THE THEORY OF TIME, SPACE AND GRAVITATION

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Key words: time, space, relativity, gravitation
PACS numbers: 95.30.Sf, 04.50.+h, 04.80.Cc

1. Introduction

Modern science knows two essentially different conceptions of time, the relational one and the substantial one. According to the first one, there exists no time "per se" in nature and time is no more than a relation between physical events. In other words, time is a specific manifestation of the properties of physical bodies and changes occurring in them. The second conception, the substantial one, assumes, vice versa, that time is an independent phenomenon of nature, a specific kind of substance, coexisting with space, matter and physical fields. The relational conception of time is conventionally associated with the names of Aristotle, Leibnitz and Einstein. The most ardent adherents of the substantial conception of time are Democritus, Newton and Kozyrev. Nowadays physics and first of all the theory of relativity is based exclusively on the relational conception of time. However, the time still remains one of the greatest mysteries of nature. Such questions as: "What is the stream of time?", "Does the direction of time exist or not?" and a number of others have not yet been solved conclusively and rigorously. We shall begin search of answers to questions connected with the nature of time from research of features of propagation of light and behaviour of a light clock in vacuum and gravitational fields.

2. Experimental Data

All measurements of the speed of light in vacuum are actually made in gravitational fields. Many such measurements are made in the gravitational field of the Earth, for example, the definition of the speed of light emitted by an accelerated atomic nucleus (Figure 1).

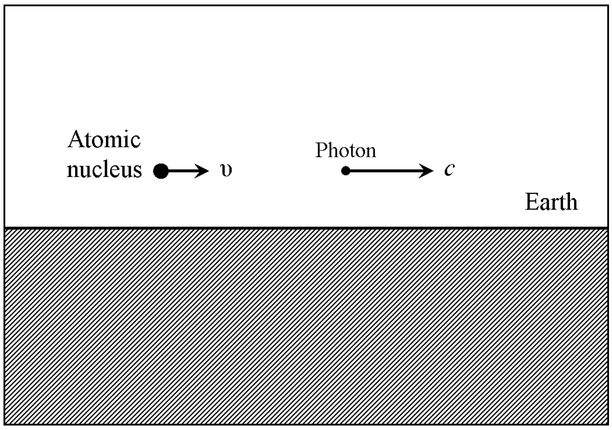

Figure 1

The radio-location of Mercury and other planets not far from a visible solar disk (Figure 2) has been performed with the purpose of measuring the propagation speed of the electromagnetic waves in the gravitational field of the Sun.

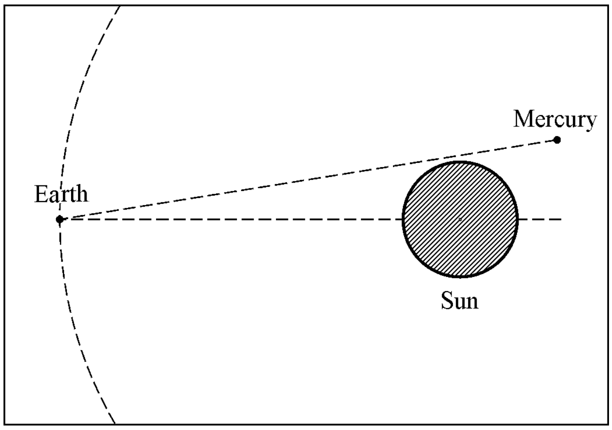

Figure 2

The light that comes from a binary star (Figure 3) propagates among surrounding stars and other masses, which are more or less evenly distributed in the Universe.

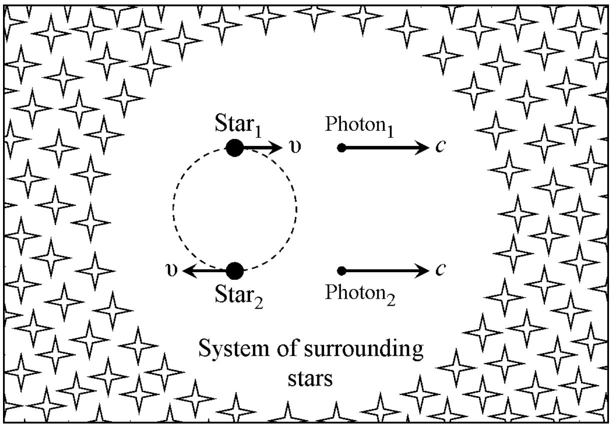

Figure 3

The same gravitational conditions occur in the central hollow area of a sufficiently great spherically symmetric mass M (Figure 4). Owing to the central symmetry typical gravitational effects - the gravitational acceleration, gravitational deviation and gravitational shift in this area are absent.

