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Proof of Einstein's Postulates

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Abstract

Based on the assumption that the experiment confirms the STR, it is shown that the magnitude of the speed of light is an extremely slowly decreasing function of its frequency. However, at frequencies less than 1 hertz, the speed light begins to decrease sharply, and at a frequency of $4{,}6 \cdot 10^{-21}$ c^{-1}, the speed of light becomes zero. Such light could serve as the Absolute Reference System, but due to their negligible mass, they do not have any effect on the processes taking place. This explains the postulate of Einstein's principle of relativity. The formulas for the change in the speed and frequency of light during the transition from one IRS to another remain unchanged, which proves Einstein's postulate of the constancy of the speed of light in any IRS.

Keywords: Einstein's postulates, speed of light, frequency of light, red shift, subquants, photonics.

The special theory of relativity (STR) was based on Einstein's principle of relativity (first postulate) and the principle of constancy of the speed of light (second postulate) [1]. All the basic formulas of STR, although confirmed by experiment, but since the derivation of these formulas is based on postulates, doubts remain about their truth, since such a coincidence can be accidental, especially since many consequences of STR are paradoxical.

On the other hand, there is an experiment, the results of which obey the formulas that we take as true, and, with some error, coincide with the STR formulas. For this reason, I will use some STR formulas, considering them, although empirical, but giving confidence to their truth.

The fundamental constant C, arising in the Lorentz transformations, has the meaning of the *limiting* speed of motion of material bodies, the limiting speed of signal transmission (interaction). It is believed that it numerically coincides with the speed of light, but there is no direct evidence of this. For example, in the monograph by M.G. Lobanovsky [2] substantiates that the speed of interaction is $\sqrt{2}$ times greater than the speed of light. Therefore, it makes sense to distinguish between the fundamental constant – the speed C and the speed of light c. The first constant reflects the general properties of space and time, while the second is associated with the properties of a specific interaction [3].

The Lorentz transformations used in STR were originally obtained on the basis of the postulate of the nonrelativistic law of addition of velocities without using the postulate of the maximum speed of light [4, 5]. After Einstein built STR based on only the first postulate, many researchers tried to abandon the use of the second postulate altogether [6 – 9]. These works describe methods of obtaining (up to an undefined constant) of Lorentz transformations without using the second postulate. The general approach to the problem is to obtain the corresponding functional equation, the solution of which leads to the formula for the addition of parallel velocities [9]. It should, however, be noted that the experimental "calculating" the sign of an indefinite constant is actually equivalent to the assumption of the presence of a maximum speed, that is, in essence, to the second postulate.

Nevertheless, attempts at axiomatization, including without the second postulate, were made later by other researchers. There are also axiomatic that do

not use the principle of relativity, but use only the principle of the constancy of the speed of light. A.K. Guts [10] can find more details in the monograph.

The purpose of this work is to find the value of the fundamental constant C, to find the dependence of the speed of light on frequency, the formula for the change in the frequency of light when switching to another Inertial Reference System (IRS) and to prove the truth within the accuracy of modern methods of studying Einstein's postulates.

2. POSTULATES OF EINSTEIN

Let us recall two main provisions of SRT, called Einstein's postulates [3].

Postulate 1. The laws of nature are the same in all coordinate systems moving rectilinearly and uniformly relative to each other. This means that the *form* of dependence of physical laws on space-time coordinates should be the same in all IRS, that is, the laws are invariant with respect to transitions between IRS. The principle of relativity establishes the equality of all IRS. It follows from this that there is no “privileged” system among the IRS and it is impossible to detect the state of absolute motion. Absolute space does not exist. This postulate is also called "*Einstein's principle of relativity*", although Poincaré [5] first published this principle.

Postulate 2. *The principle of constancy of the speed of light*. The speed of light in a vacuum is the same in all coordinate systems moving rectilinearly and uniformly relative to each other. It immediately follows from this postulate that the speed of light in a vacuum does not depend on the speed of the source, since an inertial system can be associated with the source [3]. An important consequence of the second postulate is that the speed of light does not depend on its wavelength and frequency.

