The compatibility of non-negative outcome of Michelson&Morley experiments with Lorentz-invariant transformations of the light speed in moving optical media

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From the first-principles of the relativistic theory of Lorentz-invariant addition of the speed of light (c/n) with speed (υ) of moving optical medium having a refractive index $n>1$ in the natural way there becomes clear the cause of the kinetic anisotropy of the speed of light, registered for more than 100 years in experiments like the Michelson&Morley (MM) experiment by non-zero amplitudes ($A_m\neq0$) of the shift of interference fringe. Miller's measurement (1925) and my experiments (1968) showed (in my interpretation) that the cause of this anisotropy is always associated with the presence in the light carrying medium of polarizable particles translationally moving with respect to stationary aether. The anisotropy of refractive index $n>1$ of the light carrying medium is created by the electrodynamic connection between the polarization ($\Delta\varepsilon=n^2-1$) of its particles and the polarization ($\varepsilon_{aether}=1$) of the aether. The absence of anisotropy of the speed of light in vacuum (in the aether without particles) is proved not by the disputed attribution of MM type experiments to "negative, $A_m=0$", but rather by a recognition that they are non-negative. In this case, by the actual experimental dependence of $A_m(\Delta\varepsilon)\neq0$ is easily proved the absence of anisotropy in vacuum in the asymptotic limit of the zero fringe shift $A_m(\Delta\varepsilon\to0)\to0$ at the beginning of the trend $A_m(\Delta\varepsilon)$.

Accounting for the effects of polarization of *light carrying media*, of the first order of "smallness" $(n^2-1)<<1$ in the gases and the second order of magnitude $(n^2-1)^2\sim1$ in media of higher permittivity, plays a key role in the proposed relativistic interpretation of my measurements and all the famous experiments of MM type. Revising the calculations of υ from measurements of non-zero fringe shift ($A_m\neq0$), described by MM, 1887; Miller, 1925; Kennedy, 1926; Illingworth, 1927; Joos, 1930, and many others, I found their principal error. They did not take into account not only the relativistic structure (n^2-1) of the polarization activity of particles of the luminiferous medium, but its real value $n>1$. As a result, they received the underestimated speed υ – units km/s. Accounting for the relativistic structure of only the first (n^2-1) of the order of "smallness" in the gases immediately reveals (for the same non-zero measurements $A_m\neq0$ of these authors) the real speed of "aether wind" υ as a few hundred km/s.

1. The current state of the problem

Nowadays there are accumulated serious experimental evidences of the non-negativity of the experiments of Michelson&Morley (MM) type [1]. This became evident from the *systematic* detection of the non-zero amplitude ($A_m\neq0$) of shift of the interference fringe by most of the known experimenters [1÷4]. Relationship of day and night trends of this shift with the astronomical cycles of the Earth [1] indicates to the detection by interferometers MM type with orthogonal light-carrying arms of the kinetic spatial anisotropy of the speed of light, excited by the absolute motion of the Earth in an aethereal space.

Experiments on the aberration of light almost 300 years reveal the aether as the stationary substratum. However, in historically the first theory of addition of the speed of light (c/n) in a stationary medium with the speed υ of motion of this medium in a stationary aether (see Fig.1a), proposed by Fresnel in 1825, there was introduced the controversial concept of the coefficient $\alpha=(1-n^{-2})$ of "aether drag" by the matter of the moving medium:

$$\tilde{c}_{\pm}\approx\frac{c}{n}\pm\upsilon\left(1-\frac{1}{n^2}\right)\ . \qquad (1)$$

Introducing the coefficient of "aether drag" $0\leq\alpha\leq1$, Fresnel admitted a wide variety of mobilities of the aether. That it contradicts to the experiments on the aberration of light no one paid attention before me.

I will show below that in fact there is no the phenomenon of "aether drag" in nature [1, 4]. In the Fresnel formula (1), in reality, we deal with the drag (along $\boldsymbol{\upsilon}$) of the light-wave complex by the translational motion (with velocity υ) of those particles which belong to the zone of the light-carrier of the interferometer. In this case the phenomenon of "drag" was closely related to the refractive index n of the medium. As gradually became clear to the 1870s in the Maxwell's theory, the drag of the light-complex is concerned with the contributions of the polarizability of the moving particles ($\Delta\varepsilon = n^2 - 1$) and the polarizability of stationary aether ($\Delta\varepsilon_{\text{aether}} = 1.$) in the complex structure of the refractive index ($n = \sqrt{\Delta\varepsilon_{\text{aether}} + \Delta\varepsilon} = \sqrt{1. + \Delta\varepsilon}$) of the optical medium [1].

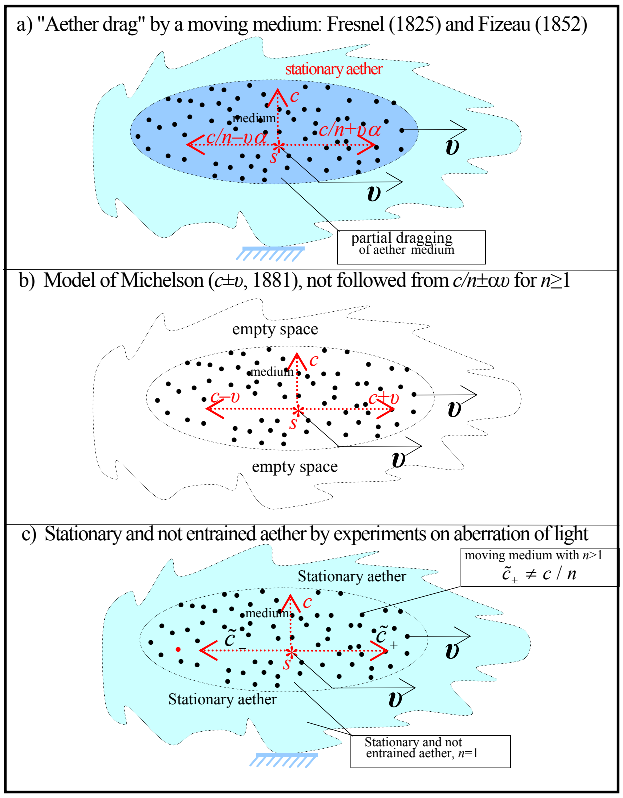

Fig.1. Scientific-historical genesis of the concept of kinetics medium in the aethereal (a, c) and empty (b) space:
$\boldsymbol{\upsilon}$ – velocity vector of the medium (or translational motion of its particles);
c – speed of light in vacuum; s – a light source.

