What Do We See: Signs Of Quantum Gravity Or Dark Energy?

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June 4, 2018

Abstract

Cosmological observations of remote objects may be interpreted in the model of low-energy quantum gravity by the author without dark energy. The theoretical Hubble diagram of the model fits observations very well. Additionally, this diagram should be the multivalued function of the redshift for soft and hard radiations; perhaps, this feature may be seen for the GRBs data set with the Yonetoku calibration. In the model, the ratio $H(z)/(1+z)$ should be equal to the Hubble constant; the constancy of this ratio is verified up to $z < 2$ with high probability using compilations of $H(z)$ observations.

$PACS$: 98.80.Es, 04.50.Kd, 04.60.Bc

1 Introduction

In the model of low-energy quantum gravity by the author [1], it is suggested that the background of super-strong interacting gravitons exists with the temperature which is equal to the one of the CMB. If single gravitons are pairing, the pressure of such graviton pairs leads to the attraction of bodies. The Newton law of gravitation is the main consequence of the model. The Newton constant G and the Hubble one H_0 are computable in the model, both of them are statistical quantities. If T is the temperature of the graviton background, then $G \sim T^6$, $H_0 \sim T^5$. Given that deviations of T have the same order of magnitude as for the CMB, we can estimate the precision with which the Newton constant may be measured: $\Delta G/G \sim 6\Delta T/T$. It may explain why the Newton constant cannot be measured with a higher precision than 10^{-4} in ground-based experiments. There are two small effects for photons in the model: the redshift due to forehead collisions with gravitons, and an additional relaxation of a photonic flux due to non-forehead collisions with gravitons. Massive bodies should move with the small anomalous deceleration due to interactions with gravitons.

2 Magnitudes of additional effects of the model

Dealing here with a flat non-expanding universe, we have the geometrical distance/redshift relation:

$$r(z) = \ln(1+z) \cdot c/H_0, \tag{1}$$

where c is the velocity of light, z is a redshift, and the luminosity distance/redshift relation:

$$D_L(z) = c/H_0 \cdot \ln(1+z) \cdot (1+z)^{(1+b)/2}, \tag{2}$$

the "constant" b belongs to the range 0 - 2.137: $b = 2.137$ for very soft radiation (this value is computed), and $b \to 0$ for very hard one. To fit this model, observations should be corrected for no time dilation as: $\mu(z) \to \mu(z) + 2.5 \cdot \lg(1+z)$, where μ is the distance modulus, $\lg x \equiv \log_{10} x$. For a remote region of the universe we may introduce the Hubble parameter $H(z)$ as:

$$dz = H(z) \cdot \frac{dr}{c}, \tag{3}$$

to imitate the local Hubble law; but it does not describe a rate of expansion now. Taking a derivative $\frac{dr}{dz}$, we get in this model:

$$H(z) = H_0 \cdot (1+z). \tag{4}$$

Due to the interaction with gravitons, massive bodies should move with the anomalous deceleration w:

$$w = -w_0 \cdot 4\eta^2 \cdot (1-\eta^2)^{0.5}, \tag{5}$$

where $\eta \equiv v/c$, v is a body velocity relatively to the background, $w_0 \equiv H_0 c = 6.419 \cdot 10^{-10}\ m/s^2$, if we use the theoretical value of H_0 in the model. This deceleration is small enough to preserve the observed stability of an Earth's-like orbit. Initially, the value of it was found with an error, and this effect was connected with the Pioneer anomaly [2].

3 Comparison of the model predictions with observations

The theoretical Hubble diagram of the model with $b = 2.137$ fits supernovae Ia observations very well [3]. This diagram should be the multivalued function of the redshift for soft and hard radiations; perhaps, this feature may be seen for the 44 GRBs data set with the Yonetoku calibration in Fig. 1. GRB observational data with the Yonetoku calibration (44 points) are taken from Table 3 of [4] and corrected for no time dilation. Graphs of $\mu_0(z)$ with $b = 1.11$ (the best fitting value with 87.62% C.L.) and $b = 2.137$ are shown with the same underestimated value of the Hubble constant (due to the overestimation of distance moduli of this data set on ~ 1.18 for the Yonetoku calibration [3]). It is