3. AGING OF PHOTONS

Fritz Zwicky in 1929 put forward a hypothesis of light aging, according to which light loses energy, which entails a decrease in its frequency with subsequent redshift [11]. In papers [12 – 14], a theoretical analysis and classification of hypotheses about the redshift in the spectra of galaxies, as the main reason for the aging of photons, was carried out.

From ether-dynamic hypotheses V.A. Atsyukovsky [15] and S.A. Nikolaev [16], it follows that with each wave oscillation, a photon emits a subquantum in the direction of its motion, called a photonic [16], and the frequency of light, accordingly, decreases, so that the final decay product of photons of any frequency is photonics. The frequency of photonics ν_f can be found by taking the ratio of the difference in photon frequencies over time interval t to the number of oscillations N in this interval. Let us choose as the defining frequencies the highest frequency $\nu_\infty \approx \infty$ of light, the photons of which were formed at the moment of the Big Bang (BB) and the smallest frequency, equal to the frequency of the photonics ν_f, which were formed from these photons with the frequency ν_∞ to the present moment, i.e. after a time T = 13799 ± 0.021 billion years $= 4.35 \cdot 10^{20}$ s, equal to the lifetime of our Universe [17]. Then the frequency of the photonics will be equal to:

$$\nu_f = \frac{\nu_\infty - \nu_f}{N} \tag{1}$$

The number of oscillations in this frequency interval during time t is equal to:

$$N = \nu_{midl} \cdot t \,, \tag{2}$$

where ν_{midl} – average photon frequency in this interval:

$$\nu_{midl} = \frac{\nu_\infty + \nu_f}{N} \tag{3}$$

Substituting (2, 3) in (1), we get:

$$\nu_f = \frac{2}{t} \cdot \frac{\nu_\infty - \nu_f}{\nu_\infty + \nu_f} \tag{4}$$

Taking into account the fact that $\nu_\infty \gg \nu_f$ and, since the decay of a photon with a frequency ν_∞ occurred during the existence of the Universe $t = \mathrm{T}$, then

$$\nu_f = \frac{2}{\mathrm{T}} = 4.6 \cdot 10^{-21} s^{-1}, \tag{5}$$

and the mass of photonics, in accordance with Einstein's law:

$$h\nu = mc^2 \tag{6}$$

will be equal

$$m_f = \frac{h\nu_f}{c^2} = 3.4 \cdot 10^{-71}\, Kg \ , \tag{7}$$

where h is Planck's constant, c is the speed of light. From formula (4), one can find the time t, which is necessary for a photon of any frequency $\nu_0 < \nu_\infty$to decay:

$$t = \frac{2(\nu_0 - \nu_f)}{\nu_f(\nu_0 + \nu_f)} \tag{8}$$

If $\nu_0 = n\nu_f$, where $n \gg 1$ is an integer, then

$$t = \frac{2(n-1)\nu_f}{(n+1)\nu_f^2} = \frac{2}{\nu_f} \cdot \frac{(n-1)}{(n+1)} < \frac{2}{\nu_f} = \mathrm{T}\ . \tag{9}$$

It can be seen from (9) that the decay time of total photons to photonics with a frequency lower than ν_∞ will be less than the time of the existence of the Universe. It follows from this that the photonics formed from such photons will simply fill the space of the Universe.

In the works of M.P. Bronstein [18, 19] showed that photons cannot spontaneously decay into elementary particles. This was done using the example of the spontaneous decay of the μ-meson [20]. Let T_0 be the lifetime of a meson at rest. Then if it moves with speed v, its lifetime is $\tau = T_0/\sqrt{1 - v^2/c^2}$. The energy of a moving meson is $E = m_0c^2/\sqrt{1 - v^2/c^2}$, where m_0 is the meson mass. The particle decay probability is inversely proportional to the lifetime $W = 1/\tau$, and the energy, respectively, $E = h\nu$, h is Planck's constant. This implies:

$$EW = -m_0c^2W_0 = \text{const}, \quad (10)$$

$$h\nu W = \text{const}, \quad (11)$$

$$W = \text{const}'/\nu. \quad (12)$$

This is the formula of M.P. Bronstein. According to the Lorentz invariance principle, this formula is universal for both mesons and photons [20]. If the probability of the decay of photons were indeed inversely proportional to the frequency, then the quanta of radio waves would decay especially quickly. But this allegedly is not observed, since the redshift of the waves in the radio range is exactly the same as in the optical one. However, the reason for the greater probability of decay of radio waves in comparison with visible light is different: from formula (9) it follows that visible light contains more photonics than radio waves. Therefore, visible light takes more time to decay completely to photonics than radio waves, and from this it follows that the probability of decay of radio waves to the state of individual photonics will be greater than the probability of decay of visible light. Thus, the arguments of M.P. Bronstein do not contradict, but confirm the correctness of the hypothesis of decay of photons into photonics.

