Relativistic Distance-Luminosity Relation

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Anisotropy of the luminous intensity of distant astronomical objects of expanding Universe in intrinsic space of the observer is shown. The relativistic distance-luminosity relation, by which radial coordinate of astronomical object is being determined taking into account Hubble anisotropy of its luminous intensity, is received. As it follows from this relation, values of radial coordinates of distant astronomical objects in intrinsic space of the observer are much smaller than values of their coordinates, calculated by classical distance-luminosity relation. This makes the presence of such hypothetical components of the Universe as dark matter and dark energy unnecessary in principle.

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Only relativistic shift of radiation frequency is usually being taken into account during the analysis of the results of astronomical observations, while relativistic anisotropy of luminous intensity of distant objects of expanding Universe is being ignored. This, as it is shown here, substantially overrates values of radial coordinates of these objects in the intrinsic space of the observer. That's why taking into account of the anisotropy of luminous intensity of distant astronomical objects, proposed here, can make the presence of dark matter and dark energy in the Universe excessive.

The following relativistic transformation of angular coordinate of propagation direction of the light, at the transition from intrinsic frame of references of time and coordinates (FR) of object, moving at the velocity *v*, to the FR of observer of this motion, is well known [1, 2]:

$$\cos\widehat{\varphi}_r = \frac{\cos\varphi_R + v/v_c}{1+(v/v_c)\cos\varphi_R}. \tag{1}$$

Here, velocity of light in the point, where object is, determined by coordinate clock [2] of the observer, according to Schwarzschild solution of the equations of gravitational field, is the function of Schwarzschild radial coordinate *r*:

$$v_c = c\sqrt{1 - r_g/r - \lambda r^2/3}\ , \tag{2}$$

where: c – constant of the velocity of light; r_g – gravitational radius of the astronomical body, from the surface of which the observation of object takes place; λ – cosmological constant, which corresponds [3] to the presence of antigravitational field in observer FR and for the accelerated expansion of the Universe, caused by this field. According to all this, transformation of numerical apertures of the beam of light, which propagates in the direction, opposite to the object motion, ($\alpha_R = \varphi_R - \pi$), is the following:

$$\sin\widehat{\alpha}_r = \sin\alpha_R\sqrt{1 - v^2/{v_c}^2}\,[1-(v/v_c)\cos\alpha_R]^{-1}. \tag{3}$$

Here α_R and $\hat{\alpha}_r$ metrical values of aperture angles of registered beam of light in moving object FR and in observer FR correspondingly.

According to Schwarzschild solution, in non-Euclidean observer space metrical value of numerical aperture of the beam of light ($\sin\hat{\alpha}_r$) can be expressed via its observed value ($\sin\alpha_r$) the following way [2]:

$$\sin\hat{\alpha}_r = (dr/d\hat{r})\sin\alpha_r = \sin\alpha_r\sqrt{1 - r_g/r - \lambda\, r^2/3}\,, \tag{4}$$

where: $d\hat{r}$ and dr – increments of metrical radial distance and Schwarzschild radius in observer FR correspondingly. By the Weyl hypothesis [2, 4, 5] distant galaxies move along the geodesic lines of space-time continuum (STC) of the observer of Universe expansion and, consequently, they are free falling on the observer horizon. Hubble relation [6]:

$$v/v_c = \sqrt{1 - v_c^2/c^2} = Hr\sqrt{c^{-2} + r_g/H^2r^3} \approx Hr/c < 1 \tag{5}$$

is the consequence of total energy of galaxy that moves inertially in rigid observer's FR:

$$U = mcv_c(1 - v^2/v_c^2)^{-1/2} = mc^2 = \text{const}\,. \tag{6}$$

Where: m – mass of the galaxy, $H = c\sqrt{\lambda/3}$ – Hubble constant, $r_g << r$. Influence of gravitational field of astronomical body, which have the STC, on the distant galaxy is equilibrated in STC of Schwarzschild solution by nothing. But, in fact, it is equilibrated by the influence of gravitational fields of all astronomical bodies of the Universe.

Taking all this into account, equivalent nonrelativistic value of the radial coordinate of astronomical object, which corresponds to classical distance-luminosity relation:

$$R = \frac{r}{1 - (Hr/c)\cos\alpha_R} \approx \frac{r}{1 - Hr/c} \approx \frac{rr_c}{r_c - r} \approx \frac{zc}{H} >> r \approx \frac{zc}{(z+1)H}\,, \tag{7}$$

may be received from the condition of invariance of the aperture diameter $D = 2r\sin\alpha_r = 2R\sin\alpha_R = \text{inv}$ of recording instrument to coordinates' transformation.

