Explanation of Michelson-Morley Experiment

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Abstract. The explanation of Michelson-Morley experiment is based on both actual and apparent reduction (equal) of light speed. The actual reduction of light speed happens only when the light is transmitted on moving material systems, on which the cohesive pressure[1,2] of the proximal space is reduced. The apparent reduction of light speed happens due to the aberration of light, which can be used as a detection criterion of the absolute motion. Lorentz factor of special relativity is the tool for the mathematical expression of the problem that had arisen from the Michelson-Morley experiment. Of course, the time dilation was an ingenious and pioneering idea, which has been accepted, ignoring, though, the real cause of the slowing of the moving clock, i.e. the phenomenon of motion.[3,4] However, this same reduction factor appears as well in the unified theory of dynamic space[1] with the Galilean transformations, by calculating the actual reduction of the light speed on moving material systems, not based on the second postulate of relativity.

Keywords: Cohesive pressure; relative light speed; apparent light speed; absolute light speed; Lorentz factor.

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1. Relative and absolute speed of light

The motion of charged[3] and uncharged particles[4] takes place by accumulation of forces on pairs of vertical meridians of the particle spherical zone as a result of pressure difference, which is placed in front of and behind the particle. Therefore, on the moving material systems the residual cohesive pressure will be then

$$P = P_0 - \Delta P, \tag{1}$$

where ΔP the pressure difference as a motion arrow[3,4] of the particle and P_0 the cohesive pressure[1,2] of the dynamic space far from the moving system.

The speed of light[5] far from the the moving system is

$$C_0 = \sqrt{\frac{P_0}{d_m}} \Rightarrow C_0^2 = \frac{P_0}{d_m}, \tag{2}$$

while the speed u of the particle[6] is

$$u = \sqrt{\frac{\Delta P}{d_m}} \Rightarrow u^2 = \frac{\Delta P}{d_m}, \tag{3}$$

where d_m the constant mass density[7] of space. The relative speed of light on the moving material system, due to Eqs 2 and 1, will be then

$$C_r = \sqrt{\frac{P}{d_m}} \Rightarrow C_r^2 = \frac{P}{d_m} = \frac{P_0 - \Delta P}{d_m} \Rightarrow C_r^2 = \frac{P_0}{d_m} - \frac{\Delta P}{d_m} \tag{4}$$

and, due to Eqs 2 and 3, the Eq. 4 becomes

$$C_r^2 = C_0^2 - u^2 \Rightarrow C_r = \sqrt{C_0^2 - u^2} \Rightarrow C_r = C_0\sqrt{1 - \frac{u^2}{C_0^2}}. \tag{5}$$

Hence, the speed of light on a moving material system is reduced, irrespective of the direction of motion, according to the reduction factor $\sqrt{1 - u^2/C_0^2}$ (Eq. 5).

Of course, if ω is the angle between C_0 and speed u of a moving system, then the relative speed of light (Fig. 1) is $C_r = \sqrt{C_0^2 - u_x^2}$ (Eq. 5), where $u_x = ucos\omega$. Namely, only the component u_x, parallel to the speed of light C_0, causes an actual reduction of light speed, due to reduction of the cohesive pressure (Eq. 1), while the component u_y, vertical to the speed of light C_0, causes an apparent reduction of light speed, due to the aberration of light, as it will be described in the following section 2.