In 1852, the formula (1) receives the experimental confirmation in the Fizeau experiment, which measured on a flow of water (n=1.33) the magnitude α=0.436, that coincided with the theoretical value of $\alpha=(1-n^{-2})$ with the accuracy of about 10^{-2}. The credibility to the theory of Fresnel grew, there were arisen the theories of light propagation in moving media, in which the coefficient of "aether drag" takes the values "$0 \le \alpha \le 1$". In particular, in the mid-19th century the theory of Stokes admitted the complete drag (α=1) of the aether by the bodies. But, according to (1), the value of α=1 is realized only when $n=\infty$. In other words, when $n \to \infty$ from (1) there is obtained $\tilde{c}_{\pm} \to \pm\upsilon$. In the other limit, α=0, when n=1 (in vacuum) from (1) we obtain $\tilde{c}_{\pm} = c$. Consequently, Michelson used for the interpretation of his experiments the "mechanically" non-invariant form $\tilde{c}_{\pm} = c \pm \upsilon$, which is not followed from the already existed there asymptotic theory of the addition of velocities (1) in moving optical media (in the whole region of the implementation of the parameter $0 \le \alpha \le 1$).

Is it possible that just the asymptotic behavior of (1) at n=1. and α=0, prompted by an erroneous interpretation of experiments of MM type as negative, suggested to Einstein the formulate on of the second postulate of special relativity? According to the latter in the aether without particles (in vacuum) there should be the isotropy of the speed of light $\tilde{c}_{\pm}(\boldsymbol{\upsilon})$ =const.? Below I will show, that the Fresnel formula (1) (despite of its appearance in 1825) is the right Lorentz-invariant first-order approximation of the relativistic theory of addition of velocities in moving media. Therefore, the ignoring of the theory of addition of velocities by Fresnel (1), that rightly suggests the inapplicability of the form $\tilde{c}_{\pm} = c \pm \upsilon$ in optical interferometer with air light-carrier in which $n>1$, should be regarded as a gross blunder of Michelson. It brought about the chain of errors of interpretation of fundamentally positive experiements of MM type, which I criticize during the past 40 years [1, 4]. Curiously, but no one has noticed up to 1968 [1] that the form $\tilde{c}_{\pm} = c \pm \upsilon$ can not be deduced from (1).

2. Experimental evidence for the isotropy of the speed of light in space without particles by means of the non-zero shift of interference fringe in the interferometers of MM type

Aethereal space with no particles (vacuum, $n=1$) is indeed isotropic, but it is an isotropy that is not directly observed since in aethereal light-carrying medium there is no polarizable moving inertial objects. I proved this experimentally (Fig.2) by the direct pumping of air from the light-carrying zones of the interferometer. In the process, of the pumping the shift of the fringe at elevated and normal air pressures is observed, but disappears at a pressure of 10 mm Hg. It turns out that we need positive experiments measured non-zero shifts ($A_m \neq 0$) of interference fringe for several values of $n>1$ of different light-carriers of the interferometer in order that we may beyond the parameters of aether light-carriers with $n=1$ from the region of its isotropy $\tilde{c}_{\pm}(\mathbf{\upsilon}) = c$ to the region of real light mediums with $n>1$ of the zone of anisotropy $\tilde{c}_{\pm}(\mathbf{\upsilon}) \neq c$ (Fig. 2). Getting to the zone of the interferometer sensitivity ($n>1$) enabled me to obtain some non-zero values of fringe shifts A_m (Fig. 2), which revealed a rectilinear trend according to $A_m(n^2-1)$ on the polarization-dielectric contribution ($n^2-1=\Delta\varepsilon$) of particles of light carrying mediums. The inverse asymptotic slope of this trend to $\Delta\varepsilon \to 0$ or $n \to 1$ (i.e. to vacuum) reveals the onset of the condition of isotropy of the speed of light $\tilde{c}_{\pm}(\mathbf{\upsilon}) = c$ for $n=1$ by the condition $A_m(\Delta\varepsilon=0)=0$ (see Fig.2).

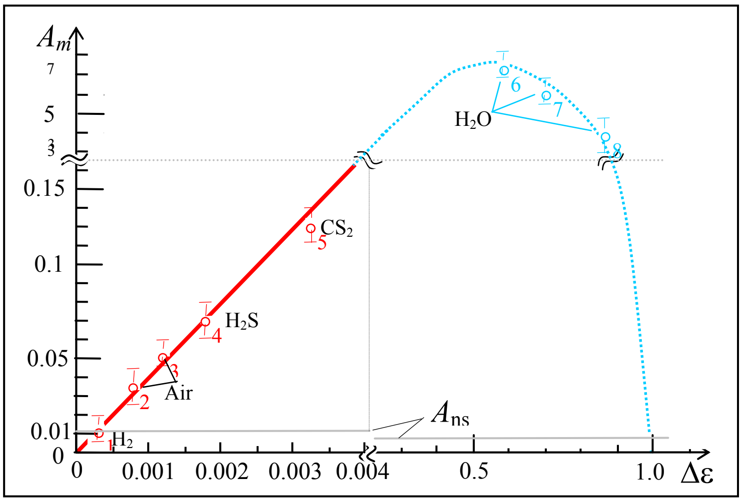

Fig.2. Dependence $A_m(\varepsilon)$ of amplitude A_m of shift of interference fringe on the polarization contribution ($\Delta\varepsilon$) of particles to the total permittivity $\varepsilon=1+\Delta\varepsilon$ of the medium light-carrier of Michelson interferometer, found by me in 1968 [2].

Points 1÷5 were obtained at l=6 m and $\lambda=6\cdot10^{-7}$ m, and the points 6÷8 – at l=30 cm for wavelengths $\lambda_6=1{,}2\cdot10^{-6}$ m, $\lambda_7=6\cdot10^{-7}$ m, $\lambda_8=3\cdot10^{-7}$ m, respectively.

Position of the points 6–8 is reduced to a single ratio $l/\lambda=10^{-7}$, characteristic of measurement of the interferometer with gas light-carrying medium. A_{ns} – the mean average level of the amplitude of interference fringe noise jitter.

The asymptotic limit $A_m(\Delta\varepsilon\to0)\to0$ of non-zero shift of interference fringe on the MM type interferometer reveals the absence of anisotropy of the speed of light in aether without particles (in vacuum) for $\Delta\varepsilon=0$ or $n=1$.

According to Maxwell's theory, the light differently polarizes particles and aether, depending on the angle between $\boldsymbol{\upsilon}$^$\boldsymbol{c}$, exciting the spatial dispersion of the refractive index $n(\boldsymbol{\upsilon}$^$\boldsymbol{c}) \neq$const. In different directions of space the refractive index $n(\boldsymbol{\upsilon}$^$\boldsymbol{c})>1$ is different. In the process of turning on 90^0, the MM-interferometer feels this anisotropy, indicating non-zero shift of interference fringe. It is only in an absolute vacuum (in the absence of particles in the interferometer light-carriers zones), there is zero shift of the fringe, because the polarization of the "pure" aether in all directions of propagation of light is the same: $n_{\text{aether}}(\boldsymbol{\upsilon}\hat{}\boldsymbol{c})=1$; $(c/n)=c$, and anisotropy of the speed of light is absent.

