Interferometer for measuring absolute motion velocity

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ABSTRACT. Scheme of modernized Michelson's interferometer, capable of registering the fact of a device motion with respect to the light-carrying environment, is proposed. The appropriate estimating calculations are made.

1 Introduction

It is known that experiments with Michelson's interferometer were tried in order to discover the Earth's motion with respect to the light-carrying environment – ether. It was supposed, that in mutually perpendicular arms of the device, photons as the ether wave formations will undergo the influence of the Earth's motion with respect to the environment in a different way. However, the experiment did not demonstrate the expected phenomenon. For explaining the reason of the independence of the interferential pattern on the device orientation, three assumptions were made :

(1) All moving bodies decrease their dimensions in the direction of motion, in accordance with $l = l_0\sqrt{1 - V^2/C^2}$ (Fitzgerald–Lorentz's hypothesis),

where l_0 is the body's length in the resting state, l is the body's length during its motion with the velocity of V with respect to the resting frame, C is the light velocity. All quantities are measured with the devices of the resting frame.

(2) Bodies do not change their dimensions, but the velocity of the

photons having corpuscular properties is summed with the source velocity (Ritz's ballistic hypothesis).

(3) Photons' velocity does not depend on the velocity of the frame, in which the light velocity is measured. This assumption forms one of the bases of the Special Relativity Theory (SRT), but goes beyond the limits of the common sense.

Lately in the literature one can quite often come across the assumption that all elementary particles are soliton formations of the light-carrying environment. On the basis of this supposition, one can propose the fourth variant of explaining the results of Michelson's experiments, and also make up a relativity theory, not only well-agreed with all corresponding experiments, but also free from the well-known paradoxes of the SRT [1, 2]. In the present work, the scheme of the experiment, which supposedly will allow fixing the fact of motion with respect to the light-carrying ether with the devices of the isolated laboratory, will be represented.

2 Fizeau's Experiments

As it is known, in Fizeau's experiments, there was quite effectively registered the fact of the dependence of the photons' velocity with respect to the coordinate frame, connected with the device, on the velocity of the water stream with respect to the device. In these experiments, the ray of the light source S was divided by the light-dividing plate into two parts, which were directed in opposite directions at the same contour, passed through two cuvettes with moving water, came back to the dividing plate and interfered, Fig. 1. In this case, the water in the cuvettes moved in such a way that promoted the motion of photons on the first ray and prevented the motion of photons on the second ray. This asymmetry in the action of moving optical environment upon the photons led to the shift of the observed interferential stripes.

First it was supposed that the moving water would completely drag the photons. Since photons moved at one and the same contour, it was possible to influence the interferential pattern only by the water motion in the cuvettes. In this case, the difference Δt in the times of the photons propagation in opposite directions determines the shift degree of the interferential stripes.

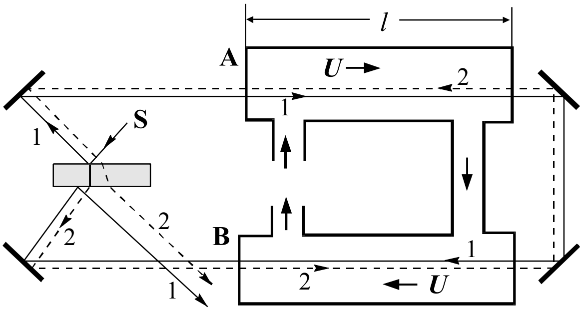

Fig. 1. Scheme of Fizeau's experiment : S – light source ; 1 and 2 – interfering beams of photons, from which ray 1 is propagated along the water stream, and ray 2 – opposite the stream.

