International Journal of Innovation in Science and Mathematics
Volume 9, Issue 6, ISSN (Online): 2347–9051

The Michelson-Morley Experiment Explained by Abolishing the Second Postulate of Relativity

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Date of publication (dd/mm/yyyy): 11/11/2021

***Abstract* – The Lorentz length contraction leads to paradoxes like that of Ehrenfestu. In this paper an explanation of the result of the Michelson-Morley experiment is presented by abolishing the second postulate of relativity which has been questioned, especially for the one-way light trips. The aim of the paper is in fact to demonstrate that a variable light speed is consistent with the unexpected result of the Michelson-Morley experiment and that the length contraction is not necessary to explain it. Relativity, applying Occam's razor, is thus applied only to time or, more precisely, to the density of events (however without implying the relativity of simultaneity. To this end a function of the speed of light applicable to light sources in motion with respect to a privileged inertial system is introduced. This function takes into account the fact that the photons emitted by a moving light source could be slowed down because, in addition to moving along their trajectory, they undergo a translation. The function also predicts the possibility of the existence of hidden stars due to their high speed and direction of motion.**

***Keywords* – Michelson-Morley Experiment, Length Contraction, Light Speed New Function, Hidden Stars.**

I. INTRODUCTION

The length contraction of FitzGerald-Lorentz [1] leads to paradoxes like that of Ehrenfest [2]: the perimeter of a hard disk that rotates rapidly (at relativistic speeds) around its axis should contract while the radius remains unchanged. The second postulate of relativity states that the speed of light is the same in every frame of reference but the Michelson-Morley experiment shows only that pulses of light in an inertial system make round trips at the same average speed. The Sagnac Effect highlights that this does not occur for one-way travels of light and therefore the second postulate of relativity can not be maintained (see, among others, Selleri [3], Franchini [4], Gift [5]. Moreover, even the principle of strong relativity has been contested. Hafele and Keating’s experiment [6] [7] has shown that time for a moving body can slow down with respect to a body at rest but it can also accelerate and this implies that the principle of strong relativity can not be correct [3] [8].

In this paper an explanation of the result of the Michelson-Morley experiment is presented by abolishing the second postulate of relativity. The length contraction is not necessary to explain the unexpected result of this experiment and relativity, applying Occam's razor, is limited to time or, more precisely, to the density of events. To this aim a light speed function applicable to light sources in motion with respect to a privileged inertial system is introduced. The function returns the speed values that pulses of light emitted by a light source in motion with respect to a hypothetical privileged system have in this system. It is shown how, by obeying the here hypothesized physical law mirrored by this function, the result of the Michelson-Morley experiment is easily explained without having to resort to length contractions and the abandonment of synchronicity.

Another consequence of the adoption of this function is the prediction of low speeds of distancing of the light pulses in directions different from that of the motion of the light source. The function seems to suggest the existence of hidden stars due to their relativistic speed and direction of motion, which could be perceptible, if very distant from us, only by the effects of their gravitational field.

II. Inertial Systems without Length Contraction

We begin the discussion by presenting a system that we assume is immobile in space. Figure 1 shows this system (say it S_1). It is circular in shape and with a radius equal to $3c$, that is the path of light in three seconds. In S_1 there are eight mirrors (m_1 , m_2, m_3, m_4, m_5, m_6, m_7 and m_8) and one light source (*ls*). The mirrors are all at the same distance ($3c$, say it d) from the light source which is in the center of the circle.

Call $\theta_{i,S1}$, with i = 1 to 8, the angles, in S_1, between the trajectories of light pulses sent from *ls* towards the mirrors and the trajectory of the light pulse p_1 sent towards m_1, thus assuming that $\theta_{1,\,S1} = 0°$. The amplitudes of these angles are not indicated in Figure 1 but it is easy to see that, for i = 1 to 8, they are respectively the following: 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°.

If the light pulses (say them p_i, for i = 1 to 8) start from *ls* all at the same time, they reach the mirrors at the same time, 3 seconds later (in S_1: we assume that S_1 is at rest). If the inertial system S_1 is in motion with respect to another inertial system (say it S_0), according to the second postulate of relativity and as demonstrated by the Michelson-Morley experiment nothing changes for an observer at rest in S_1, while to an observer at rest in S_0 time in S_1 appears dilated and lengths in the motion direction appear shortened. These transformations are necessary to preserve the isotropy of the light speed for all the observers in every inertial system.