4. UNIVERSAL CONSTANT *C*

In the work of N. D. Mermin [9], by solving the functional equation

$$v_{CA} = f\left(v_{CB,}\, v_{BA}\right), \quad (13)$$

where v_{CA}, v_{CB}, v_{BA} are the velocities of bodies *A, B, C,* relative to each other, the law of addition of parallel velocities was found

$$w = \frac{v+u}{1+Kvu}, \quad (14)$$

where K is the formal constant. This constant cannot have a negative value, since, otherwise, the addition of two positive speeds, each of which is greater than

$(-K)^{-0.5}$, would result in a net negative speed. The value $K = 0$ leads to the Galilean addition form

$$w = v + u \,, \tag{15}$$

and the value $K = {}^{1}/_{C^2}$ to the addition formula of the STR

$$w = \frac{v+u}{1+\frac{vu}{C^2}} \,, \tag{16}$$

where C is a fundamental constant with the dimension of speed. Other values of K lead to other types of STR. Einstein's STR uses formula (16) and other corresponding formulas, the value of C in which remains unknown.

Since a photon emits photonics, the photon itself can be considered as consisting of an integer number of photonics. However, photonics, being a part of a photon, apparently form a single homogeneous, or some other substance, and not a discrete structure, which is a simple collection of photonics. Therefore, a photon is represented as a photonic moving with a speed v, the frequency of which is equal to the frequency of the photonν_v:

$$h\nu_v = m_f^v C^2 \,, \tag{17}$$

The mass of a moving photonic is, respectively, equal to:

$$m_f^v = \frac{m_f}{\sqrt{1-\frac{v^2}{C^2}}} \tag{18}$$

Substituting (18) into (17), we obtain

$$h\nu_v = \frac{m_f C^2}{\sqrt{1-\frac{v^2}{C^2}}} \,, \tag{19}$$

whence the speed of the photonics, and, therefore, the speed of light (photon) with the frequency ν_v is equal to:

$$v = C\sqrt{1 - \frac{m_f^2 C^4}{h^2 \nu_v^2}} \,. \qquad (20)$$

From equality (20) it follows that the dependence of the speed of light on its frequency is an increasing function: the greater the frequency of light, the greater its speed, and at $\nu_v = \infty$ the speed of light is maximum:

$$v = v_{max} = C \,. \qquad (21)$$

According to the experimental data, visible light with a frequency of 10^{15} s has a speed [21]:

$$v_0 = 299792458 \pm 0.4 \ \text{м/s} \qquad (22)$$

Equality (22) shows that if we change the value of the velocity v_0 within the measurement error by the value

$$|\alpha| \ll \pm 0.4 \,, \qquad (23)$$

then it will remain true. Therefore, for the sake of convenience of calculations, we will choose the speed of visible light equal to

$$v = 299792458 - 3 \cdot 10^{-71} \pm 0.4 \ \text{м/s} \qquad (24)$$

Substituting this value v into equality (20) and solving it with respect to C, we find

$$C = 299792458 \pm 0.4 \ \text{м/s} \qquad (25)$$

Conclusion: all STR formulas include not just the speed of light, but the fundamental constant C, equal to the speed of light with a frequency $v = \infty$.

5. PROOF OF EINSTEIN'S FIRST POSTULATE

From formula (20), taking into account (5), we find the frequency ν_{min}, at which the speed of light v is equal to zero:

$$h^2\nu_{min}^2 = m_f^2 C^4 \quad (26)$$

$$\nu_{min} = \frac{m_f\, C^2}{h} = 4.6 \cdot 10^{-21} c^{-1} = \nu_f \quad (27)$$

The frequency obtained is many orders of magnitude lower than the frequencies, the corresponding light of which can be detected by modern methods. Photonics, i.e. have zero velocity and are at rest. The set of resting photonics is a "standing" light, which can serve as the Absolute Reference System (ARF).