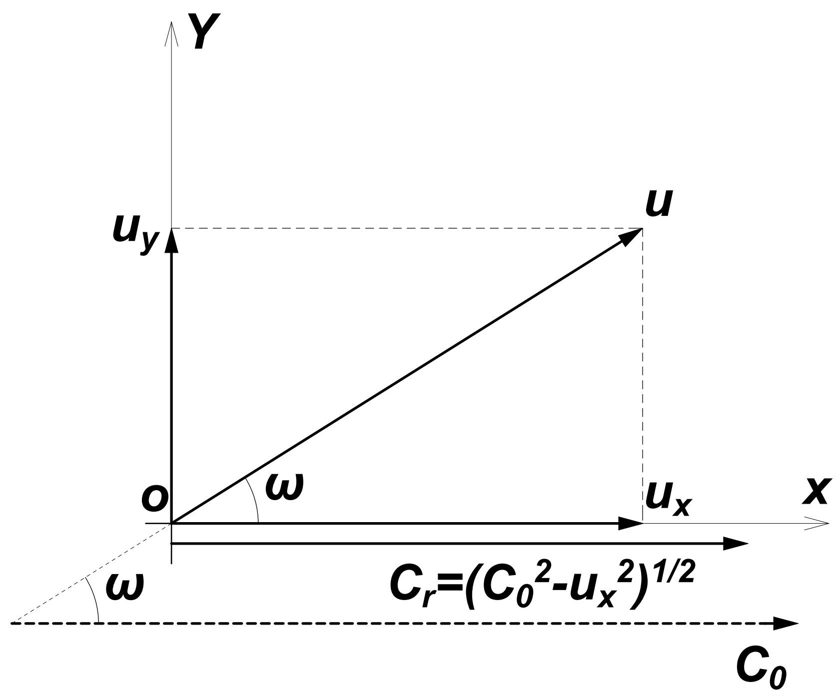

Figure 1. Component u_x causes an actual reduction of light speed

Given that, the relative speed of light $C_r = \sqrt{C_0^2 - u^2}$ (Eq. 5) is a function of speed u (that imposes the motion arrow) of the moving system, it is expected the absolute speed of light C to be the algebraic sum of u and C_r, namely it is

$$C = C_r \pm u \Rightarrow C = \sqrt{C_0^2 - u^2} \pm u. \tag{6}$$

So, as it concerns light, there is no need to apply the Lorentz transformations (since it is $C_r < C_0$), but the Galilean transformations, exactly as they apply at the motion of material bodies on moving systems.

2. Aberration of light - Apparent speed of light

When light moves far from dynamic fields (e.g. electrical or gravitational fields) or in regions where the Cosmic change of cohesive pressure[1,2] of dynamic space is negligible, then it moves in straight line and any aberrance from this straight line determines the so called phenomenon of aberration of light. This phenomenon is caused by the apparent aberration and the change of light speed, due to the absolute motions of either the observer, or the light source, or both. In Fig. 2a, where observer and light source are stationary, observer at point O observes the E/M waves from light source S transmitted by the laser device.

