

## Special Relativity of the Big Bang Universe Based on the Doppler Effect

Pavle I. Premović

Laboratory for Geochemistry, Cosmochemistry and Astrochemistry,  
University of Niš, [pavleipremovic@yahoo.com](mailto:pavleipremovic@yahoo.com), Niš, Serbia

Many cosmologists consider the Big Bang hypothesis is the best theory we have to explain the birth and existence of the Universe. According to this theory, the Universe was formed approximately 13.8 billion years ago when it expands from a point, known as a singularity. The Universe has been expanding ever since and is still occurring.<sup>1</sup> From this singularity, all energy and matter of this Universe came into being.

The Big Bang model of the Universe says that nearby or distant galaxies<sup>2</sup> are (apparently) at rest in space. The distance change between the Earth and these galaxies is not due to their motion through space but the space between the Earth and them is expanding. As a consequence, light emitted by nearby or distant galaxies is redshifted.

In contrast, some cosmologists in the past and at present consider that nearby or distant galaxies are moving from each other and, of course, also away from the Earth. So, the measured redshift of their light by Earth's observer is caused by their speed relative to the Earth:  $v_G$ . This speed is defined by a formula of non-relativistic Doppler shift<sup>3</sup> for light

$$v_G = cz_G \quad \dots (1),$$

in which  $z_G$  is the redshift of light coming from a nearby or distant galaxy to the Earth and  $c$  ( $\approx 3 \times 10^8$  m sec<sup>-1</sup>) is the speed of light. A good approximation for  $v_G = cz_G \ll c$  is  $v_G = cz_G \leq 0.1c$  or briefly  $z_G \leq 0.1$  [1]. So, the above eqn. is valid for nearby galaxies.

One of the concepts of Special relativity (SR) is length contraction which depends upon the second postulate of SR that the speed of light  $c$  is the same in all inertial frames of reference.

We suppose (very roughly) that a nearby or distant galaxy is rod-shaped traveling with a radial speed  $v_G$  away and relative to Earth's observer, Fig. 1a. Denote with  $L_0$  the rest length of this (rod-shaped) galaxy which is measured by an observer in the galaxy's reference frame and the moving length with  $L$  which is measured by Earth's observer. SR states that the moving length  $L$  is shorter than  $L_0$ . In other words, these two lengths are related to each other by the SR formula for length contraction

---

<sup>1</sup> A period just after the Big Bang called inflation.

<sup>2</sup> 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 with distant galaxies having  $z_G > 0.1$  [1]. Of course, there is no sharp boundary between nearby and distant galaxies.

<sup>3</sup> The **low-speed** limit of the relativistic Doppler effect.

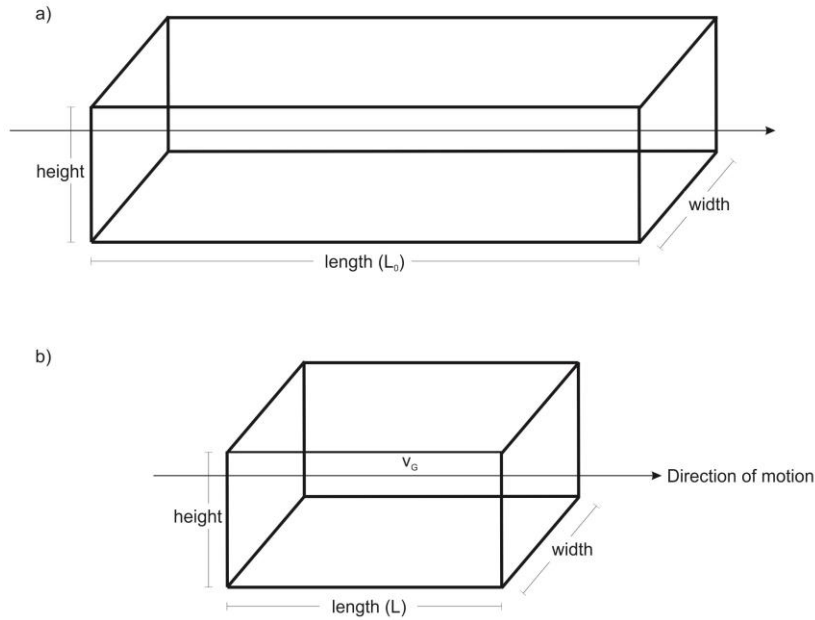


Fig. 1. The rod-shaped nearby or distant galaxy:  
a) at the rest ( $v_G = 0$ ) and b) moving with  $v_G/c = 0.87$ ,  $z_G \approx 3.8$  and  $L_0/L = 0.5$ .

$$L = L_0 \sqrt{1 - v_G^2/c^2} \quad \dots (2).$$

Of course, the length contraction of nearby and distant galaxies is observable by Earth's observer. According to this equation, the magnitude of this contraction in the direction of motion depends on their speed  $v_G$ . Presumably, its height and width would remain the same during length contraction. In the case of nearby galaxies  $v_G \leq 0.1c$  and they would contract by  $\leq 5\%$ .

Eqn. (1) is not valid for distant galaxies (redshift  $z_G > 0.1$ ) moving with a relativistic speed. In this case, the above mentioned cosmologists rely on a formula for relativistic Doppler shift

$$z_G = [\sqrt{(1 + v_G/c)/(1 - v_G/c)}] - 1.$$

According to this equation, distant (rod-shaped) galaxies with  $v_G = 0.87c$  would have redshift  $z_G \approx 3.8$  and they would contract by about 50%, Fig. 1b. Distant (rod-shaped) galaxies with  $v_G \geq 0.9995c$  would have redshift  $z_G$  about 40 and would be contracted about 99%. In other words, the relativistic "Doppler" world of galaxies with  $z_G \geq 40$  would appear almost two-dimensional to Earth's observer.<sup>4</sup>

<sup>4</sup> The SR contraction of distant galaxies (or their two-dimensional appearance) can be seen by Earth's observer at rest because their diameter (or dimension, in general) is much smaller than the distance between these galaxies and the Earth. So, the light emitted from the galaxy's different points would reach this observer at the same instant of time (read: Terrell effect).

## References

- [1] P. I. Premović, *Nearby and distant galaxies: a brief note*. The General Science Journal.
- [2] T. M. C. H. Davis, C.H. Lineweaver, *Expanding confusion: common misconceptions of cosmological horizons and the superluminal expansion of the Universe*. Publ. Astronom. Soc. Australia 21, 97–109 (2004).