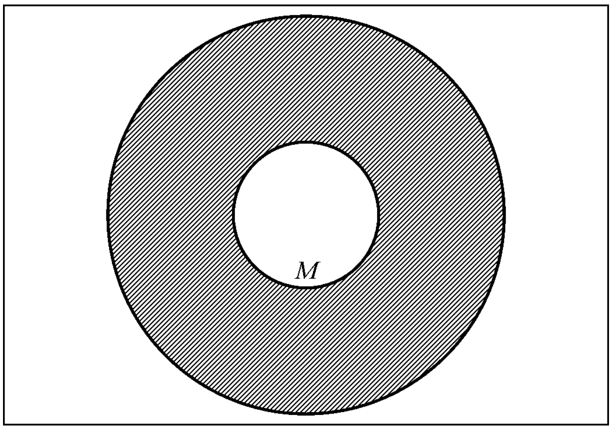

Figure 4

These experiments and observations demonstrate:

1) Constancy of the local speed of light on a terrestrial surface and in a circumterrestrial space in the frame of reference connected to the Earth;
2) Decrease in the speed of light in the gravitational field of the Sun from the point of view of the remote terrestrial observer;
3) Independence of the propagation speed of light in interstellar space from the speed of a light source.

The item 1 proves that the local speed of light is a constant relative to the Earth. The item 3 does not exclude, that the speed of light in interstellar space is a constant relative to the system of surrounding masses. If one ignores the gravitation, then these items allow one to suppose that the speed of light is a constant in any inertial frame of reference, for example, in the frame of reference connected with the atomic nucleus moving relative to the Earth (Figure 1). However, if the gravitational field acts on the speed of light relative to the source of the gravitational field, and it is observed in item 2 as delay of a radar signal, then the constancy of the speed of light in items 1 and 3 can also be a consequence of action of the gravitation.

How the gravitational field acts on the speed of light? Different theories give different answers to this question. For objectivity we shall research this question on the basis of existing experimental data only, i.e. outside of the ether theory, outside of the special and general theory of relativity and outside of many alternative theories of gravitation. It means that for physical modelling we shall not use the concept of luminiferous ether, the concept of classical gravitational forces, the principle of constancy of the speed of light and the principle of equivalence between acceleration and gravitation. Besides, we cannot a priori accept the expanded principle of relativity because the gravitation excludes a possibility of existence of absolutely isolated material systems, breaking the main condition of this principle. We cannot exclude probable gravitational influence on electromagnetic and other physical processes. As is well known, the assumption of a possibility of exception of all surrounding masses was a serious error for Newton. In forthcoming modelling we intend to use existing laws of conservation of energy and momentum, which are reliably confirmed in experiments. However, we take into account that preservation laws based on concepts of homogeneous space and time can be broken or have more complex form in heterogeneous space and time.

3. Physical Modelling

Let a photon move from point A, which is located at a sufficiently large distance from mass M, to point B, which is located in the neighborhood of M (Figure 5). From the point of view of the observer situated at point A, the photon has the following initial characteristics: the speed is c, and the momentum is $p = mc$, where m is a kinetic mass of the photon. We consider the kinetic mass of the photon as one of two components of its momentum, so that $m = p/c$. Here the momentum and speed are real physical quantities that have a physical meaning, and they together define the physical meaning of the kinetic mass. We see that the concept of the kinetic mass in contrast to the classical concept does not include force and acceleration because of force action.

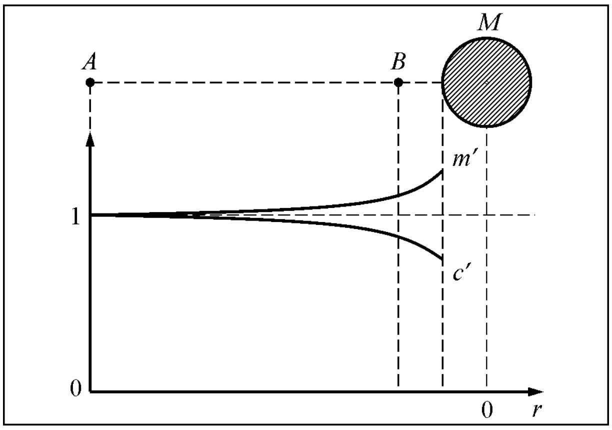

Figure 5

Within the bounds of our abstract physical model, where a space-time curvature and classical gravitational forces are absent, we can suppose that the gravitational field of mass M does not change the modulus of the photon momentum for the remote observer situated at point A:

$$p = \text{const}\,, \tag{1}$$

but increases the kinetic mass of the photon to

$$m' = m + \Delta m\,, \tag{2}$$

and it decreases the photon speed to

$$c' = mc/m' = c/(1 + GM/rc^2)\,, \tag{3}$$

where r is the distance from the photon to the center of mass M, and G is a matching coefficient. The reverse moving of the photon after reflection at point B is accompanied by the decrease in the kinetic mass of the photon and the increase in its speed, which again reaches value c at point A. The change in the speed and kinetic mass of the photon in given conditions is observed at point A as the increase in the photon travel time. Taking into account results of physical modeling, all of experimental data that are presented above (see Section 2), and also the identical speed of light emitted by equatorial points of the rotating Sun (Figure 6), we accept as a physical assumption that the gravitational field is a field of allowed speeds of light, which establishes the allowed speed of the photon relative to the source of the gravitational field by means of change in the kinetic mass of the photon. This effect of dynamical stabilization of the speed of light relative to massive objects we shall name "the gravidynamic effect".