We assume that the device is resting with respect to the light-carrying environment. Velocity C_1 of the photons in the water for ray 1 is summed with the water motion velocity U. Since the photons' velocity in the environment is reversely proportional to the refraction quotient n, the resulting velocity for complete dragging of the photons by the water in ray 1 is equal to

$$C_1 = \frac{C}{n} + U \tag{1}$$

For the photons of ray 2 :

$$C_2 = \frac{C}{n} - U \tag{2}$$

The time of the photons' motion along the water motion in both cuvettes, each of which has length l :

$$t_1 = \frac{2l}{\frac{C}{n} + U} \tag{3}$$

The time of the photons' motion opposite the water motion in both cuvettes :

$$t_2 = \frac{2l}{\frac{C}{n} - U} \tag{4}$$

The difference Δt_0 in the times of the cuvette passing by the photons is equal to

$$\Delta t_0 = t_2 - t_1 = \frac{2l}{\frac{C}{n} - U} - \frac{2l}{\frac{C}{n} + U} \tag{5}$$

In Fizeau's experiments, the water velocity U was equal to 7 m/s, the cuvette length l is equal to 1.5 m, the refraction quotient is n=1.333. For C=3·10^8 m/s, in accordance with (5), we have

$$\Delta t_0 = 8.29215 \cdot 10^{-16}\text{sec.} \tag{5*}$$

This difference in the times of the photons motion through the cuvettes had to lead to the stripes shift at the half of the photons' wavelength, i.e. the light stripes had to occupy the place of the black ones. However, the experiment showed that the phenomenon occurs in such a way as if only partial dragging of photons by the water takes place – approximately a half of the calculated degree, with some dragging coefficient $\chi = 1 - 1/n^2$, [3].

With taking into consideration the photons dragging by the water stream, the expression (5) acquires the following form :

$$\Delta t_1 = \frac{2l}{\frac{C}{n} - U\left(1 - \frac{1}{n^2}\right)} - \frac{2l}{\frac{C}{n} + U\left(1 - \frac{1}{n^2}\right)} \tag{6}$$

Numerically, in case of the above-mentioned conditions of Fizeau's experiment :

$$\Delta t_1 = 3.62548 \cdot 10^{-16}\text{sec} \tag{6*}$$

The result (6*) is well agreed with the experiment. In this case, the relation $\Delta t_1/\Delta t_0$ is quantitatively equal to the dragging coefficient χ for water, χ=0.437.

3 Fizeau's Experiments From the Viewpoint of the Soliton Hypothesis

If all bodies, including transparent ones, consist of soliton formations of the light-carrying environment, and photons are specific oscillations of this environment, then there must be observed the effect of partial dragging the photons by the bodies moving with respect to the ether, by analogy with Fizeau's experiments. Moreover, Fizeau's experiment itself must be analyzed from this viewpoint.

Assume that in this case the dragging coefficient is the same as in case of the photons' motion in the moving environments, i.e. $\chi = 1 - 1/n^2$. Thus, the expression (6) for the time differences should be analyzed, since one should take into consideration not only the water motion with respect to the device, but also the motion of the device together with the Earth with respect to the ether. Let V be the velocity of the Earth motion with respect to the ether (and together with the Earth – also the velocity of our interferometer motion) and its direction coincide with the direction of the photons' motion in ray 1, Fig. 1. In this case, the photons' velocity in cuvette **A** is summed not only with the velocity of the water motion U with respect to the device, but also with the velocity V of the water motion with respect to the immovable ether, therefore, the photons move with respect to the ether with the following velocity :

$$C_1 = \frac{C}{n} + (V + U)\chi \tag{7}$$

During the time t_1 of the photon's motion in cuvette **A** with the length of l, the end of this cuvette will be transmitted at the value Vt_1, therefore, the photons of ray 1 will pass the distance $C_1 t_1$, larger than the cuvette length :

$$C_1 t_1 = l + V t_1 \tag{8}$$

Thus, taking (7) into consideration :

$$t_1 = \frac{l}{\frac{C}{n} + (V + U)\chi - V} \tag{9}$$

In cuvette **B** the time of the photons' motion (in the same ray) is determined from the following balance :

$$l - V t_2 = C_2 t_2 \tag{10}$$

where

$$C_2 = \frac{C}{n} - (V - U)\chi \tag{11}$$

Thus, we have the time t_2 of motion of ray 1 in cuvette **B** :

$$t_2 = \frac{l}{\frac{C}{n} - (V - U)\chi + V} \tag{12}$$

Analogously, ray 2 in cuvette **B** is dragged by the cuvette in the direction of the Earth's motion and, as a result, transmitted back a little by the water stream :

$$C_3 = \frac{C}{n} + (V - U)\chi \tag{13}$$

The photon of ray 2 will catch up the end of cuvette **B** during the time t_3, therefore

