Constancy of speed of light as the interaction effect

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Abstract

The new phenomenon of dynamic stabilization of the propagation velocity of electromagnetic waves is discovered. The dependency of the inertial mass and the proper time of accelerated particles on the action of the gravitational field of surrounding masses is defined.

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

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

![Figure 1](image1.png)

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

![Figure 2](image2.png)

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.
The same gravitational conditions occur in the central hollow area of a sufficiently great spherically symmetric mass $M$ (Figure 4). Typical gravitational effects - the gravitational red or blue shift, gravitational deviation and gravitational acceleration in this area are absent.

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

The item 1 proves that the local velocity of light is a constant relative to local massive object. The item 3 proves that the velocity 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 velocity of light is a constant in any inertial frame of reference, for example, in the frame of reference connected with the accelerated atomic nucleus (Figure 1). However, if the gravitational field has ability to influence the velocity of light relative to the source of the gravitational field, as is observed in item 2 by the delay of a radar signal, then the constancy of the velocity of light in items 1 and 3 can also be a consequence of the gravitation influence.
How does the gravitational field act on the velocity of light? We shall research this question outside of the classical Newtonian theory of gravitation and outside of the special and general theory of relativity. This implies that we shall not use the concept of Newtonian gravitational forces, the principle of constancy of the velocity of light and the principle of equivalence between acceleration and gravitation.

2. 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 mass $M$ (Figure 5).

![Figure 5](image)

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 value of 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 the velocity are real physical quantities that have a physical meaning, and they together define the physical meaning of the kinetic mass.

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

$$p = \text{const}$$  \hspace{1cm} (1)

Instead it increases the kinetic mass of the photon to

$$m' = m + \Delta m$$  \hspace{1cm} (2)

and by that it decreases the photon speed to

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

where $r$ is the distance from the photon to the center of mass $M$, and $G$ is matching coefficient. The reverse moving of the photon to point $A$ 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 a finite point of travel. Change of the photon speed in the gravitational field is observed as a change in the photon travel time. Taking into account results of physical modeling, all of the experimental facts that are presented above (see Section 1), 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 velocities, which establishes the photon velocity 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 photon velocity relative to massive objects we shall name "the gravidynamic effect".

![Image of Figure 6]

**Figure 6**

**Note:** The Equation (3) is indirectly based on local observation of change in the kinetic mass of the photon in the Earth's gravitational field and remote observation of the decrease in the velocity of light in the Sun's gravitational field. However, the actual velocity of the photon in the gravitational field of the Sun has for the remote terrestrial 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 is a theme of special research. In this paper we shall research the physical consequences of the gravidynamic effect in pure form without the participation of the second assumption.

### 3. Time Dilation

The gravidynamic effect decreases the local speed of light at point $B$ (Figure 5), so 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):

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

Starting from the equivalence of a light clock to any other clocks, we conclude that a decrease of the light speed causes a proportional deceleration of the local time. Thus, the gravidynamic effect slows down both the local speed of light and the local time.
From the point of view of the remote observer situated at point $A$ (Figure 8) the photon speed in all central hollow area of the great mass $M$ is equally 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.

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:

$$p = m'c'$$

in process of the photon movement from point $A$ to point $B$ remains constant for the remote observer situated at point $A$ (see Section 2), but for the local observer situated at point $B$ the local value of momentum of this photon:

$$p' = m'c$$

is increased proportional to the local time dilation.
4. Emission of Light by the Moving Source

The speed of light in the central hollow area of a great mass $M$ (Figure 9) is equal to $c$ for the local observer fixed relative to $M$ (see Section 3). Let the atomic nucleus be accelerated up to the speed $\nu$ relative to the local observer. By the data, the speed $\nu$ is much less than the speed $c$.

According to the classical vector addition of velocities, the speed of the photon emitted by the atomic nucleus tends to exceed speed $c$ relative to $M$. However, the gravidynamic effect increases the kinetic mass of the photon to:

$$m' = m(1+\nu/c),$$  \hspace{1cm} (7)

and in this way retains the photon speed at a level $c$ relative to $M$. Classical gravitational forces or a difference of gravitational potentials, which take place in the Newtonian theory of gravitation are not necessary for that. The gravidynamic effect by definition can change the kinetic mass of the photon for conformity of its speed to the allowed speed relative to the massive object (see Section 2).

In case of emission of light in the opposite direction (Figure 9), the gravidynamic effect decreases the kinetic mass of the emitted photon:

$$m' = m(1-\nu/c),$$  \hspace{1cm} (8)

and in this way stabilizes its speed at $c$ relative to mass $M$.