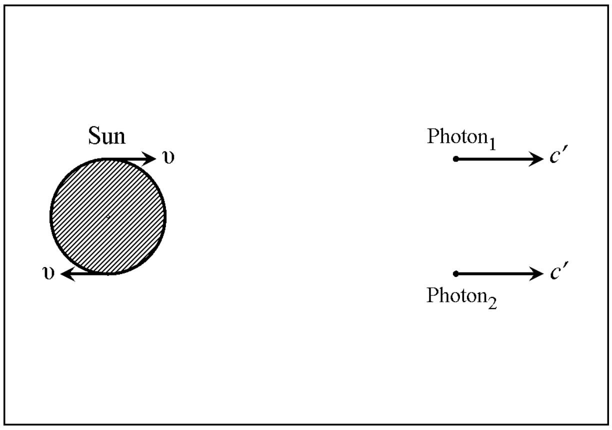

Figure 6

Note: The Eq. (3) has the empirical nature. It is based on local observation of change in the kinetic mass of photons in the Earth's gravitational field and remote observation of decrease in the kinetic mass of photons in the gravitational field of stars. However, the actual speed of light measured in the Sun's gravitational field has for the remote observer a more complex dependence. Therefore, in addition to the gravidynamic effect an acceptance of a second physical assumption is necessary for full quantitative conformity. This step will be made in Section 9. In Sections 4 – 8, we shall research the physical consequences of the gravidynamic effect in pure form without the participation of the second physical assumption.

4. Time Dilation

The gravidynamic effect decreases the local speed of light at point B (Figure 5), and it increases the period between reflections of light in a local clock that is based on propagation of light between two parallel mirrors (Figure 7):

$$T' = T(1 + GM/rc^2)\,. \tag{4}$$

Starting from the equivalence of a light clock to any other clocks, we conclude that a decrease of the speed of light causes a proportional dilation of the local time. Thus, the gravidynamic effect slows down both the local speed of light and the local time.

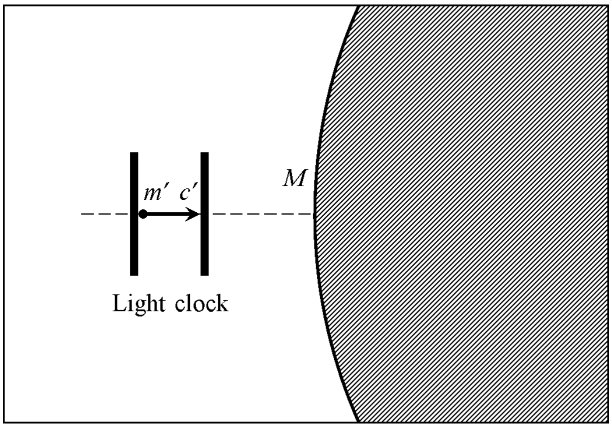

Figure 7

From the point of view of the remote observer situated at point A (Figure 8) the photon speed at any point of the central hollow area of a great spherically symmetric mass M is decreased by the gravidynamic effect to the value c' (see diagram in Figure 8). However, for the local observer situated at point B the local speed of the photon is equal to the typical light speed c. The cause of this consists in the following: during the unit of the local time T' dilated by the gravidynamic effect, the photon slowed by the gravidynamic effect covers a distance, which is typical for light.

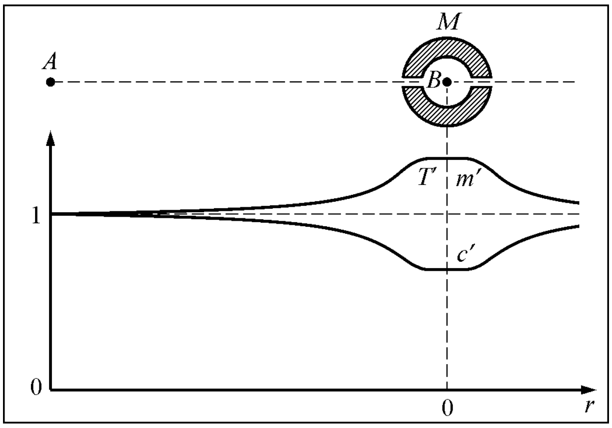

Figure 8

Other characteristics of the photon also differ for these two observers. For example, the momentum modulus of the photon as a product of the kinetic mass and speed:

$$p = m'c' \tag{5}$$

in process of the photon movement from point A to point B remains constant for the remote observer situated at point A (see Section 3), but for the local observer situated at point B the local value of momentum of this photon:

$$p' = m'c \tag{6}$$

is increased proportional to the local time dilation.

