**Explanation of the results of the Michelson experiments using classical mechanics**

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*The article is attempts to show that the results of A.A. Michelson experiments not conflict with classical mechanics, but rather confirm it. Using the laws of conservation of momentum and energy in the consideration of the Michelson interferometer allows us to conclude that the path difference of separated beams is independent of speed and direction of movement of the luminiferous medium.*

PACS number: **03.30.+p**

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## 1. The introduction

In order to confirm the hypothesis of ether A.A. Michelson [1], [2], [3], [4], [5], [6] proposed is not a direct measurement of the speed of light in the stationary ether, and the determination of the ratio of values of the speed of light in two orthogonal directions in the system of axes moving relative to stationary ether.

Proposed A.A. Michelson method of conducting of the experiment [7], using the phenomenon of interference of light, was allowed to register the movement of the Earth relative to the stationary ether, if light traveled in the ether.

For conducting of experiments A.A. Michelson is applied interferometer, the concept of which is shown in fig. 1.

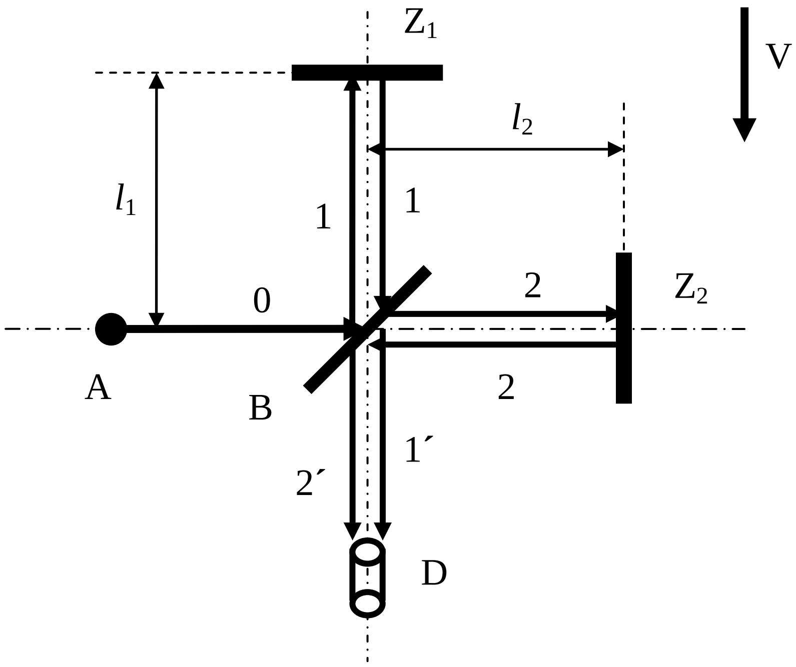


Fig. 1

A beam **0** of monochromatic light [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12 ], [13], [14] from the source **A** IDOOVDWDQQOHRIRQSODQH glass plate **B** (back surface of which is coated with a thin semi-transparent layer of silver), and part of that light is reflected from the plate **B** (beam **1**), and a part - passes through the plate **B** (beam **2**).

Then the beam **1** reflected from a flat mirror $\mathbf{Z_1}$, partially passes through the plate **B**, and as a beam **1´** enters with a telescope **D**.

A beam **2** (passing through the compensating plate, not shown in fig. 1) is reflected from a plane mirror $\mathbf{Z_2}$, returned to the plate **B**, is partially reflected from the silvered surface of the plate **B**, and also as a beam **2´** enters the telescope **D**.

Thus, in the telescope **D** there are two parts (beams **1´** and **2´**) of the same beam **0** of light from a source **A**.

Since the beams **1´** and **2´** are coherent, the interference pattern (clear and dark stripes) in the telescope **D** can observe.

In the telescope **D** the interference pattern must change with changing time intervals passing the beam **1** path **B - $\mathbf{Z_1}$ - B** (from the plate **B** to the plate **B** through the mirror $\mathbf{Z_1}$) and beam **2** path **B - $\mathbf{Z_2}$ - B** (from the plate **B** to the plate **B** through the mirror $\mathbf{Z_2}$).

All optical parts of the Michelson interferometer (light source **A**, plate **B**, mirrors $\mathbf{Z_1}$ and $\mathbf{Z_2}$ and telescope **D**) rigidly fixed to the cross-shaped metal frame [1], [2], [3].