$$Ct_3 = l + Vt_3 \tag{14}$$

Thus,

$$t_3 = \frac{l}{\frac{C}{n} + (V-U)\chi - V} \tag{15}$$

Photons of ray 2 will pass through cuvette **A** during the time :

$$t_4 = \frac{C}{\frac{C}{n} - (V+U)\,\chi + V} \tag{16}$$

Difference $\Delta\, t$ in the times of motion of rays 1 and 2 in the cuvettes, taking into account the Earth's motion, is equal to :

$$\Delta\, t_3 = (t_3 + t_4) - (t_1 + t_2) \tag{17}$$

or :

$$\begin{aligned}\Delta\, t_3 =& \frac{l}{\frac{C}{n} + (V-U)\chi - V} + \frac{l}{\frac{C}{n} - (V+U)\chi + V} \\ &- \frac{l}{\frac{C}{n} + (V+U)\chi - V} - \frac{l}{\frac{C}{n} - (V-U)\chi + V}\end{aligned} \tag{18}$$

It is easy to see, that if $V \to 0$, expression (18) turns into expression (6), as it must be. For the velocity $V = 37{\cdot}10^4 \quad m/s$ (determined through Doppler's effect for relict radiation), for Fizeau's experiment conditions, the calculations through (18) give the following result :

$$\Delta t_3 = 3.62549 \cdot 10^{-16}\text{sec} \tag{18*}$$

and it coincides with the results of Fizeau's calculations through (6*) up till the sixth digit. These calculations are made with taking partial dragging of the photons by the moving water into consideration, but without taking the motion of the device itself into account ($\Delta t_1 = 3.62548{\cdot}10^{-16}$ *sec*). Physically this result means that the Earth's motion with tremendous velocity with respect to the light-carrying environment practically does not influence the results of Fizeau's experiments (for example, if one changes the orientation of Fizeau's device in the opposite direction when trying the experiments), since the influence of the velocity V upon the photons' motion in one cuvette is almost completely compensated by analogous influence in the other cuvette. As a result, only the influence of the moving water upon the interferential pattern is left.

4 Modernized Michelson's Interferometer

The result obtained above gives us some reason to hope that partial dragging of the photons by moving transparent bodies is, however, available in the nature, and if the experiment is organized properly, it can be discovered experimentally. The modernized Michelson's interferometer, in which the light ray (in case of direct motion from the dividing plate to the mirror) propagates through an optically dense substance, and comes back to the plate in the air, can serve as the first candidate for being such a device, Fig. 2.

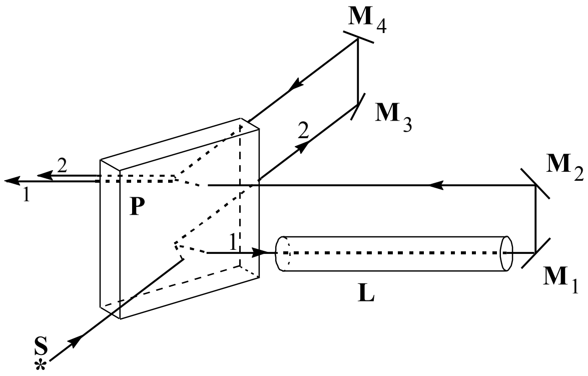

Fig. 2. Modernized Michelson's interferometer.

The radiation of the source S is diffracted by the plate P into two rays. Ray 1 in the direct direction passes through the rod L, is reflected from the mirrors M_1 and M_2 and comes back to the plate P in the air. Ray 2 passes the way to the mirrors M_3 and M_4 in the air, and then interferes with ray 1.

If such a device is turned at 180^o, the conditions for the ray passing in perpendicular direction will not change, however, now the Earth's motion will not promote the propagation of the photons in the rod, but will prevent. Thus, there must appear the asymmetry in the degree of the moving rod's action upon the photons' motion with respect to the ether, and it should be manifested in the change of the interferential pattern. The necessary estimative calculations can be made according to the methods given above.

