How to verify the redshift mechanism of low-energy quantum gravity

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Abstract: In the model of low-energy quantum gravity by the author, the redshift mechanism is quantum and local, and it is not connected with any expansion of the Universe. A few possibilities to verify its predictions are considered here: the specialized ground-based laser experiment; a deceleration of massive bodies and the Pioneer anomaly; a non-universal character of the Hubble diagram for soft and hard radiations; galaxy/quasar number counts.

1. Introduction

Many people consider the discovery of dark energy to be the main finding of present cosmology. They are sure that an existence of dark energy has been proved with observations of new, precise, era of cosmology, and it is necessary only to clarify what it adds up. Because of this, new cosmological centers are created and addicted to this main goal. It seems to me that a new scientific myth has risen in our eye; it is nice, almost commonly accepted, with global consequences for physics, but it is really based on nothing. What was a base for its rising? In 1998, two teams of astrophysicists reported about dimming remote SN 1a [1,2]; the one cannot be explained in the standard cosmological model on a basis of the Doppler effect if the universe expands with deceleration. Their conclusion that the Universe expands with acceleration since some cosmological time served a base to endenizen dark energy. But this conclusion is not a single possible one; if the model does not fit observations, probably, the one may simply be wrong.
If we stay on such the alternative point of view, what should namely be doubt in the standard cosmological model? I think that it should be at first its main postulate: a red shift is caused with an expansion of the Universe. If this postulate is wrong, then the whole construction of the model will wreck: neither the Big Bang nor inflation, nor a temp or character of expansion would not be interested. In the model of low-energy quantum gravity by the author [3], the alternative redshift mechanism is quantum and local. I review here a few possibilities to verify its predictions.

2. Possibilities to verify the alternative redshift mechanism

In my model [3], any massive body must experience a constant deceleration $w \approx -Hc$, where H is the Hubble constant and c is the light velocity, of the same order of magnitude as observed for NASA deep-space probes Pioneer 10/11 (the Pioneer anomaly) [4,5]. This effect is an analogue of cosmological redshifts in the model. Their common nature is forehead collisions with gravitons. If my conjecture about the quantum nature of this acceleration is true then an observed value of the projection of the probe's acceleration on the sunward direction w_s should depend on accelerations of the probe, the Earth and the Sun relative to the graviton background. It would be very important to confront the considered model with observations for small distances when Pioneer 11 executed its planetary encounters with Jupiter and Saturn. In this period, *the projection of anomalous acceleration may change its sign* [6].
How to verify the main conjecture of this approach about the quantum gravitational nature of redshifts in a ground-based laser experiment? If the temperature of the background is $T = 2.7K$, the tiny satellite of main laser line of frequency ν after passing the delay line will be red-shifted at $\approx 10^{-3}$ eV/h and its position will be fixed [7]. It will be caused by the fact that on a very small way in the delay line only a small part of photons may collide with gravitons of the background. The rest of them will have unchanged energies. The center-of-mass of laser radiation spectrum should be shifted proportionally to a photon path l. Then due to the quantum nature of shifting process, the ratio of satellite's intensity to main line's intensity should have the order: $\sim (h\nu/\bar{\varepsilon})(H/c)l$, where $\bar{\varepsilon}$ is an average graviton energy. An instability of a laser of a power P should be only $\approx 10^{-3}$ if a photon energy is of $\approx$ 1eV. It will be necessary to compare intensities of the red-shifted satellite at the very beginning of the path l and after it. Given a very low signal-to-noise ratio, one could use a single photon counter to measure the intensities.