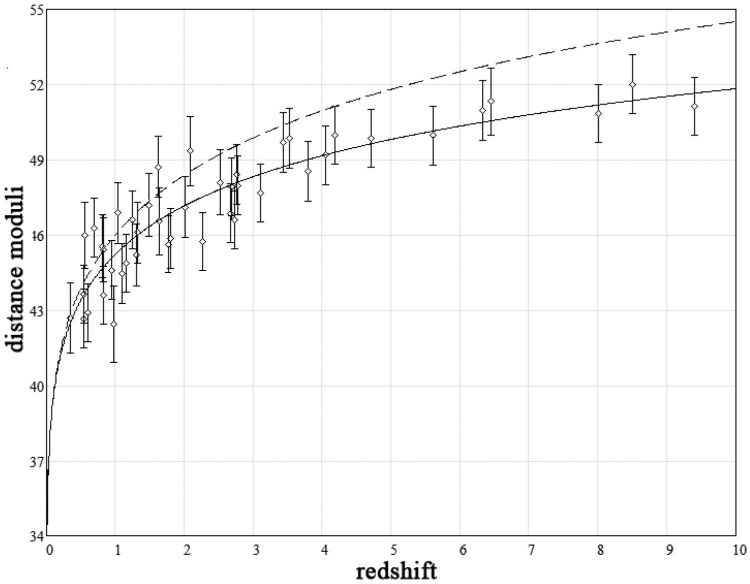

Figure 1: The theoretical Hubble diagram $\mu_0(z)$ of this model with the best fitting value of $b = 1.11$ (solid) and with $b = 2.137$ (dashed); GRB observational data with the Yonetoku calibration (44 points) are taken from Table 3 of [4] and corrected for no time dilation.

interesting, that the Einstein–de Sitter model with $\Omega_M = 1$ bests the $LCDM$ cosmological model in this case with 81.72% C.L.

In the model, we have for the Hubble parameter $H(z)$: $H(z)/(1+z) = H_0$ (the same connection takes place in the constant expansion rate cosmology Rh = ct [5]), that gives a possibility to evaluate the Hubble constant using observed values of the Hubble parameter. The constancy of this ratio is verified up to $z < 2$ with high probability using compilations of $H(z)$ observations [3]. As an example, the comparison of the observed ratio $H(z)/(1+z)$ with the evaluated constant value of H_0 is shown in Fig. 2, where $\sigma_{0i} \equiv \sigma_i/(1+z_i)$, σ_i is the standard deviation of $H(z_i)$; 51 Hubble parameter measurements H(z) are taken from Table 1 of [6]. Taking into account only 48 points with $z < 2$, we have 98.78% C.L. of the constancy of the ratio with the following estimate of H_0: $< H_0 > \pm\sigma_0 = (60.497 \pm 2.54)$ $km\ s^{-1}\ Mpc^{-1}$. The three points with $z = 2.33,\ 2.34,\ 2.36$ have small estimated dispersions and the big influence on the probability of fitting. For the full set of 51 points we have 51.12% C.L. of the constancy of the ratio with the estimate: $< H_0 > \pm\sigma_0 = (61.239 \pm 3.156)$ $km\ s^{-1}\ Mpc^{-1}$. If we consider 49 points (without of two points with $z = 2.34,\ 2.36$), we have 91.01% C.L. of the constancy of the ratio, and $< H_0 > \pm\sigma_0 = (60.751 \pm 2.804)$ $km\ s^{-1}\ Mpc^{-1}$, that is similar to the result for 48 points with $z < 2$. There is an essential difference between all estimated in such the

