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Michelson-Morley experiment - the factual analysis

Gocho V. Sharlanov

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Abstract

The article starts with a general introduction to the problem in modern physics about the constancy of the speed of light for all frames of reference. In the "General Introduction" is presented the fundament of a real solution about all "unexpected" and "inexplicable" results of the experiments related to the measurement of the velocity of light in the time-spatial region "on the Earth surface".

*The famous "Michelson-Morley" experiment has been carried out in order to determine the change of the speed of light due to the motion of the Earth in its orbit around the Sun. On the base of the known speed of the Earth (approximately 30 km/s), the Michelson's expectations have been that the displacement of the interference fringes will be different at night and during the day (when the directions of the "ether wind" caused by the movement of the Earth in its orbit around the Sun are opposite),… and will correspond to the calculations made. However, the result has been unexpected - no displacement was fixed. The problem has **two reasons**. **The first is that the speed of light in vacuum depends on the intensity of the gravitational field.** The intensity of the gravitational field near the Earth's surface is dominating by the mass of the Earth and remains the same during the revolution of the Earth around the Sun. Therefore, the speed of the electromagnetic radiation (of the light) remains constant during the travel of the Earth through space. **The second reason** is the inappropriate conceptual design used in the construction of Michelson's interferometer. **The difference in the speed of light between the two light beams, traveling in two opposite directions on the same arm, is completely compensated if the "two-way light beam interferometer" is used**. That is why, the existing difference of the speed of light due to the rotation of the Earth around its axis in the direction „East-West" and "West-East" (in the reference system related to the Earth's surface), cannot be fixed. However, that difference is observed at the experiments analyzed above – at the experiments "One-way measurement of the speed of light" and the experiment "Michelson-Gale-Pearson".*

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1. General Introduction.

1.1. Concerning the used frames of reference and the speed of light.

The electromagnetic field exists on the space. The hypothetical "luminiferous aether" (the medium for the propagation of the electromagnetic radiation), turns out to be the warped space-time by the celestial bodies itself. In order to reveal the behavior of electromagnetic radiation in the gravitational field, we must recognize the following **two important statements**:

–

Newton's law of universal gravitation states that in the Universe, any particle or body with a mass m_1 attracts any other particle or body (with a mass m_2) with a force that is directly proportional to the product of their masses (m_1 and m_2), and inversely proportional to the square of the distance between their centers (r), where G is the gravitational constant:

$$F = G\frac{m_1 m_2}{r^2} \qquad (1)$$

We have to aware, that space cannot be affected by the gravitational forces (cannot be attracted), because the space has no mass. Therefore, Newton's law of universal gravitation has another important meaning:

> ***First statement:*** *From this law, it becomes clear that the space is stationary – that means "the vacuum is stationary". This is undeniable, because space has no mass, and the gravitational forces do not attract it (the space does not rotate along with the Earth, but only the material bodies and the molecules in the atmosphere).*

–

Reminder:

Frames of reference.

The reference system (frame of reference) is a concept in physics (usually associated with the movement) to denote the point of view of the observer.

When we talk about a frame of reference (reference system), we usually imagine it as a coordinate system and we talk about an observer or an experimenter attached to it. *When an observer is attached to a frame of reference, this frame is stationary for the observer.*

Coordinate systems.

The reference frames used in dynamics are known as *coordinate systems*. The most widely used is the *Cartesian coordinate system* which consists of an *origin* and *three axes*. The *axes* are fixed lines, sized/ dimensioned with numbers, corresponding to the same unit of length, perpendicular to one another, and with direction for each axis. The common point where the axes cross is known as the *origin* of the coordinate system.

Using the *Cartesian coordinate system*, in a time-spatial region with constant measurement units (a region with a uniform intensity of the gravitational field), the location of any point in the space can be described, as well as the change into the time of the location of any point.

As a consequence, in the experiment, we distinguish two main frames of reference:

1) Reference system related to the Earth's surface. This is the frame of reference we usually use. In this frame of reference (for an observer, positioned at a point on the Earth's surface) – any object immovably fixed on the Earth's surface, is stationary. This frame of reference is fixed to the

moving surface of the Earth and it is moving in the stationary space due to the rotating of Earth around its axis in the stationary space.

