is insignificant.

In the further text, we will consider only galaxies that are formed during BE. In Fig. 1, E and G represent the relative position of the Earth and galaxy G when the Earth is born. Let us denote with D the distance between these two astronomical objects at that time. After Earth's formation and to the present, galaxy G moves away from it at an average recession speed υ_G for an additional distance of $4.55\upsilon_G$.[2]

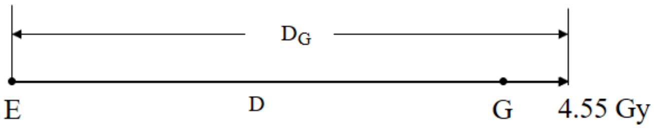

Fig. 1. Relative positions of the Earth and galaxy G and their distances.

At present, we measure the total distance D_G between the Earth and the galaxy G which can be expressed with a simple formula

$$D_G = D + 4.55\upsilon_G$$

where D_G and D are expressed in Gly, the unit of 4.55 is Gy. For convenience, this equation can be written as

$$D = D_G - 4.55\upsilon_G \quad \ldots (2).$$

Denote with z the redshift of a galaxy at the distance D from the Earth. Elementary physics and Hubble's law [eqn. (1)] imply that this galaxy travels a distance $4.55\upsilon_G$ with an average recession speed $\upsilon_G = (cz_G + cz)/2$. Of course, this formula is valid only for z_G and z lower than or equal to 0.1 (or ≤ 0.1). A bit of algebra applied to eqn. (1) yields $z = z_G(D/D_G)$. After simple mathematical manipulation, we can write eqn. (2) in the following form

$$D = D_G(2D_G - 4.55cz_G)/(2D_G + 4.55cz_G) \quad \ldots (3).$$

Of course, if galaxies are formed during BE then

$$D_G - D = 4.55c(z_G + z)/2.$$

Substituting z with $z_G D/D_G$ and plugging the value of c, and after a bit of algebra, we get

$$D = D_G - 2.275z_G(1 + D/D_G) \quad \ldots (4).$$

Here, the unit of 2.275 is Gly.

[2] Fig. 1 would be drawn by the observer "Adam" created when Earth was created.

As one of the direct distance measurement methods, the "megamaser" method has demonstrated its capability for precise distance measurement of distant galaxies, i. e. galaxies beyond our Local Group. But it appears this method is suitable for very few of distant galaxies - "megamaser" galaxies. For the present case, we select five of these galaxies whose redshift z_G and distance D_G from the Earth (determined by the megamaser method) are known, Table 1. The peculiar motion of these galaxies is negligible.

Table 1. "Megamaser" galaxies.

Name of galaxy	Redshift[S] z_G	D_G [Mly] Megamaser	D [Mly][1]
NGC 1052	0.004930	65 [2]	50
UGC 3789	0.010679	162 [3]	120
NGC 6323	0.02592	349 [4]	250
NGC 5765B	0.02754	411[5]	300
NGC 6264	0.03384	447 [6]	320

[S]From Simbad (Astronomical database, Centre de données astronomiques de Strasbourg, Université de Strasbourg) and [1]calculated using eqn. (3).

Plugging into eqn. (3) D_G and z_G, given in Table 1, we calculated the distance D of these galaxies to the just-born Earth, Table 1.

A simple calculation shows that the average value of D/D_G of selected galaxies is about 0.72. Since z_G of these galaxies is much smaller than 0.72 (Table 1) eqn. (4) can be approximate to

$$D = D_G - 2.275z_G(1 + D/D_G) = D_G - 1.72 \times 2.275z_G = 1.7\text{ (Gly)} - 3.9\text{ (Gly)}z_G.$$

Since z_G of the selected galaxies is much smaller than 0.1 (Table 1) then the minimum D should be ~ 1.3 Gly. In contrast, the calculated D for the "megamaser" galaxies is < 0.350 Gly therefore they are formed after the Earth or during AE.

Of course, the above approach can be applied to any galaxy with $z_G \leq 0.1$ if we know its distance D_G from the Earth.

References

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