Using the assumption of the constancy of the speed of light in the stationary ether, the authors of books [1], [2], [3], [4], [5], [6], [7], [8], [9], [10 ], [11], [13], [14] proposed to assume that in the case when the velocity vector **V** of the ether relative to the Michelson interferometer is parallel to the line connecting the plate **B** with a mirror $\mathbf{Z_1}$, and is directed to the side opposite the mirror $\mathbf{Z_1}$:

- the length $\mathrm{L}_1$ of the path **B - $\mathbf{Z_1}$ - B** of beam **1** in the system of axes in which the ether is stationary, is:

$$L_1 = \mathrm{c} \cdot t_1 = \mathrm{c} \cdot t_{11} + \mathrm{c} \cdot t_{12} = \frac{l_1 \cdot \mathrm{c}}{\mathrm{c} - \mathrm{V}} + \frac{l_1 \cdot \mathrm{c}}{\mathrm{c} + \mathrm{V}} = \frac{2l_1}{1 - \left(\frac{\mathrm{V}^2}{\mathrm{c}^2}\right)} \qquad (1)$$

where, as shown in fig. 2:

**c** - speed of light in vacuum,

$t_1$ - time of motion of the photon of beam **1** on the path **B - $Z_1$ - B**,

$t_{11}$ - time of motion of the photon of beam **1** on the path **B - $Z_1$**,

$t_{12}$ - time of motion of the photon of beam **1** on the path **$Z_1$ - B**,

$l_1$ - length of path **B - $Z_1$** (or length of path **$Z_1$ - B**) of beam **1** in the system of axes in which the Michelson interferometer is stationary,

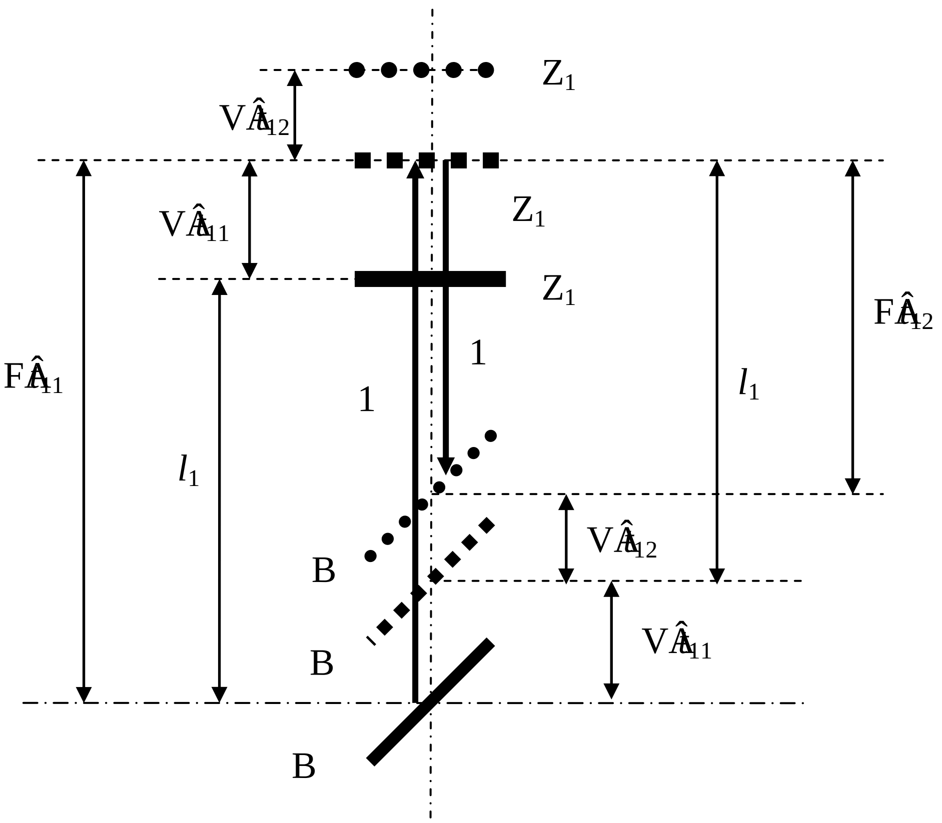


Fig. 2

- the length $L_2$ of the path **B – $Z_2$ - B** of beam **2** in the system of axes in which the ether is stationary, is:

$$L_2 = c \cdot t_2 = c \cdot t_{21} + c \cdot t_{22} = \frac{2l_2}{\sqrt{1 - \left(\frac{V^2}{c^2}\right)}} \qquad (2)$$

where, as shown in fig. 3:

$t_2$ - time of motion of the photon of beam **2** on the path **B – $Z_2$ - B**,

$t_{21}$ - time of motion of the photon of beam **2** on the path **B – $Z_2$**,

$t_{22}$ - time of motion of the photon of beam **2** on the path **$Z_2$ - B**,

$l_2$ - length of path **B – $Z_2$** (or length of path **$Z_2$ - B**) of beam **2** in the system of axes in which the Michelson interferometer is stationary.

