Lack of cosmological expansion versus the Hubble crisis

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Abstract

Based on the low-energy quantum gravity model, it is shown that the overestimation of the Hubble constant at small z, characteristic of the ΛCDMcosmological model, can be eliminated using a two-parameter luminosity distance function that takes into account the change in the number of photons. This new function was fitted to a similar function in the ΛCDM model, which best describes observations. Estimates were obtained for the light attenuation parameter, which replaces the effect of dark energy, and for the Hubble constant in the new model without cosmological expansion. Such a resolution of the Hubble crisis could cause a serious conceptual crisis in modern cosmology.

1 Introduction

The modern cosmological model, based on the postulate of an expanding universe, rests on the robust mathematical foundation of general relativity. The successful description of numerous observations within this framework gives the scientific community confidence in the model's sound foundations and the assurance that even if changes are required, they will not affect its foundations. However, the specific nature of the model and the object it describesthe entire universeprecludes conducting controlled experiments or retracing the steps of certain processes to understand what is happening and why. Therefore, key concepts are accepted out of logical necessity (for example, inflation) or invented ad hoc to remain within the model's narrow framework (for example, dark energy). After all, in the latter case,

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a weakening of the light flux from distant supernovae was observed, and this could have been caused by the scattering of photons, which would have changed their number and weakened the flux. But a new substance has been discovered that should push galaxies apart, and now everyone is eager to know what it is. The Hubble crisis has now come to the fore, the main aspect of which is the significant difference between the locally measured Hubble constant [1, 2, 3] and its value obtained through microwave background analysis [4]. Another aspect is the difference in the values of this constant when adjusting observational results at different redshift ranges. There are many assumptions about the possible causes and ways to overcome this crisis (for example, [7, 8, 9, 10]), but the multifaceted nature of its manifestations is disconcerting. This article describes the possibility of interpreting this crisis as a manifestation of the attenuation of the light flux due to photon scattering by background gravitons within the framework of the low-energy quantum gravity model [5, 6].

2 Key features of the low-energy quantum model of gravity

This model is based on the assumption of the existence of a background of gravitons with low temperature but strong interactions with all particles. A new constant is introduced to describe this interaction, and to ensure that the inverse-square law holds at low velocities, it is necessary to assume an atomic structure for the bodies. In this model, gravity is interpreted as the effect of the screening of this background by the bodies [5, 11]. The model has an alternative redshift mechanism that is local and quantum, making the expansion of the universe unnecessary. The additional attenuation of light fluxes due to

dark energy is replaced by a change in the number of photons scattered by gravitons. The Newton and Hubble constants are calculated in the model as functions of the background temperature. Using the known value of Newton's constant, a new constant was calculated, and from it, the theoretical value of the Hubble constant in the model was found: $H_0 = 2.14 \cdot 10^{-18}\ s^{-1} = 66.875\ km \cdot s^{-1} \cdot Mpc^{-1}$. In the model, the luminosity distance $D_{L1}(z)$ is equal to:

$$D_{L1}(z) = \frac{c}{H_0} \cdot \ln(1+z) \cdot (1+z)^{(1+b)/2}, \quad (1)$$

where b is the attenuation factor of the photon flux caused by non-head-on collisions of photons with background gravitons. The values of parameter b must belong to the range [0, 2.137]. Therefore, the luminosity distance here must be a multivalued function of the redshift [5]: for a given z, b can have different values for sources with different spectra. This is strikingly different from the situation in the ΛCDM model, where this function is independent

