

A Simple Way to Show Space-Time Expansion

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*“And God said, “Let there be light”, and there was light.
And God saw that the light was good; and God
separated the light from the darkness. (Genesis 1:3-5)*

Abstract

A time interval in the reference frame of nearby and distant galaxies is proportional to the distance between these galaxies and the Earth and is shorter if measured in Earth's time frame. In other words, when space expands (or stretches), time also proportionally expands (or “stretches”) or, in the language of relativity, both dilate. Simply speaking, we are dealing with space-time expansion (or stretching).

Keywords: Earth, galaxy, age, distance, time, space-time expansion.

Introduction

The standard cosmology of the Universe is based on the General theory of relativity. It states that the Universe was created about 14 Gy in an event called the Big Bang. From this event space and time started expanding and this expansion is still occurring creating galaxies, stars, Sun, Earth, planets and life. According to this cosmology, nearby and distant galaxies¹ recede from the Earth because the Universe is expanding at a constant rate. The light emitted by these galaxies is redshifted and is called a “cosmological redshift”.

The best estimate of the age of the Earth (and the rest of the Solar system) is 4.55 ± 0.05 Gyr. This estimate for Earth's age is based on radiometric dating of iron meteorite fragments from the Canyon Diablo. Premović [2] concluded that the time of Earth's formation is a more reliable zero-time standard for the Universe than the Hubble zero-time (see below).

All distant galaxies were formed before the Earth. Premović [2] used for this type of galaxies the term before the Earth and labeled it as BE. In rough analogy to the historical term: before Christ or BC. For galaxies created after the Earth, he applied AE in rough analogy to the historical term: after the death of Christ or AD. A galaxy can be created BE or AE. All distant galaxies were formed in BE. Let us first consider the BE galaxies.

¹ We define nearby galaxies as those whose redshift z_G is from 0.001 to 0.1 (or $0.001 \leq z_G \leq 0.1$) and distant galaxies with $z_G > 0.1$ [1]. Of course, there is no sharp line between nearby and distant galaxies.

Derivations and Discussion

Suppose a BE galaxy recedes emitting light. Denote with G its “present” position in respect to the Earth and with D_G the distance between them², Fig. 1a. Denote with G_E the position of this galaxy in respect to the Earth when the Earth was born. Of course, the light emitted by the BE galaxy would travel to the Earth as long as it has been since the birth of the Earth, i. e. during a time equal to A_E . In equation form

$$D_G = cA_E \quad \dots (1)$$

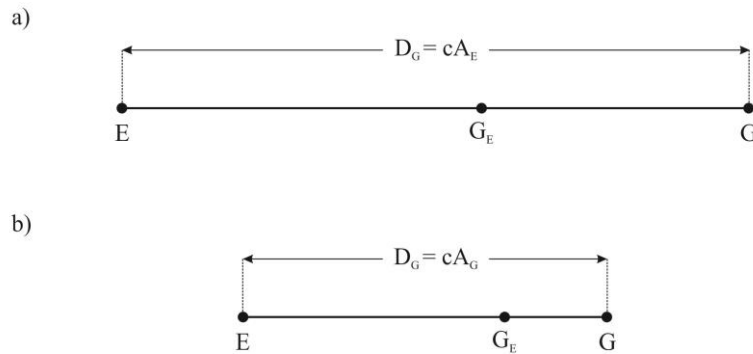


Fig. 1: a) position of the galaxies BE (1a) and AE (1b) in respect to the Earth formation about 4.55 Gy.

where c ($= 3 \times 10^5$ km sec⁻¹) is the speed of light in a vacuum. (Obviously, the ratio D_G/A_E is equal to this speed and constant with increasing distance). This appears regardless of how far the BE galaxy is from the Earth. So, Earth’s observer concludes that the age of Earth A_E in the BE galaxy’s reference frame is higher than the radiometrically measured age of the Earth, 4.55 Gy. In other words, a time interval in the reference frame of the BE galaxy is proportional to the distance between this galaxy and the Earth and is longer than measured in Earth’s time frame. Expressed in the language of cosmology, when space expands (or stretches), time also proportionally expands (or “stretches”). Simply speaking, we are dealing with space-time expansion or stretching. In the language of relativity, there is the relative time dilation between the identical clocks in the frames of reference of Earth and of a BE galaxy. In other words, the clock on a distant BE galaxy would run slower than an identical clock on Earth. According to the standard cosmology, the farther away the galaxy is, the older it is, the larger its redshift and the slower its time.

