

RESEARCH ARTICLE



On the Influence of Gravity on the Deviation of the Direction of Light Propagation and Gravitational Time Slowdown

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Abstract: It has been established that the change in the direction of light propagation near massive astronomical bodies, such as the Sun, occurs due to the refraction of light in the cosmic environment. The role of the gravitational field is exclusively to increase the density of the cosmic environment as it approaches a massive body. The gravitational field has no direct effect on the light beam or photons. The incompatibility of the energy of gravitational processes with the idea of the interaction of space-time with objects of physical reality, including massive bodies and photons, has been established. Space-time is not an object of physical reality. It has been established that due to the decrease in the optical density of the cosmic environment as it moves away from a massive body, a gravitational red shift occurs. The idea of gravitational time dilation is devoid of physical (common) sense. It is not time that slows down. It is the physical processes that occur with material objects that slow down.

Keywords: astronomical body, light refraction, space environment, gravitational field, optical density

1. Introduction

Publications explaining the phenomenon of changing the direction of light propagation near massive astronomical bodies are dated 1804 [1], 1911 [2], and 1916 [3]. The first two predict the same deviation, while the third predicts twice as much. The reliability of the first publication is equivalent to the reliability of the statement that the photon has gravitational mass. This idea is not supported and is not considered in this paper. The reliability of the second and third publications is equivalent to the reliability of the statement that space-time [4–7] interacts with physical objects – massive bodies [8–11] and photons [12–15]. This idea is considered in this paper in terms of energy exchange [16–19]. The goal is to establish the compatibility of this idea with the energy of gravitational processes [20–23]. The present work is limited to revealing the errors of the general theory of relativity.

2. Methods

2.1. Objects of physical reality (OPR)

No measurement is possible without energy exchange (see the observer effect in quantum physics). The existence of OPRs can only be established by energy exchange with them, in particular, by measurement (which is impossible without energy exchange). No work, action, or interaction is possible without energy exchange. It necessarily follows from the last three statements that any OPR is an energy carrier. A massive body is an energy carrier, which is

clearly confirmed when it hits an obstacle. A massive body can be measured in a wide variety of aspects (mass, temperature, density, hardness, etc.). In all these and other measurements, it is impossible to do without energy exchange. A photon is an energy carrier, which is clearly confirmed by the release of heat when it is absorbed, as well as by the pressure of light. A photon can be measured – and most importantly, its energy.

Neither space, nor time, nor space-time are energy carriers. Not a single joule can be placed in them or extracted from them. It is impossible to measure them. A clock does not directly measure time, but only the amount of deformation of the spring. After all, you can draw not only time on the dial but anything you like: the number of decayed nuclei, the tide level, budget revenues, population growth. N.B. 1. In order to measure the amount of deformation of the spring with the help of an arrow, it (the arrow) must be seen; that is, some photon energy must be obtained. N.B. 2. Time is not the most obvious marking on the dial. It is much more natural to apply angular measures to it – degrees, radians, or rhumbs. With any good coincidence of the actual values of the “measured” quantities with the readings of the pointer, in all the cases indicated, it is not they that are measured, but the magnitude of the deformation of the spring. And if the last four named quantities (not angles) can be measured directly (without a dial, spring, and pointer), since they are OPR, then time cannot be measured directly, since it is not OPR and is not an energy carrier.

You can measure the length, width, and height of a wooden block (OPR) with a ruler and assume that a fragment of space has been measured. But if the block is burned, then it will be impossible to measure the empty space left after it (akin to handing someone a donut hole). In the so-called “measurements” of space and time, it is not they that are measured, but some

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OPR – a spring, a wooden block, etc. And the measurements of space and time are just a substitution of concepts (an addition to the dial), wishful thinking, an illusion (an apparent measurement of apparent space and time). Until we learn to communicate energy to space and time and extract it, we will not be able to measure them.

2.2. Energy

This is a measure of various forms of movement and interaction of OPR. In accordance with this definition, energy is not OPR and cannot exist independently (separately from OPR). Energy is not a substance and cannot be located (without OPR) in space and space-time. (In this regard, the idea of dark energy without its material energy carrier has no physical meaning.)