Thus, the constancy of the local speed of light emitted by the particle accelerated relative to the Earth (Figure 1), the null result of Michelson-Morley experiment in the terrestrial neighborhood (Figure 10) and the constancy of the local speed of light in case of a ground-based observation of a stellar aberration are a consequence of the gravidynamic stabilization of the light speed 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 the electromagnetic waves in interstellar space, which is observed as strict periodicity of the orbital motion of a binary star (Figure 3) is a consequence of the gravidynamic stabilization of the speed of light relative to the system of surrounding stars.

5. Moving Light Clock

The speed of light in the central hollow area of a great mass $M$ (Figure 11) is equal to $c$ for the local observer fixed relative to $M$. Let a light clock be accelerated up to speed $\nu$ relative to the local observer. After acceleration of the light clock, the period between reflections of light from parallel mirrors becomes equal to

$$T' = T / \sqrt{1 - \nu^2 / c^2},$$

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

We already considered (see Section 3) how the gravidynamic effect slows down the rate of a light clock stationary relative to the gravitational field source. Here we see that
the gravidynamic effect causes an additional deceleration of the rate of a light clock moving relative to the massive object.

6. Propagation of Light in the Moving Medium

Let the photon propagation inside the transparent glass cylinder that moves with speed $\upsilon$ relative to mass $M$ (Figure 12). The photon is periodically absorbed and after a time is again emitted by material particles constituting the cylinder. A conditional speed of the photon in the absorbed state is equal to the movement speed of the material particle.

At the time of the photon motion in the space between particles (Figure 13), the gravidynamic effect stabilizes the photon speed at a level $c$ relative to mass $M$. As a result, the average effective speed of the photon becomes equal to

$$c'' = c' + \upsilon \left(1 - \frac{c'^2}{c^2}\right),$$

where $c'$ is the average effective speed of the photon, when the speed of the cylinder is equal to zero.
This result, known as a partial entrainment of light by the moving medium, was observed in water flow in the Fizeau optical experiment (Figure 14).

![Figure 14](image)

7. Variable Mass

We can define characteristics of gravitational influence on the electron and other material particles, if characteristics of gravitational influence on the electromagnetic radiation is known. The following physical model is necessary for this purpose.

A thin mirrored sphere is located in the central hollow area of a sufficiently great mass $M$ (Figure 15). Photons with kinetic masses $m_1$, $m_2$, etc. are included in sphere. By the data, the total kinetic mass of the cluster of photons is much more than the mass of sphere, therefore, inertial and gravitational properties of this compound object are mainly defined by the photons. By the way, the photons forming an electromagnetic field of the electron constitute a large part of inertial and gravitational mass of the electron. Now, let the mirrored sphere be accelerated up to speed $\upsilon$ relative to $M$. Despite of the increase in the speed of the sphere, the gravidynamic effect stabilizes the speed of the photons at a level $c$ relative to mass $M$. 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 motion of the photon after reflection from an internal surface of mirrored sphere. The photon that 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 4). The kinetic mass of other photons takes different intermediate values. As a result, the total kinetic mass of the cluster of photons grows:

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

and that increases the total inertial mass of the compound object.
The average period between reflections of the photons also increases, and that slows down the proper time of the compound object, which in addition to a role of the test mass is also a light clock.

8. Conclusion

So, we see that a local constancy of the propagation speed of electromagnetic waves, the dilation of the proper time and the increase in the inertial mass of accelerated particles are consequence of the gravidynamical effect, i.e. the local physics in many respects depends on action of surrounding masses.
References

- Barbour, J. "Dynamics of Pure Shape, Relativity and the Problem of Time," gr-qc/0309089.
- Brans, C. and Dicke, R.H. 1961. "Mach's Principle and a Relativistic Theory of Gravity," Physical Review, 124, 925-935.
- Dicke, R.H. 1964. Many Faces of Mach: Gravitation and Relativity, Benjamin Inc., New York.
- Ellis, G.F.R. "Cosmology and Local Physics," gr-qc/0102017.
- Ellis, G.F.R. and Uzan, J.P. "c' is the speed of light, isn't it?," gr-qc/0305099.
- Fraser, J.T. 1972. The Study of Time, I, New-York, Springer-Verlag.
- Katz, J., Lynden-Bell, D., and Bicak, J. "Gravitational Energy in Stationary Spacetimes," gr-qc/0610052.
- Kurucz, R.L. "The Precession of Mercury and the Deflection of Starlight by Special Relativity Alone," astro-ph/0608434.
- Landau, L.D. and Lifshitz, E.M. 1975. The Classical Theory of Fields, Pergamon Press.
- Unnikrishnan, C.S. "Cosmic Relativity: The Fundamental Theory of Relativity, its Implications, and Experimental Tests," gr-qc/0406023.
- Unzicker, A. "Mach's Principle and a Variable Speed of Light," gr-qc/0511038.
- Wald, R.M. 1984. General Relativity, University of Chicago Press, Chicago.