On the measurement of the absolute velocity of bodies

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The translation was done by N. Luchkina

Abstract

Michelson's experiment on the determination of Earth movement velocity relatively to the ether is briefly exposed. Analysis of works covering the Michelson's experiment was accomplished and the reason, no allowing to determine the velocity of Earth in its orbit, is indicated. Equations of the total displacement of the fringes of the interference picture were written, and the Robert S. Shankland's table was completed. Description of the new optical device is given.

For more than one hundred year lasts the interest of scientific community to the famous experiment on the determination of the ether velocity on the Earth, made in 1887 by one American physicist A.A. Michelson. In this experiment, according to the calculations, the result predicted by the hypothesis of A.J. Fresnel on the still ether (1788-1827), was not observed.

W. Thomson (Lord Kelvin) in 1893 writes: "Many workers and thinkers helped to form in XIX age the concept of "plenum" – the same ether serving for the transportation of light, heat, electricity and magnetism". However, there were a lot of candidates to be named that single ether in XIX age. Moreover, many of them was proposed before Maxwell and differed from each other in such properties as: degree of homogeneity and of contraction, as well of carrying away (drugging) by Earth. Existence of great number of post-Maxwellian "Maxwell's theories" is explained by this one, but no completely.

The dynamic explanation of the aberration of light of J.D. Bradley (1692-1762), of Fresnel's drugging theory and of the Michelson – Morley experiment lather – was the most important problems to be resolve for this founders of ether and creators of Maxwell's theory.

As far back as 1886 H.A. Lorentz criticizes the theory of Potsdam Michelson's experiment 1881: "It seems to me questionable, that this experiment the Fresnel's hypothesis denied". Already in 1892 he writes being worry about the Michelson – Morley experiment (1887): "I have sought a long time to explain this experiment without success, and eventually I found only one way to reconcile the result with Fresnel's theory. It consists of the assumption, that the line joining two points of a solid body doesn't conserve its length, when it is once in motion parallel to the direction of motion of Earth, and

afterwards it is brought normal to it, now the whole apparatus being turned through 90°". In his work of 1895 Lorentz wrote that this hypothesis on the reduction of sizes of bodies in the direction of the movement, as he finds out lather, "was offered by Mr. FitzGerald".

In 1900 J. Larmor publishes one essay "Ether and matter" containing the correct transformation of equations connecting one space and time coordinate with each other moving with constant velocity *v* related to the first, as well as the evidence of the fact, that it will be possible to obtain the FitzGerald – Lorentz's contraction with their aid.

For the first time H. Poincare in 1900 formulated the principle of relativity for all natural phenomena, where he affirmed in 1904: "The laws of nature must be identical both for a stationary observer and for an observer in a state of uniform and linear motion, and hence there does not and cannot exist a way of determining whether we are in such a state of motion or not".

In such away, the above-mentioned circumstances served in 1905 as a good soil for the creation of the special theory of relativity based on two principles (postulates) being appeared at the time stable, where from the famous transpositions of Lorentz was derived. Michelson in 1907 for the experiment of 1887 was with Nobel Prize awarded – the first laureate in USA.

In many teaching aids and popular publication the founding of the theory of relativity is directly connected with negative results of the Michelson – Morley experiment. However, this point of view is not in accordance with historical course of events. So confirms one American historian of physic J. Holton, citing in his articles the letter of Einstein to one American historian Davenport in February of 1954 being unknown before:

"Dear Mr. Davenport!

Already before the Michelson's work it was well known that in limit of accuracy of the experiment the influence of the movement of coordinate system on the physical phenomena and, consequently, on their laws was not observed. H.A. Lorentz showed that this can be explained on the base of his formulation of the Maxwell's theory in all cases, when it is possible to ignore the second degrees of the velocity of the system (that's in effects of the first order).