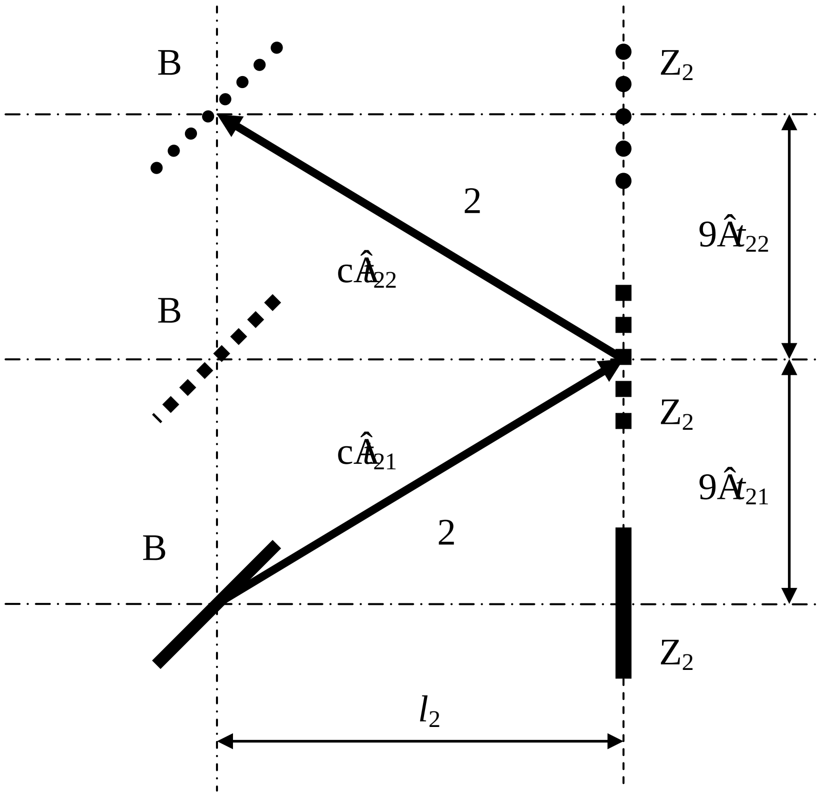


Fig. 3

From formulas (1) and (2) follows that in the special case, when the velocity vector **V** of the ether relative to the Michelson interferometer is parallel to the line connecting the plate **B** with a mirror $\mathbf{Z_1}$, and is directed to the side opposite the mirror $\mathbf{Z_1}$, the difference $\Delta L$ lengths $L_1$ and $L_2$ is :

$$\Delta L = L_1 - L_2 = \frac{2l_1}{1-\left(\frac{V^2}{c^2}\right)} - \frac{2l_2}{\sqrt{1-\left(\frac{V^2}{c^2}\right)}} \qquad (3)$$

## 2. The dependence of the difference in length ΔL on the direction of vector of velocity of the ether

We make the assumption that:

- the ether (homogeneous and isotropic environment) is moving with speed **V**, having constant quantity and direction, relatively Michelson interferometer;

- the light travels in the stationary ether at a speed **c**;

- the ether do not interact with structural elements of the Michelson interferometer;

- the light from the source **A**, moving in a Michelson interferometer, does not interact with its structural elements (mirrors, plates, telescope), ie light has not on the structural elements of the interferometer is no external influence (though the light can be reflected from or pass through them);

- the systems of axes, in which the Michelson interferometer and the ether fixed, - inertial.