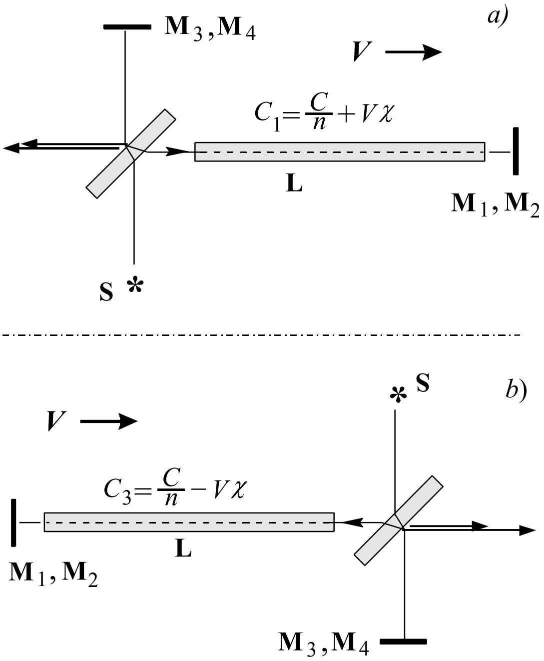

Fig. 3. Modernized Michelson's interferometer, top view.

a) When the device is oriented in the direction of the Earth's motion, the photons are partially dragged by the rod L, therefore, the time of their motion towards the mirrors M_1, M_2 decreases (in comparison with the motion time in the immovable rod), but also the time of the photons' returning to the plate P decreases, due to the plate's meeting motion.

b) When the device is turned at 180, the motion of the rod L prevents the photons' motion.

(1) Let the interferometer arm with the rod made of an optical material be oriented in the direction of the Earth's motion, whose velocity with respect to the ether is equal to V, Fig. 3, a). In the optically transparent rod with length L and the refraction quotient n, the photon moves with the velocity C_1 (by analogy with (7)) :

$$C_1 = \frac{C}{n} + V\chi \tag{19}$$

where, as before, $\chi = 1 - 1/n^2$

During the time t_1, the photon will catch up the escaping end of the rod, which will be transmitted at the value Vt_1 during this time. Therefore :

$$C_1\, t_1 = L + V\, t_1 \tag{20}$$

$$t_1 = \frac{L}{\frac{C}{n} + V\chi - V} \tag{21}$$

(2) The photon will go backwards in the air (we will neglect the difference between L and the distance from the plate **P** to the mirror) with the velocity $C_2 = C$ (ballistic hypothesis is not carried out).

$$L - V\, t_2 = C\, t_2 \tag{22}$$

Thus,

$$t_2 = \frac{L}{C + V} \tag{23}$$

(3) After turning the rod at 180, the rod's motion with respect to the ether will prevent the photons from motion :

$$C_3 = \frac{C}{n} - V\chi \tag{24}$$

$$C_3\, t_3 = L - V\, t_3 \tag{25}$$

Thus,

$$t_3 = \frac{L}{\frac{C}{n} - V\chi + V} \tag{26}$$

(4) The photon moves backwards in the air with the velocity $C_4 = C$, therefore :

$$C\, t_4 = L + V\, t_4 \tag{27}$$

Thus :

$$t_4 = \frac{L}{C - V} \tag{28}$$

The difference in the motion times is equal to :

$$\Delta t = (t_3 + t_4) - (t_1 + t_2) \tag{29}$$

Or :

$$\Delta t = \frac{L}{\frac{C}{n} - V\chi + V} + \frac{L}{C - V} - \frac{L}{\frac{C}{n} + V\chi - V} - \frac{L}{C + V} \tag{30}$$

It is not difficult to see, that if $n \to 1$, we have $\chi \to 0$, therefore, $\Delta t \to 0$, and also if χ is not equal to zero, but $V \to 0$, we have $\Delta t \to 0$ again.

The maximal velocity, which we can expect, is the velocity of the Earth's motion with respect to the relict radiation in the direction of the Lion constellation, $V = 37{\cdot}10^4 \quad m/s$. Nowadays the real refraction quotient can be equal to n=1.9 (modern glasses for spectacles), or n=2.2 (fianite), or even more, n=3.0 [4, 5]. For the mentioned conditions, if n=1.9 as a really available material, for some values of L, expression (30) gives the result, see Table 1 :

Table 1. The calculated values of the difference Δt between the times of passing the arm of the modernized Michelson's interferometer by the photons.