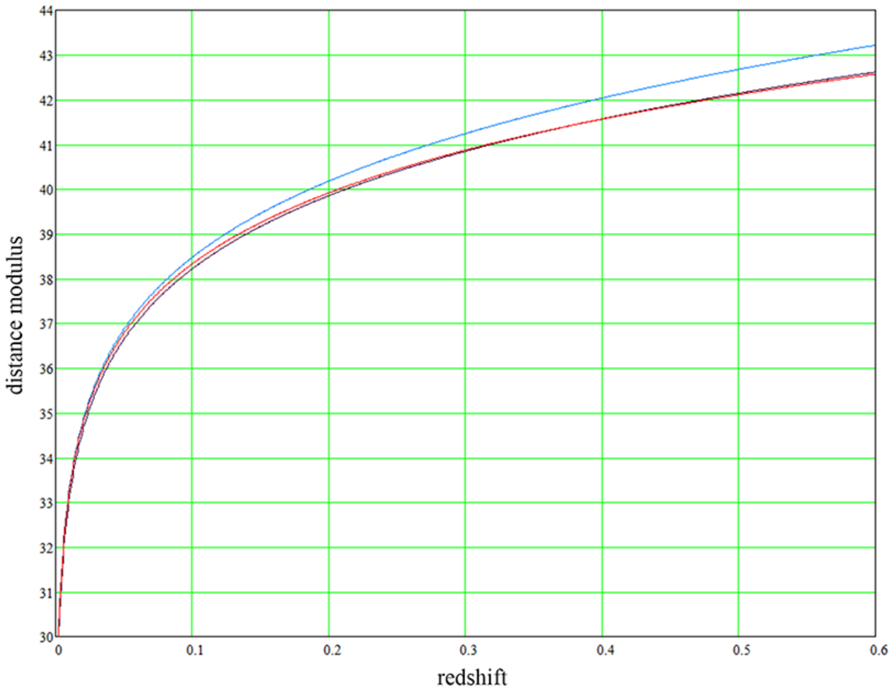

Figure 1: Plots of the functions $\mu_2(z, 73, 0.34)$ (black) and $\mu_1(z, 67.6, 0.9)$ (red) with the best-fit parameters. The plot of $\mu_1(z, 67.6, 2.137)$ (blue) is shown for comparison.

of the spectrum type. The maximum value is calculated assuming that a photon is deflected from its initial direction in any non-head-on collision. However, the photon energy at which this condition is satisfied is currently unknown, as is the energy at which all non-head-on collisions will cancel each other out and yield $b = 0$. To determine this, it is necessary to solve a complex statistical problem about the dependence of the factor b on changing photon energy. A successful fit of the type Ia supernova data using Eq.1 with $b = 2.137$ shows that for visible light, the minimum photon energy is somewhere near the visible range.

3 Comparison of two luminosity distances at low redshifts

The luminosity distance in the concordance cosmology by $w = -1$, used in [1] for small z, is:

$$D_{L2}(z) = c/H_0 \cdot (1+z) \int_0^z [(1+x)^3\Omega_M + (1-\Omega_M)]^{-0.5} dx, \tag{2}$$

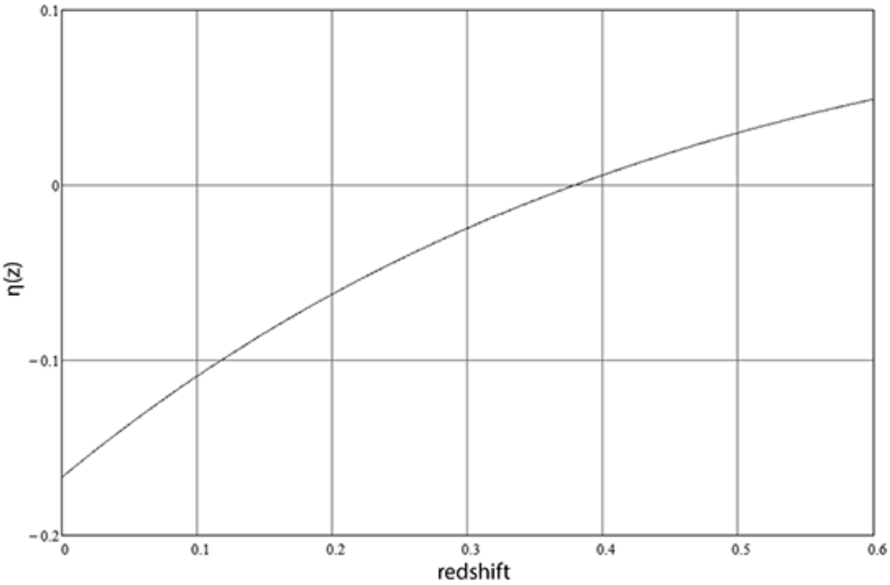

Figure 2: Graph of the function $\eta(z) = \mu_2(z, 73, 0.34) - \mu_1(z, 67.6, 0.9)$ with $< |\eta(z)| >= 0.055$.

where Ω_M is the normalized matter density. For each of the functions (1) and (2), we calculate their distance moduli $\mu_1(z, H_0, \Omega_M)$ and $\mu_2(z, H_0, b)$ using the formula: $\mu(z) \equiv 5lgD_L(z)(Mpc) + 25$.