In Figure 2 the inertial system S_1 with its light source and its mirrors is in motion to the right with respect to the inertial system S_0 at the speed of $0.5c$. The figure shows what happens without taking into account the length contraction. We can see the positions of the system S_1 at the moment t_0 (when the light pulses are emitted) and t_1 (when they finish their path returning to the light source). The ellipse in the center of the figure, along whose perimeter the mirrors are when they are hit by the pulses of light, has the diameter of the moving circle as the smaller diameter. The extremes of the greater diameter are $2c$ respectively from the position (ls,t_0) of *ls* at the moment t_0 and its position (ls,t_1) at the moment t_1: in fact, while the mirror m_5 travels a distance of $1c$ to the right, p_5 travels a distance of $2c$ to the left and therefore reaches m_5. Similarly m_1 is reached by p_1 after 6 seconds (in S_0) and then it travels to the right again a distance of $1c$, while p_1 goes back to the left and reaches *ls* (in *ls*, t_1). Note that the foci of the ellipse (not indicated in the figure) do not coincide with the light source at the center of the circles at t_0 and t_1, as would happen by applying the contraction of the lengths, but are more external. The light pulses p_1 and p_5 return to *ls* in the same moment (8 seconds after t_0 in S_0) due to the fact that their round trips are equivalent (in fact trajectories $ls,\ t_0$-m_1-$ls,\ t_1$ and $ls,\ t_0$-m_5-$ls,\ t_1$ have the same length). However all other possible trajectories are shorter and therefore the light pulses that pass through them can return to the light source at the same instant only if their speed is less than c. Note that the light pulses in S_0 do not all reach the mirrors at the same time and in this paper it is sustained that this happens even in S_1, although it is not detected by an observer in S_1.

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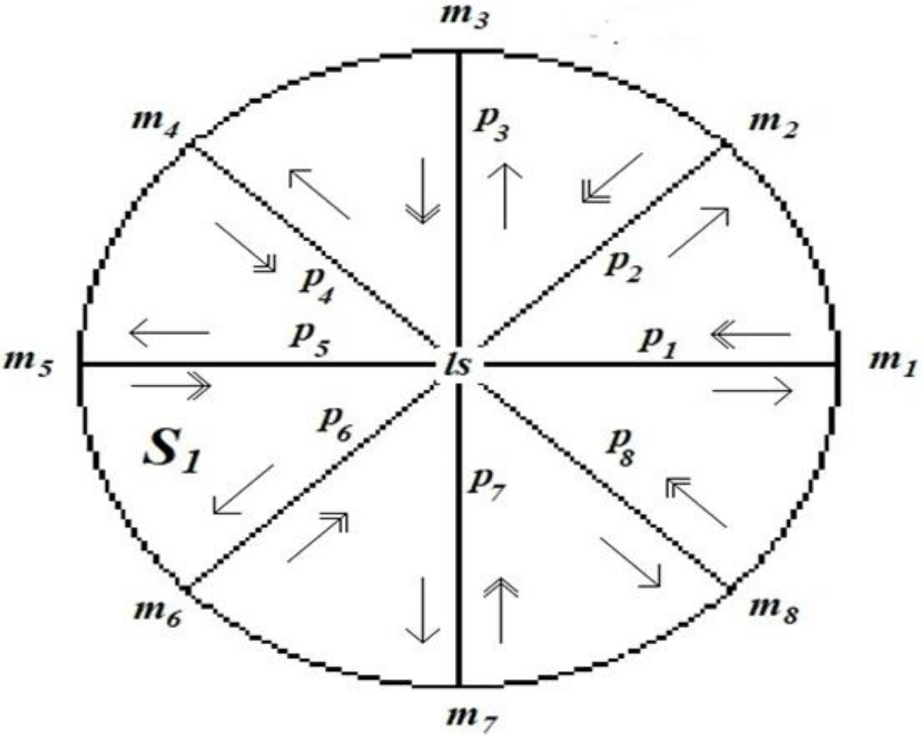

Fig. 1. In a system S_1 eight light pulses (p_1, p_2, p_3, p_4, p_5, p_6, p_7 and p_8) start simultaneously from the light source *ls* and go to the mirrors m_1, m_2, m_3, m_4, m_5, m_6, m_7 and m_8, which are at the same distance (*3c*) from *ls*. According to the second postulate of relativity and the result of the Michelson-Morley experiment for an observer at rest in S_1 they return to *ls* simultaneously, whatever is the motion of S_1 with respect to an hypothetical privileged system. The split ends indicate the return journey of the light pulses.