Here: $\cos\alpha_R \approx 1$, $r_c \approx \sqrt{3/\lambda} = c/H$ – radius of observer horizon, on the spherical surface of which the value of coordinate velocity of light v_c is equal to zero, and:

$$z = (c/v_c)(v_c + v)^{1/2}(v_c - v)^{-1/2} - 1 \approx Hr/(c - Hr) = HR/c \qquad (8)$$

– combined Doppler-antigravitational redshift of the radiation spectrum of astronomical object [7, 8].

According to this, relativistic relation between luminosity of distant astronomical object, luminous intensity of which is isotropic in its intrinsic FR, brightness and Schwarzschild radial coordinate of the object in observer FR is the following:

$$L = 4\pi R^2 E_R \approx 4\pi r^2 (1 - r/r_c)^{-2} E_R\,. \qquad (9)$$

And therefore, relativistic value of illuminance E_R, created by this object in the aperture plane of recording instrument, becomes smaller with the increasing of distance to it much faster than value of illuminance E_{cl}, determined by the classical photometrical relation:

$$E_R = (1 - r/r_c)^2 E_{cl} = (1 - r/r_c)^2 L/4\pi r^2 = \lambda L/12\pi z^2 \qquad (10)$$

And it means that values of distances to distant astronomical objects in intrinsic FR of any observer are much smaller than their values, determined by the classical photometrical relation. Linear velocities of peculiar motion of distant astronomical objects in observer FR are also much smaller because of this. This is in a good agreement with the results of observations of peculiar motions of astronomical objects under the effect of gravitational fields of other neighbouring astronomical objects. Zwicky was the one of the first who denoted the fact that values of velocities of peculiar motion of distant astronomical objects, determined by the classical photometrical distances R to them, are much bigger than calculated gravitational values of these velocities. Being based on this, Zwicky proposed hypothesis about the presence of dark matter in the Universe [9]. There may be no need in the presence of dark matter in the Universe if we determine velocities of peculiar motion of distant astronomical objects of expanding Universe by the relativistic photometrical values of their Schwarzschild radial coordinates $r = r_c R/(r_c + R) = r_c z/(1+z)$ in intrinsic FR of the observer.

This Schwarzschild radial coordinate of luminous astronomical object can be expressed via the difference between its absolute *M* and corrected apparent *m* stellar magnitudes by the relativistic distance-luminosity relation:

$$r = (10^{\xi/5} + H/c)^{-1}, \tag{11}$$

where:

$$\xi = M - m - 5 = 5\lg(1/r - H/c) = 5\lg(H/c) - 5\lg z\ . \tag{12}$$

According to (11), received here relativistic relation strictly corresponds to Hubble law ($m = 5\lg z + M + const$) and doesn't require any corrections of this law. The fact that results of astronomical observations are in a good agreement with Hubble law is verified in [10] for wide range of visible stellar magnitudes *m* of astronomical objects.

In view of the fact that equations of GR gravitational field, related to transformations of space-time coordinates, are covariant, Hubble law is fulfilled also in comoving with Universe FR, in which taking into account of relativistic effects is not required. In this not comoving with matter FR, according to Weyl hypothesis [2, 4, 5], galaxies of expanding Universe take part only in small peculiar motions. Equivalent non-relativistic distance *R*, which is determined by equation (7), is the metrical distance to astronomical object in this Weyl FR. Continuous renormalization of the value of this distance is required because of the evolutionary decreasing of length standard, which consists of matter, in Weyl FR. Therefore, in GR $R = R_0 \exp[H(\tau - \tau_0)]$ is considered as the scale factor. Red shift in Weyl FR may be the consequence of evolutionary decreasing of velocity of light $v_{cW} = v_{cW0} \exp[-H(\tau - \tau_0)]$ by metrically homogeneous scale of cosmological time τ counted by it [6, 11]. This evolutionary decreasing of the velocity of light in Weyl FR can't be observable in comoving with matter FR in principle. Adherents of Universe stationarity in fact examine it in Weyl FR. And, therefore, despite of the falsity of their world view, they often receive results that well correspond to physical reality. For example, in work [12], in which astronomical objects are examined in comoving with Universe Weyl FR, the well correspondence of supernovas with moderately ($0.3<z<0.9$) and very ($z>1$) high values of red shift to Hubble law is verified.

The lack of correspondence of supernovas to Hubble law in works [13, 14] is caused by the use of relativistic model of expanding Universe, which corresponds to the observation of Universe expansion in STC of non-rigid FR. In the case of observations in STC of rigid FR, with using the metrically homogeneous scale of time, the value of Hubble constant is invariant the same as values of Planck constant and constant of the velocity of light.

Because of invariance of cosmological constant $\lambda = 3H^2/c^2$ Schwarzschild solution of gravitational field equations corresponds to rigid FR. Therefore, strict fulfillment of Hubble law is received here only because of using of this rigid Schwarzschild FR for observations of distant astronomical objects.