Still it could be expected from the theory that such independence will not take place for the effects of the second and higher orders. The greatest Michelson's merit was that he could absolutely definitely show in a single case that the expected effect of the second order doesn't exist de facto. This Michelson's work being remarkable into the equal extent in the courage and in the clearness of the putting of the problem, as well in the inventiveness to obtain the extremely high accuracy of the measurements, constitutes the eternal contribution to science. This contribution served as the most powerful argument to the fact that "the absolute motion" doesn't exist, its, in the favor of the principle of relativity that have never been called in question in mechanics from Newton's age, but seemed to be incompatible with electrodynamics.

In my own development Michelson result has not had a considerable influence. I even do not remember if I knew of it at all when I wrote my first paper on the subject (1905). The explanation is that I was, for general reasons, firmly convinced that there does not exist absolute motion and my problem was only how this could be reconciled with our knowledge of electrodynamics. One can therefore understand why in my personal struggle Michelson's experiment played no role or at least no decisive role.

I don't object to the publication of this letter. I'm ready to given complementary explanations, if they will be required.

Sincerely yours,
Albert Einstein". [1]

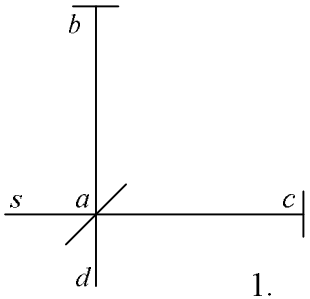
Not arguing on the issue of this letter it is possible to note, that in him esteemed Albert Einstein summed his half years occupation of theoretical physic, incompetence in which doesn't him even prevented to become a laureate of Nobel Prizes.

The prevailing in the natural science tendency to explain by all means the phenomena even with undue experience of hypotheses, conjectures and speculations, was countered by Newton with the "method of principles", implemented in the "Elements" and "Optics": based on the experience we formulate the most general rules – axioms (principles) – and from them deductively derive the laws and regulations that must be verified experimentally. The agreement with the experiment of these regulations (laws) ensures the validity of the basic tenets of the theory.

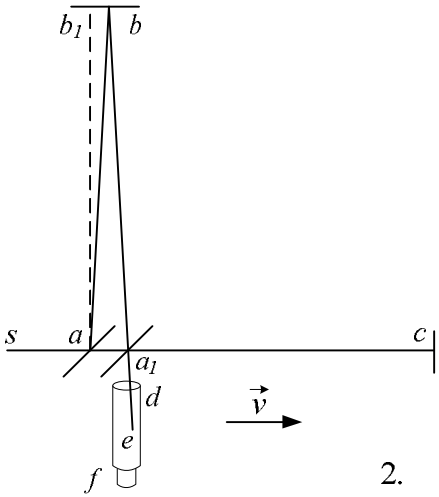
Not bringing up a hypothesis for the reconciliation of the Fresnel's theory with results of Michelson's experiments, let show their new interpretation convincingly and easily. The result of the calculation of the ether on the Earth gives a value of velocity being in conformity with the velocity received by astronomical method of measurement.

By the analysis of the train of Michelson's thoughts [2] we pay attention now to the mistakes in comprehension of the phenomena of interference, in general, and of the light, specifically, that take place in physic now.

The basic (main) schema of Michelson's interferometer is shown on the fig.1, 2. Let *sa* – be a ray of light which is partly reflected in *ab*, and partly transmitted in *ac*, being returned by the mirrors *b* and *c* along *ba* and *ca*. *ba* is partly transmitted along *ad,* and *ca* is partly reflected along *ad*. If then the paths *ab* and *ac* are equal, the two rays interfere along *ad*. Suppose now, the ether being at rest and the whole apparatus being moves in the direction *sc*, with the velocity of the Earth in its orbit. Let [fig.2] it now be required to find the difference in the two paths aba_1 and aca_1. Let *c* – be velocity of light; *v* – velocity of the Earth in its orbit; *L* – a distance *ab* or *ac* [fig.1]. Further Michelson gives a conclusion of formulas of the theoretical calculation, being on the one hand "simple and logical", and on the other hand leading to mistakes and to incorrect interpretation of results of experiment. The terminology and the sense of some concept in his article should be defined therefore.



1.



2.

