The original explanation of the Lorentz-Fitzgerald contraction phenomenon - photon pressure model

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Abstract:

The paper explains the Lorentz-Fitzgerald contraction phenomenon on the basis of Special Theory of Ether. Presented explanation is based on the construction of innovative technical model of this phenomenon, and not only on his classical mathematical description.

The model explaining the reason of the Lorentz-Fitzgerald contraction is based on the photon pressure and the properties of the light clock, so we called it the photon pressure model.

The model presented here shows how Michelson-Morley's experiment can be modified to be perhaps able to detect movement with respect to ether.

The entire article includes only original research conducted by its authors.

Key words: Lorentz-Fitzgerald contraction, photon pressure, light clock, time dilation

1. Introduction

The content of this article is a continuation of the research on the light clock, therefore it is recommended to read the article [11] in advance, which discusses the light clock and time dilation, used in this article in the photon pressure model.

The considerations in this article are made in the framework of the Special Theories of Ether (STE) [6-10].

There are infinitely many different Special Theories of Ether. In STE, there is a universal frame of reference in relation to which it is possible to measure the velocities of inertial systems. In STE the time elapse depends on the speed of moving in relation to universal frame of reference (ether). This phenomenon is called time dilation. For example, in STE without transverse contraction, motionless clocks in relation to ether are measuring time the fastest. Clocks moving in relation to ether are measuring time slower. The faster clocks move, the slower they measure time. Time dilation is a natural property of a light clock [11].

In each STE all observers evaluate the relative time elapse of any two processes in the same way, since in STE the simultaneity of events is absolute.

Each body emits photons, the amount and energy of which depends on the body temperature. The emitted photons are not homogeneous but have a Planck distribution. This phenomenon is also described by the laws of Wien and Stefan-Boltzmann. Bodies in a state of thermal equilibrium irradiate each other with photons with the same distribution. We assume that bodies emit photons in their entire volume, not just on the surface. Photons emitted inside the body are absorbed by atoms and re-emitted, i.e. they move from atom to atom. Some of the photons go outside the body and are registered as electromagnetic radiation from the black body (thermal radiation).

2. Model of longitudinal contraction (Lorentz-Fitzgerald) and transverse contraction

This chapter proposes a model explaining the Lorentza-Fitzgeralda contraction mechanism of bodies moving in relation to the universal frame of reference, in which light propagates. According to the explanation given, the contraction of bodies in motion is caused by the influence of this motion on the state of equilibrium of atoms in a solid body. We assume at least two opposite interactions affect atoms. The average distance of atoms results from the state of equilibrium between these interactions. One of these interactions is related to the light clock.

Figure 1 shows two atoms of a solid body that are in thermal equilibrium. The considered atoms are at average distance D and move in relation to the ether at velocity v. The distances between atoms are D for the observer from the ether and D' for the observer from the inertial system where the body is located. The angle between the direction determined by atoms and the direction of velocity v has a value α (this is the angle measured in the ether system).

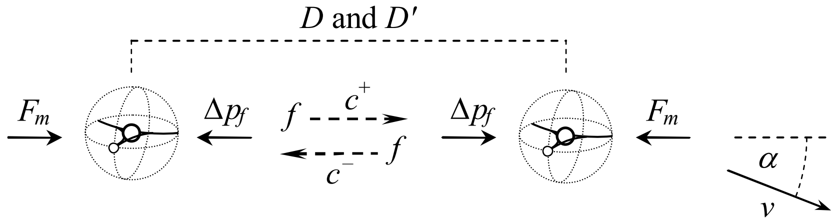

Fig. 1. There are two opposite interactions on atoms.
The average distance of atoms is the result of balance state between these interactions.