Since 1881 all believed that the device of Michelson may feel the anisotropy of space at $n=1$: and in the air (MM, 1887; Miller, 1925) and in the helium (Kennedy, 1926) and in the laboratory vacuum (Illingworth, 1927; Joos, 1930, etc.). As a result that sort of non-relativistic interpretation of the experimental observation of non-zero shift of the fringe led to a strongly underestimation (up to several km/s) or even zero values of υ (in vacuum), which formed the myth of the "negative" MM type experiments. Accounting for the effects of polarization of the particles in the gases, even in the first order $(n^2–1)$ of "smallness" gives for υ real hundreds km/s [1].

Michelson did not know as well that for processing the results of non-zero measurements $A_m\neq 0$ we will need not the contradicting to the principle of correspondence form $(c\pm\upsilon)$, but the relativistic definition of the speed of light ($\tilde{c}_{\pm}=c/n\oplus\upsilon$) in moving with the velocity υ the corporeal part of the light medium, as shown in Fig.1c [1]. Here and further: $\oplus$ – operator of relativistic addition velocities; c – speed of light in vacuum (n=1.) without particles; c/n – speed of light in the light-carrier medium with the particles, that make $n>1$. The part of the light-carrier medium associated with the translationally moving particles in the aether, is the polarizational contribution $\Delta\varepsilon>0$, which complements the constant polarizational contribution of aether ($\Delta\varepsilon_{\text{aether}}$=1.) and interacts with it, giving $n>1$. Neither Michelson nor Miller had no idea about the need to address this complicated binary-polarizable structure ($n^2=\varepsilon=1.+\Delta\varepsilon$). Therefore, the experimenters using in 1881÷1930 of the wrong expression $(c\pm\upsilon)$, instead of the relativistic rule ($\tilde{c}_{\pm}=c/n\oplus\upsilon$) to determine the speed of light in a moving medium, appeared to be far from the realities of the earthly experiment (see Fig.3).

3. The experimental anomaly of shift of the interference fringe in the vicinity of $n=\sqrt{2}$, i.e. at $\Delta\varepsilon=1$

Fig.3 shows a more complete form, and at other scale than is given above in Fig.2, the dependence $A_m(\Delta\varepsilon)$ of amplitude A_m of the shift of interference fringe from the polarization contribution $\Delta\varepsilon$ of particle in permittivity of the light-carrying medium. It is given in double logarithmic scale in order to show clearly the following three phenomena.

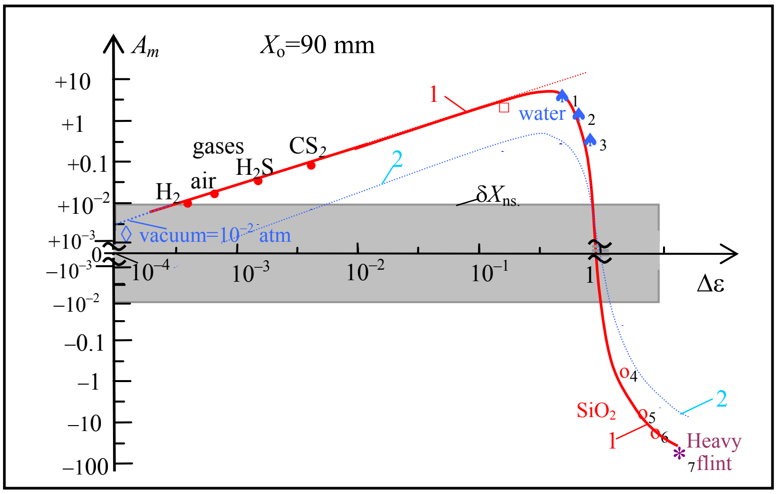

Fig.3. Dependences $A_m(\Delta\varepsilon)$ of relative amplitude $A_m=X_m/X_o$ of shift of the interference fringe on the screen of a kinescope with the width of interference fringe X_o=90 мм from the contribution $\Delta\varepsilon$ of particles into the full dielectric permittivity ($\varepsilon=1+\Delta\varepsilon$) of light-carriers of the MM type device obtained for various carriers of the light beams: ◊ – vacuum, 10^{-1} atm; • – gases; ♠$_i$ – water; □, o$_j$ – fused quartz; *$_7$ – glass "heavy flint glass" (ТФ-5) on blue beam (all experimental values are given at $l_{\parallel}=l_{\perp}$=6,0 *м* and $\lambda=6\cdot 10^{-7}$ м). Curve 1 corresponds to $A_{m\,\max}$, but curve 2 to $A_{m\,\min}$. Amplitudes $A_{m\,\max}$ correspond to the projection (approximately 480 km/c) speed of "aether wind" on horizontal plane of device, and amplitudes $A_{m\,\min}$ – to the projection about 140 km/c (at the Obninsk latitude). X_o=90 *мм* is the width of the interference fringe on the screen of a kinescope. $\delta X_{ns.}$ – noise-jitter of the interference fringe on the screen of the kinescope. The observation of amplitudes $A_{m\,\max}$ and $A_{m\,\min}$ is always shifted to local time for 12 hours.

Firstly, how it looks the dependence of $A_m(\Delta\varepsilon)$ deployed in the 4-ordinal dynamic range of the axis A_m and axis $\Delta\varepsilon=n^2-1$. *Secondly*, the dependence of $A_m(\Delta\varepsilon)$ reveals the asymptotic value of $A_m=0$ (i.e. the loss of sensitivity of the interferometer) for $\Delta\varepsilon\to 0$ only at linear scale $\Delta\varepsilon$ in Fig.2, and on logarithmic scale $\Delta\varepsilon$ on Fig.3 this asymptotic behavior is not visible. *Thirdly*, in the MM type interferometer the dependence $A_m(\Delta\varepsilon)$ has the positive sign of the shift of interference fringe at $\Delta\varepsilon<1$, and if $\Delta\varepsilon>1$ – the negative sign, so that in the vicinity of $\Delta\varepsilon=1$ the shift of interference fringe is absent, since the interferometer here, for the second time, loses the sensitivity after that he had lost it firstly at $\Delta\varepsilon=0$ (in vacuum).

Only in the end of 1960^{th} years there was for the first time demonstrated [1, 3] that in order to process properly the measurements of the appreciable non-zero amplitude $A_m\neq 0$ of the fringe shift there will be needed a new relativistic rule ($c/n\oplus\upsilon$) of addition of the velocities involving actual values $n>1$. In this event, the magnitude of the speed of the particles of the optical medium in the interferometer (several hundreds km/s) agreed with the astronomical observations is obtained provided that we specially take into account the contribution of the polarization, $\Delta\varepsilon=(\varepsilon-1)>0$ of the particles of light-carrying medium whatever a small quantity it may appear to be in the experiment [1, 4].