The result of the interference is defined through the difference of phases of the wave being interference in the point of observation. That difference depends on initial difference of waves as well on *the difference of distances* separating the point of observation from sources of each of the waves. Therefore, two waves can interference (be fold up) with each other not because their ways are equal, as that writes Michelson, that is why they aren't coherent being represented one divided wave coming from the one sours, and consequently, their initial difference of phases is equal to zero. Propagation on *ab* and *ac* make it possible for two waves to achieve the difference of the motion and of the phases in the point of meeting. Observed interference picture should be in conformity with interference of the aerial stratum (layer) being formed by mirror *b* and by the illusory image *c'* of mirror *c* in plate *a*. The image would be represented with bright and dark strips of the same sideways (circular rings), localized in the infinity and, consequently, their observation will be possible with eyes (tube or on display), being accommodated on the infinity.

Michelson writes, that during adjustment of interferometer the whole time of light movement there and back in longitudinal) direction to the Earth motion should be equal $t_1 = L_1/(c-v) + L_1/(c+v) = 2L_1 c/(c^2 - v^2)$, and the distance covered during this time is equal $ct_1 = 2L_1 c^2/(c^2 - v^2) = 2L_1/(1-\beta^2)$, where: $\beta = v/c$. The length of the other way, evidently, is equal to $ct_2 = 2L_2/\sqrt{1-\beta^2}$. The difference is equal $c\Delta_1 t = ct_1 - ct_2 = 2(L_1 q^2 - L_2 q) > 0$ therefore, where: $q = 1/\sqrt{1-\beta^2} > 1$. During the turn of the apparatus on 90°, the difference $-c\Delta_2 t = 2(L_1 q - L_2 q^2) < 0$ should be observed in the opposite direction consequently, the displacement of fringes must be $\lambda\Delta = c\Delta_1 t - (-c\Delta_2 t) = 2(L_1 q^2 - L_2 q) + 2(L_2 q^2 - L_1 q)$. As the distance between the two interference fringes corresponds to the difference of times in one period $T = \lambda/c$, the displacement in the chares of the width of strip will come to:

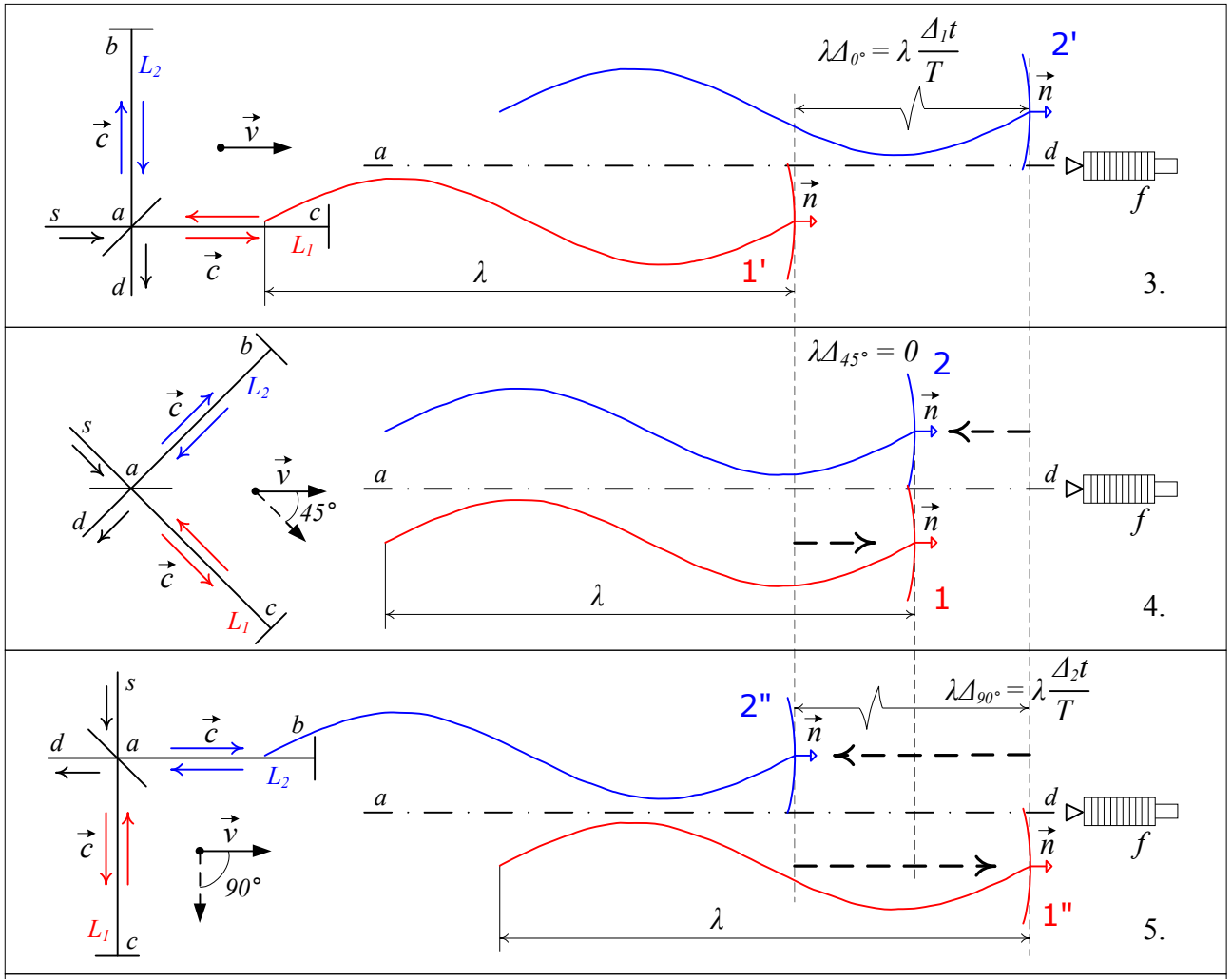
$$\Delta = \frac{\Delta_1 t}{T} + \frac{\Delta_2 t}{T} = \frac{2}{\lambda}(L_1 + L_2)\cdot(q^2 - q) \approx \frac{L_1 + L_2}{\lambda}\beta^2 .$$

