The quantum nature of gravity seen in cosmological observations

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Abstract

In the author's model of low-energy quantum gravity, the cosmological redshift, additional darkening of distant objects and a diffuse cosmic optical background, presumably detected by the New Horizons mission, can be interpreted, without cosmological expansion and dark energy, as a result of the scattering of photons on superstrongly interacting background gravitons. The constancy of the ratio $H(z)/(1+z)$ in this model is consistent with observations of the Hubble parameter $H(z)$. There is a possibility of interpreting dark matter as a gas of virtual massive gravitons.

1 Introduction

The discovery of electron diffraction led to the need to formulate quantum mechanics. Hubble's law, formulated around the same time, opened the way for models of an expanding universe in which the cosmological redshift is not related to quantum physics. But in the model of low-energy quantum gravity by the author [1, 2] the cosmological redshift has namely the quantum and local interpretation. Together with additional dimming of distant objects, it results from scattering of photons on super-strong interacting gravitons of the background. Gravity is considered as the screening effect of bodies in this background having the same temperature as CMB. The theoretical Hubble diagram of the model fits observations very well without dark energy. The Hubble parameter $H(z)$ is a linear function of z that is consistent with observations. These small effects are described here and confronted with cosmological observations.

2 Some small effects of low-energy quantum gravity

Energy losses of photons only due to forehead collisions with gravitons of the background give the following geometrical distance/redshift relation:

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

where H_0 is the Hubble constant, c is the velocity of light. Then the Hubble parameter $H(z)$ in this model without the cosmological expansion can be defined as:

$$H(z) \equiv \frac{dz}{dr} \cdot c = H_0 \cdot (1+z). \tag{2}$$

The last formula gives us a possibility to evaluate the Hubble constant using observed values of the Hubble parameter $H(z)$ from [3]. Considering Eq. (2) as a base for indirect measurements of H_0, we get for the dispersion σ_{0i}^2 of H_0 points: $\sigma_{0i}^2 = \sigma_i^2/(1+z_i)^2$. Then we shall have for the considered data set [4]: $< H_0 > \pm\sigma_0 = (63.152 \pm 4.689)\ km \cdot s^{-1} \cdot Mpc^{-1}$. The value of χ^2 is now equal to 38.56. By 40 degrees of freedom of this data set, it means that the hypothesis described by Eq. (2) cannot be rejected with 53.511% C.L. The weighted average value of the Hubble constant with $\pm\sigma_0$ error bars are shown in Fig. 1 as horizontal lines; observed values of the ratio $H(z)/(1+z)$ with $\pm\sigma_{0i}$ error bars are shown in Fig. 1, too (points). Such a large value of χ^2 is mainly due to the fact that the last three points with $z > 2$ in Fig. 1 have small σ_{0i}; without them $\chi^2 = 24,857$, which gives 93,633% C.L. for 37 degrees of freedom and $< H_0 > \pm\sigma_0 = (61.216 \pm 4.591)\ km \cdot s^{-1} \cdot Mpc^{-1}$.

Both forehead and non-forehead collisions with gravitons give the luminosity distance/redshift relation:

$$D_L(z) = c/H_0 \cdot \ln(1+z) \cdot (1+z)^{(1+b)/2}, \tag{3}$$

where the parameter b belongs to the range 0 - 2.137 ($b = \frac{3}{2} + \frac{2}{\pi} \simeq 2.137$ for very soft radiation, 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 $\lg x \equiv \log_{10} x$, and the distance modulus: $\mu(z) \equiv 5lgD_L(z)(Mpc) + 25$. In [4], I have used 31 binned points of the JLA compilation from Tables F.1 and F.2 of [5] (diagonal elements of the correlation matrix in Table F.2 are dispersions of distance moduli). Varying the value of b, we find the best fitting value of this parameter: $b = 2.365$ with $\chi^2 = 30.71$. It means that the best fitting has 43.03% C.L. This value of b is 1.107 times greater than the theoretical one. For the Hubble constant we have in this case: $< H_0 > \pm\sigma_0 = (69.54 \pm 1.58)\ km \cdot s^{-1} \cdot Mpc^{-1}$. Results of the best fitting are shown in Fig. 2.

After non-forehead collisions, scattered photons should create the light-from-nowhere effect which has not an analog in the standard cosmological model. The ratio $\delta(z)$ of the scattered flux to the remainder reaching the observer is equal to:

$$\delta(z) = (1+z)^b - 1. \tag{4}$$

By $b = 2.137$ we have, for example: $\delta(0.4) = 1.05$, i.e. this effect is big enough to explain a tentative detection of a diffuse cosmic optical background [6].