The time required for the decay of a photon of visible light with a frequency $\nu_0 = 10^{15}\ s^{-1}$ is $t = 4.35 \cdot 10^{20}\ s$, i.e. almost coincides with the lifetime of the universe. Almost the same result will be obtained for light of all ranges, which can be recorded by modern devices. Therefore, at the moment, photonics have managed to be formed only from those photons that arose at the moment of the Big Bang (BB), and all later photons are only in the stage of moving ultra-long radio waves. For this reason, they cannot serve as ARF.

Suppose that at the moment of the BB a very large, but finite number n of photons with an average frequency $\nu_\gamma = 10^{22}\ s^{-1}$ were formed in the range of γ-rays. Assuming that the mass of the Universe at the moment of BW was the same as it is now

$$M \approx 10^{56}\ Kg \quad (28)$$

you can write equality:

$$nh\nu_\gamma = \mathrm{M}\, C^2, \quad (29)$$

Where

$$n = \frac{\mathrm{M}\, C^2}{h\nu_\gamma} = 1.4 \cdot 10^{84} \text{ photonics.} \quad (30)$$

Since the Universe is expanding at a speed of 73.3 *km/s* [22], then if we assume that it was expanding at such a speed from the moment BB, then the radius of the Universe R has reached the value

$$R \approx 73.3\mathrm{T} = 3.2 \cdot 10^{25}\ m, \quad (31)$$

and the volume of the Universe, accordingly, became

$$V = \frac{4}{3}\pi R^3 = 1.4 \cdot 10^{77}\ m^3 \quad (32)$$

It is possible that the speed of dispersal of particles immediately after the BB was greater than 73.3 *km/s*, therefore, according to other estimates, $V_T \approx 3.5 \cdot 10^{80}\ m^3$. Then in 1 m^3 space of the Universe there is

$$\rho = \frac{n}{V_T} = \frac{1.4 \cdot 10^{84}}{3.5 \cdot 10^{80}} \approx 4000 \text{ photonics,} \qquad (33)$$

which corresponds to the content of 4 Absolutely resting photonics in 100 sm^3. Taking into account (7), we find that the mass density of the photonics

$$\rho_m = \rho m_f = 1.4 \cdot 10^{-67}\ \text{кг/м}^3 \qquad (34)$$

Obviously, such a negligible mass density of photonics at the modern level of science and technology practically does not affect the movement of bodies and the processes occurring in the Universe. This makes it possible to ignore the existence of ARS, which makes it fair within the accuracy of measuring the parameters of the observed phenomena and confirms the truth of Einstein's first postulate, which asserts that in any IRS all processes occur according to the same laws.

6. PROOF OF EINSTEIN'S SECOND POSTULATE

Table 1 shows the values of the speed of light, depending on its frequency, calculated by the formula

$$v = C\sqrt{1 - \frac{\nu_f^2}{\nu_v^2}}, \qquad (35)$$

which was obtained by substituting (27) into formula (20).

Table 1.

The dependence of the speed of light on its frequency

$\nu_v,\ s^{-1}$	$v,\ m/s$	Type of radiation
∞	$C = 299792458$	Ultimate light
10^{22}	$(1-10^{-93})C$	γ-rays
10^{18}	$(1-10^{-85})C$	X-rays
10^{15}	$(1-10^{-79})C$	Visible light
10^{11}	$(1-10^{-71})C$	Infrared light
10^{8}	$(1-10^{-65})C$	Radio waves
10^{4}	$(1-10^{-57})C$	Ultra-long radio waves
1	$(1-10^{-49})C$	Unobservable
10^{-10}	$(1-10^{-29})C$	– o –
10^{-19}	$0.9979\ C = 299158097.16$	– o –
10^{-20}	$0.7884\ C = 236356373.89$	– o –
$9\cdot 10^{-21}$	$0.7388\ C = 221476304.77$	– o –
$8\cdot 10^{-21}$	$0.6694\ C = 200673576.57$	– o –
$5\cdot 10^{-21}$	$0.1536\ C = 46048121.55$	– o –
$4.8\cdot 10^{-21}$	$0.0816\ C = 24462231.81$	– o –
$4.7\cdot 10^{-21}$	$0.0421\ C = 12621411.77$	– o –
$4.65\cdot 10^{-21}$	$0.0213\ C = 6378562.93$	– o –
$4.60\cdot 10^{-21}$	0	Photonics