Michelson supposed wrongly that displacement of interference fringes will double during the rotation of apparatus on 90°, since the overtaking of one ray by one other will be replaced by the lagging behind on the same value [fig.3-5] and he reflected this fact mistakenly in the equation. The interference is caused by absolute value of the wave motion difference, and, if the distance *ab* and *ac* are equal, the interference picture will not changed by the rotation of apparatus on 90°. The dotted line of chart [fig.6] is symmetrical reflected in the positive field of values, and the equation of the interference fringes displacement will be another:

$$\Delta = \frac{\Delta_1 t}{T} - \frac{\Delta_2 t}{T} = \frac{2}{\lambda}(L_1 - L_2)\cdot(q^2 + q) \approx 4\frac{L_1 - L_2}{\lambda} .$$

The next Michelson's mistake was, he supposed the distance *ab* and *ac* as equal to $L_1 = L_2$, without indicate the way of equation obtaining: "As now the ways was approximately equal, two pictures of source of light joins together, and the tube was adjusted on the clear observation of the interference fringes *to be expected*". If for the calculation of the value $\Delta_1 t/T$ intended for the apparatus adjusting, the value $\beta = 10^{-4}$ was allocated in advance, why is it necessary to search for it during measuring? So, that to be convinced in the correctness of the value accepted for the setting (adjusting)? In this instance, if after the turn of apparatus, the value β found in $\Delta_2 t/T$ distinguished from the value β accepted in $\Delta_1 t/T$, so, it was necessary to remake the setting (adjusting) of apparatus until the value β during measuring will be equal to the value β during adjusting. To sum it up: the system of equations for values β allocated during adjusting and received during measuring was not composed, and not resolved. Thus, let introduce the equation $L_1 = L_2 + d$ and let compose a system with aid of above-mentioned equation and let resolve him:

$$\begin{cases} \Delta_v = \dfrac{\Delta_1 t}{T} - \dfrac{\Delta_2 t}{T} \\ L_1 = L_2 + d \end{cases} .$$



Note:

$\vec{n}$ the normal of front of light; — · —▷ rays coming from *a* to *d* (to device *f*);

1', 2' – fronts of light after the adjustment of device;

1", 2" – fronts of light after the turn of device on 90°.

