GRAVITATIONAL AND RELATIVISTIC EFFECTS WITHIN HOT UNIVERSE MODEL

YU. E. ZEVATSKIY

Hot Universe model, filled by uniform isotropic radiation, coming from its border, is examined. Equations for gravitational forces, coincident with classical ones, and for particle momentum, coincident with relativistic expression with accuracy up to constant multiplier were obtained. It was demonstrated the Universe mass corresponds to the energy of relict radiation, divided by c^2, absorbed by the matter for the whole period from Big Rang.

Interdependence of gravitational and relativistic effects attracts researches' attention actually from the moment of special relativity theory appearance. The works addressing this question at different time were published by Poincaré, Levi-Civita, Pauli, Logunov and many other scientists. Some of the results, obtained in course of researching this problem, are contrary with conceptions of general relativity theory [1, 2]. In due time this matter raised vigorous debates [3, 4]. Besides, the data of astronomical observations of last years testifies in favor of the model with non-Riemannian metric [5]. That is why further research of this subject may be useful for determining mechanism of gravitational interaction and cosmological Universe models verification as well.

Let us examine well-known model of three-dimensional Euclidean space, filled by isotropic homogeneous radiation, arriving from its borders, located at considerable distance from being observed bodies (particles). Assume, that specified bodies may absorb this radiation; this may result in force appearance, acting on the bodies due to absorption. Let the force value F, acting on the body in direction **n**, is proportional to radiation quanta number Δn, arriving per time interval $\Delta\tau$ through the body cross section σ, for which **n** is a normal:

$$F = \sigma \frac{\Delta n}{\Delta \tau} p, \tag{1}$$

where p is average value of quanta momentum.

Thereby, in absence of other bodies, isolated body is in equilibrium, because resultant force caused by quanta absorption of isotropic homogeneous radiation equals zero. In the presence of even one additional body this equilibrium is breakdown. It happen because of deficit of radiation quanta, arriving from the side of other body. If we designate specific (per surface unit) angular quanta intensity, arriving from external borders, as $\dot{n}$, the the value of this deficit equals:

$$\Delta \dot{n} = 4\pi \dot{n} \frac{\sigma_2}{4\pi R^2}, \tag{2}$$

where σ_2 – cross section of the second body, R – distance between the bodies, $R^2 >> \sigma_2$.

Deficit of quanta from the side of the second body results to the force appearance, acting on on the first body in direction of the second one. This force, according to (1), is proportional to cross section of the first body; thereby it is possible to write:

$$F = \dot{n} \frac{\sigma_1 \sigma_2}{R^2} p\ . \tag{3}$$

This expression differs from Newtonian law of gravitation in that body's mass is substituted by the value of radiation absorption cross section σ. It is obvious that in examined model these cross sections are proportional to classic body masses. As it will be demonstrated later, the force (3) coincident with gravitational within the accuracy up to constant multiplier.

Let us consider in the frames of this model isolated body (at considerable distance from all the others – motionless), which moves at constant velocity. According to provisions of special theory of relativity, number of quanta, falling at the body from all directions, does not change. Consequently, in first approximation, at evenly moving body will not act a force in any direction, appeared due to radiation absorption. Strictly speaking, it is not the case, because for moving body homogeneity of external radiation is violated by Doppler Effect.

As it was determined with high accuracy experimentally [6], radiation frequency ν', measured by motionless observer, is related to natural frequency ν^0 of radiation source by the following relation:

$$\nu^0 = \nu' \frac{1 - {(\mathbf{v}, \mathbf{n})}/{c}}{\sqrt{1 - {\mathbf{v}^2}/{c^2}}}, \tag{4}$$

where c – is source velocity in respect of observer, vector $\mathbf{n}$ determines radiation direction in observer's frame of reference. In the considered case**,** the source is motionless and the observer (body) is moving at $\mathbf{v}$ velocity. It follows that radiation quantum frequency ν_+, falling at the body in the opposite direction of it motion, equals:

$$\nu_+ = \nu \frac{\sqrt{1 - {\mathbf{v}^2}/{c^2}}}{1 - \frac{|\mathbf{v}|}{c}}, \tag{5}$$

and radiation quanta frequency, falling from the side of the body motion equals:

$$\nu_- = \nu \frac{\sqrt{1 - {\mathbf{v}^2}/{c^2}}}{1 + \frac{|\mathbf{v}|}{c}}. \tag{6}$$

Average quanta frequency, ν, is related to average value momentum p by well-known ratio:

$$p = \frac{h}{c}\nu. \tag{7}$$

Maximum difference of quanta momentum, striking moving body, equals:

$$\Delta p = \frac{h}{c}\nu_+ - \frac{h}{c}\nu_- = 2\frac{h\nu}{c}\frac{|\mathbf{v}|}{c\sqrt{1 - {\mathbf{v}^2}/{c^2}}} = \frac{2p}{\sqrt{1 - {\mathbf{v}^2}/{c^2}}}\frac{|\mathbf{v}|}{c}. \tag{8}$$

Average quanta number, falling at the body in the opposite direction of its motion and along its motion, according to the STR clauses, are the same and equals:

$$\dot{n}_{\pm} = \frac{4\pi}{6}\dot{n}\,. \tag{9}$$

Thereby, the force, preventing free and even body motion at v velocity equals:

$$\mathbf{F}_f = -\sigma\frac{4\pi\dot{n}}{3}\frac{p}{c}\frac{\mathbf{v}}{\sqrt{1-\mathbf{v}^2/c^2}}, \tag{10}$$