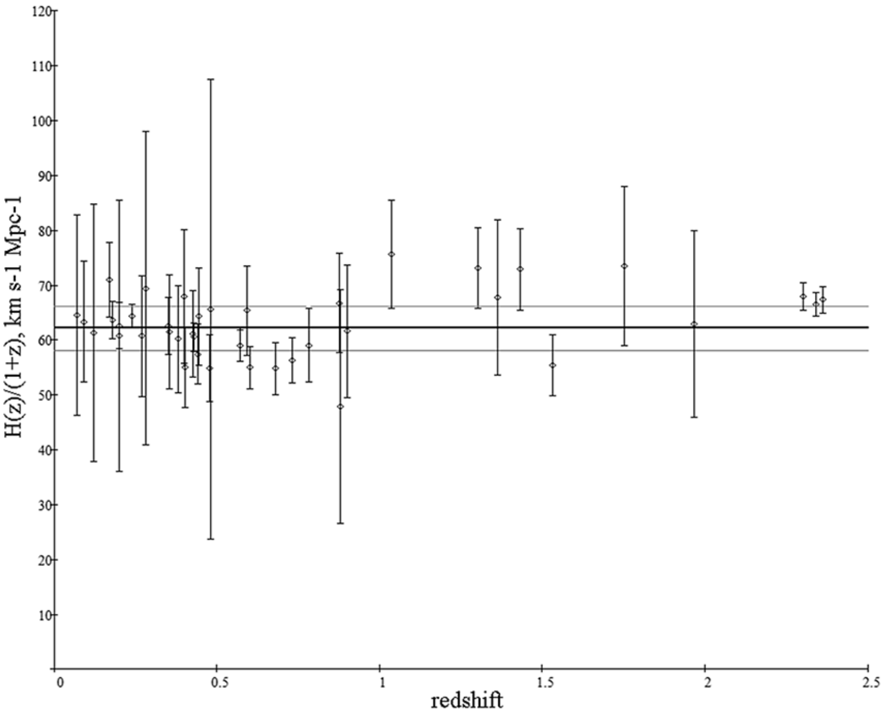

Figure 1: The ratio $H(z_i)/(1+z_i) \pm \sigma_{0i}$ and the weighted value of the Hubble constant $< H_0 > \pm\sigma_0$ (horizontal lines). Observed values of the Hubble parameter $H(z_i)$ (40 points) are taken from Table 1 of [3].

3 Virtual massive gravitons as dark matter particles

Unlike models of expanding universe, in this model a problem of utilization of energy, lost by radiation of remote objects, exists (see [2], chapter 2). A virtual graviton forms under collision of a photon with a graviton of the graviton background. It should be massive if an initial graviton transfers its total momentum to a photon; it follows from the energy conservation law that its energy $\epsilon^{'}$ must be equal to 2ϵ if ϵ is an initial graviton energy. By force of the uncertainty relation, one has for a virtual graviton lifetime $\tau : \tau \leq \frac{\hbar}{\epsilon^{'}}$, i.e. for $\epsilon^{'} \sim 10^{-3} eV$ it is $\tau \leq 10^{-12} s$. By force of conservation laws for energy, momentum and angular momentum, the virtual graviton may decay into no less than three real gravitons. In a case of decay into three gravitons, their energies should be equal to $\epsilon, \epsilon^{''}, \epsilon^{'''}$, with $\epsilon^{''} + \epsilon^{'''} = \epsilon$. So, after this decay, two new gravitons with $\epsilon^{''}, \epsilon^{'''} < \epsilon$ inflow into the graviton background. It is a source of refilling the graviton background. Collisions of gravitons with massive bodies, leading to their deceleration [4], should provide the bulk of this replenishment.

From another side, a self-interaction of gravitons of the background should also lead to the formation of virtual massive gravitons with energies less than ϵ_{min} where ϵ_{min} is a minimal energy of gravitons of an interacting pare. If

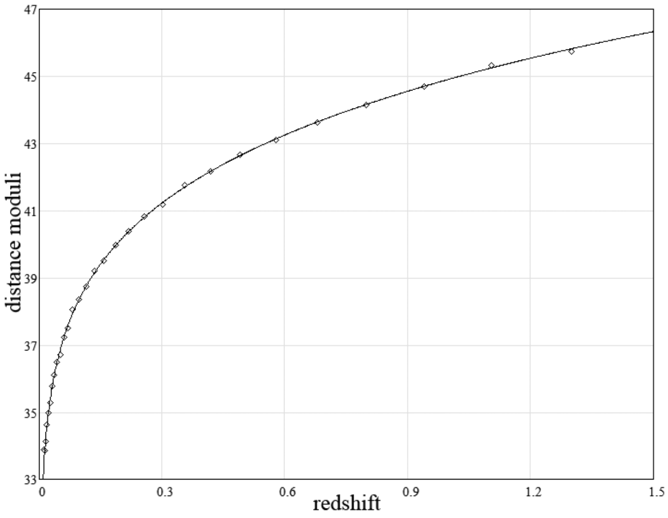

Figure 2: The theoretical Hubble diagram $\mu_0(z)$ of this model with $b = 2.365$ (solid); Supernovae 1a observational data (31 binned points of the JLA compilation) are taken from Tables F.1 and F.2 of [5] and corrected for no time dilation.

gravitons with energies $\epsilon^{''}, \epsilon^{'''}$ experience a series of collisions with gravitons of the background, their lifetime should increase. In every such a cycle collision-decay, an average energy of "redundant" gravitons will double decrease, and its lifetime will double or more increase. Only for ~ 93 cycles, a lifetime will have increased from $10^{-12}s$ to as minimum 1 Gyr. Such virtual massive gravitons, with the lifetime increasing from one collision to another, would be ideal dark matter particles. The ones will not interact with matter in any manner except usual gravitation. The ultracold gas of such gravitons will condense under the influence of gravitational attraction. In addition, even in the absence of the initial inhomogeneity in such the gas, it will easily arise. It is a way of cooling the graviton background.

The model of the composite fundamental fermions by the author [7] has all symmetries of the standard model of elementary particles on global level. Possibly virtual gravitons with very low masses are quite acceptable for the role of components of such the fermions.

4 Conclusion

The considered quantum effects are beyond the scope of the standard cosmological model. These small effects can describe cosmological observations in a very elegant and unified manner without cosmological expansion, dark energy, inflation, and the Big Bang. If the discovery of a diffuse cosmic optical background by the New Horizons mission [6] is confirm by future missions, it will be a big puzzle for the standard cosmological model. The described possibility of interpreting dark matter as a gas of virtual massive gravitons, which cannot be detected, but can be the foremother for all visible matter, seems attractive.

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