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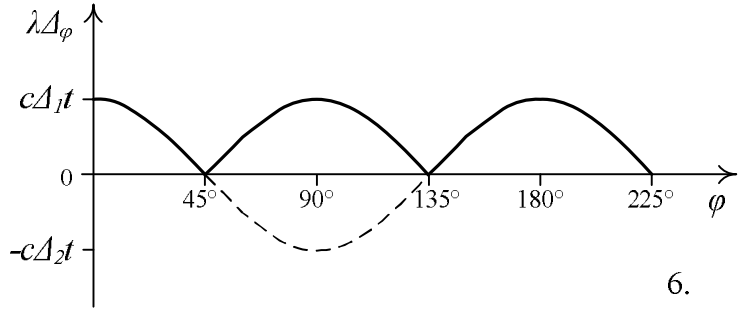


6.

$$\frac{\Delta_1 t}{T}=\frac{2}{\lambda}\left(\frac{L_1}{1-\beta^2}-\frac{L_2}{\sqrt{1-\beta^2}}\right)\Rightarrow\quad \frac{\Delta_1 t}{T}=\frac{2L_2}{\lambda}\left(\frac{1}{1-\beta^2}-\frac{1}{\sqrt{1-\beta^2}}\right)+\frac{2d}{\lambda}\cdot\frac{1}{1-\beta^2}\Rightarrow\quad \frac{2d}{\lambda}=\frac{\Delta_1 t}{T}\left(1-\beta^2\right)+\frac{2L_2}{\lambda}\left(\sqrt{1-\beta^2}-1\right)\Rightarrow$$

$$d=\frac{\lambda}{2}\left(1-\beta^2\right)\frac{\Delta_1 t}{T}+L_2\left(\sqrt{1-\beta^2}-1\right)\approx\frac{\lambda}{4}\Delta_v .$$

Let transpose the above–mentioned equation and let change $2d/\lambda$:

$$\Delta_v=\frac{\Delta_1 t}{T}-\frac{\Delta_2 t}{T}=\frac{2}{\lambda}\left(L_1-L_2\right)\cdot\left(\frac{1}{1-\beta^2}+\frac{1}{\sqrt{1-\beta^2}}\right)\Rightarrow\quad \Delta_v=\frac{2d}{\lambda}\cdot\frac{1+\sqrt{1-\beta^2}}{1-\beta^2}\Rightarrow$$

$$\Delta_v=\frac{\Delta_1 t}{T}\left(\sqrt{1-\beta^2}+1\right)-\frac{2L_2}{\lambda}\cdot\frac{\beta^2}{1-\beta^2}\approx\frac{4d}{\lambda}.$$

Let find the values β by method of consecutive approximation up to the similar value Δ_v to the value of expected displacement of the interference picture fringes by λ=0,59·10^{-6}м and $\Delta_1 t/T$, being calculated for values $\beta=10^{-4}$ and $L_1=L_2$. Let define from the determined values β the values of orbital velocity of Earth, the light velocity being equal to c=2,99792458·10^{8}м/s and of the arms lengths differences d [18].

The results of calculation of experiments by means of new method (table 2) are presented on the table 1 with the supplementary columns 7, 8. The greatest contribution into the collection of statistical information of this table brought R. Schankland.