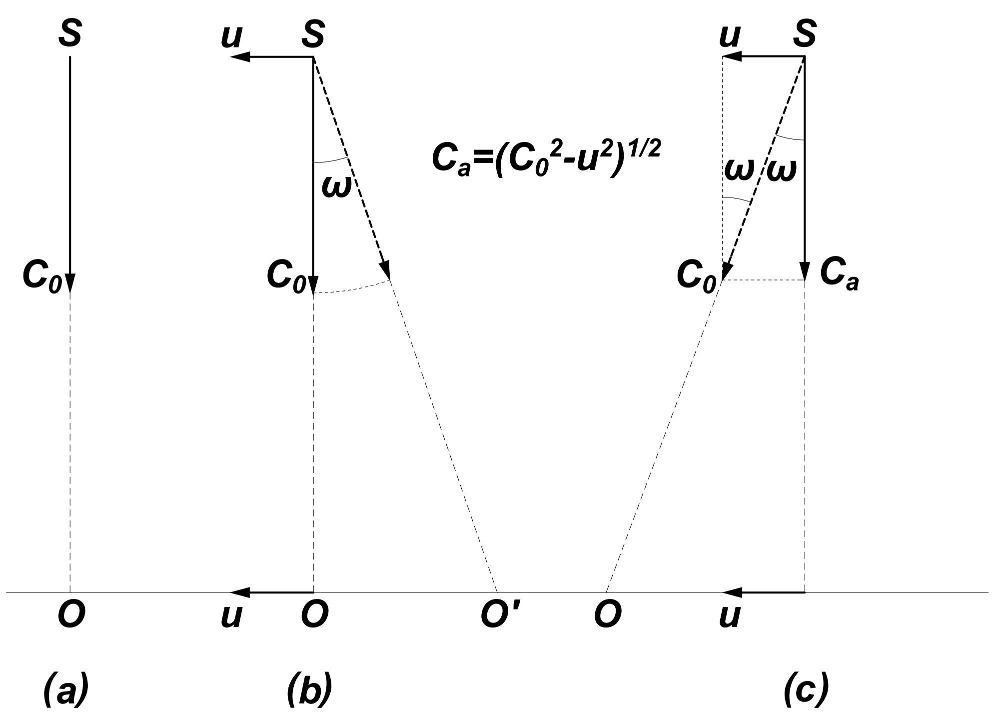

Figure 2. The aberration of light causes an apparent reduction of light speed

In Fig. 2b light source and observer are moving in parallel at speed u, vertically to the emitted laser beam, resulting the footprint of the beam to be left behind the observer, since the motion of the light source does not affect the autonomous motion of the E/M waves.[8] Therefore, the aberration of light can be used as a detection criterion of the absolute motion.

However, the laser beam must turn clockwise at an angle ω (Fig. 2c), so that the component C_a be

$$C_a = C_0 cos\omega \Rightarrow C_a = \sqrt{C_0^2 - u^2} \Rightarrow C_a = C_0\sqrt{1 - \frac{u^2}{C_0^2}}. \tag{7}$$

Then, the moving observer can see the light with the so called apparent light speed C_a.

It is noted that, the apparent change of light speed is reduced by the same reduction factor $\sqrt{1 - u^2/C_0^2}$ (Eq. 7) as in the actual reduction of light speed (Eq. 5), namely when light moves to the direction of the moving system. In this cases, the vertical motion of the moving system does not cause an actual change of light speed, but an apparent change due to the aberration of light. Therefore, in case light moves to the direction of or opposite to the moving system, an actual reduction of light speed occurs, due to reduction of the cohesive pressure on the moving material system, while in case light moves to the vertical direction of the moving system, an apparent reduction of light speed occurs by the same reduction factor $\sqrt{1 - u^2/C_0^2}$, but here due to the aberration of light, that is

$$C_r = C_a = C_0\sqrt{1 - \frac{u^2}{C_0^2}}. \tag{8}$$

Consequently, the explanation of Michelson-Morley experiment can be based on both actual and apparent reduction (equal) of light speed.

3. Explanation of Michelson-Morley experiment not based on the second postulate of relativity

It was expected the differential phase shift between light traveling the longitudinal versus the transverse arms of the Michelson interferometer. For a stationary observer the total time T_1 on arm $(KK_1) = \beta$ (indicatively see Fig. 3), where occurs an aberration of light (Eq. 7), is

$$T_1 = \frac{2\beta}{C_a} \Rightarrow T_1 = \frac{2\beta}{\sqrt{C_0^2 - u^2}} \tag{9}$$

and the total time T_2 on arm $(KK_2) = \beta$, using the Galilean transformations, is

$$T_2 = \frac{2\beta C_0}{C_0^2 - u^2}. \tag{10}$$

Dividing by parts Eqs 9 and 10, it is

$$\frac{T_1}{T_2} = \sqrt{1 - \frac{u^2}{C_0^2}} < 1 \Rightarrow T_1 < T_2. \tag{11}$$

This theoretical result is not verified by the experiment, since the superposition of the two parts of monochromatic light is maintained, which happens only, if $T_1 = T_2$. Therefore, something is wrong with the behavior of light.

This experimental result was the cause for the creation of the relativity theory and the acceptance of Lorentz transformations for light. The time dilation and the definition of time as a physical entity in the space-time continuum are the two consequences of the above creation. The time dilation (first consequence), of course, was a very great and correct idea, ignoring, though, the real cause of the slowing of the moving clock, i.e. the phenomenon of motion.[3,4] In the second consequence, however, time[9] is defined (oppositely to relativity) as the motion of the electrically opposite elementary units[10] at speed of light, according to the unified theory of dynamic space.[1] These elementary units construct matter and motion as the unique phenomena of Nature.