2) Stationary reference system. Celestial bodies and space. Everything in the Universe, possessing mass, moves. The gravitation is the driving force. It is caused by the masses of celestial bodies and it sets them into motion. Therefore, a stationary reference system cannot actually exist, because we cannot actually connect the "origin" of a stationary coordinate system to a stationary material point. Also, we cannot give exact directions to the axes because we cannot orient them to theoretically non-existing stationary points. However, we can use for most of the cases under consideration, the following approximately stationary frames of reference:

• *"Earth-centered inertial (ECI) coordinate system"*, which can be considered in our time-spatial region as a stationary coordinate system in relation to the stationary space.

The origin of this coordinate system is at the center of the Earth (which is not stationary), and *its axes* are approximately stationary in the space (aimed at very distant astronomical objects).

In other words, we can say that the *"Earth-centered inertial (ECI) coordinate system"* is related to the space itself, where the Earth rotates…, where the photons are born and propagate. If an observer is positioned at a point in this coordinate system, he/she will be stationary in relation to the space near the Earth's surface and will see that the Earth's surface moves (as a result of the Earth's rotation around its axis) in the stationary space with a certain **linear velocity** (*the velocity of a point of the Earth's surface in the stationary space, at the respective latitude).* Every point of the Earth's surface always moves in the east direction. The magnitude of the linear velocity (i.e., the speed) of a particular point of the Earth's surface, depends on the latitude and is the speed at which the point is moving along its path in the stationary space. It is approximately 0.46 km/s for any point on the equatorial line, and is zero at the points of intersection of the axis of rotation of the Earth with the Earth's surface, which points coincide with the north and south poles).

Therefore, when we are located in our local region "near the Earth's surface", and talk about *the speed of light "in vacuum"*, or *"in the empty space"* – this will mean that the speed of light is measured in relation to the *"Earth-centered inertial (ECI) coordinate system"*.

• *"Heliocentric Inertial (HCI) coordinate system"*, also can be considered in certain cases as stationary in relation to the space. *The origin* of this coordinate system is at the center of the Sun (which is not stationary), and *its axes* are approximately stationary in the space (aimed at very distant astronomical objects). An observer positioned stationary in the HCI frame, will see how the planets orbit around the Sun (how the Earth moves in its orbit around the Sun at approximately 30 km/s); how the plasma of the Sun rotates (at the equator the solar plasma rotation period is about 24.5 days and is almost 38 days at the poles).

***Note**: In this paper, as a generalized designation of "stationary in relation to the space coordinate system" is used the designation **"frame of reference related to the space itself"**. In order to be more precise, the term **"velocity"** is used when referring to the vector $\vec{V}$ (with its magnitude and direction); and the term **"speed"** is used, when referring to only the scalar magnitude $|\overrightarrow{V}|$ of the vector.*

Difference between the mechanical and the optical experiments carried out on the surface of the Earth.

• In the mechanical experiments, due to the force of gravity, the material bodies in the atmosphere are involved in the rotation of the Earth around its axis.

• In the optical experiments, however, the photons are not involved in the Earth's rotation around its axis, because they do not have a mass and the gravitational force of attraction for the photons is equal to zero – (see Newton's law of universal gravitation). Therefore, the speed of the photons is

constant in empty space (in vacuum, in the frame of reference related to the space itself /in ECI frame of reference/). The measured speed of light in the reference system related to the moving surface of the Earth in the stationary space, however, is not equal to the speed of light in the empty space, and it was proven by the experiments. The stationary space is the medium of the electromagnetic and gravitational fields. In this sense, the electromagnetic radiation is actually vibrations of the space itself.

On the speed of light in different frames of reference

The two major frames of reference, where we will consider the measurement of the speed of light (of the electromagnetic radiation), are *"the frame of reference related to the Earth's surface*" and the *"Earth-centered inertial (ECI) frame of reference"* – the system that, in the considered case, is stationary relative to the space itself.

> ***For the contemporary physics**, there is no difference between "the speed of light in the frame of reference related to the Earth's surface" and "the speed of light in the Earth-centered inertial (ECI) frame of reference, which is the speed of light in vacuum". This is because the modern physics wrongly has accepted that the speed of light is the same in all inertial frames of reference. The factual analyses of all experiments will convince anyone that this claim is a big blunder.*

Anyone will ascertain – that all experiments undoubtedly prove that there is a difference between the measured velocity of light in the *"frame of reference related to the Earth's surface"* and the speed of light *"in the empty space"* (in the *"Earth-centered inertial (ECI) frame of reference*"*).* The only exception is the conceptually incorrectly designed Michelson-Morley experiment, in which, due to the inappropriate idea (the two-way measurement of the speed of light), used in the Michelson's interferometer, this difference is completely compensated.