Table 1

Researcher	**Year**	**Location**	Length of way, sm, L_2	**Displacement**		Difference of the length of arms, nm, d	Velocity of Earth, km/sec, v	Limit of the velocity of ether, km/sec
				expected, Δ	observed, Δ_v			
1	2	3	4	5	6	7	8	9
Michelson A.A.	1881	Potsdam	120	0,04	0,01	1,475	26,035	10
Michelson A.A. and Morley E.W.	1887	Cleveland	1100	0,4	0,005	0,737	29,778	7
Morley E.W. and Miller D.C.	1902-1906	Cleveland	3220	1,13	0,007	1,032	29,883	3,5
Miller D.C.	1921	Mount Wilson	3200	1,12	0,04	5,900	29,421	–
Miller D.C.	1922-1924	Cleveland	3200	1,12	0,015	2,213	29,771	–
Miller D.C. (with solar light)	1924	Cleveland	3200	1,12	0,007	1,032	29,882	3,5
Tomaschek R. (with extra-terrestrial source)	1924	Heidelberg	860	0,3	0,01	1,475	29,461	6
Miller D.C.	1925-1926	Mount Wilson	3200	1,12	0,044	6,490	29,365	–
Kennedy R.J. and Thorndike E.M.	1926	Pasadena	200	0,07	0,001	0,148	29,757	2
Piccard A. and Stahel E.	1926	Freiballon	280	0,13	0,0034	0,501	29,437	9
Piccard A. and Stahel E.	1926-1927	Brussels and Mount Rigi	280	0,13	0,003	0,442	29,502	9
Illingworth K.K.	1927	Pasadena	200	0,07	0,0002	0,030	29,935	1
Michelson A.A., Pease F.G. and Pearson F.	1929	Mount Wilson	2590	0,9	0,005	0,738	29,894	5
Joss G.	1930	Yena	2100	0,75	0,001	0,147	29,958	1,5
Analogues of Michelson's experiments								
Essen L.	1955	Teddington	–	–	–	–	–	0,24
Townes C.H. and Cedarholm J.P.	1958	New-York	–	–	–	–	–	0,033
Champney D.C. and Moon P.B.	1961		–	–	–	–	–	0,017
Champney D.C., Isaac G.P., Khan M.	1963		–	–	–	–	–	0,005
Townes with collaborators	1964	Massachusetts Institute of Technology, MIT	–	–	–	–	–	0,03

Table 2

Magnitudes	Values						
	Potsdam, 1881	Cleveland, 1887	Cleveland, 1902-1906	Mount Wilson, 1921	Cleveland, 1922-1924	Cleveland, 1924	Heidelberg,1924
L_1, m	1,200000001475	11,000000000738	32,200000001033	32,000000005900	32,000000002213	32,000000001033	8,600000001475
L_2, m	1,200000000000	11,000000000000	32,200000000000	32,000000000000	32,000000000000	32,000000000000	8,600000000000
λ, m	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059
$\Delta_1 t/T$, $\beta=10^{-4}$, $L_1=L_2$	0,020338983	0,186440677	0,545762709	0,542372878	0,542372878	0,542372878	0,145762711
Observed, Δ_v	0,0100	0,0050	0,0070	0,0400	0,0150	0,0070	0,0100
$\beta = v/c$	0,000086842769	0,000099327282	0,000099678831	0,000098138931	0,000099306186	0,000099676821	0,000098269917
Calculated, Δ_v	0,010000000010	0,004999998457	0,007000003422	0,040000004834	0,014999998856	0,006999991431	0,009999999383
d, m	0,000000001475	0,000000000737	0,000000001032	0,000000005900	0,000000002213	0,000000001032	0,000000001475
v_{earth}, *км/sec*	26,034807	29,777570	29,882962	29,421311	29,771246	29,882359	29,460580
	Mount Wilson, 1926-1926	Pasadena, 1926	Freiballon, 1926	Brussels and Mount Rigi, 1926-1927	Pasadena, 1927	Mount Wilson, 1929	Yena, 1930
L_1, m	32,000000006490	2,000000000148	2,800000000502	2,800000000443	2,000000000030	25,900000000738	21,000000000148
L_2, m	32,000000000000	2,000000000000	2,800000000000	2,800000000000	2,000000000000	25,900000000000	21,000000000000
λ, m	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059	0,00000059
$\Delta_1 t/T$, $\beta=10^{-4}$, $L_1=L_2$	0,542372878	0,033898305	0,047457627	0,047457627	0,033898305	0,438983048	0,355932201
Observed, Δ_v	0,0440	0,0010	0,0034	0,0030	0,0002	0,0050	0,0010
$\beta = v/c$	0,000097950880	0,000099259759	0,000098192594	0,000098406953	0,000099852390	0,000099714843	0,000099929736
Calculated, Δ_v	0,043999992452	0,001000000412	0,003400000190	0,002999999942	0,000200000177	0,005000008256	0,001000004162
d, m	0,000000006490	0,000000000148	0,000000000501	0,000000000442	0,000000000030	0,000000000738	0,000000000147
v_{earth}, *км/sec*	29,364935	29,757327	29,437399	29,501662	29,934993	29,893758	29,958181