L m	Δt $\times 10^{-18}$ s	$C\Delta t$ Å	$C\Delta t/\lambda$ %
1	9.04	27.1	0.54
2	18.08	54.3	1.09
5	45.22	135.6	2.71
10	90.42	271.3	5.43
20	180.85	542.5	10.85
40	361.70	1085.1	21.70
50	452.12	1356.4	27.13
100	904.24	2712.7	54.25

(n=1.9, λ = 5000 Å)

The last column represents the ratio of the difference in the ways of the photons to the ray's wavelength, assumed for the definiteness that λ=5000 Å. As seen from the table, beginning with L=40 m, the modernized interferometer will promote the stripe shift at 1085 angstroms, which will be equal to 21.7% of the stripe width. In case of higher values of the refraction quotient, the shift will be still larger. It means that the presence of the light-carrying environment, if it exists, can be discovered certainly enough. If one uses a material with the refraction quotient n=3, the stripe shift will increase, in comparison with that given in the table, approximately at 20%. It is noticeable that the results of the experiment should not depend on the presence of Fitzgerald–Lorentz's shortening, since the device is turned not at 90°, but at 180°. The largest change of the interferential pattern must be observed, when the device is rotated in the plane passing through the axis "Earth – Lion constellation". When it is rotated in the plane perpendicular to the mentioned axis, the interferential pattern must change little.

In reality, it is problematic to provide L=100 m. If one supposes that it will be technically possible to provide the length of an optically dense and transparent body (a rod) approximately up to 2-3 meters, and by means of mirrors system make the ray pass through the rods at least 10-15 times, then finally one can obtain L=20-45 m. In accordance with the calculations table, it means that the expected stripe shift can be up to 25%. Certainly, similar experiments require experimentalists' high qualification, and quite serious financing, but in case of luck, the success would be more than simply serious.

On the other hand, it is affirmed in the literature, that the shift of interferential stripes can be registered with the exactness of about 0.2 per cent [6]. If it is so, then even for L=10 (which is quite real), where effect is expected at the level of 5 per cent, the fact of motion with respect to the light-carrying environment can be certainly registered. Moreover, there exists information that the Earth's absolute motion was fixed through the shift of interferential stripes in Miller's experiments at the level of 8%, and also in the experiments with electromagnetic signals in the coaxial cable [6].

The sensitivity of the proposed interferometer, Fig. 2, can be doubled, if in the arm of mirrors M_3-M_6 one also locates an optically dense body in such a way as it is shown in Fig. 4. In accordance with (30), the time of the photons' motion in this arm for the mentioned orientation is larger than after turning the device at 180^o, since now the photons begin their motion from the mirror M_3 in the air, and come back through an optically dense body. Therefore, the effect, influencing the shift of the interferential stripes in different arms of the device, must be summed up. Such a scheme not only increases the device's sensitivity, but also equalizes the interfering rays in their intensiveness. Obviously, in reality, instead of one rod, in the device's arm one should understand their series, moreover, in two layers.

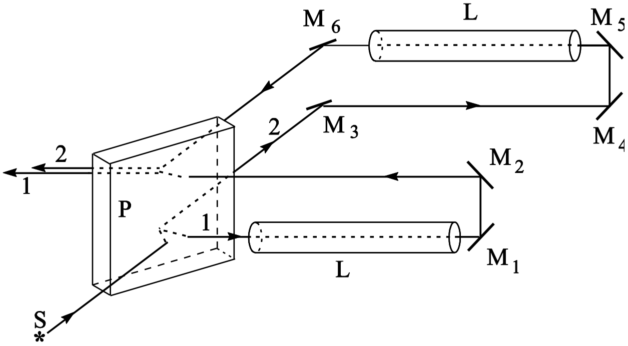

Fig. 4. Scheme of the interferometer with optically dense rods in both arms of the device.