5. Stellar Aberration

The central hollow area of a great spherically symmetric mass M (Figure 9) simulates gravitational conditions in interstellar space (see Section 2). The speed of light in this area is equal to c for the local observer fixed relative to M (see Section 4). Let the atomic nucleus be accelerated up to the speed υ relative to the local observer.

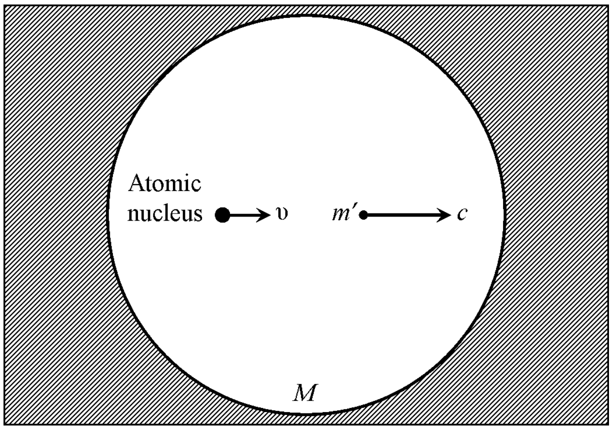

Figure 9

By the data, the speed υ is much less than the speed c. According to the classical vector addition of velocities, the speed of the photon emitted by the moving atomic nucleus should exceed speed c relative to M. According to the physical assumption (accepted in Section 3), the gravidynamic effect can change the kinetic mass of the photon for conformity of its speed to the allowed speed relative to the massive object. Therefore, the gravidynamic effect increases the kinetic mass of the photon to:

$$m' = m(1 + \upsilon / c) \tag{7}$$

and in this way stabilizes its speed at c relative to mass M. In case of an emission of light in the opposite direction, the gravidynamic effect decreases the kinetic mass of the emitted photon:

$$m' = m(1 - \upsilon / c)\,, \tag{8}$$

and it retains the photon speed at a value c relative to M.

The annual stellar aberration is formed as a result of the classical vector addition of the velocity of light and orbital velocity of the Earth. However, in the neighborhood of the Earth the gravidynamic effect stabilizes the local speed of light relative to the Earth at a value c for the local observer fixed relative to the Earth.

Thus, the constancy of the local speed of light in case of a ground-based observation of the stellar aberration and the constancy of the speed of light emitted by the atomic nucleus accelerated relative to the Earth (Figure 1) are a consequence of the gravidynamic stabilization of the speed of light relative to the Earth. The identical speed of light emitted by equatorial points of the rotating Sun (Figure 6) is a consequence of the gravidynamic stabilization of the speed of light relative to the Sun. Lastly, the constancy of the propagation speed of light in interstellar space, which is observed as strict periodicity of the orbital motion of the binary star (Figure 3) is a consequence of the gravidynamic stabilization of the speed of light relative to the system of surrounding masses.

6. Additional Time Dilation

The gravidynamic effect stabilizes the speed of light in the central hollow area of a great spherically symmetric mass M (Figure 10). This speed is equal to c for the local observer fixed relative to M (see Section 4).

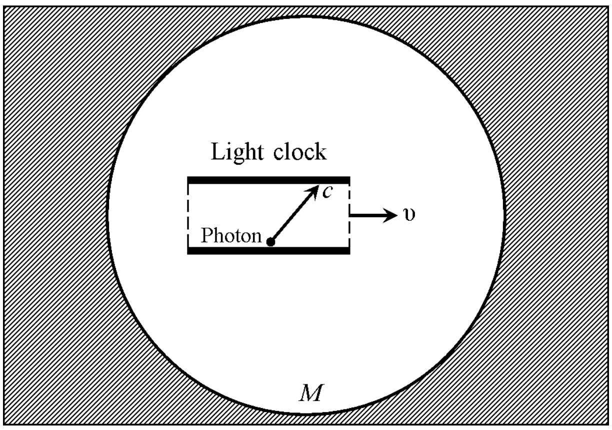

Figure 10

Let a light clock be accelerated up to speed υ relative to the local observer. After acceleration of the light clock, the period between reflections of light from parallel mirrors becomes equal to

$$T' = T / \sqrt{1 - \upsilon^2 / c^2}\,, \qquad (9)$$

where T is the period between reflections when the speed of the light clock is equal to zero.

We already researched (in Section 4) how the gravidynamic effect slows down the rate of the light clock stationary relative to the gravitational field source. Here we see that the gravidynamic effect causes an additional deceleration of the rate of the light clock moving relative to the great mass. The resulting deceleration of the rate of the light clock can be observed by the remote observer situated at point A (Figure 8).