Really, if after the turn of device on 90° the interference picture established at adjustment wasn't reconstructed and the total fringes displacement wasn't become equal to zero $\Delta_v \neq 0$, then distances *ab* and *ac* wasn't established strictly equal. After all, the insignificant difference of distances in limit of nanometers $ab \cong ac$ brings to the total remarkable displacement of fringes $\Delta_v \approx 0$, that's observed in all experiments.

Approximate calculation of values β was made similar [19], when the distance between the two interference fringes being established by the adjustment of device is equal to one half of displacement of fringes, expected by measurement (after the rotation of device on 90°), that's by value $\Delta_1 t/T = \Delta/2$.

In the rated equation of Michelson "+" is changed to "–", the inequality of distances $L_1 \neq L_2$ at the apparatus setting was introduced, the system of equation was composed and solved and, consequently, the positive result was obtained: the Earth's velocity in orbit $v = \beta \cdot c$ in all experiments wasn't distinguished in average more than on 1%. In Michelson's method this velocity is distinguished in several times (column 9).

To sum it up: Michelson thought his calculations to be error-free and without getting the expected results of experience, he hastened with the conclusion that resulted in that Einstein took the advantage of it and created the theory of relativity.

Michelson's rated equation caused the tendency to increase of distances (lengths of arms) of apparatus in subsequent experiments and the acknowledgement of the hypothesis being invented by Lorentz about the contraction of dimension of bodies in direction of movement. With the aid of this hypothesis Lorentz explained the result of experiment, but he took no notice of the lengthening of the longitudinal way of light, made by Michelson at setting. The new method of calculation attributes to the failures of the attempt to discover (detect) the movement of Earth relatively to ether and not confirms "the contraction of FitzGerald – Lorentz" – the hypothesis about the contraction of the dimensions of bodies in the direction of movement and shows (indicate) the functional connection of the total observed displacements of fringes, in parts of width Δ_v with the values of the difference of the distances (lengths of arms) *d*, being determined by the setting of apparatus (columns 6, 7):

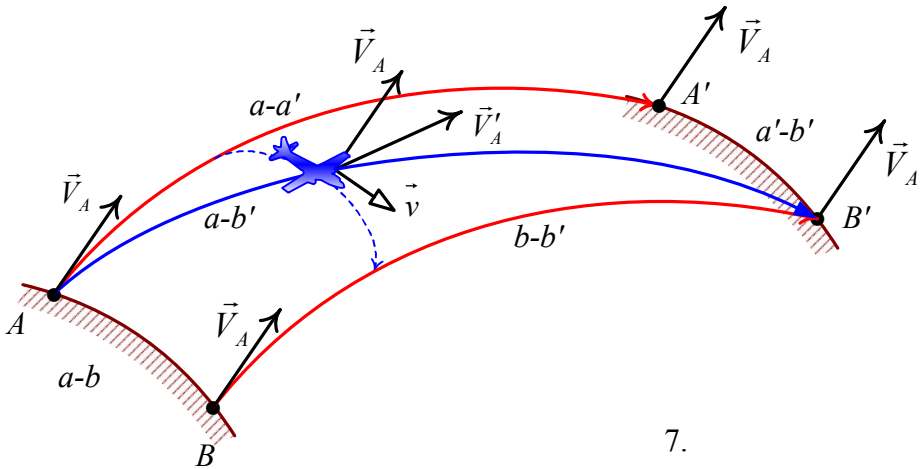
$$\Delta_v = f(d)$$

This fact serves as the theoretical grounds for the creation of interferometers – optical devices for the measurement of *absolute* velocities of weighable matter bodies. Consequently, it will be possible to define velocities and accelerations of weighable matter bodies relatively each other and their coordinate location in the space without any agent.