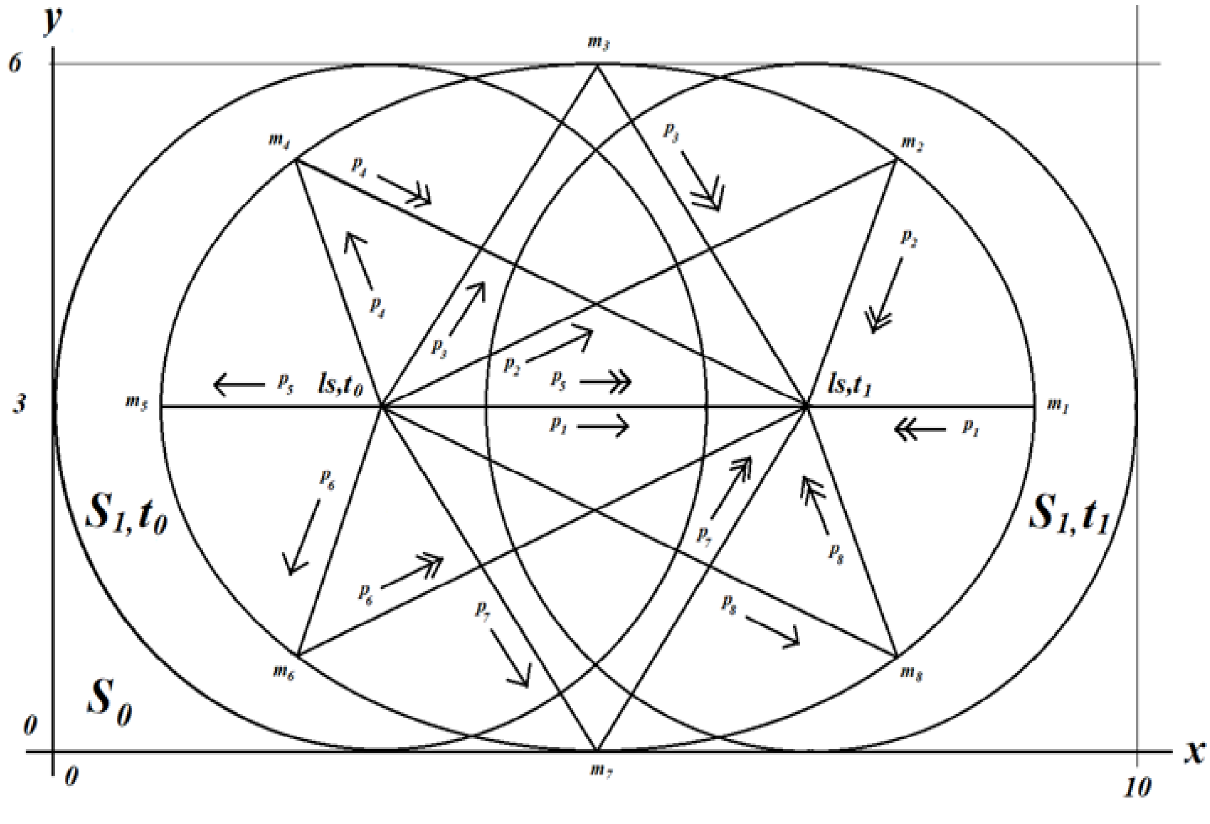

Fig. 2. The light source *ls* and the eight mirrors, which together constitute the inertial system S_1, are moving to the right with respect to the privileged system S_0 at the speed of *0.5c*. Without taking into account the contraction of the lengths, trajectories ls,t_0-m_1-ls,t_1 and ls,t_0-m_5-ls,t_1 have the same length but all other possible trajectories are shorter. The coordinates (distances) are expressed in light seconds (in S_0).

We must conclude that if we accept the second postulate of relativity, the light pulses which move along a direction other than that of the motion of their light source can return to the light source simultaneously only due to the Lorentz contraction of moving bodies.

Here we suggest that this seems an *ad hoc* explanation of the result of the Michelson-Morley experiment. Therefore we want to consider another explanation, putting aside the postulate of the constancy of the light speed which, as we have mentioned above, is quite questioned, above all due to the Sagnac Effect. A possible cause of the result of the Michelson-Morley experiment could be the slowing of the speed of light pulses that are pushed in a direction diverging from that traveled by the light source. It will be discussed in the next sections. Relativity will be maintained in the context of time (or density of events [9]), where it is verified, in the sense that it flows at different speeds in different inertial systems, without however relativizing synchronicity [9].