The assumption, that the light does not interact with structural elements of the Michelson interferometer, may include the following:

- a reflection of the beams of light from the mirror $\mathbf{Z_1}$ and $\mathbf{Z_2}$ and plate **B** is instantaneous in nature;

- the interaction between the beams of light and plate **B** (and similarly for the compensating plate) is no, when the light beams move in the plate **B**;

- miss the displacements of structural elements of Michelson interferometer (relative to their positions in the absence of influence of light) under the influences of beams of light in the system of axes, in which the Michelson interferometer is stationary;

- miss the deformations of structural elements in the Michelson interferometer (especially in mirrors and plate) under the influences (pressures) of beams of light;

- miss the changes of the frequency of light in the interaction of light beams with the structural elements of the Michelson interferometer;

- there are no changes in the values of the momentums of the light and the Michelson interferometer, as a whole, when the beams of light interact with the structural elements of Michelson interferometer;

- there are no changes of the characteristics of ether inside the space, defined by the fluxs of light - its beams, when the beams of light interact with the structural elements of Michelson interferometer;

- the constancy (in the time) of the lengths of the path $\mathbf{B - Z_1}$ and $\mathbf{Z_1 - B}$ of the beam **1** and path **B – $Z_2$** and **$Z_2$ - B** of the beam **2**, when driving of these beams of light in the Michelson interferometer with the immutability of its orientation in space.

Using the assumptions listed above, for the case when the vector velocity **V** of the ether relative to the Michelson interferometer is at an angle **α** to the vector connecting the points on the mirror **$Z_1$** and the plate **B**, from which reflected the beam **1** when moving from source **A**, we find that:

- the length $L_1$ of the path **B - $Z_1$ - B** of beam 1 in the system of axes in which the ether is stationary, is:

$$L_1 = c \cdot t_1 = c \cdot t_{11} + c \cdot t_{12} =$$

$$= \left\{ \left[ \frac{l_1}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \left[ \left( \frac{V \cdot \mathrm{Cos}\alpha}{c} \right) + \sqrt{1 - \left( \frac{V^2 \cdot \mathrm{Sin}^2\alpha}{c^2} \right)} \right] \right\}$$

$$+ \left\{ \left[ \frac{l_1}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \left[ -\left( \frac{V \cdot \mathrm{Cos}\alpha}{c} \right) + \sqrt{1 - \left( \frac{V^2 \cdot \mathrm{Sin}^2\alpha}{c^2} \right)} \right] \right\} =$$

$$= \left[ \frac{2l_1}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \sqrt{1 - \left( \frac{V^2 \cdot \mathrm{Sin}^2\alpha}{c^2} \right)} \qquad (4)$$

where, as shown in fig. 4:

**c** - speed of light in vacuum,

$t_1$ - time of motion of the photon of beam **1** on the path **B - $Z_1$ - B**,

$t_{11}$ - time of motion of the photon of beam **1** on the path **B - $Z_1$**,

$t_{12}$ - time of motion of the photon of beam **1** on the path **$Z_1$ - B**,

$l_1$ - length of path **B - $Z_1$** (or length of path **$Z_1$ - B**) of beam **1** in the system of axes in which the Michelson interferometer is stationary,