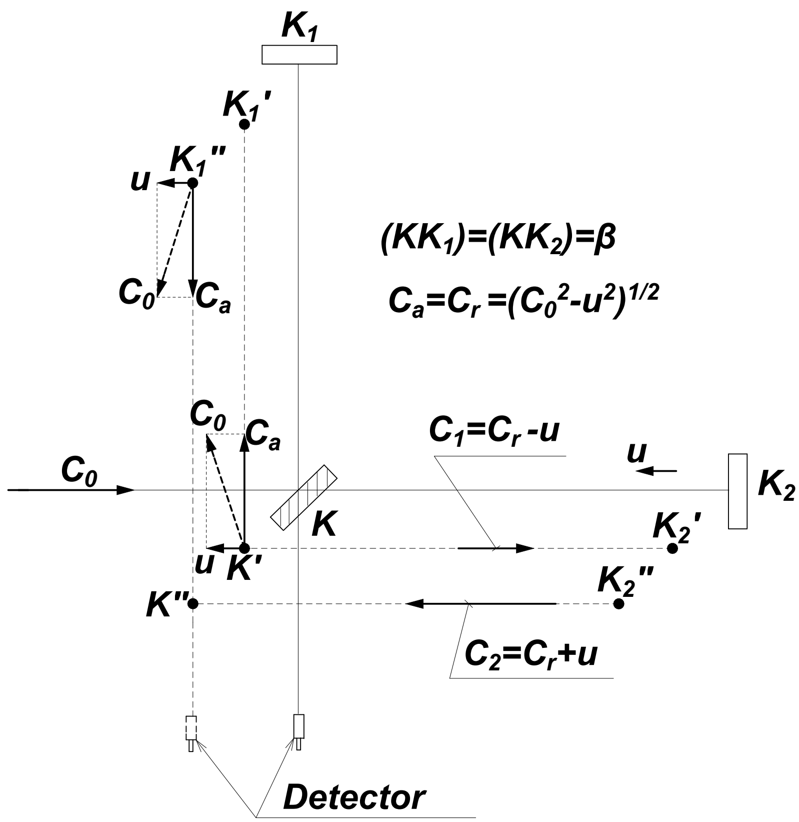

Figure 3. Schematic representation of Michelson interferometer. For the stationary observer $C_1 = C_r - u$ and $C_2 = C_r + u$ (Eq. 6) are the absolute light speeds on arm $(KK_2) = \beta$ and $C_a = \sqrt{C_0^2 - u^2}$ (Eq. 7) is the apparent light speed on arm $(KK_1) = \beta$, due to the apparent reduction of light speed, where $C_r = \sqrt{C_0^2 - u^2}$ (Eq. 5) is the relative light speed on arm $(KK_2) = \beta$, due to the actual reduction of light speed and u is the speed of interferometer (Earth)

We shall now explain the Michelson-Morley experiment, as a result of both actual and apparent reduction (equal) of light speed in the moving material systems:

The stationary observer calculates that (Fig. 3), the absolute speed of light C_1 (Eq. 6) on arm $(KK_2) = \beta$, is

$$C_1 = C_r - u \tag{12}$$

and

$$(KK_2') = C_1 t_1, \tag{13}$$

where t_1 the motion time of the interferometer at speed u, covering the distance $K_2K_2' = ut_1$. Substituting in Eq. 13, the Eq. 12 and $(KK_2') = (KK_2) - (K_2K_2') = \beta - ut_1$, it is

$$\beta - ut_1 = (C_r - u)t_1, \tag{14}$$

where $C_r = \sqrt{C_0^2 - u^2}$ (Eq. 5) the relative speed of light on arm KK_2, due to the actual reduction of light speed, thus Eq. 14, due to Eq. 5, becomes

$$t_1 = \frac{\beta}{C_r} \Rightarrow t_1 = \frac{\beta}{\sqrt{C_0^2 - u^2}}. \tag{15}$$

