The Origin of the Bimodal Distribution in the Estimates of the Hubble Constant

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Abstract: By the early 1970's estimates of the Hubble constant from Sandage and Tammann were hovering around 55. On the other hand, VandenBerg and deVaucouleurs obtained values near 100. Even at the beginning of the current millennium still was evident such bimodality. Then cosmologists corrected the diameters and magnitudes of galaxies to reconcile two or more groups receiving different values of Hubble constant. Such a "method" of averaging the results leads to a value of about 70. Here, applying the Scale-Symmetric Theory (SST), we show that the two different values for the local Universe follow from two different ways of emission of photons which causes that the same redshift leads to two different light travel times - it concerns supernova and its host galaxy. We obtain respectively 45.17 (the upper limit is 46.44) and values two times higher i.e. 90.34 (the upper limit is 92.88) - the mean value is 67.75 (the upper limit is 69.66), which are consistent with the recent observational data. Emphasize that the bimodality does not result from assumed uncertainties - just bimodality is characteristic for the near Universe.

Introduction and motivation

By the early 1970's estimates of the Hubble constant from Allan R. Sandage and Gustav A. Tammann were hovering around $55 \text{ km s}^{-1} \text{ Mpc}^{-1}$ [1]. On the other hand, S. VandenBerg and Gerard deVaucouleurs obtained values near 100 [1]. Even at the beginning of the current millennium still was evident such bimodality [1]. Then cosmologists corrected the diameters and magnitudes of galaxies to reconcile two or more groups receiving different values of Hubble constant [1]. Such a "method" of averaging the results leads to a value of about 70.

Here, applying the Scale-Symmetric Theory (SST), we show that the two different values for the local Universe follow from two different ways of emission of photons which causes that the same redshift leads to two different light travel times – it concerns supernova and its host galaxy. For the local Universe (on assumption $z << 1$), we obtain respectively 45.17 and $2 \cdot 45.17 = 90.34$ – more detailed calculations lead to the mean value $67.75^{+1.91}{}_{-0.00}$, which is consistent with the recent observational data $67.6^{+0.7}{}_{-0.6}$ [2]. Emphasize that the bimodality does not result from assumed uncertainties, just the bimodality is characteristic for the local Universe.

SST shows that the expansion of the Universe was separated in time from the inflation [3].

We showed that quasars with redshift $z = 0$ are already in the light travel time (LTT) equal to 6.753 Gyr [4] so they do not concern the local/near Universe.

There are two different mechanisms of emission of photons. The emission by supernovae leads to following formula for LTT [5]

$$L_{SST,ltt,z<0.6415,supernovae} = L_{Front,spatial}\, z\,(2 - z) / z_{front}\,. \tag{1}$$

where $L_{Front,spatial} = 4.971$ Gyr and $z_{front} = 0.6415$.

From formula (1), for $z = z_{front}$, for $L_{Front,spatial}$ we obtain $L_{Front,ltt} = 6.753$ Gyr. We can rewrite formula (1) as follows

$$D_{L,supernovae} = L_{Front,ltt}\, z\,(2 - z) / z_{front}\,, \tag{2}$$

where $D_{L,supernovae}$ is the luminosity distance for a supernova.

Such result follows from the fact that source of photons, i.e. frame of reference, is moving away from Earth with speed equal to the speed of light in "vacuum" c whereas the photons observed on Earth are entangled with the supernova (Fig. 1).

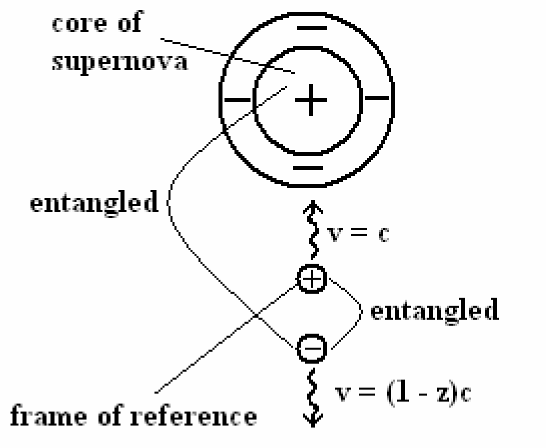

Fig. 1
Type z(2 - z) → 2z increase in space for a supernova with z << 1

On the other hand, the mechanism of emission of photons by normal stars in galaxies is different (Fig.2).

