A New Model of Gravitation

D. Skripachov

Abstract

This article describes a new model of gravitation based on Einstein's idea of interconnection of the gravitational interaction with the curvature of space (but only 3-dimensional, without the "curvature" of time). It is proposed to consider the space consisting of unit cells with dimensions comparable to the size of elementary particles. Curvature of space is interpreted through the change in the relative volume of unit cells. In the gravitational field the curvature of space is qualified as a decrease in the distension of space with increasing distance from the center of the attracting body. As an important complement of the kinematic relativistic effects of moving bodies is introduced a new kinematic effect of longitudinal distension of space. It is alleged that the gravitational interaction is manifested as a result of following of changes of kinematic effects of moving bodies for change in the local distension of curved space. It is shown that the extrapolation of the fall of matter on the center of the attracting body leads to the conclusion about the existence of density limit, as which can be accepted the matter density of the neutron star.

1 Introduction

Have we ever wondered, thinking about what could be the Grand Unification, what is its attractiveness? Even if not, let's agree that we want simplicity and ultimate clarity in understanding the surrounding world, that is what we are sometimes lacking in modern physical theories, despite their full confirmation and agreement with experiment. We even quite ready for replacement of general relativity to quantum gravity, if the latter will be able to generalize GTR at the quantum level, in the hope that the quantization will clarify everything and will eventually lead us to the GU. But if the ultimate goal is simplicity and clarity, why would we not achieve them right now? At our disposal we already have a beautiful idea of Einstein that the gravitational field is identical to curved 4-dimensional space-time. We only need to simplify this idea assuming that the gravitational field is identically to the curved space (but not time), and conduct a new rapid research of the gravitational interaction. Here is a plan of our research:

- rejection of 4-dimensional space-time,
- introduction of cellular space consisting of unit cells, the size of which is comparable to the size of elementary particles,
- interpretation of the curvature of space by change in volume of unit cells relative to each other,
- interpretation of relativistic kinematic effects by change in the geometry of space,
- setting dependency of change the geometry of space of moving bodies from the curvature of space,
- study the bending of light rays in the gravitational field,

- study the causes of anomalous precession of Mercury,
- setting density limit in the gravitational collapse,
- refinement of formula for the escape velocity for the case of sub-light motion in the gravitational field of collapsar.

2 Curvature of space and gravitation

Consider an interpretation of the curvature of space by changing the relative volume of unit cells of space. Take two parallel lines lying in one plane in three-dimensional space with hyperbolic geometry. The discrepancy of the lines can be interpreted as a decrease in volume of unit cells of space as we move away along these lines from any starting point, chosen between lines as the center. Farther from the center, the greater of decreased in volume unit cells fit in the shortest segments connecting two divergent parallel lines. The opposite example is the space with elliptical geometry. In such a space the volume of unit cells increase together with increasing the distance from the center, while number of that unit cells fit in the shortest segments connecting two parallel lines decreases. But how is curved the space near gravitating bodies?

When under the action of gravitational forces or any other forces is changed the speed of movement of bodies and particles, then also are changed kinematic effects, the Lorentz-Fitzgerald contraction and time dilation. Assume that the gravitational field is a curvature of space, which changes the velocity of the body through the change of their kinematic effects. To better understand the relationship of the kinematic effects of the body and the curvature of space, we will introduce another new kinematic effect, namely, the longitudinal distension of space (LDS). This kinematic effect means that from the viewpoint of moving observer the scale of distances of space is stretched (or "distended") along the direction of motion. The magnitude of LDS is accepted exactly equal to the Lorentz factor of the moving body. This means that we can interpret the relativistic kinematic effects through the effect of LDS (Table 1).

Table 1: Brief description of the kinematic effects

Kinematic effect	**Interrelation**
time dilation	can be interpreted through LDS
Lorentz-Fitzgerald contraction	can be interpreted through LDS
relativistic mass	has independent significance
relativistic Doppler effect	can be interpreted through LDS
longitudinal distension of space	derived from collection of time dilation and Lorentz-Fitzgerald contraction

Now, after the introduction of kinematic effect of LDS, we have enough ground to suppose that if the scale of space on motion path of shrinking, then LDS decreases in the same proportion, body movement slows down, and vice versa, if the scale of space on motion path of stretching, then LDS increases in the same proportion, body movement accelerates. Thus, one could argue that the gravitational field is a curvature of space which is appeared due to the gradient of local distension of space near the attracting body (AB).