III. Light Speed Without the Length Contraction

As we have seen in Figure 2, the paths of p_1 and p_5 have the same length. To cover these paths, the two light pulses take, for an observer in S_0 and assuming henceforth, c = 1, a time (say it T_{S0}) given by:

$$T_{S0} = 2d/(1-v^2) \quad (1)$$

In this relation d is the distance between *ls* and the mirrors and v (whose absolute value does not reach *1*) is the speed of S_1 with respect to S_0. In fact, p_1 to go from ls_{t0} to m_1 takes $d/(1\text{-}v)$ seconds (in S_0) and it takes $d/(1+v)$ seconds to go from m_1 to ls_{t1}: (1) is the sum. The path of p_5 has the same length and therefore p_5 takes the same time to reach ls_{t1}.

The path of p_3 (say it $P_{90°}$), whose angle with the direction of motion of the light source is 90 degrees (in S_1), applying the Pitagoras' theorem to the distance d (in y axis) and the half path of *ls*, is:

$$P_{90^0} = 2\sqrt{d^2 + (vT_{S0}/2)^2} \quad (2)$$

$P_{90°}$ is (together with the path of p_7) the shortest path of the light pulses emitted by *ls*.

The light pulse p_3, but it is the same for all other light pulses from *ls*, according to the result of the Michelson-Morley experiment takes (in S_1) the same time taken by p_1 and p_5. Without taking into account the length contraction and abolishing the second postulate of relativity, we obtain in S_0 a light speed of p_1 (and p_5) lower than c. Since this speed refers to photons whose trajectory is orthogonal to the trajectory of the light source, let us call it $c_{90°,S0}$. It is obtained by dividing the right member of (2) for the right member of (1):

$$c_{90^0,S0} = [(1-v^2)/d]\sqrt{d^2 + \{[d/(1-v^2)]v\}^2} \quad (3)$$

In Figure 3 there are shown the values of $c_{90°,S0}$ as a function of v, obviously for $-1<v<1$.

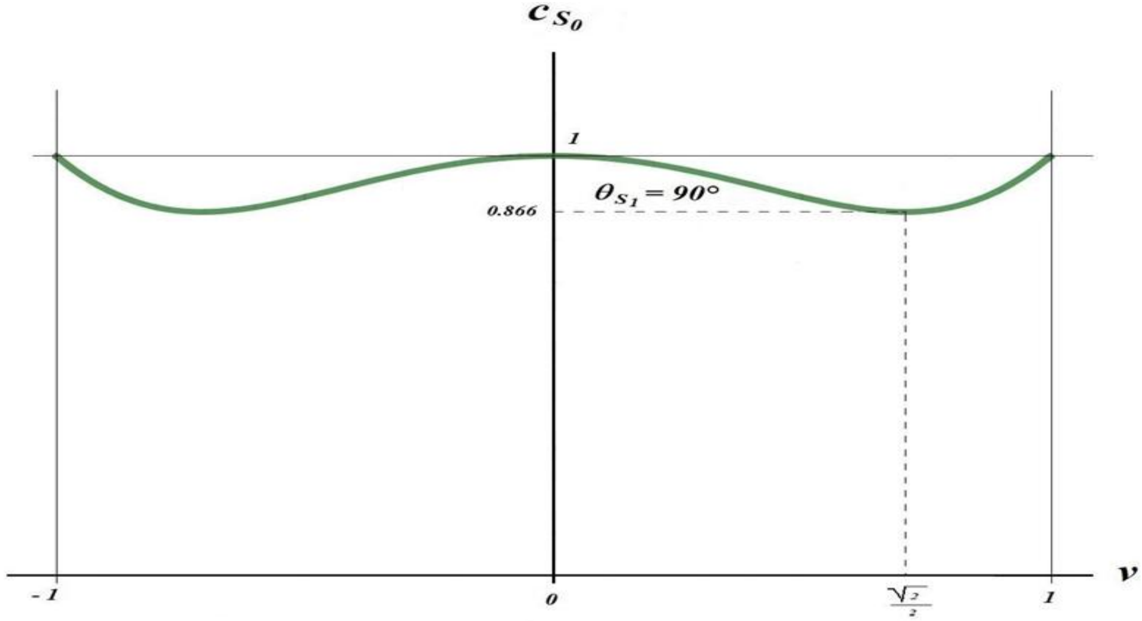

Fig. 3. The values of $c_{S0,90°}$ are shown as a function of values of v. θ_{S1} is the angle that the trajectory of p_3 forms with the trajectory of *ls* in S_1.