To eliminate this contradiction it is necessary to assume existence of a force equal by value and and opposite by direction with F_f, force, which counterbalance it. Rather suppositive it may be called «inertial force». Body impulse arises as a result of this force action on the body during a certain time interval. That time, necessary for establishing constant body velocity, is the time necessary for establishing balance with a force of Doppler resistance. If this force remains constant by value during the whole time interval ΔT, then impulse value **p**, reached by the body, equals:

$$\mathbf{p} = -\mathbf{F}_f \cdot \Delta T = \sigma\frac{4\pi\dot{n}}{3}\frac{\Delta T}{c}\frac{p\mathbf{v}}{\sqrt{1-\mathbf{v}^2/c^2}}, \tag{11}$$

On the other hand, according to the main relativistic ratio

$$E^2 - \mathbf{p}^2c^2 = m^2c^4\,, \tag{12}$$

where m denotes invariant body mass, E - its complete energy; body impulse is determined by:

$$\mathbf{p} = \frac{m\mathbf{v}}{\sqrt{1-\mathbf{v}^2/c^2}}. \tag{13}$$

Equating (11) and (13), we obtain

$$m = \sigma\frac{4\pi\dot{n}}{3}\frac{\Delta T}{c}p\,. \tag{14}$$

Thereby, gravitational and invariant masses of bodies in examined model are proportional to external radiation absorption cross-sections.

Let us examine applicability of the model to actual Universe, filled by relict radiation with average temperature 2.728 K [7], that corresponds to average wavelength 5.28 mm. Average quanta impulse of this radiation p constitutes 1.26 ·

10^{-31} kg · m/s. Value of average specific angular quanta intensity: $\acute{n}$ = $1.62 \cdot 10^{16}$ Hz·sr^{-1}·m^{-2} [7].

Equalizing force in (3) to Newtonian gravitational force, we will obtain:

$$\alpha m_1 m_2 = \sigma_1 \sigma_2 \dot{n} p, \tag{15}$$

where α denotes gravitation constant, equals $6.6742 \cdot 10^{-11}$ N· m^2/kg^2. Considering, that ratio of cross sections (σ_1 and σ_2) of relict radiation absorption to gravitational atomic and molecular masses (m_1 and m_2) is a value, slightly dependence on their structure and composition, we will obtain:

$$\frac{\sigma}{m} = \sqrt{\frac{\alpha}{\dot{n}p}} = 181 \text{ m}^2\text{кg}^{-1}. \tag{16}$$

On the other hand, this ratio may be expressed from equation (14), that will lead to the following equation:

$$\Delta T = \frac{3c}{4\pi\sqrt{\alpha \dot{n} p}} = 1.93 \cdot 10^{20} s. \tag{17}$$

Numerical value of time necessary to reach equilibrium is comparable with the Universe age (~$5 \cdot 10^{17}$s [5]) and exceeds it by more than two orders. By all appearance, this may be explained by the fact that the mass, according to (14), equivalent to sum of impulses of absorbed relict radiation quanta over the time ΔT, normalized to light velocity. Thereby, if ΔT corresponds to the Universe age, then its mass corresponds to the value of relict radiation energy (with accuracy up to multiplier c^2), transformed into matter by means of relict radiation absorption over all this time period. If the Universe was earlier hotter, this will lead to reduction of estimated value ΔT in formula (17).

In case of that considerable value of specific cross section, obtained by formula (16), actually all the quanta of relict radiation would be absorbed by surface layer of the body in condensed state. If for this process Bouguer-Lambert-Beer law is valid, then at body's density ~10^3 kg/m^3 relic radiation would be attenuated in e times by the layer with thickness several microns. That is why examined process can't adequately describe gravitational interaction.

Somewhat different type of situation occurs with extremely rarefied bodies. Considering, that in the process of electromagnetic radiation absorption by atoms and molecules significant role play electron transitions, then a certain estimate may be obtained using the data obtained for electromagnetic waves scattering (Thomson scattering) on free electrons, which cross section is independent on wavelength. It is possible to use simplification, assuming that in atoms and molecules one electron fall on two nucleons. Ratio of electron's Thomson cross-section to two atomic mass units equals:

$$\frac{\sigma_e}{2m_{aem}} = \frac{8\pi}{3}\frac{r_e^2}{2m_{aem}} = 197\ \text{sm}^2\text{кg}^{-1} = 0.327\,\text{barn/a.e.m.}, \tag{18}$$

where r_e denotes classical electron radius. This value approximately 10000 times lower than obtained in expression (16), that result in force reduction (3) in 10^8 times if compared with gravitational one. Moreover, as opposed to action on the body in condensed state, the force (3) will not be reduced in surface layer. In course of passage through formation with particles size reaching centimeter and average density ~10^{-9} kg/m^3 (permitting thermodynamical description) relict radiation, (according to Bouguer – Lambert law, will be attenuated in *e* times at distance constituting by order 10^{11} m.

That is why it is necessary to consider examined process for estimation gravitational and other interactions with participation of rarefied gas-dust formations.

This conclusion has two indirect confirmations. Despite of many years precise observations, performed in WMAP project, relative error of gravitational constant measurements is noticeably high (10^{-5}) compared to other constants [8]. Since the force (3) looks like gravitational one, then its action may result in changing observable value of gravitational constant for bodies' interaction depending on their size and density. Of course, the force from (3) will provide negligible impact on massive bodies' motion, but on dynamics of rarefied gas-dust formation this impact would be rather noticeable.

Moreover, obtained results agree with experimental data on accelerated recession of galaxies [9]. In case of cooling relict radiation, the force (3) will be reduced, that will lead to reduction in time observed value of gravitational constant.

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