Note that the proposed interferometer can be complicated, if instead of solid rods one uses pipes with a liquid moving with the velocity U. In this case, formula (30) will acquire the following form :

$$\Delta t = \frac{L}{\frac{C}{n} - (V-U)\chi + V} + \frac{L}{C-V} - \frac{L}{\frac{C}{n} + (V+U)\chi - V} - \frac{L}{C+V} \quad (31)$$

It is seen from (31) that the contribution of the water motion velocity with respect to the interferometer is insignificant, since the real value of U (about 10 m/s) is approximately at 4 orders lower than V. It means that it is not reasonable to use a moving liquid in the proposed scheme. On the other hand, usage of pipes with a liquid instead of expensive hard rods will make the experiment essentially cheaper, and it becomes possible to perform it in a laboratory with intermediate-level technical equipment.

5 Experiment Scheme with the Modernized Interferometer

It is seen from Table 1 that significant shifts of the interferential stripes can be observed only for larges values of the optical rods' length L, Fig. 4. This requirement for the interferometer, which is able to rotate around two axes, can be fulfilled, if instead of one transparent rod we use a set of equal-length rods (or a set of pipes with a transparent liquid having a large refraction quotient, for example, benzene, n=1.6), moreover, in two layers, Fig. 5.

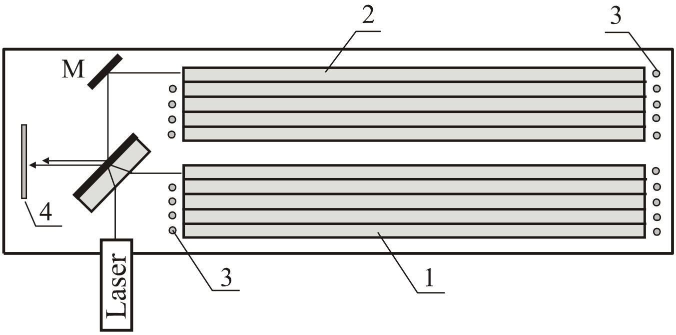

Fig. 5. Scheme of the modernized interferometer with sets of optically dense rods in both arms.

M mirror ; 1,2 – sets of optically transparent rods, or pipes with the liquid ; 3 – system of returning mirrors ; 4 – screen, on which the interference is observed (diode line)

As well as in the conventional interferometer, the laser ray is directed to the semitransparent light-division plate and divided into two parts. In this case, the reflected ray is directed to the set of rods 1, and the ray having passed the mirror layer is directed to the set of rods 2 through the mirror M, which can be made of the same material and have the same thickness as the light-division plate. The light ray in the set 1 first enters the beginning of the first rod at the upper layer (Fig. 5), passes through this rod, then by the system of returning mirrors 3 (Fig. 5) it goes back in the air to the beginning of the second rod, and so on up to the last rod of the upper layer, Fig. 6. Then the ray is transmitted by the system of mirrors to the lower layer in such a way that it would pass through the lower-layer rods again in the same direction as the upper-layer rods and go back in the air. In the lower layer, one should set at one rod less, so that the ray would go back to the silvered plate in the air in the same vertical plane as the entering ray.

In an analogous way, the passing of the rods by the ray is organized in the set 2, with the only difference that the rays moves first in the air and then returns through the rods. After the rays pass the sets of rods, the silvered plate directs the rays to the screen 4, Fig. 5, where the interferential pattern is observed (and registered by the LED ruler or another matrix). The signal is directed from the matrix to the computer, which analyzes the degree of the interferential stripes' displacement depending on the interferometer orientation in space.

The maximal displacement of the stripes is observed for two positions of the interferometer – first it should be directed to the Lion constellation, the stripes' primary position is to be fixed, then the device must be turned in the opposite direction and the degree of the stripes' shift be fixed. The degree of the stripes' shift is expected to be twice as large as in Table 1, where calculations are obtained according to formula (30) at the supposition that the optically dense rods are available only in one arm of the device.

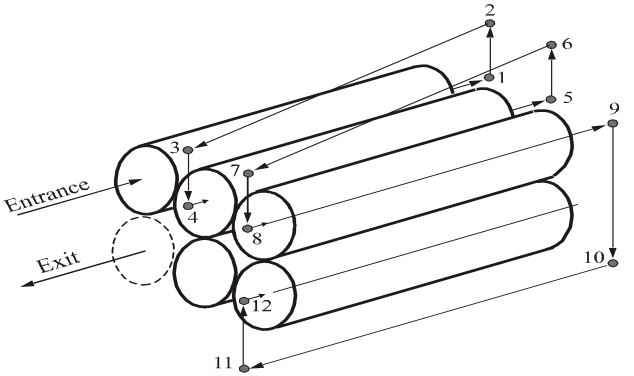

Fig. 6. Scheme of the light ray motion in the set of optically transparent rods.