3. Results

3.1. Properties of OPR

These are mass, temperature, density, hardness, etc. Properties of OPR without their carrier (OPR) do not exist in nature. For this reason, they are not OPR and are not energy carriers. Mass is not an energy carrier. An energy carrier is a body (OPR) that has mass. Length, width, and height are properties of a body. Length, width, and height are not energy carriers. Length, width, and height are components of space, which, for the same reasons, are not energy carriers.

3.2. Gravitational interaction (taking into account energy exchange)

Let two identical, substantially massive motionless bodies be held at a considerable distance from each other, such that the potential energy of their interaction is negligible. At some point, the bodies are given freedom, and they very slowly begin to move toward each other. As they approach each other, the force of attraction between them increases, and their acceleration and speed increase [24]. At the end of the path, their kinetic energy is no longer negligible, which is clearly confirmed by the deformation of the bodies during the collision. (This entire experiment is carried out in the inertial frame of reference associated with the center of mass of the bodies.)

The first (trivial) conclusion is that in the process of approaching each other, the bodies acquired energy that they did not possess before this process. Classical theory does not reveal the mechanism of gravitational interaction, but it is revealed by the general theory of relativity [3]. The gravitational interaction of bodies is carried out as follows: The first/second body interacts with space-time, bending it; space-time interacts with the second/first body, accelerating it (relative to the center of mass); and both bodies acquire significant kinetic energy, which is transformed into significant work performed by the bodies during their collision and deformation.

The inevitable question is – where did the bodies get significant energy to perform significant work, if they did not initially possess this energy? The only possible answer is – they took this energy from the object with which they interacted, and they interacted exclusively with space-time.

The second conclusion (trivial) – the bodies received significant energy from space-time. (Regardless of the question of how it got there). But! Space-time is not an energy carrier and OPR (see Section 2). It cannot receive or give energy in principle.

The third conclusion (non-trivial) – the first/second body does NOT interact with space-time, curving it, and space-time does not

interact with the second/first body, accelerating it. (Because no interaction without energy exchange is possible (see Section 2)). This, of course, means that the direction of light propagation and, accordingly, the momentum of photons near massive bodies change not due to the curvature of space-time.

But before looking for another reason, we need to finish with the gravitational interaction. Otherwise, bewilderment may arise – where did the significant kinetic energy of the approaching bodies come from, if initially there was essentially no energy?

3.3. Origin of kinetic energy: option one (textbook)

At an infinite distance from each other between two massive identical round bodies of radius R , the potential energy of their interaction Π_∞ is equal to zero. When the bodies come into contact, it is equal to:

$$\Pi_{R+R} = -\gamma \frac{mm}{R+R} = -0,5 \frac{\gamma m^2}{R}. \quad (1)$$

The kinetic energy when the bodies come into contact is equal to:

$$K = 0,5 \frac{\gamma m^2}{R}. \quad (2)$$

The energy balance has the form:

$$K = \Pi_\infty - \Pi_{R+R} = 0 - \left(-0,5 \frac{\gamma m^2}{R}\right) = 0,5 \frac{\gamma m^2}{R}. \quad (3)$$

Mathematicians will not be confused by this expression. Physicists may feel uncomfortable because positive energy converted into positive work is extracted from nothing (from zero).

3.4. Origin of kinetic energy: option two

According to the study by Popov [25], at an infinite distance from each other between two massive identical round bodies of radius R , the potential energy of their interaction Π_∞ is equal to:

$$\Pi_\infty = 1,2 \frac{\gamma m^2}{R}. \quad (4)$$

When the bodies come into contact, it is equal to:

$$\Pi_{R+R} = 0,7 \frac{\gamma m^2}{R}. \quad (5)$$

Kinetic energy (energy balance)

$$K = \Pi_\infty - \Pi_{R+R} = 1,2 \frac{\gamma m^2}{R} - 0,7 \frac{\gamma m^2}{R} = 0,5 \frac{\gamma m^2}{R} \quad (6)$$

(compare with Equation (2)). In this version, there is no mysticism, and energy does not arise from nothing. But even in this version, space-time cannot be a transmitter of energy, since it is not an energy carrier.