The degree of distension of space at any point in the neighborhood of AB with mass M can be determined by the formula:

$$\Theta = \frac{GM}{c^2\, r} + 1 \tag{1}$$

Value of Θ shows in how many times the linear size of unit cells of space is greater at given distance from the center of gravitating body than at infinity. To leave the gravitational field, any body or particle must have the initial velocity for which the Lorentz factor would be greater than Θ:

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} \geq \Theta \tag{2}$$

For photons leaving the gravitational field, the gravitational redshift is determined by the ratio between distension of space Θ_1 in the place of radiation and distension of space Θ_2 in the place of receiving:

$$1 + z = \frac{\Theta_1}{\Theta_2} \tag{3}$$

Photons passing near AB, will be deflected from a straight line towards AB at the angle:

$$\phi = \phi_1 + \phi_2 \tag{4}$$

The first term, the angle of ϕ_1 is created by gravitation of Newton:

$$\phi_1 = \frac{2\,GM}{c^2\,r}\,, \tag{5}$$

where the coefficient 2 is defined by the integral:

$$\int_{-\pi/2}^{-\pi/2} cos\beta\, d\beta\,, \tag{6}$$

where β is the angle between the radius vector and the normal (Fig. 1).

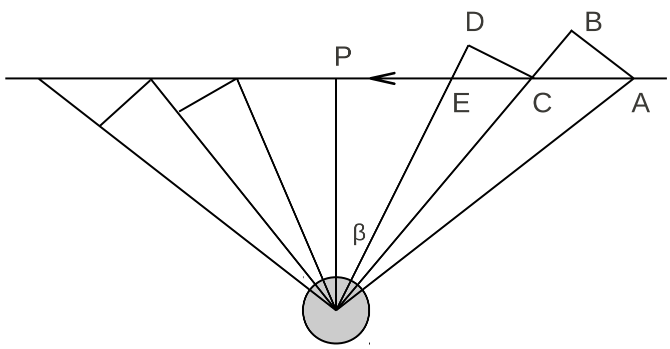

Figure 1: Beam in the gravitational field of the Sun

The second term, the angle of ϕ_2 appears as additional rotation of the trajectory due to the curvature of space. Consider the two right triangles ABC and CDE with hypotenuse lying on the trajectory of a photon approaching the Sun and cathetuses BC and DE, lying on the lines passing through the center of the Sun. With equal hypotenuse AC and CE, cathetus DE will be less than cathetus BC proportional to approximation of the photon to the Sun, and in addition, will be slightly lengthened due to increasing distension of space as we approach the Sun. As a result of this additional elongation of cathetuses the beam is slightly deflected toward the Sun. On the trajectory of the departing photon the elongation of the cathetuses lying on the lines passing through the center of the Sun decreases. Now the points of intersection of the cathetuses remain in their places, and the points of intersection of the cathetuses lying on the radius and the hypotenuse approach the Sun. The beam is again slightly deflected toward the Sun.

Thus, the additional rotation of the trajectory will be:

$$\phi_2 = \frac{2}{3}\frac{GM}{c^2\, r}\,, \tag{7}$$

where the coefficient 2/3 is defined by the integral:

$$\int_{-\pi/2}^{-\pi/2} sin^2\beta\, cos\beta\, d\beta \tag{8}$$

For photons passing through the edge of the solar disk, the total angle of rotation of the beam will be 1.167 arcseconds.

Line, for which the deflection from a straight is defined by the integral (8), can be regarded as a geodesic line. Assume that the motion in elliptical orbits is accompanied by some shift of orbit corresponding to the rotation of the geodesic passing through the pericenter, in the interval from $-\zeta$ to ζ, where ζ is equal to the angle in the right triangle between the cathetus equal to pericenter, and the hypotenuse equal to apocenter. In particular, for Mercury's orbit $\zeta = 0.8515$, and the corresponding integral is:

$$\int_{-\zeta}^{-\zeta} sin^2\beta\, cos\beta\, d\beta\; = 0.284 \tag{9}$$

Precession angle of Mercury's orbit corresponding to the rotation of the geodesic per one mercurial year will be:

$$\phi_{OM} = 0.284\,\frac{GM}{c^2\, r_{SM}}\,, \tag{10}$$

where r_{SM} is semi-major axis of orbit, r_{SM} = 57,909,000 km. Calculation yields 0.62 arcsec precession of orbit for earth century, accounting for only 1.44% of the 43" that amounts the difference between the observation and the Newtonian theory of perturbations [4]. Thus, we are faced again with the need to determine the causes of anomalous precession of Mercury. In search of such causes it would be interesting to evaluate the effect of thermal radiation recoil force. On the part of the orbit near perihelion the Sun on the Mercury's sky slows down and some time moves backwards. It lasts for about 16 days and leads to the accumulation of heat on the side facing the Sun. When passing the ascending part of the elliptical orbit the heated side of the planet turns out mostly behind the movement. In this case the thermal radiation of the heated side gives acceleration to the planet and contributes to precession of its orbit.