In the Special Theories of Ether between the values of D and D' there is a relationship derived in article [11]

$$D = \frac{D'\psi(v)\sqrt{1-(v/c)^2}}{\sqrt{1-(v/c)^2\sin^2\alpha}} \tag{1}$$

Each atom is under the influence of two interactions. One of them transmits momentum Δp_f to atoms and causes the atoms to repel each other. The other one acts on the atoms with force F_m and causes the atoms to attract each other. Figure 2 shows examples of the values of these interactions for a fixed value of speed v. Only the distance D_s between atoms is stable. If this distance increases slightly, then the attraction force is greater than the repulsive force. If this distance decreases, then the repulsive force is greater than the attraction force. If the distance of atoms increases above the distance D_n, then the intermolecular bond is permanently broken because the repulsive force becomes greater than the attraction force.

Now we will describe the repulsive effect. Atoms shown in Figure 1 emit and absorb photons with frequencies f that propagate in the ether. In the state of thermal equilibrium between atoms, n photons pass back and forth at time $\Delta t(v)$. So n is the number of photons that are in the space between the two atoms. For simplicity it is assumed that these photons reflect elastically from atoms. Atoms and photons that pass between them form a light clock. Each time when a photon reflects from an atom it transmits to it a momentum of the following value

$$\Delta p_f = 2\frac{h}{\lambda} = 2\frac{f\,h}{c} \tag{2}$$

where: λ is the wavelength attributed to the photon, f is the frequency of this wave, h is the Planck constant, while c is the speed of light in vacuum (average on the way back and forth).

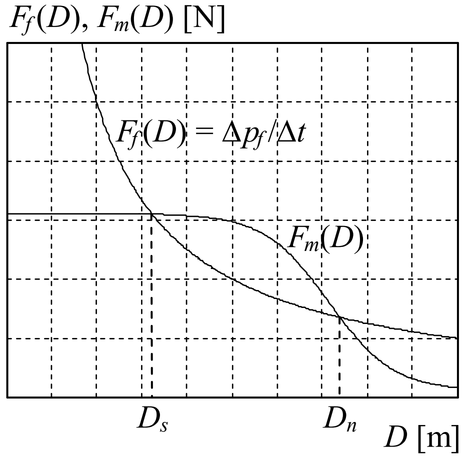

Fig. 2. Example of the values of interactions between atoms of solid body for a fixed value of speed v. $F_f(D)$ is repulsive force, $F_m(D)$ is an attraction force.

That is, photons passing between atoms push them and create internal pressure (we will call them the photons pressure).

Force is the momentum change in time. Therefore, the average force with which n photons act on one atom is (it is an action from one fixed side)

$$F_f = \frac{n\,\Delta p_f}{\Delta t(v)} = 2\frac{n\,f\,h}{c\,\Delta t(v)} \tag{3}$$

It is assumed that the number of n photons does not depend on the distance of atoms D. The time $\Delta t(v)$ that a photon needs to travel between atoms, back and forth is described by the two equations derived in the article [11] in the form

$$t = \frac{2D}{c}\frac{\sqrt{1-(v/c)^2\sin^2\alpha}}{1-(v/c)^2} \tag{4}$$

and in an equivalent form

$$t = \frac{2D'}{c}\frac{\psi(v)}{\sqrt{1-(v/c)^2}} \tag{5}$$

After substituting these equations to (3) the following is obtained

$$F_f = \frac{n\,f\,h}{D}\frac{1-(v/c)^2}{\sqrt{1-(v/c)^2\sin^2\alpha}} \tag{6}$$

and in an equivalent form

$$F_f = \frac{n\,f\,h}{D'}\frac{\sqrt{1-(v/c)^2}}{\psi(v)} \tag{7}$$

The force F_f is a function of the speed v of the body with respect to the ether and the distance D or D' between the atoms, so we will sometimes denote it with the symbols $F_f(v)$ and sometimes with the symbols $F_f(D)$. The repulsive force of atoms, written in the form (6), is inversely proportional to their distance D (measured in the ether reference frame), as shown in Figure 2. This force written in the form (7) is inversely proportional to their distance D' (measured in the body reference frame). This is due to the properties of light clock, which slows down the timing when the length of its arm increases [11]. Therefore, in Figure 2 the force $F_f(D)$ is presented in the form of a hyperbola.