3.5. Change in the direction of light propagation in a gravitational field

Interstellar space is not empty. It contains gases, dust, and elementary particles. But it contains immeasurable more dark matter, the role of which can be claimed, for example, by

newtonium – an inert chemical element predicted by D.I. Mendeleyev, the possibility of whose existence has recently received additional justification, and the excited state of which is positronium (among other things, it is very difficult to detect at the atomic level).

All this cosmic substance is distributed in interstellar space significantly unevenly. For obvious reasons, the closer to massive astronomical bodies, the higher the density of this substance. Consequently, the closer to massive astronomical bodies, the higher the optical density of the interstellar medium.

In this regard, a completely textbook phenomenon arises – the refraction of light – the curvature of a light beam toward an increase in the refractive index (toward an increase in optical density), that is, toward the center of a massive astronomical body. There is even a ready formula for the curvature of a beam experiencing this kind of refraction.

$$\frac{1}{R_v} = -\frac{d[\ln n]}{dr} \sin \beta. \quad (7)$$

Here n is the refractive index, which depends on r , and β is the angle between the ray and the direction to the center of a massive astronomical body (see Figure 1).

The effect of changing the direction of light propagation in a gravitational field is indirectly but closely related to gravitational redshift.

3.6. Gravitational redshift

As you move away from a massive astronomical body, the refractive index of the cosmic medium decreases.

$$n_2 < n_1. \quad (8)$$

$$n = \frac{c}{v}. \quad (9)$$

The speed of light increases.

$$c_2 > c_1. \quad (10)$$

It travels greater distances in the same amount of time. The wavelength ($\lambda = v\tau$) increases, which is perceived as “reddening.” This is the gravitational redshift. (In the opposite direction, there is a gravitational blueshift.) And this is a textbook case. There is no need for space-time to be curved.

3.7. Gravitational time slowdown

It is believed that gravitational time dilation leads to a change in the functioning of material objects, for example, to a decrease in the frequencies of oscillators [1, 2]. In this theory, a decrease in the frequencies of oscillators is a consequence, and time dilation is a cause. The further development of this logic is quite obvious. The frequency of the oscillator is associated with mass and elasticity [3]. Therefore, time dilation leads either to an increase in mass, or to a decrease in elasticity, or to an increase in mass and a decrease in elasticity. Let this be the first logic.

According to the second logic (historically, it arose earlier than the first), the period of oscillations of the oscillator (a fragment of time) is determined by the mass of the load and the elasticity of the spring.

$$\tau_0 = 2\pi\sqrt{\frac{m}{k}}. \quad (11)$$

Therefore, an increase in mass, or a decrease in elasticity, or an increase in mass and a decrease in elasticity leads to an increase in the time fragment τ_0 . And not vice versa. In other words, a change in mechanical parameters is the cause, and time dilation is the effect. The second logic is akin to the fact that in reality, a horse pulls a cart. The first logic is akin to the fact that a cart sets a horse in motion.

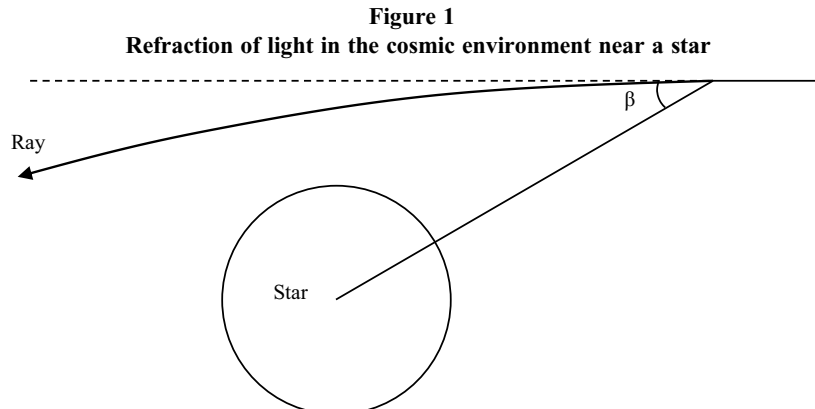
In accordance with these figurative comparisons, the first logic is recognized as unacceptable. In this regard, the question of the cause of the experimentally established phenomenon of gravitational time dilation is recognized as open. The purpose of the work is to establish this cause (in accordance with the second logic).

