90-102

объединенный
институт
ядерных
исследований
дубна

S 88

E2-90-102

V.N.Strel´tsov

ON THE INTERPRETATION OF THE MICHELSON-MORLEY EXPERIMENT

Submitted to "Europhysics Letters"

1990

The Michelson-Morley experiment [1] has already celebrated its centennial anniversary. However, as we see below, a small inaccuracy is inherent in its traditional interpretation. The elimination of this inaccuracy only changes the "sign" of the effect. Possibly, the most surprising fact lies in that the result of this "pre-relativistic" interpretation is in full agreement with the conclusions of the relativity theory which origin is to great extent due to just the indicated experiment.

1. As is known, the calculation of the times of light propagation along the longitudinal and transverse arms of the interferometer forms the basis for the interpretation of the Michelson-Morley experiment. In the first case one takes into account that the velocities of light propagation in the direction of the earth's motion (c_0) and against it (c_π) are respectively equal to

$$c_0 = c - v \quad \text{and} \quad c_\pi = c + v \,. \tag{1a,b}$$

Here the indices 0 and π denote angle θ between the directions of light propagation and the earth's motion (relative to ether). It is evident that these expressions are two limiting cases of the general formula:

$$c_\theta = c - v\cos\theta \,. \tag{2}$$

Thus, the total time of light propagation along the longitudinal arm ($\ell_{||}$ in length) of the interferometer equals

$$t_{||} = \frac{\ell_{||}}{c_0} + \frac{\ell_{||}}{c_\pi} = \frac{\ell_{||}}{c-v} + \frac{\ell_{||}}{c+v} \simeq 2\,\frac{\ell_{||}}{c}(1+\beta^2) \tag{3}$$

with $\beta = v/c$.

Calculating the time of light propagation $t_\perp$ along another (perpendicular) arm, one considers that light goes along the hypotenuse of a right angle triangle. From here it follows [2]

$$\left(c\,\frac{t_\perp}{2}\right)^2 = \ell^2 + \left(v\,\frac{t_\perp}{2}\right)^2 \tag{4}$$

and

$$t_\perp = \frac{2\ell}{c\sqrt{1-\beta^2}} \simeq 2\,\frac{\ell}{c}\left(1 + \frac{1}{2}\beta^2\right) . \tag{5}$$

From the condition of $t_{||}$ and $t_{\perp}$ equality conforming to a negative result of the Michelson-Morley experiment, we obtain the known formula of Lorentz-Fitzgerald contraction

$$\ell_{||}^{L} \simeq \ell(1 - \frac{1}{2}\beta^2). \tag{6}$$

At first Michelson assumed [3] that $t_{\perp}$ did not change and was equal to $2\ell/c$; this strengthened the expected effect by a factor of 2.

Let us consider more carefully the propagation of light along the transverse arm of the interferometer. As already noted, light goes along the hypotenuse*, i.e. at angle $\theta < \pi/2$ ($\cos\theta = \beta$) to the direction of the earth´s motion although the difference of θ from $\pi/2$ is certainly negligible. Uisng (2), we have

$$c_\theta = c - v\beta, \tag{7}$$

Taking into account that the velocity of light propagation along the transverse arm of the interferometer is thereby equal to $c(1 - \beta^2)$, instead of (4) we get [4,5]

$$[c(1-\beta^2)\frac{t_\perp}{2}]^2 = \ell^2 + (v\frac{t_\perp}{2})^2. \tag{8}$$

From here with an accuracy of up to terms of the order β^2 we find

$$t_\perp \simeq 2\frac{\ell}{c}(1 + \frac{3}{2}\beta^2). \tag{9}$$

Now the condition of $t_\perp$ and $t_{||}$ equality yields

$$\ell_{||} \simeq \ell(1 + \frac{1}{2}\beta^2) \quad \text{("elongation formula")}. \tag{10}$$

Thus, the result of systematic taking into account the influence of the earth´s motion (relative to ether) on the velocity of light propagation is the elongation and not the contraction of the longitudinal arm of the interferometer.

2. On the other hand, interpretating this experiment from the viewpoint of relativity theory [6] owing to constancy of

*It should be stressed that in this case it runs after the corresponding mirror.

the light velocity, $t_\perp$ is determined by the expression (5) as before. In this case in accordance with the relativistic rule of velocity addition, instead of (1) we find

$$c_0 = \frac{c - v}{1 - \frac{c\cdot v}{c^2}} = c, \qquad c_\pi = \frac{c + v}{1 + \frac{c\cdot v}{c^2}} = c. \tag{11a,b}$$

As a result, formula (3) for the time of light propagation along the longitudinal arm of the interferometer is rewritten in the form

$$t = 2\frac{\ell_{||}}{c}. \tag{12}$$

Equaling (5) to (12), we are led to the relativistic "elongation formula". It should be noted that this formula is a consequence of the previously introduced concept of relativistic length [7] based on the radar method of distance measurement.

REFERENCES

1. Michelson A.A., MorleyE.W. - Amer. J. Sci., 1887, 34, p.333
2. Lorentz H.A. - Arch. néerl., 1887, 21, p.103.
3. Michelson A.A. - Amer. J. Sci., 1881, 22, p.120.
4. Strel´tsov V.N. - JINR Commun. P2-86-470, Dubna, 1986.
5. Strel´tsov V.N. - JINR Commun. P2-88-61, Dubna, 1988.
6. Strel´tsov V.N. - JINR Commun. P2-5946, Dubna, 1971.
7. Strel´tsov V.N. - Found. Phys., 1976, 6, p.293.

Received by Publishing Department
on February 13, 1990.