So, in order to interpret properly the results of measurements in the air as optical medium, for which $\varepsilon=1.0006$ (for instance in the experiment by MM, Miller [2] and me [1,4]) there necessarily should be taken into consideration the contribution of the polarization of the particles of the air ($\Delta\varepsilon=0.0006$) to the approximation of 4^{th} digit after the point. In case of the measurements in the laboratory vacuum (as e.g. in the experiments made by S.Herrmann, M.Nagel et al. in 2009 [3] in the rarified air of $\sim 10^{-9}$ atm) there is required the accuracy, to account for the contribution of particles $\Delta\varepsilon=0.00000000000006$, up to the 13^{th} digit after the decimal point.

What the air dielectric permittivity $\Delta\varepsilon>0$ was not taken into account by Michelson (1881 and 1887) and Miller (1926) in [2] there has led to ~40 times understated values (3÷12km/s) of the measured by them horizontal projection of the velocity υ (since $\Delta\varepsilon^{-1/2}=0.0006^{-1/2}=40$ [1,4]). Not accounting for $\Delta\varepsilon>0$ of the laboratory vacuum in [3] gave respectively the million-fold understatement of the velocity υ (down to the absurd numbers of several microns per a second [4]). The proper accounting of the polarization contribution $\Delta\varepsilon\neq 0$ of the particles of light-carrying medium of interferometer MM always yields the velocity υ of some hundreds km/s, whether these be the particles of laboratory vacuum, air or any other optical medium [4]. In particular, at 56^0 NS the value of the horizontal projection of velocity υ changed in the range 140÷480 km/s (depending on the time of the measurement in the day or night) [1,4]. The data quoted have been obtained by me for various optical medium whose dielectric permittivity changed in a wide (known to date) interval of numbers $1.000006<\varepsilon<3.5$.

In the works [1,3,4] there were undertaken first attempts to explain the non-zero shift of the interference fringe making use not the Galilean ($c\pm\upsilon$), but Fresnel rule of addition of velocities ($c/n\oplus\upsilon\alpha$), where $\alpha=(1-n^{-2})$ is a constant. The absence of Lorentz invariance of the form ($c/n\pm\alpha\upsilon$) for second-order effects υ^2/c^2 in the MM interferometer does not secure a correct description of all peculiarities of the experimental dependence $A_m(\Delta\varepsilon)$ shown in Fig.1 if only we deliberately introduced artificial quadratic (by υ^2/c^2) amendments, specifically, the "Lorentz triangle " and "Lorentz contraction" [1].

Below we show that a correct description of the experimental dependence of 2 and 3 can be obtained from the first principles of the relativistic formula of the addition of velocities ($c/n\oplus\upsilon$). In the expansion of this formula (7) by υ/c naturally appears the term accounting for the polarization contribution of particles which is the Fresnel coefficient $\alpha=(n^2-1)/n^2=\Delta\varepsilon/\varepsilon$ occurring in the first (k=1), second (k=2) and all consecutive (k) orders of the ratio υ^k/c^k, see formula (7). This lends a new physical content of the phenomenon studied as the entrainment of the light (of the light package) by the moving in the stationary aether particle of the mobile medium. The former interpretation of α as the coefficient of "dragging of the aether medium" proved to be incorrect [1], since the stationary aether is not subject to any forms of motion or dragging.

4. Little-known features of the Lorenz-invariant description of the dynamical anisotropy of the light speed in experiments with moving optical media

Considering the rule $c\pm\upsilon$ in the extreme of vacuum (no particles, when n=1 and $c/n=c=c_0$) we find that, despite of the relative motion with the velocity υ of two abstract reciprocal inertial reference frames (IRF) – which are abstract because there are no inertial elements for IRF in vacuum – the light speed in static IRF_0 (c_0) is the same as in the moving IRF' ($\tilde{c}_\pm$). This logically follows from the math of the form of relativistic addition of the light speed in the stationary IRF_0 and the velocity υ of the moving IRF'. Indeed, according to the relativistic rule mentioned the light speed in aether (vacuum) $\tilde{c}_\pm$ in the moving IRF' appears to be equal to the light speed in the static IRF_0 ($c_0=c$):

$$\tilde{c}_\pm = c\oplus\upsilon = \frac{c\pm\upsilon}{1\pm c\upsilon/c^2} = \frac{c\pm\upsilon}{1\pm\upsilon/c} = c = c_o \ . \tag{2}$$

If now to perform a reverse transformation (for the variation $\delta c = -\upsilon$) of the velocity $\tilde{c}_\pm$ from the moving IRF' to the static IRF_0, where the light speed is known beforehand as being c_0, then from (2) we obtain in IRF_0 for $-\upsilon$ in the course of the transformation:

$$c_o = \tilde{c}_\pm \oplus(-\upsilon) = \frac{\tilde{c}_\pm \mp\upsilon}{1\mp\tilde{c}_\pm\upsilon/c^2} = \frac{c\mp\upsilon}{1\mp\upsilon/c} = c = c_o \ . \tag{3}$$

That is what would be obtained if we return to the initial stationary IRF_0, where a priori there was $c_0=c$. Formula (3) in its narrow sense was discovered by Poincare in 1904 [6, 7]. The sign "+" in it corresponds to the case when vectors $\boldsymbol{c}$ and $\boldsymbol{\upsilon}$ have one and the same direction, and "–" for the opposite orientation. This addition rule follows from well-known Lorentz group transformations furnishing the amendment to classical (Galilean) transformations as a Lorentz-factor $\sqrt{1-\upsilon^2/c^2}$. A part of the second postulate (the light speed is the *same* in all IRF) is stated and proved through formula (3). This is likely always so in the ideal vacuum where there is no particles (n=1).

However, to the middle of 20th century, owing to the great practice of measuring light speeds in various optical mediums with refractive index n>1, there was proved that, firstly, the light speed in medium with differing n>1 is *different*, and secondly, is exposed a more general rule of relativistic definition of light speed in the moving medium:

$$\tilde{c}_\pm = c/n\oplus\upsilon = \frac{(c/n)\pm\upsilon}{1\pm\dfrac{\upsilon c/n}{c^2}} = \frac{(c/n)\pm\upsilon}{1\pm\upsilon/(nc)} \ . \tag{4}$$

From (4) we have obviously the inequality $\tilde{c}_\pm \neq c/n$. What $\tilde{c}_\pm \neq c/n$ in the real optical medium with n>1, i.e. what light speeds in the static and moving mediums are *not the same* was for the first time noticed in [1]. It is formula (4) that should be regarded as primary of (3) since formula (3) follows from (4) at n=1, but not vice versa. The Lorentz invariance of formula (4) in relation to the combination c/n in IRF_0 and IRF' is usually proved in the following way. As in case of (3) the reverse transformation is performed (for the variation $\delta c = -\upsilon$) of the speed $\tilde{c}_\pm$ from the moving IRF' to the stationary IRF_0 where the speed of light is known in advance as c/n:

$$c/n = \tilde{c}_\pm \oplus(-\upsilon) = \frac{(\tilde{c}_\pm \mp\upsilon)}{1\mp\tilde{c}_\pm\upsilon/c^2} = c/n\,, \tag{5}$$