3 On the existence of density limit

Distension of space on the surface of normal stars differs little from the distension of interstellar space, but on the surface of neutron stars it is increased by about 1.2 times. Inside the neutron star is achieved the close packing of neutrons, where do not remain free unit cells of space which could accommodate additional neutrons or any other elementary particles. Further compression of close-packed neutron matter becomes impossible, and then the density of the neutron star (supposedly 5×10^{17} kg/m$^{\mathbf{3}}$) can be considered as a limit. To illustrate the reality of this limit, we will do a thought experiment, and conditionally assume that gravitational contraction does not stop on reaching the neutron density, and continues further in the stellar core under the pressure of the overlying layers. In this case, the core density reaches a new limit when the resistance to compression is balanced by the pressure of the outer layers. Nevertheless, we assume that all matter of the collapsar has fallen into one of the unit cells of space in the center. Then the central unit cell into which all stellar substance "fell", so will increase its volume with respect to unit cells of interstellar space, that it would take place comparable with how much place in an imaginary Euclidean space would occupy the original collapsar with neutron density. More precisely, the ratio between the equivalent size of the central super-cell and the equivalent size of the neutron collapsar can be expressed as the limit:

$$\lim_{r \to 0} \frac{r\,\Theta(r)}{r_{NC}\,\Theta(r_{NC})}\,, \tag{11}$$

where r_{NC} is radius of the collapsar with neutron density. For a neutron star with a mass of $1.5\mathrm{M}_{\odot}$ the equivalent size of the central super-cell which has absorbed the entire mass of the star would be about 20% of the equivalent size of the neutron star. With increasing of the mass the limit (11) tends to unity. Thus, the assumption of unlimited compression of matter in the gravitational collapse does not lead to the identification of any new effects. Therefore our thesis about the existence of the limit of neutron density can be considered proven.

Inside the collapsar the distension of space increases to the center:

$$\Theta(r) = (\Theta_S - 1) \cdot (2 - \frac{r}{r_S}) + 1\,, \tag{12}$$

where Θ_S is distension of space on the surface of the collapsar, r_S is radius of collapsar. The heavier the collapsar, the thinner iron crust and the denser halo of dark matter over its surface.

4 On the speed of bodies falling on collapsars

Speed of free (vertical) fall from infinity to the surface of collapsar can be determined by using the classical expression for the escape velocity:

$$v_{VF}(r) = \sqrt{2\,GM(r)/r} \tag{13}$$

To calculate the sub-light speed (conventionally, more than 0.2c) it is advisable to use a formula that takes into account finite speed of light:

$$v_{VF}(r) = c\sqrt{1 - \left(\frac{GM(r)}{c^2\,r} + 1\right)^{-2}} \tag{14}$$

For collapsars having a mass of a few hundred solar masses and up to calculate the speed of free fall is necessary to consider the viscous resistance of the medium of DM in the halo of the collapsar:

$$v_{RF}(r) = k_{ER} \cdot v_{VF}\,, \tag{15}$$

where k_{ER} is retardation coefficient in DM medium. For dense halo near collapsar we accept k_{ER} = 0.95, in other cases k_{ER} = 1. Travel time for any portion of the trajectory of free (vertical) fall on neutron collapsar can be determined by the formula:

$$t_{VF} = \int_{r_{LP}}^{r_{HP}} \frac{1}{v_{RF}(r)}\, dr \,, \tag{16}$$

where r_{HP} is initial (first intermediate) radius, r_{LP} is final (second intermediate) radius of the free fall.

5 Conclusions

We conducted our rapid study and saw how simple and clear can be gravitation. We found that action of gravitation is to follow the changes of the kinematic effects of moving body for change in the local distension of curved space. But we have not figured out how do bodies and particles create the curvature of space leading to gravitation. And this means that our research continues.

Acknowledgements

The author thanks his friend K. Pavlov for sincere dialogues and constant keen interest in the topic presented here.

References

[1] F. Klein, revised by W. Rosemann, Vorlesungen über Nicht-Euklidische Geometrie. Springer, Berlin, (1928)

[2] B. Novakovic, D. Novakovic, A. Novakovic, A New General Lorentz Transformation Model. AIP Conf. Proc. **517**, 437 (2000)

[3] A. F. Zakharov, Gravitational Lenses. Soros Educational Journal **8**, 77 (2001)

[4] J. L. Synge, Relativity: the General Theory. North-Holland Publishing Company, Amsterdam, (1960)

[5] Ya. B. Zel'dovich and I. D. Novikov. The theory of gravitation and stellar evolution. (Russian Edition). Nauka, Moscou, (1971)

[6] L. D. Landau, E. M. Lifshitz, The Classical Theory of Fields. Vol. 2 (6th ed.) (Russian Edition). Nauka, Moscou, (1973)

[7] J. F. Navarro, C. S. Frenk, S. D. M. White, The Structure of Cold Dark Matter Halos. ApJ **462**, 563 (1996), arXiv:astro-ph/9508025, (1995)

[8] N. P. Vekua, Nekotorye voprosy teorii differentsialnykh uravnenii i prilozheniia v mekhanike (Russian Edition). Nauka, Moscou (1991)