Here the photons detected on Earth are entangled with galaxy (it is the frame of reference) whereas the galaxy is moving away from Earth at a radial speed $v = zc$. It leads to conclusion that LTT is directly proportional to $z(1 - z)$

$$D_{L,galaxies} = L_{Front,ltt}\, z\,(1 - z) / z_{front}\,. \tag{3}$$

From formulae (2) and (3) we obtain

$$Ratio = D_{L,supernovae} / D_{L,galaxies} = (2 - z) / (1 - z)\,. \tag{4}$$

For the local/near Universe ($z << 1$) we obtain

$$Ratio = 2\ . \tag{5}$$

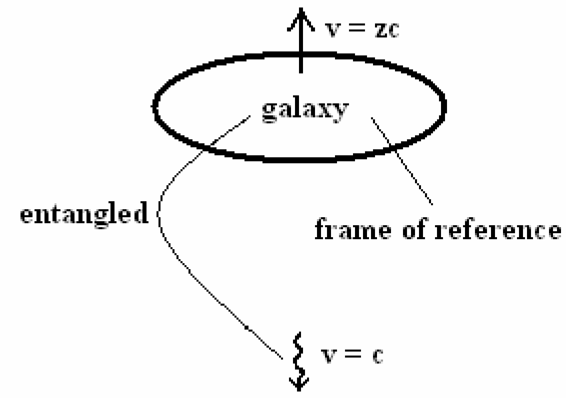

Fig. 2
Type z(1 - z) → z change in space for a local galaxy with z << 1

From formulae (2) and (3) follows that in the local/near Universe the SST gives linear cz vs D_L relation for small cz. The observational data concerning supernovae "clearly rule out models that do not give a linear cz vs D_L relation for small cz", where D_L is the luminosity distance ($Flux = Luminosity / (4\pi D_L^2)$ and $Luminosity = 4\pi R^2 \sigma T_{em}^4$, where R is the radius, σ is the Stephan-Boltzmann constant, and T_{em} is the temperature of source/blackbody) [6].

For local Universe is

$$H_o = v_r / D_L\ , \tag{6}$$

where v_r is radial velocity. It and formulae (4) and (5) lead to following formula for near Universe

$$H_{o,galaxies} / H_{o,supernovae} = 2\ . \tag{7}$$

From Fig.1 follows that the frame of reference is moving away from Earth with radial speed equal to c i.e. the same as the front of CMB. It leads to conclusion that supernovae described within SST should give correct value for the Hubble constant which is $H_o = H_{o,supernovae} = 45.24$ [1]. From formulae (2) and (6) for $z = 0.0000001$ we obtain $H_{o,supernovae} = 46.44$. But notice that initially the early Universe was the binary system of loops with a radius of $L_{Initial} = 0.191$ Gyr [1]. Applying formula (2) for $L_{Front,ltt} + L_{Initial} = 6.944$ Gyr we obtain the lower limit for the supernova Hubble constant $H_{o,supernovae,lower\text{-}limit} = 45.17$ – this result is very close to the correct value. Then from formula (7) we have $H_{o,galaxies} = 92.88$ and $H_{o,galaxies,lower\text{-}limit} = 90.34$. The normal arithmetic mean value for the near Universe is $(H_{o,supernovae} + H_{o,galaxies}) / 2 = 67.75^{+1.91}_{-0.00}$ i.e. in experiments we should obtain for near Universe a value defined by following interval <67.75, 69.66>.

Summary

Emphasize once again that the bimodality of the Hubble constant does not result from assumed uncertainties – just bimodality is characteristic for the local Universe so both groups of cosmologists obtaining results close to 45 and 90 are right. Of course, to calculate the Hubble constant we must measure the distance L from us to frame of reference at the same proper time since the beginning of the expansion of the Universe. On the other hand, the size (i.e. the transverse extend of an object) or luminosity needed to compute angular size distance or luminosity distance, are always very hard to determine [6]. It causes that the two calculated values of Hubble constant for near Universe are broadened. The unjustified corrections of diameters and magnitudes of galaxies make that the central values of the broadened results are closer together.

The normal arithmetic mean value for the Hubble constant for the near Universe calculated in this paper is $H_{o,mean} = 67.75^{+1.91}{}_{-0.00}$ but SST shows that the real value is 45.2 that leads to the age of the Universe about 21.6 Gyr and to the present-day distance to the baryonic front about 13.87 ± 0.10 Gyr [1].

We see that we need to return to the previous results and reformulate cosmology in such a way that led to two different distances for the same redshift.

References

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