The principle difference of the micro-interferometer from the Michelson's interferometer is the following. First, in the interferometer, the scheme of the light paths isn't closed. Second, the distance of the light paths is short, from several hundreds to several tens of the lengths of the waves. Third, there are two sources of the light with different lengths of the waves. The design of the micro-interferometer provides the binding to any of the used systems of

coordinates. The calculations proved that the movement of the bodies of the weighable matter relatively absolute system of coordinates which is not perceived and visualized by a man, can be registered by the micro-interferometer.

New optic instruments will find its rapid utilization, for ex., in the systems for the total automatic piloting of the airplanes. Airfields (at the beginning and the end of the landing strip) and airplanes (in the head and tail part of the fuselage) are equipped with the micro-interferometers, continuously measuring their absolute speed, i.e., two instruments per object. By the change in this speed for the Earth's surface and an airplane one can judge on their relative velocity and coordinates. Therefore, from takeoff to landing, the desired trajectory of the aircraft for the specified levels and optimum velocity is maintained by means of flight control on the commands of the laptop, computing the data of the on-board micro-interferometers. With this you can manage the flight along the shortest line connecting the airfields, and it is possible in any weather conditions without human participation. The schematic diagram of the flight is shown in Figure 7.



7.

Immovable in the "Earth" system points A and B – airfields of takeoff and landing, at diurnal rotation of the Earth around its axis and annual – around the Sun, in the absolute system of reference move along lines a-a' and b-b', close to dissyllabic spiral. Hence, these points in time t will shift with absolute velocity $\vec{V}_A$ to points A' and B' respectively. Off from A to B plane is controlled so that its in-board micro-interferometers report such an absolute velocity $\vec{V}'_A$, different from $\vec{V}_A$, which would provide a relative speed of the flight $\vec{v}$ in the "Earth" system of coordinates. Then, in time t, the plane will shift from A to B along the flight path a-b' which is steeper than the curve of the Earth's surface a-b (a'-b').

Pilots and air traffic controllers could then observe the flight of an aircraft on their screens, observing it necessarily from different angles over the conventional surface of the Earth, located along the route. The screen displays all the necessary flight and other information: height, speed of an aircraft and wind speed, accelerations, weight reduction, change in atmosphere air pressure and so on, and on the conventional airplane the operation of all means of control, fuel pumping-over etc. are demonstrated. Pilots will act as off-site observers, controlling the flight, interfering into the control process only in emergency cases. Disasters caused by aviation pilots will stop.

This control scheme is applicable to all types of missiles, and the information transferred by them during the interplanetary flights will provide the valuable material about the magnitude and direction of their velocity, acceleration and trajectory. Also with the help of micro-interferometers one can specify the configuration of the orbits of planets and other solar system objects and their instantaneous velocities.

Micro-interferometers are designed to measure only the *absolute* velocity vector of the bodies, which is the sum of about six velocity vectors, each of which can be calculated separately. For example, a change during the day in the direction and magnitude of the vector of *absolute* velocity at the point of measurement will indicate the velocity vector of the rotation of the Earth, change over a year – the orbital velocity vector of the Earth, etc. Since the magnitudes of the vectors of these two velocities at present time are precisely known and may only need to clarify, the measurements of the galactic velocity vectors of the solar system and the speed of our galaxy will make invaluable contributions to the space exploration and will lead to the discovery of the second law of gravitation, which will serve to create a complete celestial mechanics.

Through such devices navigation without satellites will become possible. A man of the Earth still has no idea how it is possible to navigate, say, for example, on the surface of the Moon or Mars. To create a satellite network there? Navstar GPS (Global Positioning System) USA or Russian GLONASS includes 28 (24) satellites distributed along six orbits at the altitude of about 20 thousand kilometers, and a lot of on-ground stations and the staff involved in the maintenance of “GPS”-receivers. The revolutionary step in the navigation without satellite will be the utilization of the micro-interferometers in “GPS”-receivers.

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