Figure 3 shows the repulsive force $F_f(v)$ as a function of speed v, resulting from formula (6). As the body increases its speed v with respect to ether, then the value of this force decreases. This means that the photon pressure that repels atoms is decreasing. Therefore, when the body moves with respect to the ether, the function $F_f(D)$ shown in Figure 2 decreases and the equilibrium point D_s shifts to the left. The force $F_f(v)$, shown in Figure 3, decreases more when the arm formed by the atoms is inclined at a smaller angle α to the velocity v. Therefore, bodies shorten more strongly in directions parallel to velocity v, than in directions perpendicular to velocity v.

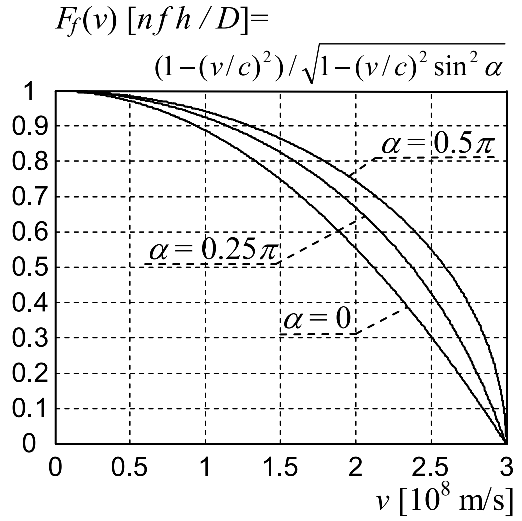

Fig. 3. Values of the repulsive force $F_f(v)$ as a function of speed v for the angles $\alpha = 0$, 0.25π, 0.5π and fixed value of distance D.

Now we will describe the attraction effect. The atoms shown in Figure 1 are compressed by the intermolecular force F_m. In this paper we do not discuss the nature of this interaction. We want to select the values of force F_m so that the atoms remain in equilibrium when they are at a distance D_s.

Atoms will be in equilibrium at a distance of D_s if the equilibrium of attraction and repulsive forces occurs.

$$F_m(v, D_s, \alpha) = F_f(v, D_s, \alpha) \tag{8}$$

After substitution of the equation (6) the following is obtained

$$F_m(v, D_s, \alpha) = \frac{n f h}{D_s} \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2 \alpha}} \tag{9}$$

Based on the relation (7), the equation for the attraction force F_m can be written in another form

$$F_m(v, D'_s) = \frac{n f h}{D'_s} \frac{\sqrt{1-(v/c)^2}}{\psi(v)} \tag{10}$$

Equations (9) and (10) represent the value of intermolecular bond force only at the stable point D_s or D'_s, shown in Figure 2. For the remaining values D, the function F_m can have different values. This means that in general we can save the following dependencies on the function F_m

$$\begin{cases} F_m(v, D, \alpha) = \dfrac{n\,f\,h}{D_s} \dfrac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2 \alpha}}\, g_m(v, D, \alpha) \\ g_m(v, D_s, \alpha) = 1 \end{cases} \tag{11}$$

or

$$\begin{cases} F_m(v, D') = \dfrac{n\,f\,h}{D'_s} \dfrac{\sqrt{1-(v/c)^2}}{\psi(v)}\, g_m(v, D') \\ g_m(v, D'_s) = 1 \end{cases} \tag{12}$$

The function g_m appearing in equations (11) and (12) is positive and continuous function that has to fulfill the conditions specified in (11) and (12). For a fixed value of speed v and angle α, the values of this function depend only on the distance D or D' of atoms. It was the function g_m that decided about the exemplary shape of the force diagram F_m in Figure 2.

For such a forces $F_f(v)$ and appropriate F_m, the dimensions of body will change if its speed in relation to the ether changes, as predicted by STE.

3. Another use of the photon pressure model

The model presented in this article can be used to interpret the known physical properties of bodies. For example, Figure 4 shows examples of differences between a hard body and a soft body. The harder is the body for which deformation of the distance D_s causes greater differences in values of forces $F_m(D)$ and $F_f(D)$ (i.e. for which the inclination of function $F_f(D)$ is greater in point D_s).

