低能量量子重力与宇宙学
没有暗能量

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April 19, 2018

摘要

低能量的量子重力模型导致一些额外的效应，这些效应对宇宙学具有重要的后果：遥远物体的红移和额外的变暗可能被解释为宇宙的膨胀和没有暗能量。模型的理论光度距离与观测的哈勃图对大信心水平拟合。在模型中，比例$H(z)/(1 + z)$应该等于哈勃常数。这个比例的恒定性通过拟合哈勃图观测值得到了高概率的证实。

一个由于额头和后脑的碰撞而加速的物体的惯性质量与引力质量的差异被重新计算了。

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

1 介绍

在我低能量量子重力模型中，引力被认为是屏蔽效果。建议在宇宙中存在一个超级强相互作用的引力子背景。该背景的温度应该与CMB的温度相等。屏蔽该背景可以为任意一组物体创建吸引和排斥力，由于单个引力子的压力。对于单个引力子，这些力是约略平衡的，但每个力都远大于牛顿引力。如果单个引力子成对，那么由于引力子对的碰撞而产生的吸引力是相应排斥力的两倍。这种量子机制的特殊性导致了黑洞的惯性质量和引力质量的差异。在这种模型中，牛顿常数与哈勃常数有关，这使得可以得到一个理论估计。我们在这里处理一个平坦的非膨胀宇宙。
fulfilled with super-strong interacting gravitons; it changes the meaning of the Hubble constant which describes magnitudes of three small effects of quantum gravity but not any expansion or an age of the universe.

In this model, the geometrical distance/redshift relation is:

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

where $H_0$ is the Hubble constant, $c$ is the velocity of light, $z$ is a redshift. The luminosity distance/redshift relation has the view:

$$D_L(z) = c/H_0 \cdot \ln(1 + z) \cdot (1 + z)^{(1+b)/2} \equiv c/H_0 \cdot f_1(z),$$

where $f_1(z) \equiv \ln(1 + z) \cdot (1 + z)^{(1+b)/2}$; the "constant" $b$ belongs to the range 0 - 2.137 ($b = 2.137$ for very soft radiation, and $b \to 0$ for very hard one).

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

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:

$$w = -cH_0(1 - v^2/c^2).$$

But recently it was shown in [3] 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.

The dependencies (1) and (3) have been gotten starting from the equation:

$$dE = -(H_0/c) Edr,$$

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:

$$dp = -(H_0/c^2) Edr.$$
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 $H_0^f$ and $H_0^b$ in $K'$ and re-calculate it for $K$. So as $H_0^f, H_0^b$ and $H_0^f', H_0^b'$ have the same dimensions as $\Delta t^{-1}$ and $\Delta t'^{-1}$, where $\Delta t$ and $\Delta t'$ are the time intervals between two events in these frames, we have:

$$H_0^f - H_0^b = \left(H_0^f - H_0^b\right) \cdot (1 - \eta^2)^{0.5},$$  \hspace{1cm} (7)

where $\eta \equiv v/c$.

Because the number of gravitons (per unit of surface area per unit of time) falling on the body from the front or from the back is the same in $K'$ as in $K$, their spectrum $f_1(\epsilon)$ in $K'$ may be presented as:

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

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

$$\kappa_f = \left(\frac{1 + \eta}{1 - \eta}\right)^{0.5}, \kappa_b = \left(\frac{1 - \eta}{1 + \eta}\right)^{0.5}. \hspace{1cm} (8)$$

In this model, the Hubble constant is equal to:

$$H_0 = \frac{1}{2\pi} \int_0^\infty h_0 f(\omega, T) d\omega = \frac{1}{2\pi} D \cdot \bar{\epsilon} \cdot (\sigma T^4),$$
where $D$ is a constant, $\bar{\epsilon}$ is an average graviton energy, $\sigma$ is the Stephan-Boltzmann constant, and $\epsilon = \hbar \omega$. Replacing $f(\omega, T) \rightarrow f_1(\omega)$, we have:

$$ f \rightarrow \kappa \cdot \bar{\epsilon}, \sigma T^4 \rightarrow \kappa \cdot \sigma T^4. $$

As a result we get:

$$ H'_{0f} = \kappa^2 f \cdot H_0 = H_0 \cdot (1 + \eta/1 - \eta), \quad \epsilon_{\bar{h}} = \kappa^2 f \cdot H_0 = H_0 \cdot (1 - \eta/1 + \eta). $$