This is that should be obtained in return to the initial static IRF_0 where a priori has been defined the value c/n of the light speed. However, for some reason there never paid proper attention to the intermediate result of the direct transform (4):

$$\left[\tilde{c}_\pm = \frac{(c/n)\pm\upsilon}{1\pm\upsilon/(nc)}\right] \neq \left[c/n = c_o\right], \tag{6}$$

which reveals the obvious inequality of light speed in the static and moving optical mediums with n>1. Exactly, (6) points out at the inevitable existence of the dynamical (in motion) anisotropy of the light speed in optical mediums, which move relative to aether with the velocity υ. Inequality (6) explicates the reason why MM-experiment are in principle implementable as positive in a certain moving laboratory, i.e. capable to detect the absolute motion of the laboratory (together with the light-carrying medium of the interferometer) relative to the stationary aether.

Recently I have found that the relativistic expression (4) of the light speed in a moving medium, besides the Lorentz-invariance in the form of (5), which may be called the integral invariance, possesses as well of an approximate Lorentz-invariance of its constituent parts in their reverse transformation. With this end we will expand the right-hand side of (4) into a series with respect to the small parameter $\upsilon/c<10^{-3}$:

$$\tilde{c}_{\pm} \approx \frac{c}{n}\left[(1 \pm \frac{\upsilon}{c} n\left(1-\frac{1}{n^2}\right) - \frac{\upsilon^2}{c^2}\left(1-\frac{1}{n^2}\right) \pm \frac{\upsilon^3}{c^3}\frac{1}{n}\left(1-\frac{1}{n^2}\right) - \frac{\upsilon^4}{c^4}\frac{1}{n^2}\left(1-\frac{1}{n^2}\right) \pm .... - (\mp 1)^k \frac{\upsilon^k}{c^k}\frac{1}{n^{k-2}}\left(1-\frac{1}{n^2}\right)\right]. \quad (7)$$

First two terms of this series, as is known [5, 6], give the prerelativistic Fresnel formula $\tilde{c}_{\pm} = c/n \pm \upsilon\alpha$, where $\alpha = (1-n^{-2}) = \Delta\varepsilon/\varepsilon$. This result is classified as one of the first achievements of special relativity theory (SRT) appeared to be capable to deduce phenomenologically this formula starting with first principles of SRT [6, 7].

Choosing from the right-hand part of (7) only two terms of the series and performing the reverse transformation of this formula by (5), also taking into account in it only terms of the first order by υ/c, then we obtain in the static medium $\tilde{c}_{\pm} = c/n$ (with the error $\sim\upsilon/c$). In other words, the classical Fresnel formula in the bounds of the approximation restricted by the accounting only for the terms of the first order by υ/c appears to be Lorentz-invariant (with the error of approximation $\sim\upsilon/c$). It is known that in the experiments of Fizeau (for ratio $\upsilon/c \sim 10^{-7}$ in water) there was corroborated the Fresnel formula with the error $\sim 10^{-2}$. This explains the success of all known Fizeau types experiments, which surely proves inequality of velocities of propagation of light in the moving and stationary optical media (liquid and solid mediums).

Similarly, confining himself in the direct transformation of velocities (7) by the three terms of the series involving first and second orders of the ratio υ/c:

$$\tilde{c}_{\pm} \approx \frac{c}{n}\left[(1 \pm \frac{\upsilon}{c} n\left(1-\frac{1}{n^2}\right) - \frac{\upsilon^2}{c^2}\left(1-\frac{1}{n^2}\right)\right], \quad (8)$$

then, having performed the reverse transformation by (5), restricted here with the accounting only for the terms of the first and second order by υ/c, we obtain another time the same result $\tilde{c}_{\pm} = c/n$.

This means that the Fresnel formula (8), being made more accurate (by retaining the terms of the second order υ^2/c^2) becomes approximately Lorentz-invariant with respect to parameter c/n (with the error of the approximation $\upsilon^2/c^2 \approx 10^{-6}$). This provides a potential basis for an experimental comparison of the velocities of propagation of light in a fixed and inertially moving optical media by means of application of the formula (8) for the interpretation of measurements on the interferometer of MM type. This program was made by me (see [1] and [4]). I checked that the retaining in (7) of any first k-terms of the expansion always yields in the reverse transformation by (5) one and the same result $\tilde{c}' = c/n$, which is invariant for moving and stationary media provided that the transformation (5) is abridged by the accounting of the respective k terms of the expansion. Clearly, that the application of the confined by k terms of the series (7) description of the processes applied is valid with the approximation error of the order υ^k/c^k.

From the given above analysis of the exact formula (4) of the relativistic definition of the light speeds in the moving and static optical mediums by means of its expansion (7) there follows a conclusion of great practical (experimental) significance. Both forms, (5) and (7), in the reverse transformation by (5) appear to be Lorentz-invariant in the range of being truncated by whole numbers $1 \leq k \leq \infty$. Obviously the experimental verification of the Lorentz-invariance of the total formula (5), as we can see from its expansion (7), demands to keep the interferometer sensitivity to all k parts of the expansion (7). In the interferometer by MM type all terms of the expantion (7) with odd "k" symmetrically compensated, i.e. they are dropped [1].

The sensitivity of the interferometer MM to the perceptible shift ($A_m \neq 0$) the interference fringe at turning about vertical axis holds in principle for even powers of "k" (0, 2, 4, 6…). The term with k=2 under terrestrial conditions has the smallness of the order $\upsilon^2/c^2 \sim 10^{-6}$, so the instrument of MM type still feels it. But the terms with k=4 (having the order of magnitude $\upsilon^4/c^4 \sim 10^{-12}$) remain above the threshold it of sensitivity. Therefore the device of MM type is unable to reproduce the whole scope of the effects described by the terms of the series (7) with k>2.

Insofar as in the interferometers of MM type the effects of the first order by υ/c are ideally compensated, the amplitudes $A_m \neq 0$ observed with them correspond to the shift of fringe occurred from the effects of the second order υ^2/c^2. The same attests also the spectral analysis of the harmonic function of the fringe shift having 2 times more short period than the period of turning the interferometer about vertical axis. It was shown in [1, 4] quite convincingly at interferometers used various light-carriers that the precision $\upsilon^2/c^2 \sim 10^{-6}$ of the effects described by the Lorentz-invariant formula (7) rather suffices in order to detect the horizontal projection of the velocity (~140÷480 km/s) which the terrestrial laboratory moves relative to aether.