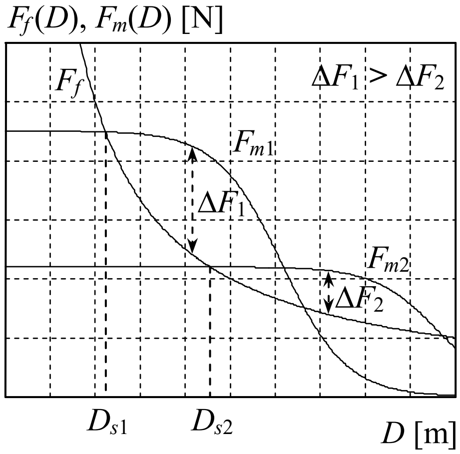

Fig. 4. Example of hard (F_{m1}) and soft body (F_{m2}).

Figure 5 shows examples of differences between a fragile body and a plastic body. The fragile body is the one for which smaller changes ΔD cause permanent breaking of intermolecular bond, i.e. reaching the point D_n.

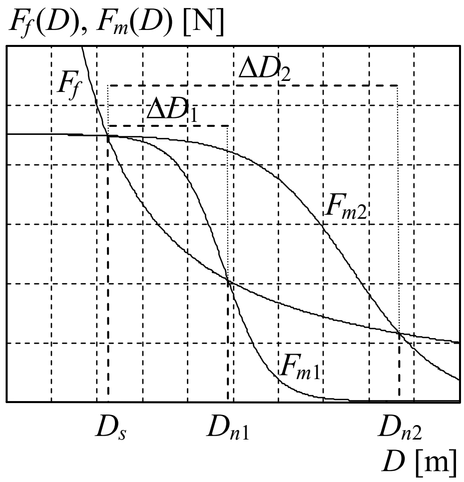

Fig. 5. Example of friable (F_{m1}) and plastic body (F_{m2}).

If the body temperature changes, the frequency f of photons causing the repulsive force changes (then it will be shown that their number n changes as well).

Figure 6 shows examples of differences between a cooler body and a warmer body. In a warmer body, the frequency of photons f is higher and the number n of photons is greater. This makes the repulsion force $F_f(D)$ in the equations (6)-(7) is greater and the diagram of this repulsion force rises upwards. If the diagram $F_f(D)$ is raised so that it no longer has any shared points with the diagram F_m, the body becomes liquid or gaseous. If the force diagrams $F_f(D)$ and $F_m(D)$ do not intersect, then there is no distance D_s of atoms for which the forces remain in equilibrium and form a rigid bond. Whether the body is liquid or gaseous depends on the external pressure and thus indirectly on the force of gravity. This is consistent with phase diagrams of equilibrium states.

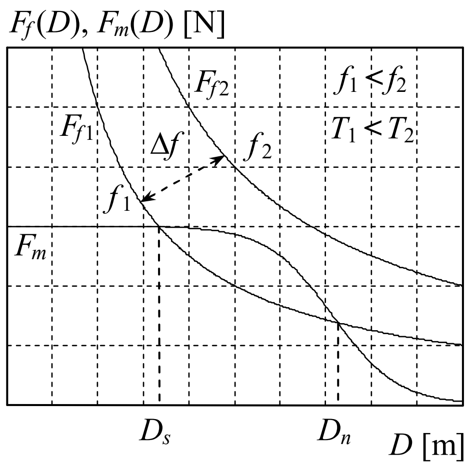

Fig. 6. Example of a body in solid state (F_{f1}) and a body in liquid or gaseous state (F_{f2}).