Then we can rewrite Eq.(6) as:

$$ dp = -(H_0/c^2)(\kappa_f^2 - \kappa_0^2) \cdot (1 - \eta^2)^{0.5} Edr = -(H_0/c^2) \cdot 4\eta(1 - \eta^2)^{-0.5} Edr. $$

Taking into account that by $v \parallel w$, where $w \equiv dv/dt$, $dp/dt$ is equal to:

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

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

$$ w = -w_0 \cdot 4\eta^2 \cdot (1 - \eta^2)^{0.5}, \quad \text{(13)} $$

where $w_0 \equiv H_0c = 6.419 \cdot 10^{-10}$ m/s$^2$, if we use the theoretical value of $H_0$ in the model. For small velocities we have now:

$$ w \simeq -w_0 \cdot 4\eta^2. \quad \text{(14)} $$

The function $g(\eta) \equiv 4\eta^2 \cdot (1 - \eta^2)^{0.5}$ in Eq. (13) has the maximum value of 1.54 by $\eta = (2/3)^{0.5} = 0.816$, i.e. the maximum deceleration is equal to: $|w|_{\text{max}} = 1.54 \cdot w_0$. The graph of this function is shown in Fig. 1. As it was shown in [3], 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: $w \simeq -7 \cdot 10^{-6} \cdot w_0$. The numerical calculations of [3] with the new formula for $w$ will be repeated soon.

The mass discrepancy in spiral galaxies is observed at very low accelerations less than $\sim 10^{-10}$ m/s$^2$ [4], i.e. this boundary acceleration has almost the same order of magnitude as the maximum deceleration $|w|_{\text{max}} \sim 10^{-9}$ m/s$^2$ in the model. Now it is unclear may these quantities be connected between themselves or not.

## 3 The Hubble diagram of this model

To fit this model, observations should be corrected for no time dilation as: $\mu(z) \rightarrow \mu(z) + 2.5 \cdot \log(1 + z)$, where $\log x \equiv \log_{10} x$. In my paper [5], results of fitting the Hubble diagram for different data sets of remote objects with the model of low-energy quantum gravity are summarized in Table 1; its part is shown here. For best fitting values of $b$ in a case of 44 long GRBs, values of distance moduli are overestimated in both calibrations: on $\sim 0.225$ for the Amati calibration, and on $\sim 1.18$ for the Yonetoku calibration. It leads to the corresponding underestimation of the Hubble constant.
Table 1: Results of fitting the Hubble diagram with the model of low-energy quantum gravity. The best fitting values of $b$ for 44 long GRBs are marked by the bold typeface.

<table>
<thead>
<tr>
<th>Data set</th>
<th>$b$</th>
<th>$\chi^2$</th>
<th>C.L., %</th>
<th>$&lt;H_0&gt; \pm \sigma_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCP Union 2.1 [6]</td>
<td>2.137</td>
<td>239.635</td>
<td>100</td>
<td>68.22 \pm 6.10</td>
</tr>
<tr>
<td>JLA [7]</td>
<td>2.365</td>
<td>30.71</td>
<td>43.03</td>
<td>69.54 \pm 1.58</td>
</tr>
<tr>
<td>109 long GRBs [8]</td>
<td>2.137</td>
<td>70.39</td>
<td>99.81</td>
<td>66.71 \pm 8.45</td>
</tr>
<tr>
<td>44 long GRBs [9], Amati calibration</td>
<td>1.885</td>
<td>39.92</td>
<td>60.57</td>
<td>60.31 \pm 31.93</td>
</tr>
<tr>
<td>44 long GRBs [9], Yonetoku calibration</td>
<td>1.11</td>
<td>32.58</td>
<td>87.62</td>
<td>38.84 \pm 18.55</td>
</tr>
<tr>
<td>quasars [10]</td>
<td>2.137</td>
<td>23.378</td>
<td>13.73</td>
<td>69.53 \pm 10.87</td>
</tr>
</tbody>
</table>

4 The Hubble parameter $H(z)$ of this model

If the geometrical distance is described by Eq. 1, for a remote region of the universe we may introduce the Hubble parameter $H(z)$ in the following manner:

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

(15)

to imitate the local Hubble law. Taking a derivative $\frac{dr}{dz}$, we get in this model for $H(z)$:

$$H(z) = H_0 \cdot (1 + z).$$

(16)

It means that in the model:

$$\frac{H(z)}{(1 + z)} = H_0.$$  

(17)