7. Propagation of Light in the Moving Medium

The speed of light in the central hollow area of a great spherically symmetric mass M (Figure 11) is equal to c for the local observer fixed relative to M. Let the photon propagation inside a transparent glass cylinder. The cylinder moves relative to the local observer with speed υ. By the data, the speed υ is much less than the speed c. The photon is periodically absorbed and in a short time is again emitted by material particles that constitute the cylinder. A conditional speed of the photon in the absorbed state is equal to the movement speed of these particles.

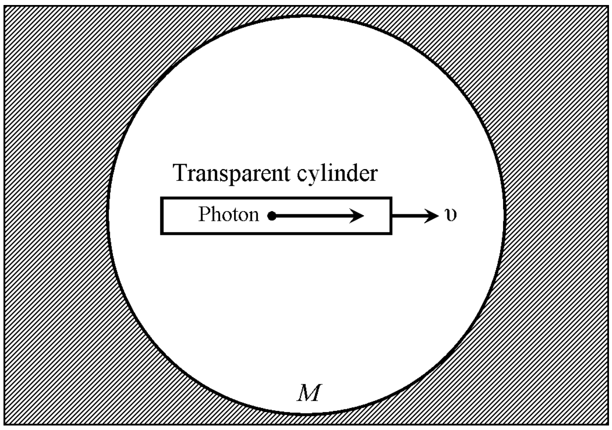

Figure 11

At the time of the photon motion in the space between particles (Figure 12), the gravidynamic effect stabilizes the photon speed at a value c relative to mass M (see Sections 4 and 5). As a result, the average effective speed of the photon becomes equal to

$$c_2 = c_1 + \upsilon(1 - c_1^{\,2} / c^2)\,, \qquad (10)$$

where c_1 is the effective speed of the photon, when the speed of the cylinder is equal to zero.

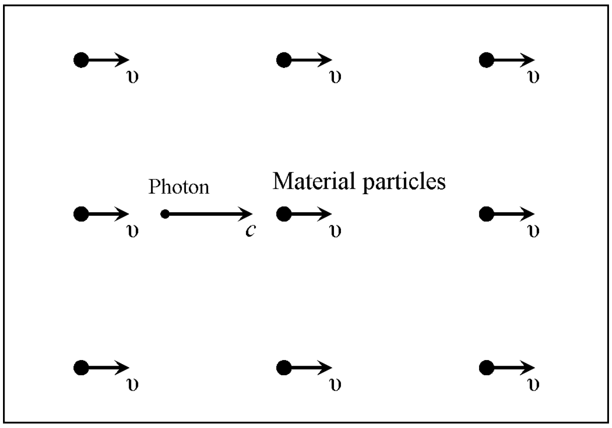

Figure 12

This result, known as a partial entrainment of light by the moving medium, was observed in water flow in the Fizeau experiment (Figure 13).

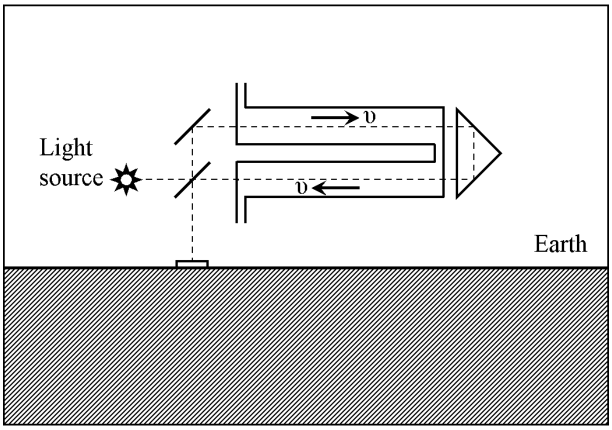

Figure 13

8. Variable Mass

We can define some characteristics of gravitational action on the electron and other material particles, if characteristics of gravitational action on photons are known. The following physical model is necessary for this purpose.

The speed of light in the central hollow area of a great spherically symmetric mass M (Figure 14) is equal to c for the local observer fixed relative to M. A thin mirrored sphere is located in this area. Photons with kinetic masses m_1, m_2, etc. are included in the mirrored sphere. By the data, the total kinetic mass of photons is much more than the proper inertial mass of the mirrored sphere. Therefore, inertial properties of this compound object are mainly defined by photons. Incidentally, in the special theory of relativity the total mass of two or more particles with a zero rest mass is not equal to zero. For example, an electromagnetic field of the electron constitutes a considerable proportion of the mass of this particle. Now, let the mirrored sphere be accelerated up to speed υ. Despite of the increase in the sphere speed relative to mass M, the gravidynamic effect stabilizes the speed of photons at a value c relative to M. The process of gravidynamic stabilization changes the kinetic mass of each photon to a variable extent depending on the speed of mirrored sphere relative to M and the direction of the photon motion after reflection from an internal surface of mirrored sphere. The photon that is reflected and further moves in the motion direction of the mirrored sphere has the maximal value of the kinetic mass. The photon moving in the opposite direction has the minimal kinetic mass (see Section 5). The kinetic mass of other photons takes different intermediate values. As a result, the total kinetic mass of the group of photons grows:

$$\sum m' = \sum m / \sqrt{1 - \upsilon^2 / c^2}\ , \qquad (11)$$

and it increases the total inertial mass of the compound object. We observe the derivative or secondary gravitational effect of the increase in the inertial mass of the object, as consequence of the gravidynamic effect.