It can be seen from Table 1 that the dependence of the speed of light on frequency in the range of frequencies available for observation from 10^4 to $10^{22}\ s^{-1}$ decreases very weakly, so that such light can be considered practically not frequency dependent. This confirms the consequence of Einstein's second postulate, which states that the speed of light does not depend on its frequency in the range of frequencies of light available for observation. However, at frequencies less than

$\sim 10^{-19}\ s^{-1}$ the value of the speed of light begins to decrease noticeably, in the frequency range less than $\sim 10^{-20}\ s^{-1}$ the speed of light is narrower decreases sharply, and at a frequency of $4.60 \cdot 10^{-21}\ s^{-1}$ becomes equal to zero, which corresponds to the state of resting photonics.

Application of the formula for the addition of velocities (16), which follows from SRT, since it is considered confirmed by experiment, but in our analysis it acts as an empirical truth if the speed of light is in the range of frequencies possible for observation by modern methods is equal to $v \approx C$ for any values u, allows you to write the equality:

$$w = \frac{v+u}{1+\frac{vu}{C^2}} = \frac{C+u}{1+\frac{u}{C}} = C \approx v\ , \qquad (36)$$

where v is the speed of light in IRS-1, u is the speed of IRS-2 relative to IRS-1. From (36) it can be seen that whatever the relative speed of different IRS from each other, the resulting speed of light in both IRS, if the frequency of light is in the region of the observed frequency range, is the same. This proves Einstein's second postulate, which states that the speed of light is the same in all IRS.

7. THE DISCUSSION OF THE RESULTS

Now it is necessary to explain the reason why the formula for the addition of parallel velocities of SRT is realized in nature in accordance with the principle of relativity of Einstein (16), and not Galileo (14) [23]? For this, consider how the frequency of light changes when it goes to another IRS. From formula (20) we find the frequency of light in IRS-1

$$\nu_v = \frac{mC^3}{h\sqrt{C^2-v^2}} \qquad (37)$$

In IRS-2, moving with a speed u relative to IRS-1, the frequency of light will be determined, respectively, by the formula

$$\nu_w = \frac{mC^3}{h\sqrt{C^2-w^2}} \qquad (38)$$

Substituting the value of w from (16) into (38), we obtain

$$\nu_w = \frac{mC^3(C^2+vu)}{hC\sqrt{(C^2+vu)^2-C^2(v+u)^2}} \qquad (39)$$

Dividing expression (39) by (37), we find:

$$\nu_w = \frac{\nu_v}{C}\sqrt{\frac{C^2-v^2}{1-C^2\left(\frac{v+u}{C^2+vu}\right)^2}} \qquad (40)$$

It is easy to verify by simple substitution of the values $0 \leq v, u \leq C$ and the data in Table. 1 into the formula (40), that if the IRS-2 moves relative to the IRS-1, then in the IRS-2 the frequency of light will be higher. For example, if we choose $v = u = C/2$, then we get that the frequency of light in IRS-2 will be greater than in IRS-1:

$$\nu_w = 5/\sqrt{12}\nu_v \approx 1{,}445\nu_v. \qquad (41)$$

Thus, the frequency of light when it passes into a moving frame of reference increases, which, from the point of view of an observer from IRS-2, leads to a blue shift. Accordingly, the light moving in IRS-2, from the point of view of an observer from a relatively resting IRS-1, will experience a redshift.

Formula (40) provides one more proof of the validity of Einstein's second postulate within the frequency of light, which can still be recorded by modern devices. Indeed, if the light in IRS-1 had speed and frequency, respectively, v and ν_v, then when it switches to moving relative to IRS-1, IRS-2, its frequency becomes ν_w. But if the light corresponded to the parameters possible for observation, then the speed of such light w, found from formula (20) or from the data in Table. 1, will be practically the same $v \approx w$. within the measurement error. This proves that the speed of light in all IRS is the same.