3.8. Energy aspect (in addition to what has been said)

In addition to what has been said about the fact that time dilation leads to a decrease in the oscillator frequency, it is proposed to pay attention to the total energy of the latter.

$$W = \frac{m\omega^2 a^2}{2}, \quad (12)$$

from which it follows that the oscillator energy also decreases. According to the first logic, the decrease in the oscillator energy is caused by the slowing down of time, which is caused by the gravitational curvature of space-time. It necessarily follows from this that part of the oscillator energy was absorbed by time, or



Note: β is the angle between the ray and the direction to the center of a star.

space-time, or space. But neither time, nor space-time, nor space can absorb nor release energy.

A counterargument is possible that the “lost” energy of the oscillator passed to the gravitating bodies responsible for the curvature of space-time. However, in the general theory of relativity, gravitating bodies do not interact with each other or with other material objects. They interact exclusively with curved space-time. Therefore, gravitating bodies can receive the “lost” energy only if space-time takes it from the oscillator and gives it to them. But space-time cannot participate in energy exchange in principle (see Section 3.2).

Therefore, in accordance with the first logic, the oscillator energy cannot decrease; consequently, its frequency cannot decrease, and therefore, time cannot slow down. In other words, in accordance with the first logic, from time slowing down, it follows that time slowing down is impossible. This additionally confirms that the first logic is unacceptable and time slowing down cannot be the cause of the decrease in oscillator frequencies (it can be a consequence).

3.9. Time slowdown

To evaluate it, it is appropriate (and even most expedient) to consider the oscillations of two harmonic oscillators (classical or quantum, it does not matter). Let one oscillator be located at an infinitely large distance from gravitating objects. The period of its oscillations is equal to Equation (11).

Let the second, exactly the same oscillator, be located at a distance r from a massive astronomical body of mass M [4]. To “turn off” gravity or, what is the same, “turn on” “antigravity” equal in magnitude to gravity, it is necessary to impart the first cosmic velocity to the oscillator. In this case, the balance of power has the form:

$$\frac{\gamma M m}{r^2} = \frac{mv^2}{r}. \quad (13)$$

This is a balance of forces. Kinetic energy is equal to:

$$\frac{mv^2}{2} = \frac{\gamma M m}{2r}. \quad (14)$$

Both the first and second oscillators are in a state of weightlessness. The second differs from the first in that it has kinetic energy (Equation (14)). Thus, the effect of gravity on the oscillator is equivalent to imparting energy to it (Equation (14)). In accordance with the famous formula $E = mc^2$, the mass of the oscillator increases and becomes equal to:

$$m_G = m + \Delta m = m + \frac{\gamma M m}{2rc^2} = m \left(1 + \frac{\gamma M}{2rc^2} \right). \quad (15)$$

Respectively,

$$\tau = 2\pi \sqrt{\frac{m_G}{k}} = 2\pi \sqrt{\frac{m}{k}} \sqrt{1 + \frac{\gamma M}{2rc^2}}. \quad (16)$$

Or

$$\tau = \tau_0 \sqrt{1 + \frac{\gamma M}{2rc^2}}. \quad (17)$$

This is the formula for gravitational “slowing down” of time.