When q is a quantum output of a cathode of a used photomultiplier, N_n is a frequency of its noise pulses, and n is a desired ratio of a signal to noise's standard deviation, then an evaluated time duration t of data acquisition would have the order: $t = (\bar{\varepsilon}^2 c^2/H^2)(n^2 N_n/q^2 P^2 l^2)$. Assuming $n = 10, N_n = 10^3\ s^{-1}, q = 0.3, P = 100\ mW, l = 100\ m,$ we would have the estimate: $t = 200,000$ years, that is unacceptable. But given $P = 300\,W$, we get: $t\ \approx 8$ days, that is acceptable for the experiment of such the potential importance. Of course, one will rather choose a bigger value of l by a small laser power forcing a laser beam to whipsaw many times between mirrors in a delay line - it is a challenge for experimentalists. Maybe, it will be more convenient to work with high-energy gamma rays to search for this effect in a manner similar to the famous Pound-Rebka experiment [8].
The luminosity distance in this model is [3]: $D_L = a^{-1}\ln(1+z)\cdot(1+z)^{(1+b)/2}$, where $a = H/c$, z is a redshift. The theoretical value of relaxation factor b has been found in the assumption that in any case of a non-forehead collision of a graviton with a photon, the latter leaves a photon flux detected by a remote observer: $b = 2.137$. It is obvious that this assumption should be valid for a soft radiation when a photon deflection angle is big enough and collisions are rare. It is easy to find a value of the factor b in another marginal case - for a very hard radiation. Due to very small ratios of graviton to photon momenta, photon deflection angles will be small, but collisions will be frequent because the cross-section of interaction is a bilinear function of graviton and photon energies in this model. It means that in this limit case $b \to 0$. For an arbitrary source spectrum, a value of the factor b should be still computed, and it will not be a simple task. It is clear that $0 \le b \le 2.137$, and in a general case it should depend on a rest-frame spectrum and on a redshift. It is important that the Hubble diagram is a multivalued function of a redshift: *for a given* z, b *may have different values.* Theoretical distance moduli $\mu_0(z) = 5\log D_L + 25$ are shown in Fig. 1 for $b = 2.137$ (solid), $b = 1$ (dot) and $b = 0$ (dash) [9]. If this model is true, all observations should lie in the stripe between lower and upper curves. For Fig. 1, supernova observational

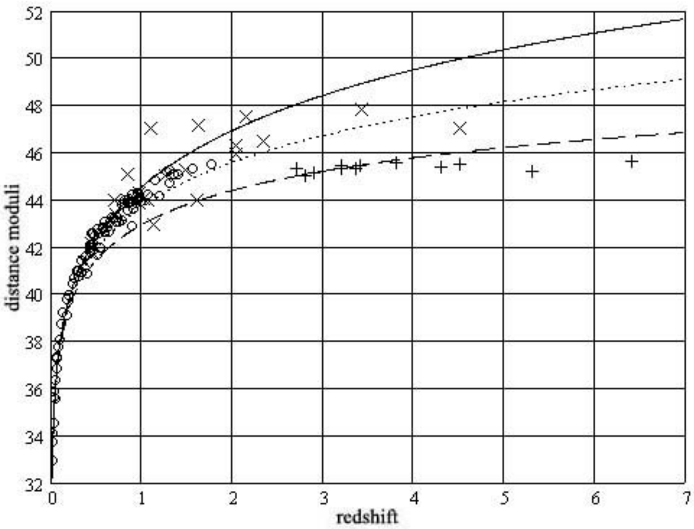

Fig. 1. Hubble diagrams $\mu_0(z)$ with $b = 2.137$ (solid), $b = 1$ (dot) and $b = 0$ (dash); supernova observational data (circles, 82 points) are taken from Table 5 of [10], gamma-ray burst observations are taken from [11] (x, 24 points) and from [12] (+, 12 points for $z > 2.6$).

data (circles, 82 points) are taken from Table 5 of [10], gamma-ray burst observations are taken from [11] (x, 24 points) and from [12] (+, 12 points for $z > 2.6$). As it was recently shown by Cuesta et al. [13], the Hubble diagram with $b = 1$ (in the language of this paper) gives the best fit to the full sets of gamma-ray burst observations of [11,12] and it takes place in the standard FLRW cosmology plus the strong energy condition. Twelve observational points of [12] belong to the range $z > 2.6$, and one can see that these points peak up the curve with $b = 0$ which corresponds in this model to the case of very hard radiation in the non-expanding Universe with a flat space. In a frame of models without expansion, any red-shifted source may not be brighter than it is described with this curve.