The presented model also explains the mechanism of thermal expansion. For a warmer body, the graph of $F_f(D)$ function moves upwards (Figures 6). Then the stability point D_s moves to the right, i.e. the distance between atoms and the dimensions of solid body increases. In the presented model, thermal expansion and Lorentz-Fitzgerald contraction are based on the same mechanism, i.e. change of photons pressure inside the solid body. In case of thermal expansion, the pressure changes due to a change in temperature, because then the number of photons and their momentum changes. In case of Lorentz-Fitzgerald contraction, the pressure changes due to a change in the speed of body relative to the universal frame of reference, because then the frequency changes with which photons transmit the momentum to atoms of the solid body (frequency measured in the ether system).

4. Estimation of the number of photons of thermal radiation

In the presented model atoms emit and absorb photons (electromagnetic radiation). It is expected that part of photons oscillating between atoms escapes from the body area. Such prediction is in accordance with the fact that each body emits electromagnetic thermal radiation called the radiation of a black body. The distribution of black body radiation was described by Max Planck, who postulated that it originated from the vibrations of harmonic oscillators that emit and absorb this radiation. Therefore, the model presented here is consistent with the analysis based on which Max Planck derived an equation for the distribution of black body radiation.

We will now calculate the density and intensity of the photons of thermal radiation near the surface of the body emitting this radiation.

According to Wien's law, as body temperature increases, the main wavelength of thermal radiation emitted by the body decreases proportionally. Wien's law enables to calculate the frequency of photons for which the distribution of all photons in the black body radiation has a maximum value (mode in statistics). That is

$$f_{\text{mode}} = \frac{c}{\lambda_{\text{mode}}} = \frac{c}{b/T} = \frac{c}{b}T \quad [1/\text{s}] \tag{13}$$

The photon energy has a value of

$$E_f = f\,h \quad [\text{J}] \tag{14}$$

Symbol ρ_T [1/m^3] designates the photon density, that is the number of photons of thermal radiation that are in a volume of 1 m^3 (near the body surface). These photons have different frequencies described in the Planck distribution. For the purpose of this paper, for simplicity it is assumed that the frequency of all photons has a value (13). Then the energy of all photons in a volume of 1 m^3 is obtained after placing (13) to (14) and multiplying by ρ_T. Then the following is obtained

$$E_{m^3}(T) \approx \rho_T \frac{c}{b}T\,h \quad [\text{J}/\text{m}^3] \tag{15}$$

The energy of photons of thermal radiation, which escapes to the outside through its unit surface per second, is described by the law of Stefan-Boltzmann radiation in the form of

$$E_{m^2/s}(T) = \sigma T^4 \quad [\text{J}/(\text{s}\,\text{m}^2)] \tag{16}$$

Since photons move at an average speed of c, thus in the unit volume there are photons with the energy that is obtained by dividing (16) by c

$$E_{m^3}(T) = \frac{E_{m^2/s}(T)}{c} = \frac{\sigma T^4}{c} \quad [\text{J}/\text{m}^3] \tag{17}$$

After comparing the equations (15) and (17), the following is obtained

$$\rho_T \frac{c}{b}T\,h \approx \frac{\sigma T^4}{c} \tag{18}$$

On this basis, an estimation of the photon density near the surface of a black body is obtained (the number of photons in the unit volume)

$$\rho_T = N_S\,T^3 \approx \frac{\sigma b}{h c^2}T^3 \quad [1/\text{m}^3] \tag{19}$$

For constant values

$$\begin{aligned} \sigma &= 5{,}670400\cdot 10^{-8} && [\mathrm{J/(s\,m^2\,K^4)}] \\ b &= 2{,}897768\cdot 10^{-3} && [\mathrm{m\,K}] \\ h &= 6{,}6260693\cdot 10^{-34} && [\mathrm{J\,s}] \\ c &= 2{,}99792458\cdot 10^{8} && [\mathrm{m/s}] \end{aligned} \tag{20}$$

we can calculate the value of the constant N_S. Equation (19) takes the form of

$$\rho_T = N_S\, T^3 \approx 2\,759\,179\cdot T^3 \quad [\mathrm{1/m^3}] \tag{21}$$