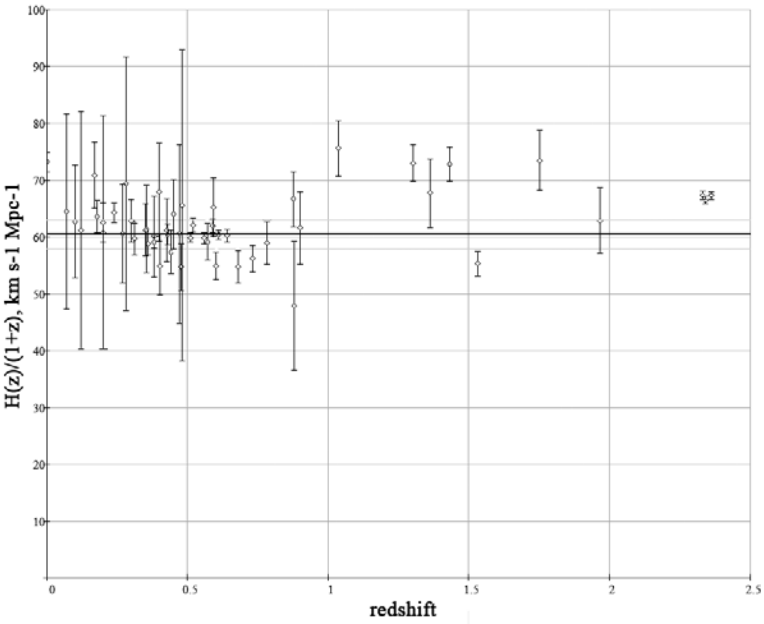

Figure 2: The ratio $H(z_i)/(1+z_i) \pm \sigma_{0i}$ and the weighted value of the Hubble constant $< H_0 > \pm\sigma_0$ (horizontal lines); 51 $H(z)$ observational data points are taken from Table 1 of [6].

manner values of the Hubble constant and its theoretical value in the model: $H_0 = 2.14 \cdot 10^{-18}\ s^{-1} = 66.875\ km \cdot s^{-1} \cdot Mpc^{-1}$.

In a frame of the flat LCDM model, authors of [7] have gotten the estimate: $< H_0 > \pm\sigma = (68.00 \pm 2.20)\ km\ s^{-1}\ Mpc^{-1}$ with statistical and systematic errors, using a subset of 40 points of the considered here data set ($0.070 \leq z \leq 2.33$). In the flat LCDM model, it should be: $H(z)/s(z) = H_0$, where $s(z) \equiv (\Omega_m \cdot (1+z)^3 + (1-\Omega_m))^{0.5}$. To have the same conditions for the comparison, I done calculations with the same definition of χ^2 as in [3], and given $\sigma_{0i} \equiv \sigma_i/s(z_i)$, $\Omega_m = 0.293$ (the best fitting value from [7]). The result is: $< H_0 > \pm\sigma = (68.462 \pm 3.065)\ km\ s^{-1}\ Mpc^{-1}$ for the full subset with 99.75% C.L. of the constancy of the ratio $H(z)/s(z)$, and $< H_0 > \pm\sigma = (68.615 \pm 3.162)\ km\ s^{-1}\ Mpc^{-1}$ with 99.73% C.L. by $z < 2$. Returning to the full set of 51 points, we get in the flat LCDM model: $< H_0 > \pm\sigma = (68.641 \pm 2.776)\ km\ s^{-1}\ Mpc^{-1}$ with 98.85% C.L. of the constancy of the same ratio.

We get in my model the following smaller estimate for this subset of 40 points: $< H_0 > \pm\sigma = (60.566 \pm 3.513)\ km\ s^{-1}\ Mpc^{-1}$ with 79,33% C.L. of the constancy of the ratio $H(z)/(1+z)$. For 39 points of this subset with $0.070 \leq z < 2$ the estimate is: $< H_0 > \pm\sigma = (60.062 \pm 3.041)\ km\ s^{-1}\ Mpc^{-1}$ with 98,20% C.L. The best fitting values of the Hubble constant in the model are more than on 10% smaller than in the case of LCDM due to the fact that the average value of the function $(1+z)/s(z)$ in the range of $z \in [0;\ 2]$ is equal to ~ 1.1 by $\Omega_m \simeq 0.3$ (with the maximum value of this function of 1.153). Probably, the situation will be clearer when $H(z)$ is measured in the range of $z \in (2.1;\ 10)$ where the function $(1+z)/s(z)$ changes from 1 up to 0.55 by $\Omega_m = 0.3$.

4 Conclusion

As it is shown here, the comparable probabilities of fitting may be achieved in the considered model and in the flat LCDM one (with an additional free parameter) to fit observational values of the Hubble parameter up to $z < 2$. It is necessary to re-analyze the used methods of $H(z)$ measurements to understand why measured values of it are noticeably smaller than expected ones in this model by the high probability of the constancy of the observed ratio $H(z)/(1+z)$. For example, the cosmic chronometers method is based on a Friedman-Robertson-Walker metric and the derivative dz/dt, where t is the cosmic time, but in this model we should deal with the derivative dz/dr to measure $H(z)$.

The theoretical Hubble diagram of the model fits observations well enough for SNe Ia data sets. The diagram for hard radiation of long GRBs should have another value of the parameter b, that is, probably, confirmed by the comparison with the long GRBs data set in the Yonetoku calibration.

The considered small local quantum effects of the interaction of photons with gravitons of the background lead to another possibility to interpret cosmological observations: not only without dark energy, but also without a cosmological expansion and the Big Bang. The tentative existence of these tiny effects may change the role of general relativity in cosmology.

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