In this model, the galaxy number counts/magnitude relation is [14]: $f_3(m) = (\phi_* \kappa / a^3) \cdot m \cdot \int_0^{z_{max}} l^{\alpha+1}(m,z) \cdot \exp(-l(m,z)) \cdot (ln^2(1+z)/(1+z))dz$. To compare this function with observations by Yasuda et al. [15], let us choose the normalizing factor from the condition: $f_3(16) = a(16)$, where $a(m) \equiv A_\lambda \cdot 10^{0.6(m-16)}$ is the function assuming "Euclidean" geometry and giving the best fit to observations [15], $A_\lambda = const$ depends on the spectral band; an upper limit is $z_{max} = 10$. In this case, we have two free parameters - α and L_* - to fit observations, and the latter one is connected with a constant $A_1 \equiv A/a^2 L_*$ if $l(m,z) = A_1 f_1^2(z)/\kappa^m$. We have for A_1 by $H = 2.14 \cdot 10^{-18} s^{-1}$ (it is a theoretical estimate of H in this model [3]): $A_1 \approx 5 \cdot 10^{17} \cdot (L_\odot / L_*)$, where $L_\odot$ is the Sun luminosity. Matching values of α shows that $f_3(m)$ is the closest to $a(m)$ in the range $10 < m < 20$ by $\alpha = -2.43$. The ratio $(f_3(m) - a(m))/a(m)$ is shown in Fig. 2 for different values of A_1 by this value of

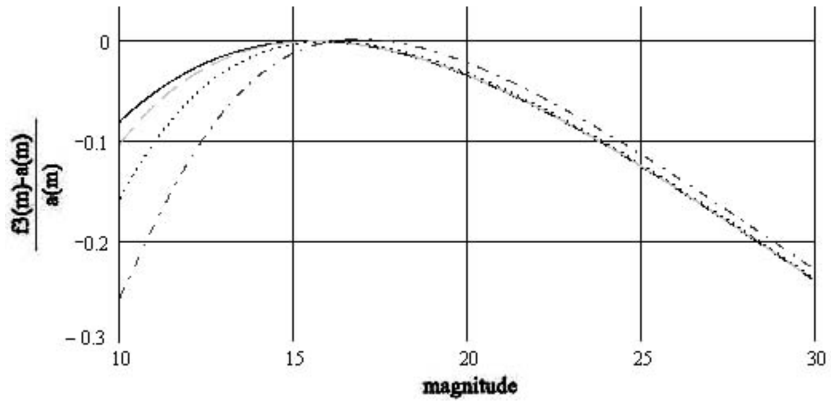

Fig. 2. The relative difference $(f_3(m) - a(m))/a(m)$ as a function of the magnitude m for $\alpha = -2.43$ by $10^{-2} < A_1 < 10^2$ (solid), $A_1 = 10^4$ (dash), $A_1 = 10^5$ (dot), $A_1 = 10^6$ (dadot).

α. If we compare this figure with Figs. 6,10,12 from [15], we see that the considered model provides a no-worse fit to observations than the function $a(m)$ if the same K-corrections are added for the range $10^2 < A_1 < 10^7$ that corresponds to $5 \cdot 10^{15} > L_* > 5 \cdot 10^{10}$. *Observations prefer a rising behavior of this ratio up to* $m = 16$, *and the model demonstrates it.*