For example, at room temperature (293 K), near the surface of the body, the density of thermal radiation photons is

$$\rho_{T=293K} \approx 6{,}9404\cdot 10^{13} \quad [\mathrm{1/m^3}] \tag{22}$$

The intensity of thermal radiation photons, i.e. the number of photons passing per unit time through 1 m^2 of a black body surface, is obtained by multiplying the formula (19) by the speed of light c

$$I_T = c\, N_S\, T^3 \approx \frac{\sigma\, b}{h\, c} T^3 = 8{,}2718\cdot 10^{14}\cdot T^3 \quad [\mathrm{1/(s\,m^2)}] \tag{23}$$

$$I_{T=1K} \approx 8{,}2718\cdot 10^{14} \quad [\mathrm{1/(s\,m^2)}] \tag{24}$$

$$I_{T=293K} \approx 2{,}0807\cdot 10^{22} \quad [\mathrm{1/(s\,m^2)}] \tag{25}$$

5. Estimation of the photon pressure value

We will calculate the photon pressure inside bodies, assuming that the density of photons inside the bodies is the same as the density of the photons of thermal radiation, i.e. outside the bodies. The photon density (21) only takes into account photons moving away from the body in one of the six directions. Therefore, the number of photons moving back and forth is twice as high. Therefore, the number of n photons creating the force (9) in a volume of 1 m^3 is $2\rho_T$.

According to the formula (6) the photon pressure is ($S = D^2$ is the surface occupied by the atom)

$$p_T = \frac{F_f}{S} = \frac{n}{S\,D} f\, h \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} = 2\rho_T f\, h \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} \tag{26}$$

After taking into account the equation (13) we obtain

$$p_T \approx 2\rho_T f_{\mathrm{mode}}\, h \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} = 2\rho_T \frac{h\,c}{b} T \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} \tag{27}$$

On the basis of (22) we obtain

$$p_{T=293K} \approx 2\rho_{T=293K} \frac{h\,c}{b} T \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} \tag{28}$$

$$p_{T=293K} \approx 2{,}78802\cdot 10^{-6} \frac{1-(v/c)^2}{\sqrt{1-(v/c)^2 \sin^2\alpha}} \quad [\mathrm{Pa}] \tag{29}$$

Graphs of the fraction occurring in formula (29) are shown in Figure 3. The photon pressure does not depend on the type of body, but depends on its temperature T, the speed v of moving with respect to the ether and the angle α of the inclination of the direction of this pressure with respect to the velocity v.

The obtained value of the photon pressure (29) is very small in relation to the pressure necessary to crush the solid, which, for example, for steel is 200-1000 MPa, depending on the type of steel. Therefore, in order for the photon pressure model to fit the real data, it must be supplemented with an additional repulsive force of atoms. This additional repulsive force has values depending on the type of body. It creates a much greater pressure than the photon pressure. Its value does not directly depend on the movement of the body in relation to the ether, but is dependent on the photons of the photon pressure. That is, photons of photon pressure are something like a catalyst that activates the ability of atoms to repel.

When the body is crushed, it is counteracted by photon pressure and this additional, much bigger, repulsive force. The movement of the body in relation to the ether affects the photon pressure, which by some unknown mechanism affects this additional force that repels atoms, therefore the moving body deforms (Lorentz-Fitzgerald contraction).

6. Proposals for experiments that can detect motion against the ether

If the actual change in body dimensions in motion is due to stresses in solid bodies, it is very likely that different substances will contract slightly in a different way. It may be that each substance has its own individual function $\psi(v)$. If both arms of the interferometer in the Michelson-Morley experiment are made of the same material, they will shorten proportionally as it described in the Special Theories of Ether [9], [10], [11]. This makes the experiment unable to detect motion relative to the ether. But if the arms are made of different substances, then perhaps the Michelson-Morley's experiment will be able to detect motion relative to the hypothetical universal frame of reference in which light propagates.

Therefore, Michelson-Morley's experiment should be carried out, in which each arm is made of a different material. It is necessary to investigate which materials give the greatest effect.