All of the above related to light. But the formula for the addition of velocities (16) is applicable to any material bodies, if by frequency we mean the frequency of De Broglie waves. Let us write formula (40) at the speed of light $v = 0$, in this case $\nu_v = \nu_f$:

$$\nu_w = \frac{\nu_f}{\sqrt{1-\frac{u^2}{C^2}}}, \qquad (42)$$

ν_w is the frequency of light, measured in IRS-2, moving at a speed u relative to

IRS-1. For a material body resting in IRS-1, you can write

$$\nu_0 = \frac{m_0 C^2}{h}, \tag{43}$$

where ν_0 is the de Broglie frequency, m_0 is the rest mass of the body, and if the body moves with the speed u, then

$$\nu_u = \frac{m_u C^2}{h}. \tag{44}$$

Let us write (42) taking into account (43) as applied to a material body:

$$\nu_u = \frac{\nu_0}{\sqrt{1-\frac{u^2}{C^2}}} \tag{45}$$

We equate (44) and (45):

$$\frac{m_u C^2}{h} = \frac{\nu_0}{\sqrt{1-\frac{u^2}{C^2}}}. \tag{46}$$

Substituting (43) into (46), we obtain a formula for the mass of a moving body, which coincides with a similar STR formula:

$$m_u = \frac{m_0}{\sqrt{1-\frac{u^2}{C^2}}}. \tag{47}$$

As can be seen from the above, the answer to the question about the truth of the formula for the addition of velocities (16) for light is explained by the fact that during the transition to the IRS-2, moving relative to the IRS-1, the energy of the relative motion of the IRS does not transform only into a change in the speed of light, but is redistributed between a change in frequency and a change in the speed of light, and change in accordance with formulas (16) and (40). In the case of other material bodies, the redistribution of the added energy occurs between the speed of the body (16) and the mass of the body (47), as well as the de Broglie frequency (43, 44), which differs from the body weight only by the presence of the proportionality coefficient. If it were not for this redistribution, then Galileo's principle of relativity would operate (15). The question of why this is exactly the case remains open.

The photonics themselves form "standing light" and fill the space of the Universe, thereby creating an Absolute Reference System, and the speed and

frequency of light, albeit in an insignificant degree, within the range of observed frequencies, but depend on each other. Therefore, Einstein's postulates are proven only in a pragmatic sense. If we judge in principle, then they are not true. However, for solving many problems, the use of these postulates and SRT can serve as a hint for finding even more accurate solutions based on the existence of ARS, and vice versa, solutions from the point of view of ARS Theory, in some cases, may turn out to be simpler and clearer that such are in SRT. In fact, it turned out that the results of applying SRT and the Theory of ARS, within the range of light frequencies from 10^{-18} to $10^{22}\ s^{-1}$ and more, do not differ.

8. CONCLUSIONS

1. It is shown that photons decay into subquanta – photonics with mass $m_f = 3.4 \cdot kg$ and frequency $\nu_f = 4.6 \cdot 10^{-21} s^{-1}$.
2. The dependence of the speed of light on its frequency has been established, from which it follows that within the frequency range from 10^{-18} to $10^{22}\ s^{-1}$, including the range of ultra-long radio waves to γ-rays, is practically constant, but the speed of light with a frequency less than $10^{-18}\ s^{-1}$, decreases sharply, so that at a frequency of $\nu_f = 4.6 \cdot 10^{-21} s^{-1}$ becomes equal to zero .
3. The set of resting photonics can be considered as ARS, which, however, due to their small mass, has practically no effect on the processes occurring in the Universe. This proves the validity of Einstein's first postulate.
4. Derived the formula for the change in the frequency of light in the transition to another IRS.
5. It is shown that the speed of light within the frequency range from 10^{-18} to $10^{22}\ s^{-1}$ and the accuracy of modern methods of its measurement is practically the same in all IRS. This is proved by Einstein's second postulate.
6. It is concluded that the reason for the nonlinearity of the formula for adding velocities is that the energy of the relative motion of one IRS in relation to

another is redistributed between the change in speed and frequency – in the case of light, and speed and mass in the case of another material body.

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