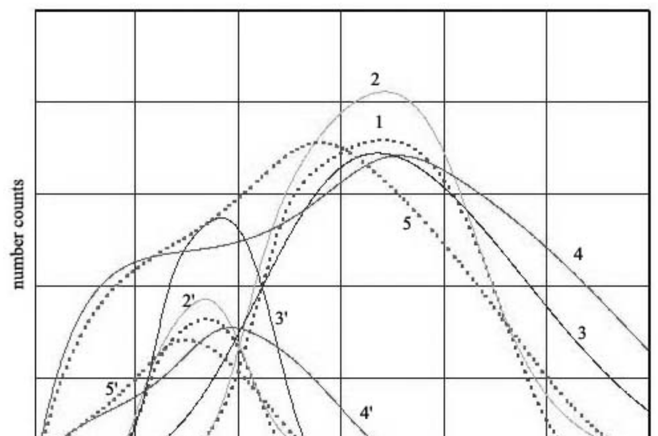

Fig. 3. QSO number counts $f_5(m,z)$ (arbitrary units) as a function of the redshift for different luminosity functions: Gaussian (1', 1 dot), the double power law (2', 2), Schechter's (3', 3), combined (4', 4 solid and 5', 5 dot) with parameters given in the text of [14]. The left-shifted curve of each couple (1' - 5') corresponds to the range $16 < m < 18.25$, another one (1 - 5) corresponds to $18.25 < m < 20.85$.

For quasars, I computed the galaxy number counts/redshift relation $f_5(m,z)$ with a different (than for galaxies) luminosity function $\eta\,'(l(m,z))$ [14]. In Fig 3, there are a couple of curves for each case: the left-shifted curve of any couple (1' - 5') corresponds to the range $16 < m < 18.25,$ another one (1 - 5) corresponds to $18.25 < m < 20.85.$ These ranges are chosen the same as in the paper by Croom et al. [16], and you may compare this figure with Fig. 3 in [16]. We can see that the theoretical distributions reflect only some features of the observed ones but not an entire picture. Perhaps, it is necessary to consider some theoretical model of a quasar activity to get a distribution of "instantaneous" luminosities (a couple of simple examples is considered in [14]).

3. Conclusion

One can verify the quantum and local redshift mechanism of this model in different ways, but I think that the most cogent one would be the described prompt measurement of a possible length-dependent red shift of radiation spectrum in the laboratory experiment. A negative result of this experiment would be a very strong support of the standard cosmological model; a positive one might open the door not only for new cosmology, but for otherwise quantum gravity, too.

References

[1] Riess, A.G. et al. *AJ* 1998, , 1009.
[2] Perlmutter, S. et al. *ApJ* 1999, , 565.
[3] Ivanov, M.A. In the book "Focus on Quantum Gravity Research", Ed. D.C. Moore, Nova Science, NY, 2006, pp. 89-120; [hep-th/0506189], [http://ivanovma.narod.ru/nova04.pdf].
[4] Anderson, J.D. et al. *Phys. Rev. Lett.* 1998, , 2858.
[5] Anderson, J.D. et al. *Phys. Rev.* 2002, *D65*, 082004; [gr-qc/0104064 v4].
[6] Ivanov, M.A. [arXiv:0711.0450v2] [physics.gen-ph].
[7] Ivanov, M.A. [gr-qc/0410076].
[8] Pound, R. V.; Rebka Jr., G. A. *Phys. Rev. Lett.* 1959, , 439; 1960, , 337.
[9] Ivanov, M.A. [astro-ph/0606223].
[10] Riess, A.G. et al. *ApJ*, 2004, , 665; [astro-ph/0402512].
[11] Bloom, J.S., Frail, D.A., and Kulkarni, S.R. *ApJ*, 2003, , 674.
[12] Schaefer, B.E. *BAAS*, 2005, , 1418; 207 AAS Meeting, 2006.
[13] Cuesta, H.J.M. et al. [astro-ph/0609262].
[14] Ivanov, M.A. [astro-ph/0606223].
[15] N. Yasuda et al., *AJ* 2001, , 1104.
[16] Croom, S.M. et al. MNRAS, 2004, 349, 1397.