According to the Lorentz transformation and some STE transformations, the dimensions of bodies accelerated to speed c will be zero. It is to be expected that in reality this will not be the case. Each theory acts only to some limited extent. Theoretical predictions for inertial systems unavailable for experiments are the outcome of extrapolation results obtained in experiments in inertial systems available for experiment. It is expected that during the acceleration of body the new mechanisms will appear (e.g. repulsive force of atoms will increase very much) and the body will stop contraction according to the patterns. Sufficiently densely packed atoms will not come close together even if the photons pressure does not act on them. However, in modern physics it is common that the results of extrapolation are treated literally and, for example, it is claimed that the Lorentz transformation shows that in the real world bodies accelerated to speed c will shorten to zero dimensions.

According to equations (15) and (21), the energy and number of photons forming photons pressure decreases to zero when the body temperature drops to absolute zero. This means that in bodies cooled to low temperatures, the photon pressure stops functioning. However, it is known that the dimensions of such bodies do not decrease to zero, as could be deduced from the presented model. It follows that at low temperatures, when the atoms are already close enough, another mechanism is revealed which does not allow the atoms to come any closer. This is the same mechanism as that referred to in the previous paragraph. This conclusion from the presented model can be very useful in planning an experiment that would enable to detect our motion in relation to the hypothetical ether. That is, the arms of interferometer should be cooled down to low temperatures. Perhaps the temperature of liquid nitrogen will be sufficient. At low temperatures, the interferometer arms should not undergo the Lorentz-Fitzgerald contractions, which compensated for the differences in time dilatation of the classical light clock. If there is indeed an ether in which light propagates, such an experiment with the interferometer should give a positive result. Perhaps the better effect will be obtained when one arm of the interferometer is cooled to low temperatures and the other is heated to freely undergo contractions.

7. Final conclusions

The paper proposes a photon pressure model to explain the phenomenon of longitudinal contraction (Lorentz-Fitzgerald contraction) and transverse contraction (transverse contraction may occur in a Special Theory of Ether). Contraction of bodies in motion results from the electromagnetic interaction between atoms of a solid body (the photon pressure). In the presented model the balance of position between atoms is affected by the speed at which the body moves in relation to the ether. Therefore, the dimensions of solids depend on their velocity and are closely related to time dilation. The model presented here combines the properties of relativity theory with universal frame of reference (STE) and physics of a solid body.

If in the Special Theory of Relativity (STR) and Special Theory of Ether kinematics a light signal is used to synchronize the clocks, then the light clock is automatically introduced in these theories as a time standard [11]. In other words, STR and STE are theories in which time is measured by the light clock. These are theories that describe the practical aspects of using such clocks. Therefore, in these theories there is a time dilation phenomenon on which the photon pressure model explaining the Lorentz-Fitzgerald contraction is based.

In the presented model, Lorentz-Fitzgerald contraction is a physical property of solid body, not a property of space-time, as it is today interpreted within the Special Theory of Relativity. It is the bodies that contract, not the space.

Presented analysis shows that one of the ways to measure the movement in relation to the ether may be to conduct Michelson-Morley experiment using an interferometer, the arms of which are made of two different substances, or an interferometer which arms (or one arm) are cooled to low temperatures.

For each kinematics it is possible to derive many dynamics. Examples for Special Theory of Ether were derived in monograph [6]. The examples for Special Theory of Relativity were derived in the article [12].

In the article [10] it was shown that Lorentz transformations should be assigned a different interpretation than that adopted in the Special Theory of Relativity. The problem that mathematical formulas can be assigned different physical interpretations is not just about the Lorentz transformation. For example, in article [13] it was shown that gravitational waves should be interpreted as a ordinary modulation of gravitational field intensities.

There are numerous articles on the subject of relativistic mechanics with significant theoretical results. The article [1] presents the original definition of acceleration in Special Theory of Relativity, while in article [2] the formalism concerning the three-vector and four-vector relative velocity was been shown. The articles [3] and [4] relate to important insights on time dilation in relativity, while article [5] presents alternative ideas for relativity.

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