Deceleration of massive bodies due to forehead and backhead collisions with gravitons

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Abstract

The additional deceleration of massive bodies in the model of low-energy quantum gravity due to forehead and backhead collisions with gravitons is re-calculated in this note. It is shown that this deceleration w is equal to: $w = -H_0 c \cdot 4v^2/c^2 \cdot (1 - v^2/c^2)^{0.5}$, where H_0 is the Hubble constant, c is the velocity of light, v is the body's velocity relative to the background.

1 Introduction

In the model of low-energy quantum gravity by the author which is based on the conjecture of an existence of the graviton background with the average graviton energy of the order of 10^{-3} eV [1], redshifts of remote objects and the additional dimming of them may be interpreted without any expansion of the Universe [2]. Also in the model we have for the Hubble parameter $H(z)$: $H(z) = H_0\ (1 + z)$, where H_0 is the Hubble constant, z is the redshift; this dependence fits observational data of $H(z)$ with high probability [2].

Due to forehead collisions of a massive body with gravitons, the body acceleration w by a non-zero velocity v had been found [1] to be equal to:

$$w = -cH_0(1 - v^2/c^2), \tag{1}$$

where c is the velocity of light. The value of w by small velocities: $|w|$ $Hc = 6.419 \cdot 10^{-10}\, m/s^2$ has the same order of magnitude as a value of the observed additional acceleration $(8.74 \pm 1.33) \cdot 10^{-10} m/s^2$ for NASA probes (the Pioneer anomaly) [3], and it seemed to me that this effect namely of such the magnitude may explain the Pioneer anomaly. But recently it was shown in [4] that this value is too large to provide, for example, the observed stability of the Earth-like orbit. Here I would like to re-analyze this problem.

2 Forehead and backhead collisions of a body with gravitons

Dependence (1) has been gotten starting from the equation:

$$dE = -(H_0/c)Edr, \tag{2}$$

describing average energy losses of a photon (or a body, as it was supposed in [1]) with an energy E on a way dr. While for a photon its momentum p and energy E are proportional, for massive bodies it is not so. A transferred quantity by collisions is the momentum, and we should express its differential dp before calculations of the body deceleration:

$$dp = -(H_0/c^2)Edr. \tag{3}$$

Besides of forehead collisions, the body should also experience backhead collisions with gravitons; it means that for massive bodies we can write the following similar expression:

$$dp = -(H_{0f}/c^2 - H_{0b}/c^2)Edr, \tag{4}$$

where H_{0f} and H_{0b} correspond to forehead and backhead collisions with gravitons. This equation is written in the CMB frame K, in which the CMB is isotropic - in the sense that deviations from the isotropy cannot be made smaller in any other frame. We shall use here also the rest frame of the body K', which moves relatively K with the velocity v.

The Doppler effect should lead to the different values of energies of gravitons which are incident from the front and from the back in K'. We can find the difference of H'_{0f} and H'_{0b} in K' and re-calculate it for K. So as H_{0f}, H_{0b} and H'_{0f}, H'_{0b} have the same dimensions as Δt^{-1} and $\Delta t'^{-1}$, where Δt and $\Delta t'$ are the time intervals between two events in these frames, we have:

$$H_{0f} - H_{0b} = (H'_{0f} - H'_{0b}) \cdot (1 - \eta^2)^{0.5}, \tag{5}$$

where $\eta \equiv v/c$.

If $\kappa \equiv \epsilon'/\epsilon$ is the ratio of new and old (in K' and K) energies of gravitons falling on the body from the front or from the back, and κ is the same for each graviton, their spectrum $f_1(\epsilon)$ in K' may be presented as:

$$f_1(\epsilon) = f(\epsilon/\kappa, T) = (1/\kappa^3) \cdot f(\epsilon, \kappa T),$$

where $f(\epsilon, T)$ is the Planck spectrum in K by the temperature T, ϵ is the graviton energy. This spectrum is a result of the stretching/compression of the Planck spectrum by the same temperature T along the ϵ axis in κ times. For gravitons which are incident from the front (κ_f) and from the back (κ_b) in K', we have:

$$\kappa_f = \left(\frac{1+\eta}{1-\eta}\right)^{0.5}, \kappa_b = \left(\frac{1-\eta}{1+\eta}\right)^{0.5}. \tag{6}$$

In this model, the Hubble constant is equal to:

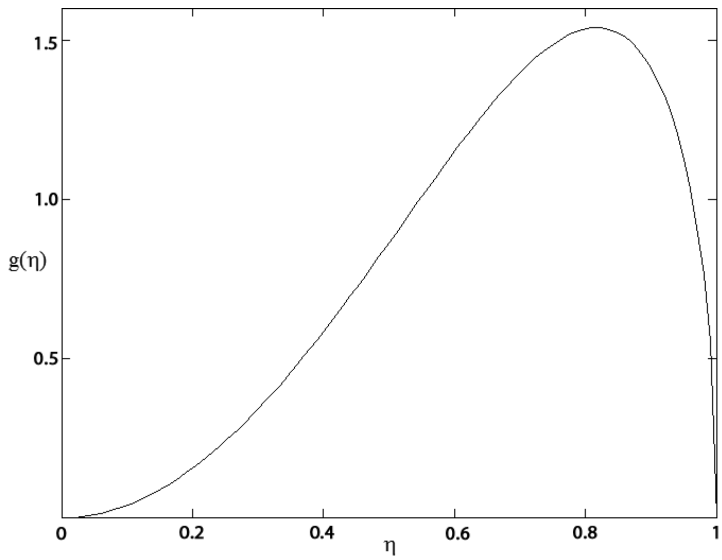

Figure 1: The graph of the function $g(\eta)$.

$$H_0 = \frac{1}{2\pi}\int_0^{\infty} \hbar\omega \boldsymbol{f}(\omega, T)d\omega = \frac{1}{2\pi}D \cdot \bar{\epsilon} \cdot (\sigma T^4),$$

where D is a constant, $\bar{\epsilon}$ is an average graviton energy, σ is the Stephan-Boltzmann constant, and $\epsilon = \hbar\omega$. Replacing $\boldsymbol{f}(\omega, T) \rightarrow \boldsymbol{f}_1(\omega)$, we have: $\bar{\epsilon} \rightarrow \kappa \cdot \bar{\epsilon}, \sigma T^4 \rightarrow \kappa \cdot \sigma T^4$. As a result we get:

$$H'_{0f} = \kappa_f^2 \cdot H_0 = H_0 \cdot (1 + \eta/1 - \eta), \quad (7)$$

$$H'_{0b} = \kappa_b^2 \cdot H_0 = H_0 \cdot (1 - \eta/1 + \eta). \quad (8)$$

Then we can rewrite Eq.(4) as:

$$dp = -(H_0/c^2)(\kappa_f^2 - \kappa_b^2) \cdot (1 - \eta^2)^{0.5} E dr = -(H_0/c^2) \cdot 4\eta(1 - \eta^2)^{-0.5} E dr. \quad (9)$$

Taking into account that by $\mathbf{v} \| \mathbf{w}$, where $\mathbf{w} \equiv d\mathbf{v}/dt$, dp/dt is equal to:

$$dp/dt = mw \cdot (1 - \eta^2)^{-1.5}, \quad (10)$$

and $E = mc^2 \cdot (1 - \eta^2)^{-0.5}$, $dr = vdt$, we get finally for the deceleration w:

$$w = -w_0 \cdot 4\eta^2 \cdot (1 - \eta^2)^{0.5}, \quad (11)$$

where $w_0 \equiv H_0 c = 6.419 \ 10^{-10} \ m/s^2$, if we use the theoretical value of H_0 in the model. For small velocities we have now:

$$w \quad -w_0 \cdot 4\eta^2. \quad (12)$$

The function $g(\eta) \equiv 4\eta^2\ (1 - \eta^2)^{0.5}$ in Eq. (11) has the maximum value of 1.54 by $\eta = (2/3)^{0.5} = 0.816$, i.e. the maximum deceleration is equal to: $|w|_{max} = 1.54 \cdot w_0$. The graph of this function is shown in Fig. 1. As it was shown in [4], by $|w| \sim 10^{-4} \cdot w_0$ the stability of the Earth-like orbit will be high enough. By $v = 4 \cdot 10^5$ m/s we have now: $w\ -7 \cdot 10^{-6} \cdot w_0$.

3 Conclusion

Found expression (12) for the anomalous deceleration of massive bodies in the case of small velocities should ensure a sufficient stability of the Earth-like orbits. It is planned to model numerically a modification of dynamics due to it soon.

At present, the main conjecture of this approach about the quantum gravitational nature of redshifts may be verified in a ground-based laser experiment if advanced LIGO technologies will be partly used [2]. The Hubble diagram of sources with hard and soft spectra may differ in the model (for example, the diagram for GRBs may differ from the one for SNe Ia), and some signs of this difference are seen, perhaps, in the case of the long GRBs data set [2].

References

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