–

> ***Second Statement:** The gravitational force affects the space by contracting it.*

Experiments show that the propagation of the electromagnetic radiation and the electromagnetic properties of the atoms depend on the intensity of the gravitational field (on the density of this medium/on the contraction of the space/). In his article from 1911, *"On the Influence of Gravitation on the Propagation of Light"*, Einstein discussed the change of *the speed of light in vacuum* (proposing a formula), when the light enters the regions with a different gravitational potential which actually are regions with different intensity of the gravitational field:

> *"If we call the speed of light at the origin of co-ordinates co, then the speed of light c at a place with the gravitation potential Φ will be given by the relation:*
>
> $$c = c_0\left(1 + \frac{\Phi}{c^2}\right) \qquad (2)$$
>
> *The principle of the constancy of the speed of light holds good according to this theory in a different form from the one that usually underlies the ordinary theory of relativity." (Einstein, 1911).*

In the same article Einstein also points out that the frequency of any electromagnetic radiation changes depending on the gravitational potential:

$$\nu = \nu_0\left(1 + \frac{\Phi}{c^2}\right) \qquad (3)$$

The frequency of certain electromagnetic radiation defines the base unit of time *"second"*. Therefore, the base unit of time *"second"* also changes in places with different gravitation potential (with different intensity of the gravitational field), because the duration of the same number 9,192,631,770 time-periods of the used particular electromagnetic radiation will change (see the definition of the "second" since 1967). This means that in regions with weaker gravitation (where the frequency increases), the base unit of time "second" becomes shorter (with shorter duration). In this paper, Einstein does not discuss the change in the wavelength of electromagnetic radiation. However, in other articles related to the general theory of relativity is discussed that in regions with higher gravitation, the base unit of length "metre" is contracted (the wavelength of any electromagnetic radiation is shortened) – see the definition of the "metre" in SI accepted in 1960.

It is clear, however, that the space is stationary, but the contraction of the space (changed density of the medium of propagation of the electromagnetic radiation), is moving along with the celestial bodies. All celestial bodies (as well as the Earth) are traveling through the space-time of the Universe along with the distortion (contraction) of the contiguous, warped by the bodies themselves (and belonging to them) time-spatial domains, which we can name *"near the surface of the celestial bodies"*.

The misunderstanding of the dominant part of the physical society consists in the fact that the contraction of space moves along with the celestial bodies, but the space remains stationary!

The intensity of the gravitational field "near the surface of the celestial body", remains practically the same, during the travel of the celestial body through the space, because the intensity of the gravitational field is determined (dominated) by the mass of the celestial body. *The speed of light* ***in vacuum*** (in the stationary empty space), in any particular time-spatial domain, corresponds to the intensity of the gravitational field in this time-spatial domain.

> *Therefore, during the travel of the celestial body through the space,* ***the constant intensity of the gravitational field "near the surface of the celestial body" determines the constant "speed of light in vacuum" there****.*