The laser ray (Entrance) reflected from the silvered plate is directed to the beginning of the first rod of the rods' upper layer, passes through it, then it is directed by the mirrors 1, 2, 3 and 4 in the air to the beginning of the second rod, etc. up to the last rod. The ray, which has gone from the last rod, is directed by the mirrors 9, 10, 11 and 12 in the air to the beginning of the last rod in the lower layer, and it is so in all rods of the lower layer, until the ray returns to the dividing plate through the place of the absent first rod (Exit) of the lower layer (on Fig. 4 it is depicted at the top).

The necessary orientation of the device in space can be provided in the simplest way by means of the azimuth equipment, Fig. 7. The interferometer together with the coherent radiation source and screen is fixed on the equipment in such a way that it would be possible to direct the optical rods along the line "the Earth – the Lion constellation" and in the opposite direction. Then by rotation of the equipment around the vertical axis the interferometer is oriented in the opposite direction, Fig. 7. During the rotation the program fixes the degree of the stripes' shift. Such experiments can be performed twice a day – at the moment when the Lion constellation rises and when it sets, indoors, of course. The presence of the stripes shift will testify, on the one hand, to the presence of the light-carrying environment, and on the other hand, to the possibility of fixing the absolute motion with the media of an isolated laboratory.

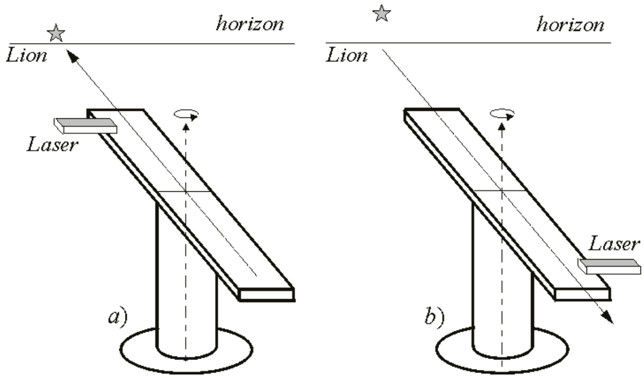

Fig. 7. Modernized interferometer mounted on the azimuth equipment.

First the device is oriented in the direction of the Lion constellation, figure *a*), in this case, the interferential stripes' position is considered as primary. Then the device is oriented in the opposite direction, figure *b*).

Since the light signal is expected to be significantly higher than the matrix sensitivity threshold, one can assume than it will be possible to limit the turning at 180 degrees in time to about 5 minutes. The turning at 360 degrees will last 10 minutes, and the interferential pattern should acquire the primary form. During this time the position of the constellation on the celestial sphere will not change essentially. In 12 hours the experiments can be repeated – at the moment when the constellation sets.

Finally we will analyze the question about the influence of Fitzgerald-Lorentz's contraction upon the equipment sensitivity. It follows from (30), that the more the rods' length is, the high the interferometer sensitivity becomes, and vice versa. Therefore, Fitzgerald-Lorentz's contraction decreases the equipment sensitivity. For estimating the sensitivity decrease, in formula (30), one should write LG instead of L, where

$$G = \sqrt{1 - V^2/C^2}, \quad V{=}370\ km/s \text{ and } C = 3 \cdot 10^8\ km/s$$

Really one can expect that L=40 *meters* (for example, 20 *meters* in each set of rods and 5 rods 2 *meters* long in each layer). For the velocity V=370 *km/s* we obtain $G \approx 0.9999992$. As a result, LG=39.99997 *meters*, i.e. the divergence of the calculated and measured results will be in the 7th digit. In accordance with Table 1, in case of the given device's length, we claim to the accuracy up to the 4th digit (but not more), i.e. for the mentioned Earth's velocity, Fitzgerald-Lorentz's contraction does not influence the proposed equipment sensitivity significantly.

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Keywords : absolute motion, Michelson's interferometer, special relativity theory.

(Manuscrit reçu le 14 février 2014)