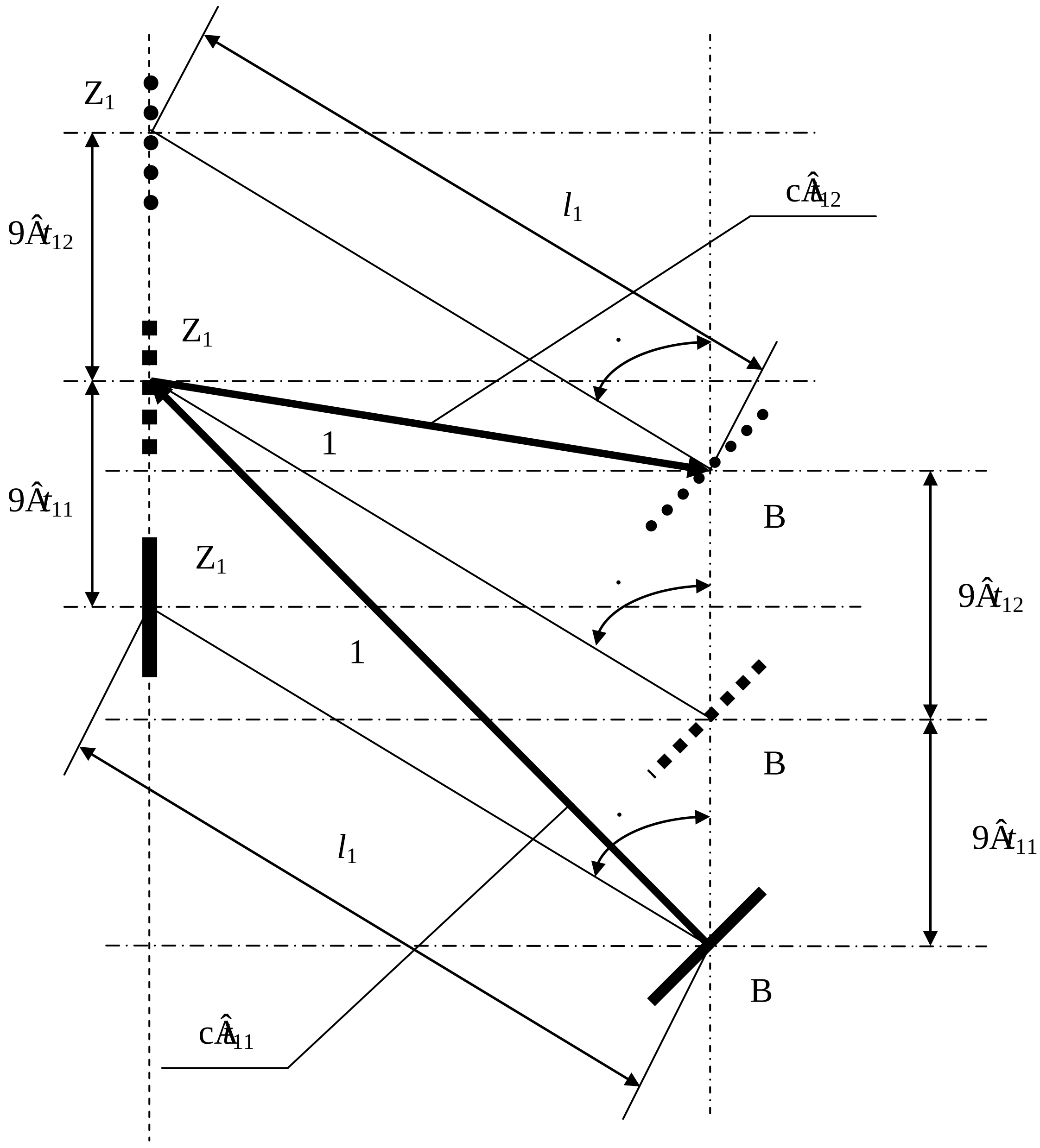


Fig. 4

- Based on the perpendicular of surface of mirrors **$Z_1$** and **$Z_2$**, the length $L_2$ of path **B – $Z_2$ - B** beam **2** in the system of axes, in which the ether is stationary, is:

$$L_2 = c \cdot t_2 = c \cdot t_{21} + c \cdot t_{22} =$$

$$= \left\{ \left[ \frac{l_2}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \left[ \left(\frac{V \cdot \mathrm{Sin}\alpha}{c}\right) + \sqrt{1 - \left(\frac{V^2 \cdot \mathrm{Cos}^2\alpha}{c^2}\right)} \right] \right\}$$

$$+ \left\{ \left[ \frac{l_2}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \left[ -\left(\frac{V \cdot \mathrm{Sin}\alpha}{c}\right) + \sqrt{1 - \left(\frac{V^2 \cdot \mathrm{Cos}^2\alpha}{c^2}\right)} \right] \right\} =$$

$$= \left[ \frac{2l_2}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \sqrt{1 - \left(\frac{V^2 \cdot \mathrm{Cos}^2\alpha}{c^2}\right)} \qquad (5)$$

where:

$t_2$ - time of motion of the photon of beam **2** on the path **B – $Z_2$ - B**,

$t_{21}$ - time of motion of the photon of beam **2** on the path **B – $Z_2$**,

$t_{22}$ - time of motion of the photon of beam **2** on the path **$Z_2$ - B**,

$l_2$ - length of path **B – $Z_2$** of beam **2** in the system of axes in which the Michelson interferometer is stationary.

From formulas (4) and (5) follow that the difference ***ΔL*** of the lengths $L_1$ and $L_2$ is:

$$\Delta L = L_1 - L_2 =$$

$$\left[ \frac{2}{1 - \left(\frac{V^2}{c^2}\right)} \right] \cdot \left\{ \left[ l_1 \cdot \sqrt{1 - \left(\frac{V^2 \cdot \mathrm{Sin}^2\alpha}{c^2}\right)} \right] - \left[ l_2 \cdot \sqrt{1 - \left(\frac{V^2 \cdot \mathrm{Cos}^2\alpha}{c^2}\right)} \right] \right\} \qquad (6)$$

At an angle **α = 0**, the formula (6) reduces to the formula (3).