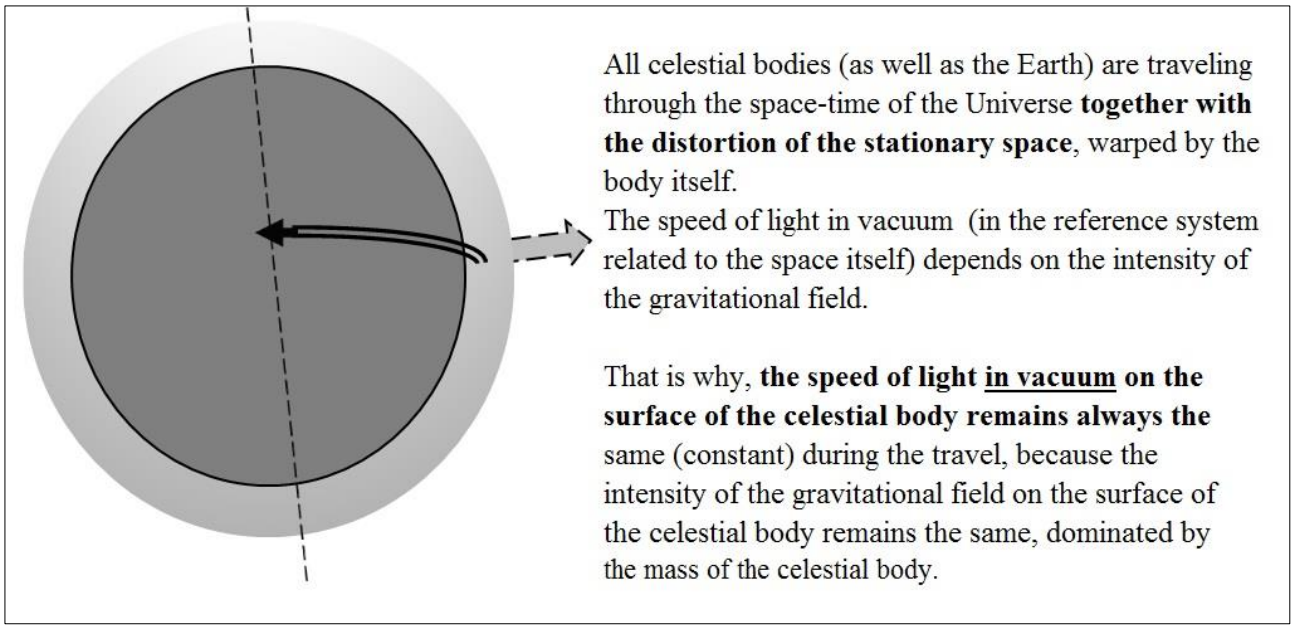

Figure 1. Moving of the celestial bodies together with the distortion of their "own time-spatial domain"

Therefore, that is the reason why there is no variation in "the speed of light in vacuum" when the Earth moves in its orbit around the Sun and together with the Solar System in the Galaxy.

As a consequence, we have to be aware that the behavior of the electromagnetic radiation in vacuum must be considered in two aspects:

- in regions with different intensity of the gravitational field.
- in regions (local time-spatial domains) with a uniform intensity of the gravitational field;

The local physical reality is a "local time-spatial domain". It is any time-spatial domain with a practically uniform (the same) intensity of the gravitational field in the vicinity of any celestial body, which remains constant in the general motion of the celestial bodies in the Universe, and where the base units of time and of space (length) can be considered to be constant. Our local physical reality can be named "near the Earth's surface".

1.2. The speed of light in regions with different intensity of the gravitational field.

The speed of light in vacuum depends on the intensity of the gravitational field. In regions with different intensity of the gravitational field, the speed of light in vacuum (in relation to the stationary space) is different and it has been proven by experiments:

*1) The speed of light **in vacuum** is higher in regions with weaker gravitation.*

In regions with a weaker intensity of the gravitational field, the electromagnetic waves will not so more be so suppressed by the gravity – they will oscillate more freely (easier). It means that they will oscillate with a higher frequency $\boldsymbol{\nu}$ – the "time period" of the electromagnetic oscillations will be of shorter duration. It means that and the "spatial period" (the wavelength $\boldsymbol{\lambda}$) of the electromagnetic oscillations will be greater (they will "jump" with larger wavelength). Therefore, the increased frequency and the increased wavelength of each electromagnetic radiation determine not only the shortening of the "second" and the lengthening of the "meter", but also increase in the speed of light in vacuum $(c = \nu\lambda)$. That was proven by the registered anomalies in the accelerations of the space-probes "Pioneer 10", "Pioneer 11", "Galileo", "Ulysses"…

"The expected travel time of the communicational electromagnetic signals (based on the constancy of the speed of electromagnetic radiation) between the spacecraft and the Earth, turns out to be much more than the real travel time. So we register backward attraction (acceleration) of the ship to the Sun." (Sharlanov, 2011).

The new higher speed will be valid again for the entire electromagnetic spectrum – it will be again a local physical constant. This logic coincides with the idea of the general theory of relativity.

*2) The speed of light **in vacuum** is lower in regions with stronger gravitation.*

Experimentally, (using the units of measurement defined on the Earth's surface), a slower speed of radar electromagnetic signals has been experimentally measured in the region with strong gravitation (near the Sun) by American astrophysicist Dr. Irwin I. Shapiro (Shapiro time delay effect), reported in 1964. The result of this experiment was confirmed later much more precisely using controlled transponders aboard the "Mariner-6" and "Mariner-7" spacecrafts as they orbited the planet Mars.

1.3. The speed of light in regions with a uniform intensity of the gravitational field.

In regions with a uniform intensity of the gravitational field, the speed of light in vacuum (in relation to the stationary space) is a local constant in any local time-spatial domain with a uniform intensity of the gravitational field, and this concerns the whole spectrum of electromagnetic radiation.