How can we justify the behavior evidenced in Figure 3? Let us see below how we could do it.

IV. An Explanation of the Michelson-Morley Experiment by Abolishing the Second Postulate of Relativity

We support the thesis that the speed of light varies in S_0 if the pulse of light goes in a direction other than that of the motion of the light source in the privileged inertial system S_0.

As it is well known, the light speed in the vacuum inversely depends on the square root of the product between the magnetic permeability and the electrical permittivity (in the vacuum).

However, when the direction of the light pulse is inclined or orthogonal (in S_1) with respect to the direction of the motion (in S_0) of the light source, this inclination appears to be modified to an observer at rest in S_0 (compare Figure 1 and Figure 2). However it is not correct to say that the ray of light changes inclination: it is more appropriate to say that the trajectory of the light pulse undergoes a progressive translation. Photons are therefore involved in two processes: a move away from the light source, whose speed in a system at rest depends on the magnetic permeability and on the electrical permittivity, and a translation in another direction. The latter process slows down the former the greater the inclination of the direction of the light pulse with respect to the direction of motion of the light source. In fact the speed of all processes occurring in an inertial system slows down if the system is moving with respect to another system and we add: with respect to the privileged inertial system S_0.

On the nature of the privileged system we can hypothesize that it could be constituted by space itself or by the inertial field of the universe in combination with a local gravitational field [9]. Many famous scholars, starting from Poincare [10] to Sagnac [11], continued to believe in the existence of the luminiferous ether even after the publication of the Special Relativity Theory [12] and even Einstein [13] [14] reconsidered his position on the ether in the years of his maturity.

Today, although it is no longer defined as "ether", various authors [15] believe in the existence of a privileged system or field.

Figure 4 shows the relation between the velocity (abscissas v) of the system S_1, expressed in terms of c, and the local time (in S_1) expressed in terms of time in S_0. The relation is well known but in Figure 4, following Paolilli [9], the local time is explicitly measured as the ratio between the speed of the processes in S_1 and the speed of analogous processes in S_0 (S_1ps/S_0ps). In the graph the highlighted point, for which $\sin(\Psi)=\cos(\Psi)$, the abscissa ($\sqrt{2}/2$) is equal to the ordinate and corresponds to the abscissa v in Figure 3 for which the speed of light in S_0 is the lowest possible.

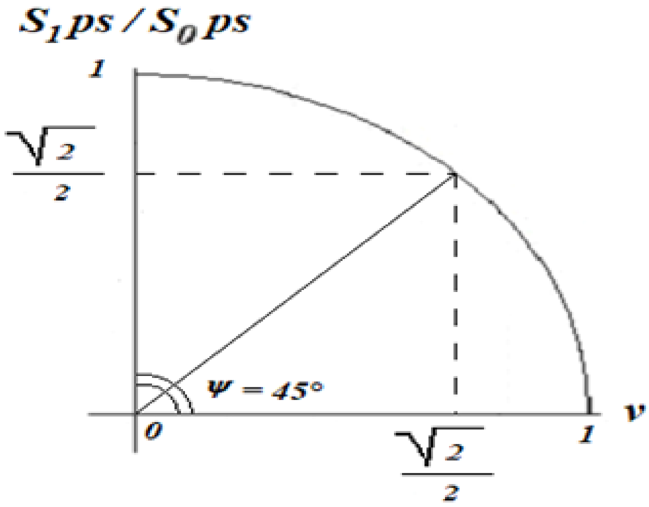

Fig. 4. The graph shows the relationship between the speed v of the inertial system S_1 with respect to the privileged inertial system S_0 (abscissas) and the ratio between the speed of the local processes in S_1 and the speed of analogous processes in S_0, or local time (ordinates).

This is not really strange: in fact the sum (and the product) of the two coordinates in the graph of Figure 4 is maximum for $\Psi = 45°$ (the sum of of their squares is obviously constant), that is for $v = \sqrt{2}/2$, and it is precisely for this speed (absolute value) that (3) returns the smallest value of $c_{90°,S0}$.