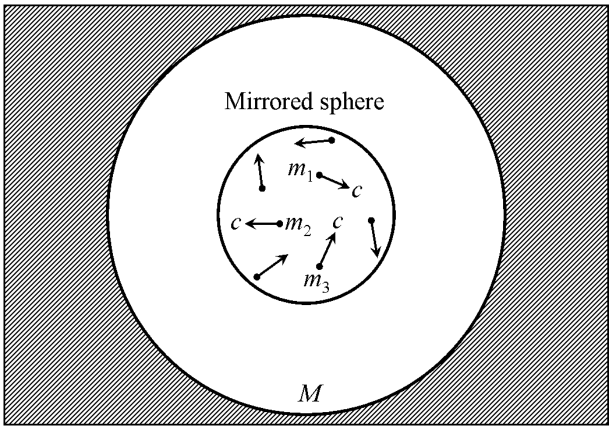

Figure 14

The average period between reflections of photons also increases, and it slows down the proper time of the compound object, which in addition to a role of the test mass is also a spherical light clock. Interestingly, that in the frame of reference connected with moving compound object, conversely, the proper time of the observer fixed relative to mass M is accelerated. The gravidynamic effect really slows down the proper time of the object moving relative to surrounding masses, and it excludes apparition of the clock paradox.

9. Delay of the Electromagnetic Signal

The gravidynamic effect explains a large number of experimental data: 1) The identical speed of light emitted by equatorial points of the rotating Sun (Section 5); 2) The time dilation in the gravitational field (Section 4); 3) The additional time dilation in case of a movement of the test particle relative to surrounding masses (Sections 6 and 8); 4) The null result of the Michelson-Morley experiment; 5) The constant speed of light emitted by the moving atomic nucleus (Section 5); 6) The partial entrainment of light by water flow (Section 7); 7) The feature of the observation of the stellar aberration (Section 5); 8) The constant speed of light from the binary star (Section 5); 9) The increase in the inertial mass of the accelerated test particle (Section 8).

However, the gravidynamic effect in accordance with Eq. (3) explains only 120 of the 240 microseconds of the observable delay of a radar signal in the gravitational field of the Sun (Figure 2). An unknown factor doubles the expected time, i.e. this factor has the same numerical dependence as the gravidynamic effect. The problem can be solved, if we shall include in our alternative theory of gravitation as a second physical assumption the effect of local shortening of length:

$$L' = L/(1 + GM/rc^2)\,. \qquad (12)$$

This gravitational effect reduces the local length in three spatial dimensions, and it increases the total length of the trajectory of the electromagnetic wave. The effective speed of propagation of the electromagnetic wave in the gravitational field of mass M (Figure 15) from the point of view of the remote observer situated at point A becomes equal to

$$c'' = c/(1 + 2GM/rc^2 + G^2M^2/r^2c^4)\,. \qquad (13)$$

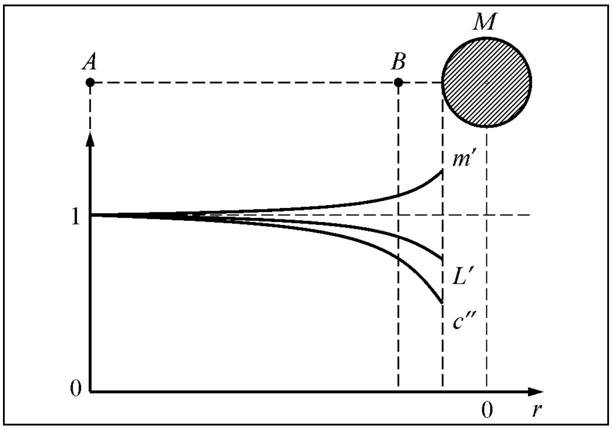

Figure 15

10. Gravitational Deviation

In consequence of the dependency of the speed of light on the gravidynamic effect and the effect of local shortening of length (see Section 9), the gravitational field of mass M (Figure 16) acts in the role of a refractive medium with a variable index of refraction:

$$n = 1 + 2GM/rc^2 + G^2M^2/r^2c^4\,. \qquad (14)$$

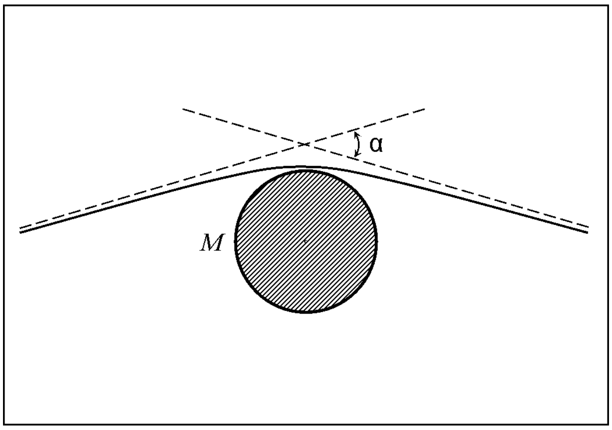

Figure 16

The angle of refraction of light in weak gravitational fields, for example in the gravitational field of the Sun, is equal to

$$\alpha = 4GM/rc^2\,, \qquad (15)$$

where r is the minimal distance of the light beam from the center of mass M.