The SH0ES collaboration obtained for the Hubble constant at $\Omega_M = 0.34$ [1]: $H_0 = (73.04 \pm 1.04)\ km \cdot s^{-1} \cdot Mpc^{-1}$. To estimate the parameters of function (1), we can find the best fit of $\mu_1(z, H_0, b)$ to $\mu_2(z, H_0, \Omega_M)$ with these specified parameters, varying the values of the parameters H_0, b of μ_1. Let us consider the best fit to be the minimum of the mean absolute value of the difference between the two functions: $\eta(z) \equiv \mu_2(z, 73, 0.34) - \mu_1(z, H_0, b)$ over a given range of $z \in [0, 0.6]$: $< |\eta(z)| >= min$. Having performed this fitting, we obtained the following estimates for H_0 and b: $H_0 = 67.6\ km \cdot s^{-1} \cdot Mpc^{-1}$, $b = 0.9$ with $< |\eta(z)| >_{min}= 0.055$. Figure 1 shows plots of the functions $\mu_2(z, 73, 0.34)$ (black) and $\mu_1(z, 67.6, 0.9)$ (red) with the best-fit parameters. For comparison, the plot of $\mu_1(z, 67.6, 2.137)$ (blue) is also shown. Figure 2 shows a graph of the function $\eta(z) = \mu_2(z, 73, 0.34) - \mu_1(z, 67.6, 0.9)$ with $< |\eta(z)| >= 0.055$. In the same way, changes in one of the parameters of the function $\mu_1(z, H_0, b)$ were found, corresponding to the replacement of $H_0 = 73\ km \cdot s^{-1} \cdot Mpc^{-1} \rightarrow H_0 = (73 \pm 1)\ km \cdot s^{-1} \cdot Mpc^{-1}$ in $\mu_2(z, 73, 0.34)$. As a result we have with $< |\eta(z)| >_{min} \in [0.043, 0.066]$:

$$H_0 = 67.6 \pm^{2.6}_{0.8}\ km \cdot s^{-1} \cdot Mpc^{-1} | b = 0.9,$$

$$b = 0.9 \mp^{0.07}_{0.10} | H_0 = 67.6\ km \cdot s^{-1} \cdot Mpc^{-1}.$$

In the cosmological expansion model, there is a time dilation effect, so the results of distance modulus measurements for supernovae Ia are corrected to account for this effect. In the model without expansion, the inverse correction must be made due to the absence of this effect as follows: $b \to b+1$. After this correction, we obtain the final result:

$$H_0 = 67.6 \pm^{2.6}_{0.8} \ km \cdot s^{-1} \cdot Mpc^{-1} | b = 1.9,$$

$$b = 1.9 \mp^{0.07}_{0.10} | H_0 = 67.6 \ km \cdot s^{-1} \cdot Mpc^{-1}.$$

The obtained estimate of the Hubble constant is in good agreement with the estimate: $H_0 = (67.4 \pm 0.5) \ km \cdot s^{-1} \cdot Mpc^{-1}$ found based on the ΛCDM cosmological model from the Planck measurements of the CMB anisotropies [4]. as well as with the theoretical estimate of this model. Importantly, the model uses a two-parameter function $D_L(z)$, but with a different set of parameters than the ΛCDM model. This resolution of the Hubble crisis could lead to a serious conceptual crisis in modern cosmology, which is based on the hypothesis of an expanding universe. The obtained estimate of the attenuation parameter b in the visible range, showing that it is less than its maximum theoretical value, can help to understand why the values of H_0 obtained at different intervals of z decrease with increasing z.

4 Conclusion

The possible change in the number of photons due to their scattering contradicts the expectations of the metric theory of gravity, which underlies modern cosmology. The quantum redshift mechanism described in the model eliminates the need for an expanding universe, and, together with the possibility of attenuation of the light flux, also rules out dark energy. This locality of the redshift could, in principle, be tested in a laser experiment on Earth [5]. The presence of excess scattered light far from the Sun could be detected by deep space missions [6, 12]. Attempts to resolve the Hubble crisis using dark energy variations can only cease once it is established that the attenuation of the radiation depends on the spectrum of the source. A striking example of this would be luminosity distance measurements for GRBs with their supernovae-independent calibration. In this model without expansion, the angular diameter distance coincides with the geometric distance and increases logarithmically with increasing redshift. Planned large cosmological surveys could reveal this with luminosity-distance-independent measurements of angular diameter distances for $z > 1.5$.

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