We can hypothesize that the "resistance" that the electromagnetic wave finds in its propagation is maximum when both motions, along the direction of propagation (above all if $\theta_{S1} = 90°$ or $\theta_{S1} = 270°$) and along the direction of motion of S_1, touch the value of $\sqrt{2}/2$. Therefore the light speed will be the slowest in S_0 for $v = \sqrt{2}/2$ (and if $\theta_{S1} = 90°$ or $\theta_{S1} = 270°$). For the (impossible) case of $v = 1$ the photon will be immobile in S_1 but it will be transported at its maximum speed along the direction of motion of S_1.

Definitely, the growth of the translation along the abscissa axis increases the aforementioned "resistance" while the slowing down of the local processes reduces it. Growing v, (that is $\cos(\Psi)$), the balance between these two components is positive until $v<\sqrt{2}/2$ (that is $\sin(\Psi)> \cos(\Psi)$), negative for $v>\sqrt{2}/2$ (that is $\sin(\Psi)<\cos(\Psi)$).

Below we present the formula for the speed ($c_{\theta,S0}$) in S_0 of a light pulse which makes a round trip between a source and a mirror, both moving in the same direction and at the same speed v with respect to the privileged system S_0. Taking into account that $v = \cos(\Psi)$ and $S_1ps/S_0ps = \sin(\Psi)$, the function can be so written:

$$c_{\theta,S0} = \sqrt{1 - |\sin\theta|\cos^2(\Psi)\sin^2(\Psi)} \tag{4}$$

$c_{\theta,\ S0}$ is the speed of the light pulse (whose trajectory has an angle θ (in S_1) with the trajectory of the light source (in S_0). In the formula the absolute value of $\sin(\theta)$ is introduced to obtain the absolute value of the light speed in S_0, whatever its direction.

Since $cos(\Psi) = v$, function (4) can also be written as follows, thus being able to represent it graphically assuming v as an independent variable:

$$c_{\theta,S0} = \sqrt{1 - |\sin\theta|\, v^2 (1 - v^2)} \tag{5}$$

Just for the sake of clarity, function (5) is presented taking into consideration the speed of light c without equating it to 1 (so the value of v will be between 0 and c):

$$c_{\theta,S0} = \sqrt{c^2 - |\sin\theta|\, v^2 [(c^2 - v^2)/c^2]} \tag{6}$$

As it appears evident in Figure 5, the relation highlighted by means of (5) for θ = 90° is identical to that of (3) which has been described in Figure 3. The graph of Figure 5 also shows the relations obtained by means of (5) for the angles of the other trajectories already shown in Figure 1 and in Figure 2. Also in this case it could be possible to ascertain that the length of the trajectories calculated taking into account (5) is the same as those shown in Figure 2.

Note that the values returned by the function for trajectories with an angle of 270° are the same as those relating to trajectories with an angle of 90° and that the values returned for trajectories of 45° are the same as those relating to trajectories with an angle of 135°, 225° and 315°. In the graph for simplicity only the angles of 0°, 45° and 90° are indicated.

However it is important to underline that the light speed in S_0 calculated by means of (5) perfectly satisfies the results of the Michelson-Morley experiment: pulses of light directed in various directions travel along equivalent round-trip paths in S_1, coming back to the light source at the same time, whatever let be the motion of S_1 with respect to the here hypothesized privileged system S_0.