"The "speed of light in empty space" is the correlation between the frequency and the wavelength for the whole electromagnetic spectrum, which is a local constant for our and for any other local time-spatial domain, where the intensity of the gravitational field is uniform." (Sharlanov, 2016).

However, in regions with a uniform intensity of the gravitational field (as in the region "near the Earth' surface"), **the experiments register different velocity of light in relation to the moving frames of reference in the stationary space.** This reality is confirmed by:

• the experiments "One-way measurement of the speed of light", (Marmet, P. 2000), (Kelly, A., 2005);

• the "Sagnac experiment" (Sagnac, 1913);

• the experiment "Michelson-Gale-Pearson" (Michelson & Gale, 1925).

All of the experiments related to the speed of light measurement have their real explanation in accordance with the classical mechanics and the Galilean relativity (which are indisputably valid and lawful in our local time-spatial domain "on the Earth's surface").

The exception is only the Michelson-Morley experiment… The analysis of the Michelson-Morley experiment (Sharlanov, 2018), shows that the inappropriate conceptual design, used in the construction of the Michelson interferometer (the advanced version of which is used in the famous Michelson-Morley experiment, held in 1887), is actually the primary root cause for the great delusion that *"the speed of light is the same in all inertial frames of reference"*, which is the core of the special theory of relativity. The difference in the velocity of light (in the frame of reference related to the moving Earth's surface in the stationary space,) between the two light beams, traveling in two opposite directions on the same arm, is completely compensated if the "two-way light beam interferometer" is used.

"Actually, if even the "ether wind" exists (caused by the Earth's motion through the stationary luminiferous ether) – the difference in the speed of light between the two light beams, traveling in two opposite directions on the same arm, is completely compensated. ***It is true for any arm in any direction!*** *In other words, if the projection of the velocity of the "ether wind" on the direction of one of the light beams is (+V), then the projection of the velocity of the "ether wind" on the direction of the reflected light beam (traveling in opposite), will be exactly (-V)." (Sharlanov, 2016).*

The "unexplained anisotropy of the light velocity", depending on the direction of the light beam in the "one-way measurement of the speed of light" experiments performed using the GPS system, has its explanation that corresponds to the physical reality. The results of the "Michelson-Morley experiment" are analyzed in this paper. The results of experiments "One-way measurement of the speed of light", of the "Sagnac experiment", of the "Michelson-Gale-Pearson experiment", and of the Fizeau experiment are analyzed in detail in the monograph (Sharlanov, 2018). Moreover, the essence of the so-called "fundamental tests of the special theory of relativity", which have considered as three major types, are revealed. This monograph includes the analysis of the article *"On the Electrodynamics of Moving Bodies"*, presenting the special theory of relativity, and shows **exactly where and how** the claim *"the speed of light is the same in all inertial frames of reference"* was applied. It also presents *"Thesis on the behavior of the electromagnetic radiation in the gravitational field of the Universe" (in 10 Statements)*, which actually rejects *the postulate of the constancy of the speed of light for all frames of reference*, and shows solution of other big problems in physics today, such as: ***"the accelerated expansion of the Universe"***, and ***"the dark matter and the dark energy in the Universe".***

2. Analysis of the "Michelson-Morley experiment".

The theories of light at that time.

Historically, in the seventeenth century, two rival theories of the nature of light were proposed – the wave theory and the corpuscular theory.

The Dutch astronomer Huygens proposed the wave theory of light – the first mathematical theory of light. The known mechanical waves propagate through a material medium (solid, liquid, or gas) at a wave speed which depends on the elastic and inertial properties of that medium. Two basic types of wave motion for mechanical waves were known: transverse waves and longitudinal waves. For Huygens, the light was a longitudinal wave (like sound waves in air) and propagates through a medium called "ether", or "aether". The ether must fill all the space and be weightless and invisible (in fact, as the space itself).

In 1690 Newton proposed *the corpuscular theory of light*. For him, the light was emitted from a source in small particles, and this view was accepted for over a hundred years.

The quantum theory put forward by Max Planck in 1900 combined the wave theory and the particle theory, and showed that light can sometimes behave like a particle and sometimes like a wave.

After the development of Maxwell's theory of electromagnetism, the questions about the speed of light and what medium supports the transmission of electromagnetic waves arose again. For James Clerk Maxwell and other scientists of that time, the answer was based on the supposition of Christiaan Huygens, that light travels in a hypothetical medium called *"luminiferous aether"* – the space-filling substance, thought to be necessary as a transmission medium for spreading of the electromagnetic radiation.