## 3. Mechanical analog of the Michelson interferometer

As can be seen from (6) difference of length ***ΔL*** beams **1** and **2** must be independent of the angle **α**, ie difference of length ***ΔL*** is dependent on the direction of vector velocity **V** of the ether relative to the Michelson interferometer.

Unfortunately, the experiments of Michelson [1], [2], [3], [4], [5], [6], [7],

[8], [9], [10], [11] , [12], [13], [14] in the limits of tolerable errors showed no changes in the interference pattern in the telescope **D**.

Given the absence of displacements of the interference fringes in the Michelson experiments, the authors of the books [1], [2], [3], [4], [5], [6], [7], [8], [9], [10] , [11], [13], [14] concluded that there is no ether wind and the invariance of the speed of light in vacuum.

But could the negative result of the Michelson experiments have other causes?

Consider the simplest model of closed mechanical system, which is approximate to the operation of the Michelson interferometer.

Assume, there are a mechanical system, as shown in fig. 5, which consists of a rectangular parallelepiped with sides **A**, $\mathbf{Z_1}$, $\mathbf{Z_2}$ and **D**, plate **B**, located inside this parallelepiped, and two spherical point bodies **1** and **2**, originally located on the side **A** of the parallelepiped on an infinitely small distance from each other.

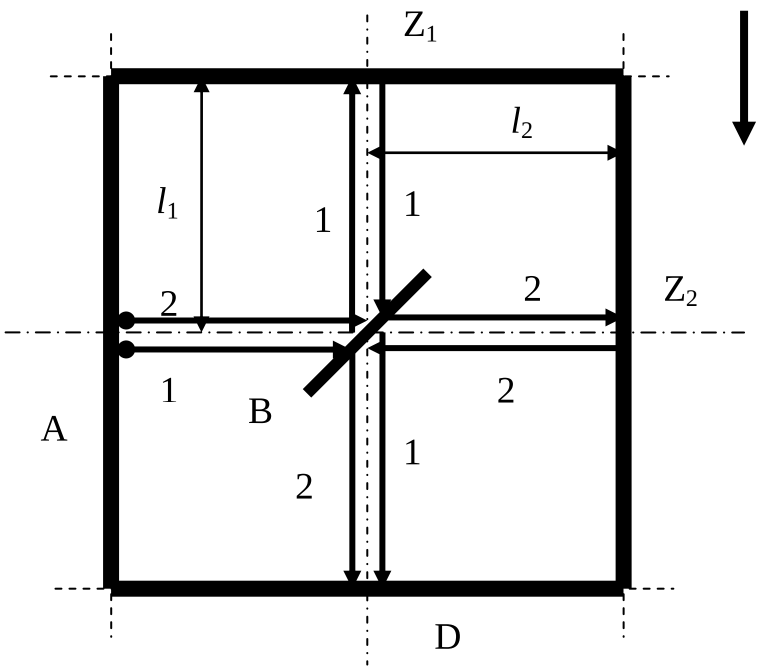


Fig. 5

Bodies **1** and **2** is unconditional elastically repel from the side **A**, having the velocity are equal magnitude and direction.

The body **1** HQWHUV DW DQ DQJOH RI ƒWR WKH SODWH **B**, then first is unconditional elastically reflected from the plate **B**, then from the side $\mathbf{Z_1}$ and collides the side **D**.

The body **2** is unconditional elastically reflected from the side $\mathbf{Z_2}$, falls at DQ DQJOH RI ƒWR WKH SODWH **B**, is unconditional elastically reflected from the plate **B** and collides the side **D**.

All sides of the parallelepiped and the plate **B** rigidly attached.

When the motion of bodies **1** and **2** inside the parallelepiped there is no rotation of the parallelepiped around its center of mass.

If we assume the impossible, that the reflection of the bodies **1** and **2** from the sides of the parallelepiped and the plate **B** is no change in the momentum of the parallelepiped (bodies **1** and **2** do not have any pressure on the sides of the parallelepiped and the plate **B**, while the directions of the movement of the bodies **1** and **2** change in the interaction with them), in the moving system of axes, moving relative to the stationary system of axes, in which the parallelepiped is fixed, at the velocity **V**, in which the vector is parallel to the axis of the parallelepiped, passing through its sides **A** and $\mathbf{Z_1}$, and is directed toward the opposite side $\mathbf{Z_1}$:

- the length $L_1$ of the path **B** - $\mathbf{Z_1}$ - **B** of body **1** in the moving system of axes is:

$$L_1 = \mathrm{v} \cdot t_{11} + \mathrm{v} \cdot t_{12} = \frac{l_1 \cdot \mathrm{v}}{\mathrm{v} - \mathrm{V}} + \frac{l_1 \cdot \mathrm{v}}{\mathrm{v} + \mathrm{V}} = \frac{2l_1}{1 - \left(\frac{\mathrm{V}^2}{\mathrm{v}^2}\right)} \qquad (7)$$

where:

**v** - velocity of the body **1** (or **2**) by separating it from the side **A** in the moving systems of axes,

$t_{11}$ - time of motion of the body **1** on the path **B** - $\mathbf{Z_1}$,

$t_{12}$ - time of motion of the body **1** on the path **Z1 - B**,

$l_1$ - length of path **B** - $\mathbf{Z_1}$ (or length of path **Z1 - B**) of body **1** in the stationary system of axes;

- the length $L_2$ of the path **B - $Z_2$ - B** of body **2** in the moving system of axes is:

$$L_2 = \mathrm{v} \cdot t_{21} + \mathrm{v} \cdot t_{22} = \frac{2l_2}{\sqrt{1 - \left(\frac{\mathrm{V}^2}{\mathrm{v}^2}\right)}} \qquad (8)$$

where:

$t_{21}$ - time of motion of body **2** on the path **B – $Z_2$**,

$t_{22}$ - time of motion of body **2** on the path **$Z_2$ - B**,

$l_2$ - length of path **B – $Z_2$** (or length of path **B – $Z_2$**) of body **2** in the stationary system of axes.

As can be seen, the formula (7) is similar to the formula (1), and the formula (8) is similar to the formula (2).

But it is impossible that the bodies to interact without changing their momentums.

When considering changes in momentums (and of course energies) of the parallelepiped and the bodies **1** and **2** in the reflection of these bodies from the sides of the parallelepiped and the plate **B**, then in the moving system of axes, moving relative to the stationary system of axes, in which the parallelepiped is fixed, at a velocity **V**, the vector which is parallel to the axis of the parallelepiped, passing through its sides **A** and **$Z_1$**, and is directed toward the opposite side **$Z_1$**:

- the length $L_1$ of the path **B - $Z_1$ - B** of body **1** in the moving system of axes is:

$$L_1 = \mathrm{v} \cdot t_{11} + \mathrm{v}_{12} \cdot t_{12} = \frac{l_1 \cdot \mathrm{v}}{\mathrm{v} - \mathrm{V}_{z11}} + \frac{l_1 \cdot \mathrm{v}_{12}}{\mathrm{v}_{12} + \mathrm{V}_{z12}} \qquad (9)$$

where:

**v** ± the velocity of the body **1** (or **2**) by separating it from the side **A** in the moving system of axes,

**$V_{z11}$** - the velocity of the parallelepiped towards the side **$Z_1$** when separated the body **1** from the side **A** in the moving system of axes,

**$v_{12}$** - the velocity of the body **1** by separating it from the side **$Z_1$** in the moving system of axes,

$t_{11}$ - time of motion of the body **1** on the path **B - $Z_1$**,

$t_{12}$ - time of motion of the body **1** on the path **$Z_1$ - B**,

$l_1$ - length of path **B - $Z_1$** (or length of path **$Z_1$ - B**) of body **1** in the stationary system of axes;

- the length $L_2$ of the path **B - $Z_2$ - B** of body **2** in the moving system of axes is:

$$L_2 = \mathrm{v}_{21} \cdot t_{21} + \mathrm{v}_{22} \cdot t_{22} =$$

$$= \frac{l_2 \cdot \mathrm{v}_{21} \cdot \left[\mathrm{V}_{z221} + \sqrt{\mathrm{v}_{21}{}^2 - \mathrm{V}_{z121}{}^2}\right]}{\mathrm{v}_{21}{}^2 - \mathrm{V}_{z121}{}^2 - \mathrm{V}_{z221}{}^2}$$

$$+ \frac{l_2 \cdot \mathrm{v}_{22} \cdot \left[-\mathrm{V}_{z222} + \sqrt{\mathrm{v}_{22}{}^2 - \mathrm{V}_{z122}{}^2}\right]}{\mathrm{v}_{22}{}^2 - \mathrm{V}_{z122}{}^2 - \mathrm{V}_{z222}{}^2} \qquad (10)$$

where:

**$v_{21}$** - the velocity of the body **2** by separating it from the plate **B** in the moving system of axes,

**$V_{z121}$** - the velocity of the parallelepiped towards the side **$Z_1$** when separated the body **2** from the plate **B** in the moving system of axes,