4. Discussion

There is a textbook formula for gravitational time dilation, derived from ideas about the curvature of space-time, which is in satisfactory agreement with experiments.

$$\tau^* = \frac{\tau_0}{\sqrt{1 - \frac{2\gamma M}{rc^2}}}. \quad (18)$$

The extent to which the Equation (17) obtained above agrees with experiments can be assessed by comparing Equations (17) and (18).

$$\begin{aligned} \chi = \frac{\tau}{\tau^*} &= \frac{\tau_0 \sqrt{1 + \frac{\gamma M}{2rc^2}}}{\frac{\tau_0}{\sqrt{1 - \frac{2\gamma M}{rc^2}}}} = \sqrt{1 + \frac{\gamma M}{2rc^2}} \sqrt{1 - \frac{2\gamma M}{rc^2}} = \\ &= \sqrt{1 - \frac{2\gamma M}{rc^2} + \frac{\gamma M}{2rc^2} - \left(\frac{\gamma M}{rc^2} \right)^2} = \\ &= \sqrt{1 - 1,5 \frac{\gamma M}{rc^2} - \left(\frac{\gamma M}{rc^2} \right)^2}. \end{aligned}$$

$$\begin{aligned} \frac{\gamma M}{rc^2} &= \frac{6,6743 \cdot 10^{-11} \cdot 5,9722 \cdot 10^{24}}{6,3713 \cdot 10^6 \cdot (2,99792458 \cdot 10^8)^2} \left(\frac{m^3 s^{-2} kg^{-1} \cdot kg}{m \cdot m^2 s^{-2}} \right) \\ &\approx 0,7 \cdot 10^{-9}. \end{aligned} \quad (19)$$

The final ratio of time intervals is

$$\chi \approx 1. \quad (20)$$

Thus, Equation (17) agrees with experiments approximately as well as Equation (18).

5. Conclusion

The change in the direction of light propagation near massive astronomical bodies occurs due to the refraction of light in the cosmic environment. The role of the gravitational field is exclusively to increase the density of the cosmic environment as it approaches a massive body and the corresponding increase in its optical density. The gravitational field does not have any effect directly on the light beam or on photons, but it does affect the optical refractive index of the cosmic environment (see the previous remark). The incompatibility of the energy of gravitational processes with the idea of the interaction of space-time with objects of physical reality, including massive bodies and photons, has been established. The following has been established in passing. The existence of any OPR can only be confirmed by energy exchange with it. No work, action, or interaction is possible without energy exchange. Any OPR is an energy carrier. Space-time is not an object of physical reality, is not an energy carrier, and cannot interact with anything; it cannot accelerate massive bodies, cannot change the momentum of photons, and accordingly, the direction of their movement. It is impossible to directly measure space, time, and space-time. No objects of physical reality, including massive bodies, can interact with space-time in any way; they cannot bend it. At the same time, it is possible to bend space-time. For this, the imagination of researchers is quite sufficient, especially Lobachevsky and Riemann.

It has been established that due to the decrease in the optical density of the cosmic environment as it moves away from a massive body, a gravitational red shift occurs. The idea of

gravitational time dilation is devoid of physical (common) sense. It is not time that slows down. It is the physical processes that occur with material objects that slow down. Time dilation is an illusion. The same as a moving platform for a passenger looking out of a train window. Massive astronomical bodies do not affect time, but rather material objects. Time (and its “slowdown”) is not the cause of any phenomena. On the contrary, time (and its “slowdown”) is a secondary (conditioned) parameter of material processes. Formal evidence of this is that in formulas (Equations (11), (17), (18), and many others), time is always on the left side (what is on the left follows from what is on the right). Gravitational “slowdown” of time is determined by Equation (17).

Opponents may demand an explanation of ALL the effects of the general theory of relativity. But even if the explanations for the curvature of light and the red shift were not presented, would this prove that space-time is an object of physical reality, an energy carrier that participated in energy exchange, and that the arguments presented are devoid of common sense? Let other effects of the general theory of relativity wait in the wings and find their interpreters. It is believed that the Newtonian theory of gravity is bad because in it the gravitational effect is transmitted instantly, that is, with an infinitely high speed. However, there are no obstacles to limiting this speed at least to the speed of light, especially since “gravistatics” and electrostatics are mathematically almost isomorphic, which gives good prospects for bringing “gravitodynamics” into line with electrodynamics.

Many of the presented arguments are obvious (and even trivial), but failure to take them into account can and does lead to the emergence of unusual ideas such as the interaction of material objects with immaterial (imaginary) ones (essentially, supernatural phenomena, akin to adding kilometers to kilograms).

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Igor P. Popov: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

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