Clearly, evolutional process [6-8], which causes the Universe expansion, forms not only antigravitational field, but also global gravitational lens, which corresponds to this field, in observer STC. This lens has Hubble negative lens power:

$$\varphi_H = -1/r_c = 1/R - 1/r \approx -H/c \tag{13}$$

and forms virtual image of infinitely far points of space of Weyl FR on the fictive surface of observer horizon.

Because of this, concentration of galactic clusters increases with approaching to observer horizon, while their dimensions and mass decreases. This is verified by observations of XMM-Newton X-ray Observatory [15, 16] and makes many astronomers doubt about the presence of dark energy in the Universe [17, 18]. And, according to (10), this is verified by the fact that brightness of galactic clusters tends to zero with approaching to observer horizon, which in fact embraces the whole infinite Universe [6, 7]. According to Schwarzschild solution, the presence of this observer horizon in STC of any astronomical body is inevitable when the value of cosmological constant is nonzero. Galaxies of expanding Universe freely fall on observer horizon. However they can't reach observer horizon because the value of velocity of light v_c on its fictive surface is nonzero. According to GR, free fall is the inertial motion and doesn't require expenditure of dark energy.

So, radial coordinates of distant astronomical objects of expanding Universe are much smaller than it follows from the classical distance-luminosity relation, which doesn't take into account anisotropy of luminous intensity of these objects in observer STC. Therefore, the presence of dark matter in the Universe may be unnecessary. Taking into account the absence of expenditure of energy in the process of infinitely long free fall of distant astronomical objects on the observer horizon [6 – 8], the presence of dark energy in the Universe is also excessive. However, the presence of nonenergetical antigravitational field in the observer STC is doubtless.

The presence of fictitious necessities of dark matter and dark energy and the possibility of relativistic substantiation of the absence of these necessities are the one more convincing proof of the correspondence of special and general relativities to physical reality.

[1] A. Einstein, Ann. d. Phys., **17**, 891 (1905).

[2] C. Moller, *The Theory of Relativity* (Clarendon Press Oxford, Oxford, 1972).

[3] A. G. Riess, L.-G. Strolger, J. Tonry et al., Astrophys. J., **607**, 665 (2004); astro-ph/0402512.

[4] P. Danylchenko, *Gauge-evolutional interpretation of special and general relativities*, (O. Vlasuk, Vinnytsia, Ukraine, 2004), p. 33; E-print archives, http://pavlo-danylchenko.narod.ru/docs/Possibilities_Eng.html.

[5] P. Danylchenko, *Is The Universe eternal?* (NiT, Kyiv, 2005); E-print archives, http://n-t.org/tp/mr/vl.htm .

[6] P. Danylchenko, *Theses of reports of XII-й Russian gravitational conference*, edited by Yu. G. Ignatjev (Russian Gravitational Society, Kazan, 2005), p. 84; E-print archives, http://sciteclibrary.ru/rus/catalog/pages/8453.html.

[7] F. Zwicky, Helvetica Phys. Acta **6**, 110 (1933).

[8] R. M. Soneira, Astrophys. JL, **230**, L63 (1979).

[9] H. Weyl, Phys. Z. **24,** 230 (1923).

[10] H. Weyl, Philos. Mag. **9**, 936 (1930).

[11] P. Danylchenko, *Gauge-evolutional interpretation of special and general relativities*, (O. Vlasuk, Vinnytsia, Ukraine, 2004), p. 82, E-print archives, http://pavlo-danylchenko.narod.ru/docs/Schwarzschild_Eng.html

[12] K. Khaidarov, Eternal Unierse (Kazakhstan, Borovoye: Bourabai, 2003), E-print: http://bourabai.narod.ru/universum.htm

[13] S. Perlmutter et al., Astrophys. J. **517,** 565 (1999), E-print archives, astro-ph/9812133.

[14] S. Perlmutter, Phys. Today **56,** 53 (2003).

[15] D. Lumb et al., The XMM--NEWTON Omega Project: I. The X-ray Luminosity - Temperature Relation at z>0.4, E-print archives, astro-ph/0311344.

[16] A. Blanchard et al., The XMM--NEWTON Omega Project: II.Cosmological implications from the high redshift L-T relation of X-ray clusters, E-print archives, astro-ph/0311381.

[17] F. Jansen, A. Blanchard, Has XMM-Newton cast doubt over dark energy? European Space Agency News Release. Posted: December 12, 2003, E-print archives, http://www.spaceflightnow.com/news/n0312/12darkenergy/ .

[18] B. Dumme, New doubts on dark energy, PhysicsWeb, E-print archives, http://physicsweb.org/articles/news/7/12/8 .