The last formula gives us a possibility to evaluate the Hubble constant using observed values of the Hubble parameter $H(z)$. The weighted average value of the Hubble constant may be calculated by the formula:

$$<H_0> = \frac{\sum H(z_i)/(1 + z_i) / \sigma_i^2}{\sum 1/\sigma_i^2}.$$  

(18)

The weighted dispersion of the Hubble constant may be found with the same weights:

$$\sigma_0^2 = \frac{\sum (H(z_i)/(1 + z_i) - <H_0>)^2 / \sigma_i^2}{\sum 1/\sigma_i^2}.$$  

(19)

The $\chi^2$ value is calculated as:

$$\chi^2 = \sum \frac{(H(z_i)/(1 + z_i) - <H_0>)^2}{\sigma_i^2}.$$  

(20)
Figure 2: The ratio \( H(z)/(1+z) \pm \sigma \) and the weighted value of the Hubble constant \( < H_0 > \pm \sigma_0 \) (horizontal lines). Observed values of the Hubble parameter \( H(z) \) (40 points) are taken from Table 1 of [11].

In [5], I have done these calculations for two data sets of \( H(z) \). Here I repeat them for the bigger data set of 40 observations of \( H(z) \) from the paper [11]. We have for this case:

\[
< H_0 > \pm \sigma_0 = (62.082 \pm 4.092) \text{ km s}^{-1} \text{ Mpc}^{-1}.
\]  
(21)

The weighted average value of the Hubble constant with \( \pm \sigma_0 \) error bars are shown in Fig. 2 as horizontal lines; observed values of the ratio \( H(z)/(1+z) \) with \( \pm \sigma \) error bars are shown in Fig. 2, too (points). The value of \( \chi^2 \) in this case is equal to 10.69. By 40 degrees of freedom of this data set, it means that the hypothesis described by Eq. (16) cannot be rejected with 99.9999% C.L.

I have used earlier the same values of dispersion for \( H_0 \) points as the ones of \( H(z) \). Considering Eq. (17) as a base for indirect measurements of \( H_0 \), we get for the dispersion \( \sigma_0^2 \) of \( H_0 \) points:

\[
\sigma_0^2 = \sigma_i^2/(1+z_i)^2.
\]  
(22)

Then we shall have for the considered data set:

\[
< H_0 > \pm \sigma_0 = (63.152 \pm 4.689) \text{ km s}^{-1} \text{ Mpc}^{-1}.
\]  
(23)
The value of $\chi^2$ is now equal to 38.56. By 40 degrees of freedom of this data set, it means that the hypothesis described by Eq. (16) cannot be rejected with 53.511% C.L. The dramatic increase of $\chi^2$ is mainly due to the last three points with $z > 2$ in Fig. 2 with small $\sigma_0$; without them, $\chi^2 = 24.857$ that gives 93.633% C.L. by 37 degrees of freedom.

The $R_h = ct$ cosmological model (a Friedmann-Robertson-Walker cosmology with zero active mass) has the same function $H(z)$ as the considered one [12]; $R_h$ is the Hubble radius. As it is shown in [12], this function fits 30 cosmic chronometers observations with $z < 2$ with a larger probability than five other considered functions of different models, including the flat ΛCDM.

Some authors try in a frame of models of expanding universe to find the deceleration-acceleration transition’s redshift using the same data sets. The above conclusion that the ratio $H(z)/(1 + z)$ remains statistically constant in the available range of redshifts is model-independent.

5 Conclusion

The Hubble diagram for GRBs may differ in the model from the diagram for SNe Ia, and some signs of this difference are seen, perhaps, in the case of the 44 long GRBs data set. In the model, space-time is flat, and the geometrical distance as a function of the redshift coincides with the angular diameter distance. The geometrical distance of this model is very different from the one of the standard model; for example, the age of the Universe of the standard model: $\sim 13.5$ Gyr corresponds here to $z \simeq 2.6$.

The found expression for the anomalous deceleration of massive bodies: $w = -w_0 \cdot 4\eta^2 \cdot (1 - \eta^2)^{0.5}$ should ensure a sufficient stability of the Earth-like orbits. It is planned to model numerically a modification of dynamics due to it very soon.

From a point of view of this approach it seems that all attempts to unify general relativity and quantum mechanics using them as corner stones of the future more general theory are doomed to failure. The future theory should be underlaying one for general relativity and quantum mechanics which will be specific approximations of it by some restrictions.

References