We know that the frequency of light emitted by the BE galaxy, ν , is inversely proportional to time and proportionally decreases with the distance between the Earth and this galaxy. Consequently, the energy of this light also decreases because it is proportional to its frequency. (In equation form: $E = h\nu$ where E is light’s energy and h is Planck’s constant). Since the

² Just to remind the reader that at that moment Earth’s observer “Adam” and a bit later “Hubble” came into a “cosmic contact” with nearby or distant galaxy. Emission of light by the BE galaxy occurred in the past and this light has reached the Earth when “Hubble” was able to measure its redshift.

wavelength of light, $\lambda = c/v$, increases as its frequency decreases, the light in the BE galaxy is redshifted.

Previous discussion is based on zero time of the Universe is the birth of the Earth. However, if we assume that the time of birth of the galaxy G is zero time of the universe then $D_G = cT$ where T is the time of the present day Earth relative to that zero time. However, as far as we know, the time of birth of distant galaxies is highly debatable.

Suppose that a distant galaxy is created when Earth is created and at a position relatively close³ to the Earth in the then Universe. According to eqn. (1), now the distance of this previous galaxy's position to the Earth is about $(4.55c \Rightarrow) 4.55$ Gly. If the distance of the Earth to a galaxy is larger than 4.55 Gly then this galaxy is the BE-type. If this distance is smaller than 4.55 Gly, the galaxy is the AE-type.

Consider now an AE galaxy. Most of the previous consideration for BE-type galaxy is also applicable to this type of galaxy.

Let G_E to represent a position in respect to the Earth when this galaxy is born and G represents its position after 4.55 Gy, Fig 1b. Now, the light emitted by this galaxy would travel to Earth as long as it has been since the birth of this galaxy, i. e. A_G . In expression

$$D_G = cA_G \quad \dots (2).$$

The starting point of many papers related to D_G is the Hubble's law equation which is valid only for nearby galaxies: $cz_G = H_0 D_G$, where $H_0 (= 7 \times 10^{-10} \text{ y}^{-1})$ is Hubble's constant representing the constant rate of the Universe expansion caused by the expansion of space-time itself. After some rearrangement, we can write this equation as follows

$$D_G = z_G c / H_0.$$

The terms $1/H_0$ and c/H_0 in this equation are Hubble's age (or Hubble's zero-time) and Hubble's length, respectively. For the above value of H_0 their values are about 14 Gy and 14 Gly.

Combining eqn. (2) and eqn. (3) we have

$$A_G = z_G / H_0 \quad \dots (3).$$

Accordingly, if $z_G \leq 0.1$ then $A_G \leq 1.4$ Gy and if $z_G > 0.001$ then $A_G > 0.0014$ Gy.

The direct distance measurement method so-called the "megamaser" method has demonstrated its capability for precise distance measurement. But it appears this method is suitable for very few nearby galaxies - "megamaser" galaxies [1, and references therein]. For the present case, we select five of these galaxies whose redshift z_M and distance D_M from the Earth (determined by

³ Its distance to the Earth should be large enough, which would prevent its recession motion from being affected by the gravitational forces of the Milky Way. For example, the nearby Andromeda galaxy is about 2.2 Mly away from Earth and yet it is exposed to the gravitational influence of the Milky Way.

the megamaser method) is known, Table 1. The peculiar motion of these galaxies is negligible. Since their distance from the Earth is less than 4.55 Gly all of them are created in AE. This is consistent with our previous report [2]. The calculated age of the selected “megamaser” galaxies A_M is given in Table 1.

Table 1. Selected “megamaser” galaxies

Name of galaxy	z_M^*	D_M [Gly]**	A_M [Gy]***
NGC 1052	0.004930	0.065	0.07 (0.065)
UGC 3789	0.010679	0.162	0.15 (0.162)
NGC 6323	0.02592	0.349	0.37 (0.349)
NGC 5765B	0.02754	0.411	0.39 (0.411)
NGC 6264	0.03384	0.447	0.48 (0.447)

*See [1] and the references therein. **Calculated using eqn. (2).

***Calculated using eqn. (3). In the round brackets calculated using eqn. (2).

Finally, there is a possibility that the speed of light c is not constant and depends on the distance of a nearby or a distant galaxy to the Earth. One of the nearby galaxies NGC 1052 has a rather small distance D_G from the Earth: 65 Mly, Table 1. Introducing this value into eqn. (1) we estimate that in this case, the speed of light c would be about 4300 km sec^{-1} . Of course, this result is complete nonsense that excludes this possibility.

Scientists estimate that in our galaxy alone (Milky Way), there are billions of planetary systems similar to our Solar system. On the other hand, in the Universe there are billions of galaxies. If the speed of light c is universal, we propose that the equations (1) and (2) are universal can be applied to all planetary systems of all galaxies in the Universe. Moreover, Hubble’s law is probably also universal so then eqn. (3) is also universal.

References

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