The time on arm $(KK_1) = \beta$, due to Eq. 8, is

$$t_1' = \frac{\beta}{C_a} = \frac{\beta}{C_r}, \tag{16}$$

as it is t_1 (Eq. 15) on arm KK_2, namely

$$t_1' = t_1 = \frac{\beta}{\sqrt{C_0^2 - u^2}}, \tag{17}$$

due to the apparent reduction of light speed (Eq. 7) and t_2' the return time on arm K_1K with an apparent reduction of light speed, that is

$$t_2' = \frac{\beta}{\sqrt{C_0^2 - u^2}}. \tag{18}$$

At the return of light (on arm K_2K), covering the distance $C_2t_2 = (K_2'K'') = (K_2'K_2'') + (K_2''K'')$ at time t_2 of interferometer motion, when covering the distance $(K_2'K_2'') = ut_2$ with speed u, where C_2 (Eq. 6) the absolute light speed and $(K_2''K'') = \beta$, then

$$C_2t_2 = ut_2 + \beta, \tag{19}$$

and for $C_2 = C_r + u$ (Eq. 6) the Eq. 19, due to Eq. 15, becomes

$$C_rt_2 + ut_2 = ut_2 + \beta \Rightarrow t_2 = \frac{\beta}{C_r} \Rightarrow t_2 = \frac{\beta}{\sqrt{C_0^2 - u^2}} = t_1, \tag{20}$$

where $C_r = \sqrt{C_0^2 - u^2}$ (Eq. 5) the actual reduction of light speed. Accordingly, $t_2 = t_1 = \beta/\sqrt{C_0^2 - u^2}$ (Eq. 20), due to Eq. 18, becomes

$$t_2 = t_1 = \frac{\beta}{\sqrt{C_0^2 - u^2}} = t_2', \tag{21}$$

where t_2' the return time on arm K_1K with an apparent reduction of light speed. Therefore, it is

$$t_1 = t_1' = t_2 = t_2' = \frac{\beta}{\sqrt{C_0^2 - u^2}}, \tag{22}$$

namely time is same on arms KK_1 and KK_2 of interferometer. The total time on arm KK_1, and due to Eq. 22, is

$$T_1 = t'_1 + t'_2 = \frac{2\beta}{\sqrt{C_0^2 - u^2}} \Rightarrow T_1 = \frac{2\beta}{\sqrt{C_0^2 - u^2}} \tag{23}$$

and the total time on arm KK_2, due to Eq. 22, is

$$T_2 = t_1 + t_2 = \frac{2\beta}{\sqrt{C_0^2 - u^2}} \Rightarrow T_2 = \frac{2\beta}{\sqrt{C_0^2 - u^2}}, \tag{24}$$

namely as much as on arm KK_1 and due to Eqs 23 and 24, we have

$$T_1 = T_2 = \frac{2\beta}{\sqrt{C_0^2 - u^2}} \Rightarrow T_1 = T_2. \tag{25}$$

Hence, for this reason the superposition of the two parts of the monochromatic light is maintained.

A similar explanation of Michelson-Morley experiment applies if the observer is on the moving system, i.e. on the Earth. Consequently, the Michelson-Morley experiment has been explained on the basis of both actual and apparent reduction (equal) of light speed.

Therefore, in case light moves to the direction of or opposite to the moving system, an actual reduction of light speed occurs, due to the reduction of the cohesive pressure.

However, in case light moves to the vertical direction of the moving system, an apparent reduction of light speed occurs by the same reduction factor, but here due to the aberration of light.

4. The slowing of moving clocks

Assuming a clock on a moving material system , with a time period $T = 2\pi\sqrt{m/k}$ in a linear oscillation or with a time period $T = 2\pi\sqrt{I/\mu}$ in a rotational oscillation, where k the string constant, m the mass, I the moment of inertial and μ the torsion constant, then the following relationships applie

$$\frac{T_0}{T} = \sqrt{\frac{k}{k_0}} = \sqrt{\frac{\mu}{\mu_0}} = \sqrt{\frac{P}{P_0}} \Rightarrow \frac{T_0}{T} = \sqrt{\frac{P}{P_0}}, \tag{26}$$

since the reduction of elastic forces[2] of oscillations in material bodies takes place to each direction, due to the residual cohesive pressure $P = P_0 - \Delta P$ (Eq. 1), where T_0 the time period of a stationary clock, P_0 the cohesive pressure[1,2] of the dynamic space far for the moving system and ΔP the motion arrow[3,4] of the moving system.