11. Mercury Perihelion Shift

A thin mirrored sphere with photons is located in a neighborhood of mass M (Figure 17). By the data, the total kinetic mass of photons is much more than the mass of the mirrored sphere. Therefore, inertial and gravitational properties of this compound object are mainly defined by photons.

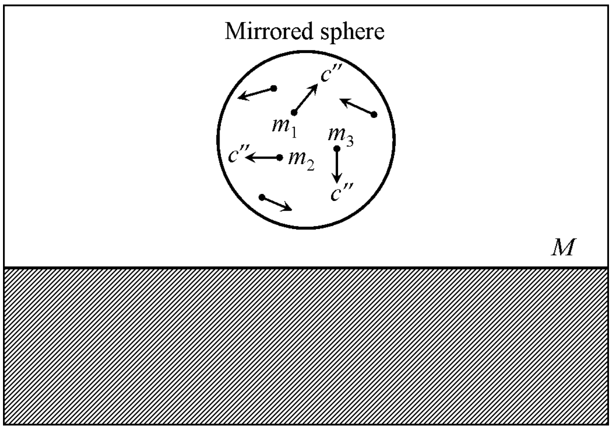

Figure 17

The common refracting action of the gravidynamic effect and the effect of local shortening of length (see Section 10) accelerates the compound object in the direction of mass M . We observe the standard gravitational acceleration without participation of classical gravitational forces. The refracting action reaches a maximum if the mirrored sphere moves in the horizontal direction with the speed υ, which approaches to the local speed of light c'' (Figure 18).

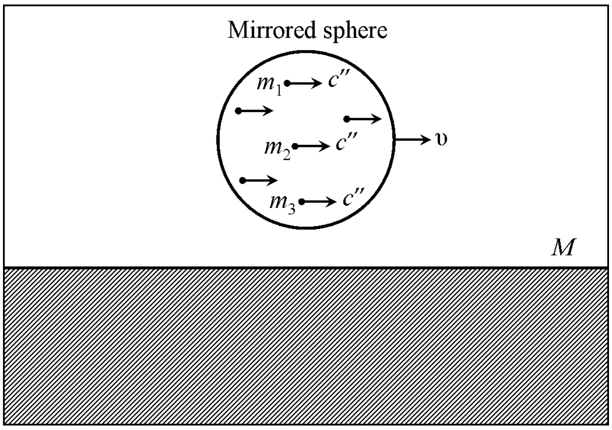

Figure 18

In this case, the gravitational acceleration of the sphere twice exceeds the value of the Newtonian theory of gravitation. This effect can be observed as a double angle of the deviation of the test particle moving with the sub-light speed in the gravitational field of the massive star.

In case of the comparatively low Mercury speed relative to the Sun, the small increase in the gravitational acceleration in comparison with the classical value still takes place, and it is observed as the anomalous Mercury perihelion shift (Figure 19).

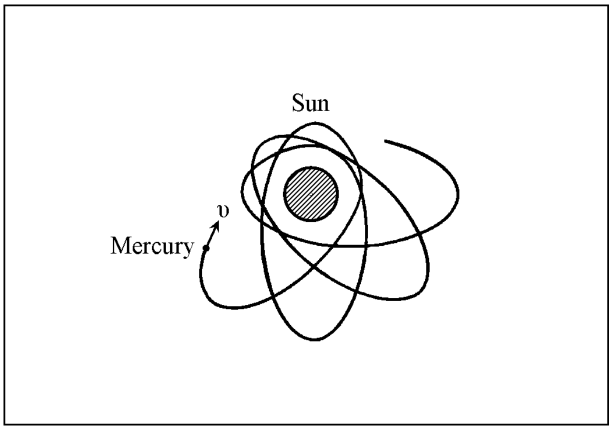

Figure 19

12. Feature of Time Dilation

The effect of local shortening of length decreases the effective speed of light (see Section 9), but, in contrast to the gravidynamic effect (see Section 4), does not increase the period between reflections of light in a light clock, because the geometrical sizes of two parallel mirrors and the distance between them are also decreased by this effect. Thus, the local time dilation is always caused only by the gravidynamic effect (see Sections 4, 6 and 8).