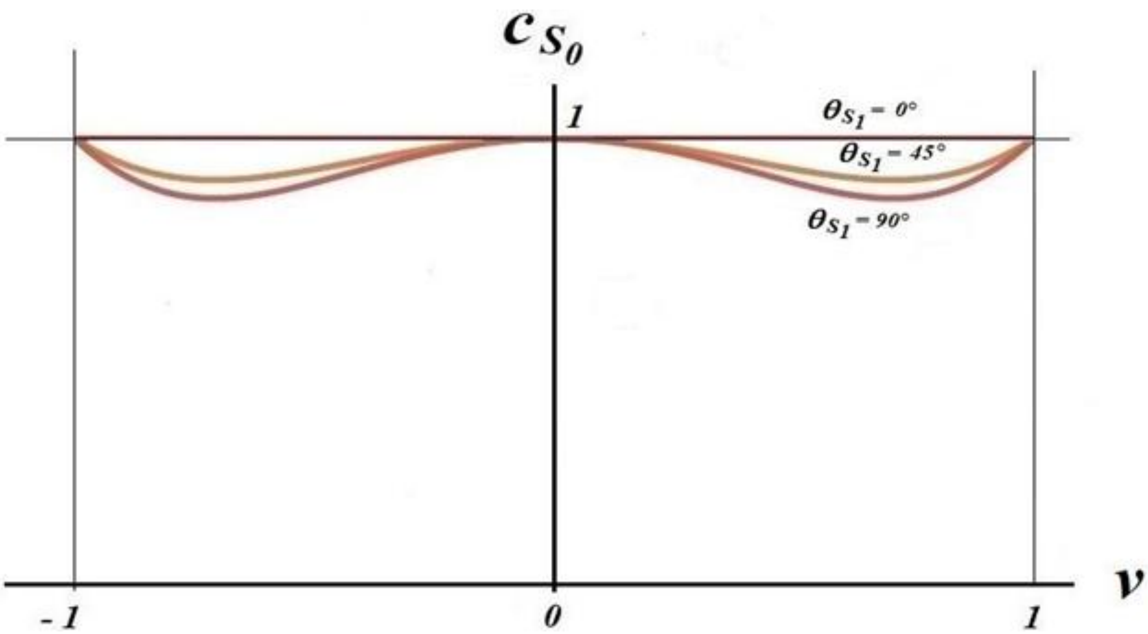

Fig. 5. The ordinates of the graph indicate the speed (in S_0) of light pulses emitted in different directions with respect to the direction of motion of the S_1 system, by a light source in S_1. The abscissas indicate the velocities of S_1.

Figure 6 shows the speed in S_0 of light pulses, emitted by a light source moving at the speed of $0.5c$, as a function of the angle θ.

The three points highlighted have as abscissas the values of the angles of the trajectories of p_2, p_3 and p_4 in S_1 and as ordinates the absolute values of the velocities of these pulses of light in S_0 (but also, respectively, of p_6, p_7 and p_8).

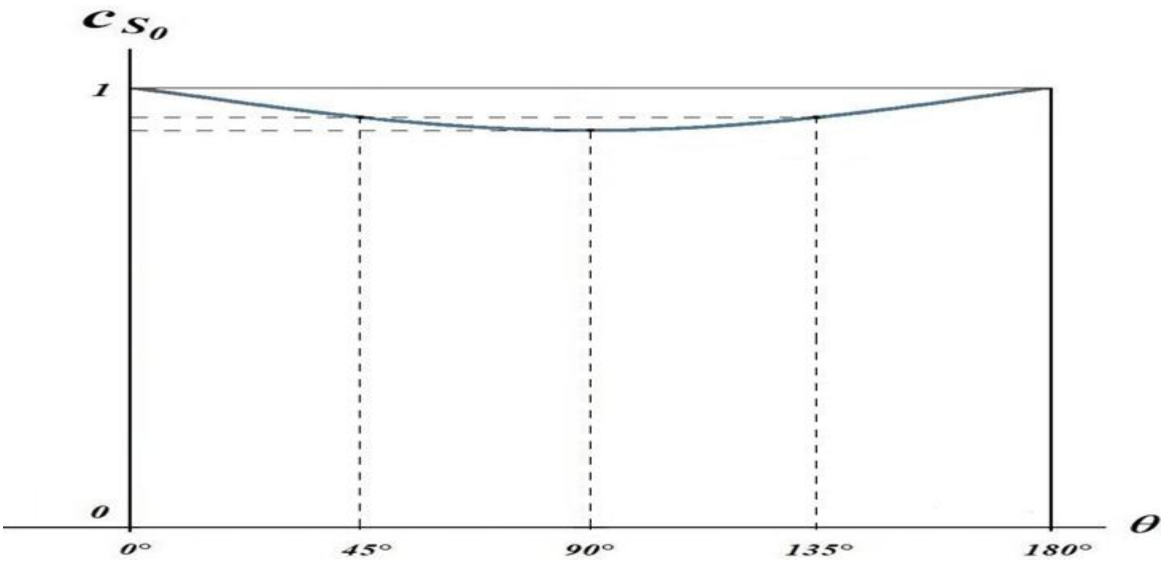

Fig. 6. The speed in S_0 of light pulses emitted by a light source moving at the speed of *0.5c* as a function of *θ*. The three points highlighted are referred to p_2, p_3 and p_4 (but also to p_6, p_7 and p_8) of Fig. 2. The speed of the light pulse in S_0 for θ = 90° is approximately *0.9c*.