5. About light-carrying medium as a region of interaction of moving (particles of the medium) and stationary (aether) inertial frames of reference

(non existence of the phenomena of aether drag)

The rational observer of the terrestrial laboratory needs not in quest for an external inertial frame of reference (straightly – of the external reference body) in order to detect and measure his absolute motion if he employs the modern knowledge of the Maxwell's electrodynamics [1]. According to its material equations, the polarization of the optical medium by the light in two ways is exposed in their dielectric permittivity $\varepsilon = n^2$ having a binary composition $\varepsilon = 1 + \Delta\varepsilon$ [1, 4]. The first contribution $1. = \varepsilon_{aether}$ of this form Maxwell relates to the polarization of the stationary aether which is everywhere in the space, the second contribution $\Delta\varepsilon > 0$ was connected by Maxwell with the particle's polarization which imparts to the optical medium the permittivity $\varepsilon = (\varepsilon_{aether} + \Delta\varepsilon) > 1$. At last, in this theory the quantity ε straightly determines the speed of light in the medium. In the static medium, the light speed is $c_0 = c/n = c/\sqrt{\varepsilon}$, where c is the speed of light in vacuum in the absence of particles (when n=1.). In the moving medium, according to (5) and (6), the speed of light $\tilde{c}_{\pm} = (c/n) \pm \upsilon/[1 \pm \upsilon/(nc)]$ is not equal to the light speed $c_0 = c/n$ in the static medium. Particles of the medium may be immobile in aether and translationally moving with respect to it with the velocity υ as it is observed for all particles of the solar system and hence for those of the Earth.

The binary composition $\varepsilon = 1 + \Delta\varepsilon$ is the result of polarizations of different substrates forming two inertial references frames (IRF) which always coexist within any optical medium involving particles. One of this frames (IRF_0) is connected with the stationary aether occurring everywhere in the Universe, and the second one, as a rule a moving frame (IRF'), is locally related with the particles of the laboratory detector of its motion – with the particles of light-carrying medium of the MM-interferometers. Thus, in any terrestrial laboratory with locally static with respect to each other mechanical units of MM device (the light source, arms of the interferometer, particles of light-carrying medium, an "observer" etc.) always occur in one and the same place two inertial frames of reference. Viewing from the standpoint of Maxwell's electrodynamics, the rational observer of a terrestrial laboratory, owing to MM interferometer, always has at hand two IRFs, which resolve the absolute velocity of their motion. From the point of view of the Maxwell's theory, the particles motion (IRF ') relative to a stationary luminiferous aether (IRF_o) partially entrains the light wave, but not aether. The phenomena of entrainment of the aether does not exist in nature, since aether can move nowhere, i.e. before aether (without aether, instead of aether) there is no empty space in nature.

We will give more accurate definition of their position. One of them, $IRF_0(\boldsymbol{\upsilon} \cdot \mathbf{c} = 0)$, is as if it would be at rest in the transverse arm of the MM interferometer stipulated by the orthogonality $\boldsymbol{c} \perp \boldsymbol{\upsilon}$ of the velocities added. The other inertial reference frame $IRF'(\boldsymbol{\upsilon} \times \boldsymbol{c} = 0)$ of the longitudinal arm of the MM interferometer moves along $\pm\boldsymbol{c}$ with the velocity $\boldsymbol{\upsilon} \| \boldsymbol{c}$. These two IRFs are sufficient in order to measure the velocity of the absolute motion of the laboratory. No assistance of a third outside inertial reference guide, as stated by Galileo in the classical theory of relativity and Einstein in SRT, is needed. In this there is the gist of the new theory of relativity of the absolute (self-) motions of any isolated inertial objects irrespective to external motions of other bodies (this "new" theory of relativity is almost equivalent to the Lorentz teory). It is through these two orthogonal IRFs, the MM interferometer with orthogonal arms obeys to the form (8) and responds positively at turning by 90^0 (i.e. has a natural non-zero shift of interference fringe)..

I noticed this new feature of the Lorentz-invariant transformations in the form of (4)÷(8) in 1970 [1]. This enabled me to realize actually all the reasons why the former experiments by Michelson, Miller and others failed and to demonstrate that MM type experiments with optical medium as light-carrier are positive in the whole wide range of their dielectric permittivities $1.000005 < \varepsilon < 3.5$ ([1, 4] and Fig.2 and 3).

6. Lorentz-invariant definition of the velocity υ of motion of optical media with *n*>1 by the results of measurement of non-zero amplitude of the fringe shift ($A_m \neq 0$) with the MM type interferometer

By 1970 I was able to compose a formula for the expected from the experiment relative amplitude A_m of shift of the interference fringe. The point is that the classical scheme of the beam optics ($t_{\|} = L_{\|}/\tilde{c}_{+} + L_{\|}/\tilde{c}_{-};\ t_{\perp} = L_{\perp}/\tilde{c}_{+} + L_{\perp}/\tilde{c}_{-},\ \Delta t = t_{\perp} - t_{\|}$) used in order to calculate the delay of light in orthogonal arms of the MM-interferometer when we employ the prerelativistic Fresnel relation for the light speed in the laboratory frame of reference:

$$\tilde{c}_{\pm} \approx \frac{c}{n}\left[(1 \pm \frac{\upsilon}{c} n \left(1 - \frac{1}{n^2}\right) \right], \tag{9}$$

yielded the expression of the difference of the delay times in the form of a very complicated function taking into account the full permittivity (ε) of the light-carrying medium and part of it ($\Delta\varepsilon = n^2 - 1$), associated with polarized particles (excluding the polarization of the aether):

$$\Delta t = \frac{(l_{\|} + l_{\perp})}{c} \frac{\upsilon^2}{c^2} F(\varepsilon, \Delta\varepsilon, \Delta\varepsilon^2). \tag{10}$$

This form did not reproduce all features of the experimental dependence shown in Fig.1. So we have to introduce into it amendments to the second order effects υ^2/c^2. I have to complement the deduction by the Lorentz contraction of the length $l_{\|}$ of the longitudinal arm and amended the length of the transverse arm by the "Lorentz triangle" as is described in details in [1]. In the result, expressing $A_m = c\Delta t/\lambda$ the amplitude A_m of the fringe shift via Δt, there was obtained the following dependence $A_m(\Delta\varepsilon)$:

$$A_m = \frac{2l}{\lambda\sqrt{\varepsilon}} \frac{\upsilon^2}{c^2} \Delta\varepsilon (1 - \Delta\varepsilon). \tag{11}$$

Dependence (11) describes all peculiarities of measured by me dependences (see Fig.1 and 2). In particular, (11) reproduces the three main features, revealed by me, of the experimental dependence $A_m(\Delta\varepsilon)$ [1, 4]:

1) the linear growth of A_m with the increase of the contribution Δε of the polarization of the particles of gaseous light-carrying medium having $\Delta\varepsilon \ll 1$ (growth of amplitude A_m of the fringe shift in Fig.1 is proportional to Δε: o_1 – hydrogen; o_2 – air at 1 atm and 40% humidity; o_3 – the same at the pressure of 2 atm; o_4 – gas H_2S; o_5 - gas CS_2);

2) the reverting asymptotic tendency of the experimental dependence $A_m(\Delta\varepsilon)$ to zero when $\Delta\varepsilon \to 0$, e.g. with the air being rarified (see Fig.1: o_1 – the air at the pressure of 0.5 atm or hydrogen have $\Delta\varepsilon \sim 0.0003$; at the rarefied air up to ~ 0.1 atm or helium Δε decreases to ~ 0.00005, so the interferometer loses its sensitivity, i.e. the amplitude A_m is not distinguishable from the background noise A_{ns});

3) the change of the sign of the experimental dependence $A_m(\Delta\varepsilon)$ at $\Delta\varepsilon = 1$ (in Fig.2 the sign of A_m at gases and water is positive, because $\Delta\varepsilon < 1$, and for fused silica it is negative, because $\Delta\varepsilon > 1$).

Clearly, the respective formula by Michelson [2]:

$$A_m = \frac{2l}{\lambda}\frac{\upsilon^2}{c^2} \tag{12}$$

was incapable to reproduce similar features of the run of the experimental dependences $A_m(\Delta\varepsilon)$, at least because it does not account for $n=\sqrt{\varepsilon}$ and $\Delta\varepsilon$. That is why almost the whole century the Michelson formula mislead all attempts to interpret experiments both of Michelson (1981, 1987, 1926) and Miller (1925), Kennedy (1926), Illingworth (1927), Pease (1930), Joos (1930), Shamir and Fox (1968), Trimmer (1973) and others.

Now it became clear that using the approximate (with the accuracy $\sim 10^{-6}$) Lorentz-invariant formula (8) for $\tilde{c}_{\pm(8)}$, which takes into account the second order ratio υ^2/c^2 when calculating the delay in the arm parallel to υ, just gives the structure sought for of the formula (11):

$$t_{\parallel} = \frac{l_{\parallel}}{\tilde{c}_{+(8)}} + \frac{l_{\parallel}}{\tilde{c}_{-(8)}} = \frac{2ln}{c}\left[1 - \frac{\upsilon^2}{c^2}\frac{\Delta\varepsilon(1-\Delta\varepsilon)}{\varepsilon}\right], \tag{13}$$

in the form not demanding any other amendments to the geometro-optical calculation of the times $t_{\parallel}$ and $t_{\perp}$. Indeed, applying the same formula (8) to calculation of the delay in the arm $t_{\perp}$ perpendicular to υ (when $\upsilon_{\perp} = 0$, a $\tilde{c}_{\pm(\upsilon_{\perp}=0)} = c/n$) appears to be sufficient for this arm

$$t_{\perp} = \frac{l_{\perp}}{\tilde{c}_{+(\upsilon_{\perp}=0)}} + \frac{l_{\perp}}{\tilde{c}_{-(\upsilon_{\perp}=0)}} = \frac{2l_{\perp}n}{c}, \tag{14}$$

in order not to insert into it the "relativistic" corrections of the type of "Lorentz triangle" and Lorentz contraction, which already was accounting for in relativistic form (13).

Subtracting (13) from (14) we obtain the final expression of Δt (where $l_{\perp}=l_{\parallel}=l$):

$$\Delta t = t_{\perp} - t_{\parallel} = \frac{2l}{c\sqrt{\varepsilon}}\frac{\upsilon^2}{c^2}\Delta\varepsilon(1-\Delta\varepsilon). \tag{15}$$

Substituting (15) into expression $A_m = c\Delta t/\lambda$ yields the expression (11) needed for the expected from Fig.1 and 2 dependence of the relative amplitude of shift of the interference fringe on $\Delta\varepsilon$ [1].

7. Unnoticed reason of reducing and even nullifying the shift ΔX_m of the interference fringe in a lot of MM type experiments

From the formula (15), which well reproduces the measured by me (Fig.1) dependence of fringe shift $\Delta X_m(\Delta\varepsilon)$ obtained, follows very important for the practice conclusion. The sign of the fringe shift ΔX_m for the optical medium of the arms of the interferometer having $\varepsilon<2$ is opposite to the sign of the fringe shift for the optical medium of arms of the interferometer having $\varepsilon>2$. This means that would in the arms of the interferometer occur simultaneously two kinds of the light carrying sections with $\Delta\varepsilon'<1$ and with $\Delta\varepsilon''>1$ having the lengths $\Delta l'$ and $\Delta l''$ than, according to (15), they will compete with each other by the rule:

$$\Delta l'\Delta\varepsilon'(1-\Delta\varepsilon') + \Delta l''\Delta\varepsilon''(1-\Delta\varepsilon''). \tag{16}$$

Firstly I have confronted with this effect in 1970 when employed in the experiment with air arms the glass phase-changer (or phase-compensator). According to (16) at some interrelation of lengths, e.g. of the gas l' and glass l'' sections, the phase shift (15) may be vanishing. Three important practical conclusions follow from this experimental observation. This effect I have found for the first time in 1970 noticing it primarily from the decrease of sensitivity of Michelson interferometer to the fringe shift ΔX_m registered:

1) glass plates as phase-changers (or phase-compensator) installed in the device with air light-carriers across the beam paths decrease the fringe shift comparing with the case when there is no such plates;

2) the increase of the thickness (>1 mm) of glass base of the half-transparent plate bifurcating the beam reduces the fringe shift in comparison with the case when the thickness of this plate does not exceed 0.1÷0.2 mm;

3) installation of reflective mirrors facing by the glass side to the rays, reduces the observed fringe shift in an interferometer with the air light carriers compared with the installation of metal reflecting mirrors.

At a certain proportion of optical paths, e.g. of the air piece of the light-carrier with the positive sign of the contribution into the optical length of the arm {$\Delta\varepsilon'(1-\Delta\varepsilon')>0$, since $\Delta\varepsilon'<1$} and the glass part of the light-carrier having the negative sign of contribution into the optical length of the arm {$\Delta\varepsilon''(1-\Delta\varepsilon'')<0$, since $\Delta\varepsilon''>1$}, the total value of the phase difference and the corresponding to it fringe shift becomes noticeably less. At equal optical lengths of the competing stretches of the light-carrier of the interferometer arms $l'\Delta\varepsilon'(1-\Delta\varepsilon')+l''\Delta\varepsilon''(1-\Delta\varepsilon'')$ the fringe shift is vanishing. From this experimental fact, which is well described within each arm by the formula (16) of special relativity, there follow important practical inferences.