Timeless speed[6] of the moving system, with linear speed u, is

$$u_a = \frac{u}{C_0} = \sqrt{\frac{\Delta P}{P_0}} \Rightarrow \frac{u^2}{C_0^2} = \frac{\Delta P}{P_0}. \tag{27}$$

So, due to Eqs 5, 27 and 1, we have

$$\frac{C_r}{C_0} = \sqrt{1 - \frac{u^2}{C_0^2}} = \sqrt{1 - \frac{\Delta P}{P_0}} = \sqrt{\frac{P_0 - \Delta P}{P_0}} = \sqrt{\frac{P}{P_0}}, \tag{28}$$

namely it is

$$\sqrt{\frac{P}{P_0}} = \sqrt{1 - \frac{u^2}{C_0^2}}. \tag{29}$$

Therefore, $T_0/T = \sqrt{P/P_0}$ (Eq. 26), due to Eq. 29, becomes

$$\frac{T_0}{T} = \sqrt{1 - \frac{u^2}{C_0^2}} = \frac{1}{\gamma} \Rightarrow \frac{T}{T_0} = \gamma > 1 \Rightarrow T > T_0, \tag{30}$$

where

$$\gamma = 1/\sqrt{1 - \frac{u^2}{C_0^2}}, \tag{31}$$

as symbolized in special theory of relativity.

So, the moving clock, with the longest time period T, slows down, compared to stationary clock with time period T_0 (Eq. 30).

5. Consequences due to slowing of the moving clocks

The time measured by a clock on the moving system of Earth, according to the theory of relativity, is reduced as

$$t = t_0\sqrt{1 - \frac{u^2}{C_0^2}}, \tag{32}$$

where t_0 is the time measured by a stationary clock on reference system of Ether (Michelson-Morley experiment). For $\gamma = 1/\sqrt{1 - u^2/C_0^2} > 1$ (Eq. 31) the Eq. 32 becomes

$$\frac{t}{t_0} = \sqrt{1 - \frac{u^2}{C_0^2}} = \frac{1}{\gamma} \Rightarrow t = \frac{t_0}{\gamma} \Rightarrow t < t_0. \tag{33}$$

On Ether the light has traveled a distance L_0, while on Earth light has traveled a distance L (according to the theory of relativity), so it is ‡

$$L = L_0\sqrt{1 - \frac{u^2}{C_0^2}}, \tag{34}$$

because the distance is also reduced by the known reduction factor $\sqrt{1 - u^2/C_0^2} = 1/\gamma$ (Eq. 31) and substituting this in Eq. 34, it is

$$L = \frac{L_0}{\gamma}. \tag{35}$$

Also, light speed C, measured by an observer on the moving system (Earth), is

$$C = \frac{L}{t} \tag{36}$$

‡ Also, the relationship $L/L_0 = \sqrt{P/P_0}$ (Eq. 26) applies (according to the theory of dynamic space), given that the reduction of elastic deformations[2] takes place due to residual cohesive pressure $P = P_0 - \Delta P$ (Eq. 1) and due to $\sqrt{P/P_0} = \sqrt{1 - u^2/C_0^2}$ (Eq. 29), we have $L = L_0\sqrt{1 - u^2/C_0^2}$ (not based on the second postulate of special relativity).

and substituting therein $L = L_0/\gamma$ (Eq. 35) and $t = t_0/\gamma$ (Eq. 33), it is

$$C = \frac{L_0/\gamma}{t_0/\gamma} = \frac{L_0}{t_0} \Rightarrow C = \frac{L_0}{t_0}. \tag{37}$$

However, $C_0 = L_0/t_0$ is the speed of light measured by an observer on Ether. Therefore

$$C = C_0, \tag{38}$$

namely the speed of light looks as a constant (seemingly) on the moving system (second postulate of relativity), but in reality it has been reduced.