Finally a consequence of the application of the function presented in this paper must be highlighted: pulses of light whose trajectory is very divergent by the trajectory in S_0 of the light source (for example if θ = 90°) move away very slowly from the point of emission if the speed of the light source is very close to *c*. In the (impossible, according to modern physics) case where $v = c$, they stop as in the event horizon of a black hole: only the gravity of the light source should be perceptible. On the other hand at speed *c* the internal processes of the light source and therefore also the emissions of light pulses stop.

V. Conclusion

In this paper a new function has been presented that returns values of light speed as a function of the motion of the light source in the privileged system and of the angle between the trajectory of this light source and the trajectory of the pulsed light.

It has been shown how, by means of this function, the results of the Michelson-Morley experiment is easily explained without having to accept surreal scenarios in which space contracts and synchronicity becomes relative, thus confining relativity only to time or, to say better, to velocities.

Another aspect relative to this function is the prediction of low speeds of distancing of the light pulses in directions other than that of the motion of the light source, which in extreme cases could be perceived only by means of its gravitational field.

References

[1] H.A. Lorentz, "Electromagnetic phenomena in a system moving with any velocity smaller than that of light", *Proceedings of the Royal Netherlands Academy of Arts and Sciences*, 6, 809-831, 1904.
[2] P. Ehrenfest, "Gleichförmige Rotation starrer Körper und Relativitatstheorie" (Uniform rotation of rigid bodies and relativity theory), Physikalische Zeitschrift (Physical Journal), 10, 918, 1909.
[3] F. Selleri, "La Relatività Debole. La fisica dello spazio e del tempo senza paradossi" (The Weak Relativity. The physics of space and time without paradoxes), Milan, Melquìades, 2011.

[4] G. Franchini, 'L'effetto Sagnac" (The Sagnac effect), *https://www.google.com/url?sa=t&source=web&rct=j&url=https://cdlfbari.cloud.ba.infn.it/wp-content/uploads/file-manager/CIF/Triennale/Tesi%2520di%2520laurea/13-14-FRANCHINI%2520Giovanni.pdf&ved=2ahUKEwjD2IS0qdXwAhWNnqQKHUxHAsEQFjAAegQIAxAC&usg=AOvVaw0ucBqO1ynwhluEkAgr_lrD&cshid=1621412864782*, 2013-2014.

[5] S. J. G. Gift, "Light Speed Invariance is a Remarkable Illusion", *Physics Essays*, 23 (1), 2007.

[6] J. C. Hafele, R. E. Keating, "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains", *Science*, 177 (4044), 166-168, 1972.

[7] J. C. Hafele, R. E. Keating, "Around-the-World Atomic Clocks: Observed Relativistic Time Gains", *Science*, 177 (4044), 168-170, 1972.

[8] A.L. Paolilli, "Superluminal relativistic phenomena in the hypothesis of a privileged inertial system", *International Journal of Innovation in Science and Mathematics*, 8 (4), 159-164, 2020.

[9] A.L. Paolilli, "Time like money is a mental product: Does Space-time really exist?", *International Journal of Innovation in Science and Mathematics*, 9 (4), 41-47, 2021.

[10] H. Poincaré, "Les rapports de la matière et de l'ether" (The relations of matter and ether), *Journal de physique theorique et appliquée* (Journal of theoretical and applied physics), 5 (2), 347-360, 1912.

[11] G. Sagnac, "Sur la preuve de la réalité de l'éther lumineux par l'expérience de l'interférographe tournant" (On the proof of the reality of the luminous ether by the experiment of the rotating interferograph), *Comptes Rendus de l'Académie des Sciences* (Reports from the Academy of Sciences), 157, 1410-1413, 1913.

[12] A. Einstein, "Zur Elektrodynamik bewegter Körper" (Electrodynamics of moving bodies), *Annalen der Physik* (Annals of Physics), Volume 322 (10), 891-921, 1905.

[13] A. Einstein, "Äther und relativitäts-theorie: Rede gehalten am 5. Mai 1920 an der Reichs-Universität zu Leiden (Ether and Relativity Theory: Speech given on May 5, 1920 at the Reich University of Leiden), Berlin, Springer, 1920.

[14] L. Kostro, "Einstein and the ether", Montreal, Apeiron, 2000.

[15] G.I. Burde, "Cosmological models based on relativity with a privileged frame", arXiv:1805.10995 [physics.gen-ph], 2018.

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