In order not to lose a part of sensitivity of the interferometer to registering the shift of interference fringe, one should not use as a splitter (or phase-changer, phase-compensator) the glass plates with $\Delta\varepsilon>1$ in the arms of the interferometer with the gas (in particular, air and pumped out) and water light-carriers, respective values: for the air (with various humidity) $\Delta\varepsilon'=+(0.00006\div0.001)$ and for the water (in visible range of light wavelength) the magnitude $\Delta\varepsilon''\cdot(1-\Delta\varepsilon'')\approx+(0.1\div0.25)$ is positive; for the various kind of glass the magnitude $\Delta\varepsilon''\cdot(1-\Delta\varepsilon)=-(0.7\div2)$ is negative. Having found this effect I employed for changing the phases in the air arms of the interferometer a water triplex plate formed by the water layer of thickness ~3÷5 mm between two glass plates each of thickness ~0.1mm. The thickness of the glass base for the bifurcation plate I also reduced down to 0.1÷0.3 mm. The effective value $\Delta\varepsilon''(1-\Delta\varepsilon'')$ of such compound of the triplex and thin intermediate plate at $\lambda=6\cdot10^{-7}$ m is about +0.15, i.e. it has the same sign as the value $\Delta\varepsilon'=+0.0006$ for air {wavelength is indicated because in the materials mentioned the frequency dispersion $\Delta\varepsilon(\nu)$ is appreciable}.

I note that Michelson and Morley in [2] used a splitting and compensating plate thickness of 1.25 cm, that reduced by the negative sign of the quantity $\Delta\varepsilon''(1-\Delta\varepsilon'')$ the effective length of the interferometer arms by 60 ÷ 90% (depending on the permittivity of the applied glass used and humidity of the air at the time of the measurement).

In order not to lose partially or wholly the sensitivity of the interferometer to the shift of interference fringe one should not use glass mirrors, serving for the reflection of the light beams (for lending to the beams a zigzag path which shortens the size of the interferometer arms) and having the common everyday orientation of the glass layer facing to the beams. By my estimations from (16), originally found in experiments [1], the thickness of the glass layer $\Delta l''$~0.3 mm of each mirror, facing by the glass to the beam, wipes out in the MM type interferometer the phase obtained from 1 m of the air passage of the beam. For the interferometer with l=11 m, six zigzag reflecting mirrors with the thickness of glass layers $\Delta l''$~0.3 mm, facing to the beams, are capable three times to reduce the magnitude of the observed shift of interference fringe. Would the thickness of the glass layer of the total zigzag mirrors be $\Delta l''$~0.5 mm (and this is more probable taking into consideration the endurance of mirrors) then such the interferometer will have almost zero sensitivity to the shift of the interference fringe when turning it at 90^0. In order to eliminate this harmful effect one should employ metal mirrors or glass mirrors faced by the back side of the amalgam layer to the beam (taking off in advance a protective coating and polishing this layer from the back side. The best thing will be to use polished metal mirrors and very thin splitting and compensating glass plate.

No wonder if there will come out dozens or hundreds of such interferometers where the inconsiderate employment of reflecting glass mirrors brought to observing with them no shift of interference fringe thus supporting by such a false evidences the myth of the "negativity" of Michelson experiments. Clearly, this sorry experiments entrenched the SRT hypothesis of lack in the world of the superpermeable aether substratum and the myth of "non-observability" of absolute motion from the inside of the moving in aether laboratory. My experimental investigations disprove all these falsities [1, 4].

8. Conclusion

The applying of Lorentz-invariant formula (8) to the calculation of light propagation times in longitudinal ($t_{\|}$) and transverse ($t_{\perp}$) arms of the interferometer immediately yields the correct relations (15) and (11) not needing amendments for the Lorentz contraction of the arm $l_{\|}$ and "Lorentz triangle" in the arm $l_{\perp}$. Probably, these amendments are phenomenally inherent in first principles of the relativistic form (8). Formulas (15) and (11) are Lorentz invariant in the above mentioned sense of its approximate validity for all optical media with any value of *c/n* admitting great variety of light speeds in moving and static optical mediums. The discovery (1970) by me of formula (11) counterpoising the erroneous formula (12) of Michelson, which was used by all experimenters [2, 3] before my works [1, 4], explicates the first fatal reason why they obtained underestimations (1÷12 km/s) of the "aether wind" velocity. This inadvertency lied in that the contribution $\Delta\varepsilon$ into the full dielectric permittivity ε of the polarization of the particle of light-carrying medium of the interferometer was not taken into account in (12). Actually the Michelson formula (12) is an idealistic squeezing of the correct formula (11) where the polarizable matter (as $\Delta\varepsilon$) of light-carrying medium is omitted. Not accounting $\Delta\varepsilon$ of the air lead to that all estimations of the "aether wind" velocity by means of (12) in [2, 3] got understated in $\Delta\varepsilon^{-1/2} \approx 40$ times. Would Michelson from the very inception used the correct formula (11), then in all works [2, 3] be obtained guite another estimation of "aether wind" velocities – lying in the range $100<\upsilon<500$ km/s. In this case nobody will be able to refer speculatively such velocities of "aether wind" to inaccuracy of experimental data.

Formula (11) reveals yet another fatal point serving to implanting the myth of "negativity" of MM type experiments. No interferometer neither in the past not at present does without including in its light carrying space of the glass auxiliary units and tuning or adjusting appliancies. I demonstrated experimentally that all such glass components reduce in a certain extent the sensitivity of the interferometer with air light-carriers to the fringe shift. The full loss of sensitivity is even possible. None of the fatal failures mentioned was disclosed until my works. That is why the given by me demonstrations of the Lorentz-invariant algorithm of processing and interpretation of the results of experiments at MM type interferometers by means of (11) can be regarded as a great step in reviving an interest to the scientific problem of aether in physics.

So, the postulate of the relativistic theory of the 20th century concerning the invariance of the light speed in moving or static inertial frames remains valid only in those regions of spatial distribution of an optical medium where n=const. Obviously, vacuum (aether with n=1) is rather a particular case, embraced by SRT, among far more great number of dynamic manifestations of the "relativism" of moving optical media in aether. Only a special medium – vacuum without particles (n=1) – will be left for SRT in a future physics.

But in vacuum without particles there can not be inertial frames of reference necessary in any experiment, so the SRT is a theory without direct experiments to test it. It can be checked indirectly, as I did by measuring the shift of interference fringe on interferometers with light-carrying media with different concentrations of particles in the aether, i.e. with various contributions $\Delta\varepsilon$. Extrapolation of the dependence of $A_m(\Delta\varepsilon)$ to $\Delta\varepsilon \to 0$ (i.e. to zero quantity of particles of light carriers or zero inertial system particles) gives $A_m \to 0$, indicating through this experiment of mine the absence of anisotropy of the speed of light in the substance of aether (i.e. in vacuum with n=1 and $\Delta\varepsilon$= 0).

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