This equality of light speeds arose, because the speed of light, reduced by the factor $\sqrt{1 - u^2/C_0^2}$ (Eq. 5), is measured by a clock that slows down, due to the longest time period T (with $T > T_0$) by the same factor $\sqrt{1 - u^2/C_0^2}$, according to Eq. 30.

6. Epilogue of Michelson-Morley experiment

The interpretation of the Michelson-Morley experiment, as based on the second postulate of relativity, has since remained without a physical explanation, but has now been proved in section 3. In the special relativity, the time dilation has been accepted, ignoring, though, the real cause of the slowing of the moving clock, i.e. the phenomenon of motion.[3,4] In the general relativity, time is defined as a physical entity (as a fourth dimension) in the space-time continuum, while in the dynamic space,[1,2] time[9] is the motion phenomenon itself, i.e. the motion of the elementary units.[10] In addition, the experimental result of increased life of fast moving muons is used as a proof of relativity theory. However, the unified theory of dynamic space clearly outlines the structure of particles and their motion,[4] which decreases the cohesive pressure of the proximal space. So, the cortex of muon[11] resists easier to the reduced attraction of cohesive pressure, thus slowing their decay and prolonging their life.

In the question "Why theory of relativity has correct applicable results?", the following answer is given:

The reduction factor $\gamma = 1/\sqrt{1 - u^2/C_0^2}$ (Eq. 31), the so called Lorentz factor, is the tool for the mathematical expression of the problem that had arisen from the Michelson-Morley experiment. This same reduction factor appears also in the unified theory of dynamic space with the Galilean transformations, by calculating the actual reduction of the light speed on moving material systems. So, Lorentz transformations prove correct, but not based on the second postulate of relativity and thus, the relativity theory has correct applicable results. However, the application of Galilean transformations is preferable, at calculating the relative speed of light on the moving material systems. Moreover, the application of the Lorentz transformations on imaginary (non-material) systems can lead to unreasonable results. The actual reduction of light speed happens only when the light is transmitted on moving material systems, on which the cohesive pressure of the proximal space is reduced.

7. References

[1] N.I.Gosdas, *Unified theory of dynamic space*, Greek edition (Trohalia, Athens, 1999).

[2] M.Tzoumpas, *Hubble's Law and antigravity - Higgs boson and gravity*, http://viXra.org/abs/1710.0082 (subsections 2.2. and 2.3.) [Quantum Gravity and String Theory].

[3] M.Tzoumpas, *What is de Broglie's wave-particle?*, http://viXra.org/abs/1806.0248 (section 1) [Quantum Gravity and String Theory].

[4] M.Tzoumpas, *Time as motion phenomenon - Physics Laws do not apply to inertial systems*, http://viXra.org/abs/1802.0372 (section 3-5) [Relativity and Cosmology].

[5] M.Tzoumpas, *Hubble's Law and antigravity - Higgs boson and gravity*, http://viXra.org/abs/1710.0082 (subsection 2.5.) [Quantum Gravity and String Theory].

[6] M.Tzoumpas, *The timeless Universe*, http://viXra.org/abs/1804.0408 (section 1) [Astrophysics].

[7] M.Tzoumpas, *Hubble's Law and antigravity - Higgs boson and gravity*, http://viXra.org/abs/1710.0082 (subsection 2.4.) [Quantum Gravity and String Theory].

[8] M.Tzoumpas, *The structure of autonomous motion E/M waves*, http://viXra.org/abs/1511.0025 (sections 1 and 2) [Quantum Gravity and String Theory].

[9] M.Tzoumpas, *Time as motion phenomenon - Physics Laws do not apply to inertial systems*, http://viXra.org/abs/1802.0372 (section 1) [Relativity and Cosmology].

[10] M.Tzoumpas, *Hubble's Law and antigravity - Higgs boson and gravity*, http://viXra.org/abs/1710.0082 (subsection 2.1.) [Quantum Gravity and String Theory].

[11] M.Tzoumpas, *Time as motion phenomenon - Physics Laws do not apply to inertial systems*, http://viXra.org/abs/1802.0372 (section 2) [Relativity and Cosmology].