**$V_{z221}$** - the velocity of the parallelepiped in the opposite direction of the side **$Z_2$** when separated the body **2** from the plate **B** in the moving system of axes,

$t_{21}$ - time of motion of body **2** on the path **B – $Z_2$**,

**$v_{22}$** - the velocity of the body **2** by separating it from the side **$Z_2$** in the moving system of axes,

**$V_{z122}$** - the velocity of the parallelepiped in the opposite direction of the side **$Z_1$** when separated the body **2** from side **$Z_2$** in the moving system of axes,

**$V_{z222}$** - the velocity of the parallelepiped towards the side **$Z_2$** when separated the body **2** from side **$Z_2$** in the moving system of axes,

$t_{22}$ - time of motion of body **2** on the path **$Z_2$ - B**,

$l_2$ - length of path **B – $Z_2$** (or length of path **$Z_2$ – B**) of body **2** in the stationary system of axes.

Given that the parallelepiped with the bodies **1** and **2** is a closed mechanical system, the values of speeds $\mathbf{V_{z11}}$, $\mathbf{v_{12}}$, $\mathbf{V_{z12}}$, $\mathbf{v_{21}}$, $\mathbf{V_{z121}}$, $\mathbf{V_{z221}}$, $\mathbf{v_{22}}$, $\mathbf{V_{z12}}$ and $\mathbf{V_{z222}}$ can be determined by using the laws of conservation of momentum and energy.

In turn, the application of the laws of conservation of momentum and energy in the consideration of a closed mechanical system consisting of the parallelepiped and the bodies **1** and **2** leads to the conclusion that the difference $\Delta L$ of the lengths $L_1$ and $L_2$ does not depend on the magnitude and direction of the velocity **V** of the motion of the moving inertial system of axes relative the parallelepiped.

## 4. Using the laws of conservation of momentum and energy to explain the results of the Michelson experiments

If you look closely at the baseline on which settle the method of evaluation of the results of the Michelson experiments, you can find one very weak spot - is the assumption that the light from the source **A**, moving in the Michelson interferometer, does not interact with its structural components (mirrors, plates , telescope).

How can a beam of light reflected (to change the direction of its momentum) of the mirror and it does not have any influence on these mirrors?

It is - it is unreal!

More close to reality can be a method of evaluation of the results of the Michelson experiments, based on the following assumptions:

- the ether (homogeneous and isotropic environment) is moving with speed **V**, having constant quantity and direction, relatively Michelson interferometer;
- the light travels in the stationary ether at a speed **c**;
- the ether do not interact with structural elements of the Michelson interferometer;

- the light from the source **A**, moving in a Michelson interferometer, interact with its structural elements (mirrors, plates, telescope);

- the systems of axes, in which the Michelson interferometer and the ether fixed, - inertial.

- Spatial changes in the structure of ether, representing the elastic vibrations - light, occur only in a limited volume surrounding the Michelson interferometer (ie light is not propagate any source beyond of the interferometer the outside).

If we consider the suggest assumptions and the fact that the Michelson interferometer is a single structure consisting of inflexibly connected elements, the Michelson interferometer and the surrounding ether can be regarded as conventionally closed system, which must be carried out the laws of conservation of momentum and energy (as the momentum and energy of ether does not change beyond of the outside of the Michelson interferometer).

The difference in the functioning of the Michelson interferometer and previously reviewed its mechanical analog is that the effect of light on the structural elements of the interferometer is different from the effects of certain bodies and the effect is more like a stream of ether, which has a periodically varying characteristics, on the structural elements of the interferometer.

Using the laws of conservation of momentum and energy in the consideration of the mechanical analog Michelson interferometer allow derive that the difference $\Delta L$ of the lengths $L_1$ and $L_2$ does not depend on the magnitude and direction of the velocity **V** of the moving inertial system of axes with respect to the mechanical analog.

A similar result should lead and use the laws of conservation of momentum and energy in the consideration of the motion of the beams of light in the Michelson interferometer, ie in the Michelson interferometer the difference of the path of the separated beams will be constant, independent of the speed and direction of the ether (and therefore changing the spatial position of the Michelson interferometer should not be changes the interference pattern in the telescope **D**).

## 5. The conclusion

Experiments, conducted A.A. Michelson with the use by the interferometer, may not serve as confirmation of the lack of the ether, as using the Michelson interferometer can not register the ether wind.

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