13. Gravitational Energy

A thin mirrored sphere with photons is located in the neighbourhood of mass M (Figure 17). By the data, the total kinetic energy of photons is much more than the proper energy of the mirrored sphere, i.e. the internal energy E of the given compound object is mainly formed by photons. The common refracting action of the gravidynamic effect and the effect of local shortening of length increases the speed and kinetic energy of the object (see Section 11). From the point of view of the remote observer situated at point A (Figure 20), the increase in the kinetic energy of the compound object during movement from point A to point B is accompanied by the decrease in the internal energy of the object:

$$E' = E/(1+GM/rc^2)\,. \qquad (16)$$

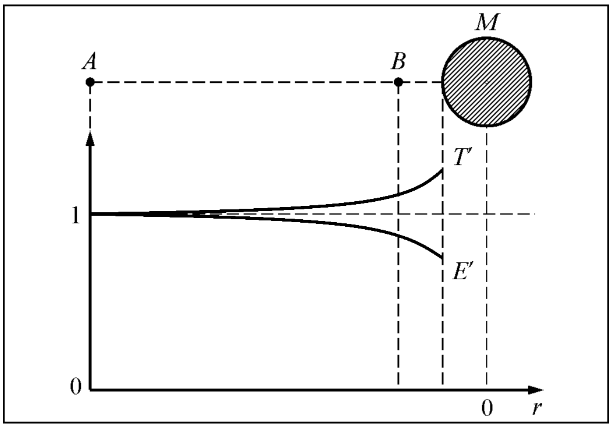

Figure 20

The full energy of the object remains constant: the refraction, as is well known, does no mechanical work and does not change full energy of system. The transformation of internal energy of the object to its kinetic energy is a unique feature of the gravitation action, and this feature excludes equivalence between acceleration and gravitation. For the local observer, who together with the compound object is accelerated by the gravitation, the internal energy of the object remains invariable because of the identical action of the gravitational field on the observer and object of observation.

We see that the energy used for gravitational acceleration is not distributed in the gravitational field, but localized in the mass, which participates in the gravitational acceleration. This implyies that the gravitational field has no proper positive or negative energy, i.e. has a zero energy density.

14. Red Shift

The gravitational field has a zero energy density (see section 13). Therefore, the photon movement from point B to point A (fig.21) is not accompanied by change in energy and frequency of the photon. The momentum modulus of the photon remains also invariable (see section 3). The gravitational red shift that is observed at point A is consequence of the local time dilation at point B (see section 4). Besides, the remote observer situated at point A can interpret the red shift as a decrease in the internal energy of a light source at point B (see section 13).

15. Ockham's Razor

From gravitational acceleration of the physical model of the material particle (see Section 11) and also from identical gravitational acceleration of different material particles follows, that any material particle at elementary level consists of structures, which have the kinetic mass and move with the speed of light. This conclusion excludes zero sizes of material particles and reduces a number of types of masses to one type - the kinetic mass. Earlier, we have already refused the contradictory concept of a zero rest mass (see Section 3). This type of mass by definition cannot characterize the moving particle. Therefore, we have accepted the concept of kinetic mass. The classical inertial mass and the so-called transverse mass of material particles are a consequence of the kinetic mass (see Section 8). A number of forms of energies also decrease to one form - the kinetic energy. Indeed, if components of the material particle at the certain structural level have the kinetic mass and move with the speed of light, then any potential energy is the latent form of the kinetic energy. We can see that the potential gravitational energy is not exception (see Section 13).

16. Relational Time

We investigated the gravitational action on the time flow speed, and now we know that the time not only is measured by the motion, for example, in the light clock, but also is formed by the motion. It means that properties of time are completely defined by properties of the motion. Many different types of motions exist, and each type of the motion forms the proper time. The proper time of the material particle is formed by all types of motions in this particle. The speed of light is the most common speed of motions in any material particle (see Section 15). Therefore, the decrease in the speed of light caused by the gravidynamic effect leads to the dilation of the proper time of the particle (see Sections 4, 6 and 8).

17. Conclusion

In 1889, Fitzgerald had accepted the effect of longitudinal length contraction as a physical assumption for an explanation of the null result of Michelson-Morley experiment. In 1892 the number of assumptions has been independently increased by Lorentz. At present time on the basis of known features of the propagation of light in gravitational fields, we have accepted two physical assumptions: the gravidynamic effect (Section 3) and the effect of local shortening of length (Section 9). These assumptions completely cover the sphere of relativity and gravitation: from the Fizeau experiment (Section 7) up to the gravitational red shift (Section 14). On the basis of these assumptions we have developed the consistent theory of time, space and gravitation.

The existence of the effect of local shortening of length is indirectly confirmed by several experimental facts, and it is the unique effect that explains the second half of delay of the electromagnetic signal in the solar gravitational field (Section 9) without the double dilation of the local time (Section 12).

The gravidynamic effect and its consequences are supported by a large number of experiments and astronomical observations. Therefore, we are assured that this phenomenon exists. Nevertheless, an additional confirmatory experiment is still necessary.