Vectors, scalars, vector projection and scalar projection.

> ***Vector (Euclidean vector)**, in physics, is a quantity that has both magnitude (size, length) and direction. It is represented as an arrow, whose length is proportional to the quantity's magnitude. However, the vector has no position. It means that the vector is not altered if it moves parallel to itself.*
>
> ***Scalar** is a quantity that has a magnitude but not a direction, as the "speed of light in vacuum".*

For example, velocity and acceleration (with magnitude and direction) are vector quantities, while speed (the magnitude of velocity), time, temperature, length, and mass are scalars. In English, in physics, the term "velocity" often is used, when we mean the vector $\vec{\boldsymbol{V}}$ with its direction; and the term "speed" is used, when we mean only the scalar magnitude $\left|\vec{\boldsymbol{V}}\right|$ of the vector.

> ***Vector projection** of a vector "A" on (or onto) a coordinate axis, or on a nonzero vector "B" (also known as the vector component or vector resolution of "A" in the direction of "B") is the orthogonal projection of "A" on a straight line parallel to "B". It is a vector parallel to "B".*
>
> ***Scalar projection** of a vector on a coordinate axis (with direction), or on another nonzero vector, is a scalar, equal to the length of the orthogonal projection of the vector on the axis, and with a negative sign if the projection has an opposite direction with respect to the axis (or to the vector) direction. In Cartesian coordinates, the components of the vector are the scalar projections on the coordinate axes.*

In this way, the scalar projection of the vector $\vec{V}$ on another vector can be recorded as $\left(\left|\overrightarrow{V_0}\right| \cos\theta\right)$, where θ is the angle between the two vectors. In other words, some of the scalars in physics have two directions, that correspond to the signs "plus" and "minus", while a vector can have infinite directions.

2.1. About the theories of light and the velocity of light. Experiments – expectations and results.

The Earth rotates around its axis, moves in its orbit around the Sun, and together with the Solar System moves around the center of our galaxy Milky Way.

The expectations of the scientists at the end of the 19th century.

According to the hypothesis of the existence of a "stationary luminiferous ether", there is an invisible substance filling the space, which was thought to be the necessary medium for the propagation of electromagnetic radiation (light). The expectations of the scientists have been that if the hypothesis of the "stationary ether" is correct, the velocity vector of the created *"ether wind"* at the Earth's motion at any time, must be equal to the sum (vector addition), but in the opposite direction of the following three vectors:

(1) ***the velocity vector of motion of the entire Solar System*** *as it whirls around the center of our Galaxy at about 220 km/s (if we measure the speed by means of the units of time and length defined on the Earth's surface); plus*

(2) ***the velocity vector of the Earth's motion*** *in its orbit around the Sun (which is approximately 30 km/s); plus*

(3) ***the vector of the linear velocity of the Earth's surface at the location of the experiment*** *(due to the Earth's rotation around its axis). We know that the linear velocity of the Earth's surface of any point at the equatorial line is approximately 0.46 km/s, but it is equal to zero at the points of intersection of the axis of rotation with the Earth's surface, which points coincide with the north and south geographic poles.*

Figure 2 is an illustration of the expected ***"ether wind"***, at the motion of the Earth through the hypothetical medium called *luminiferous ether*. The figure depicts the Sun, the Earth and the Earth's orbit. The three types of dotted lines depict the three components of the supposed "ether wind", which have opposite directions to the aforementioned three vectors. The figure does not correspond to the scale (the radius of the Sun is about 109 times larger than the radius of the Earth, and the difference between the speeds of motion of the Earth and of the Solar System is much greater.

The expectations of the scientists have been that the "ether wind" will affect the speed of a light beam (will increase or decrease the speed of light):

- *On the one hand, if the experiment is carried out at a fixed location on the surface of the rotating Earth, then the part of the vector "ether wind", created by the motion of the Earth on its orbit around the Sun, should have varying magnitude and direction over time (e.g. at night and during the day).*

- *On the other hand, the experimenter can point the light beam in different directions. Thus, the effect of the generalized ether wind vector (vector addition) on the speed of the light beam was expected to be different. In this way, the "ether wind" will have a different effect on the speed of the light beam, since the scalar projection of the generalized vector "ether wind" on the trajectory of the light beam will be different.*

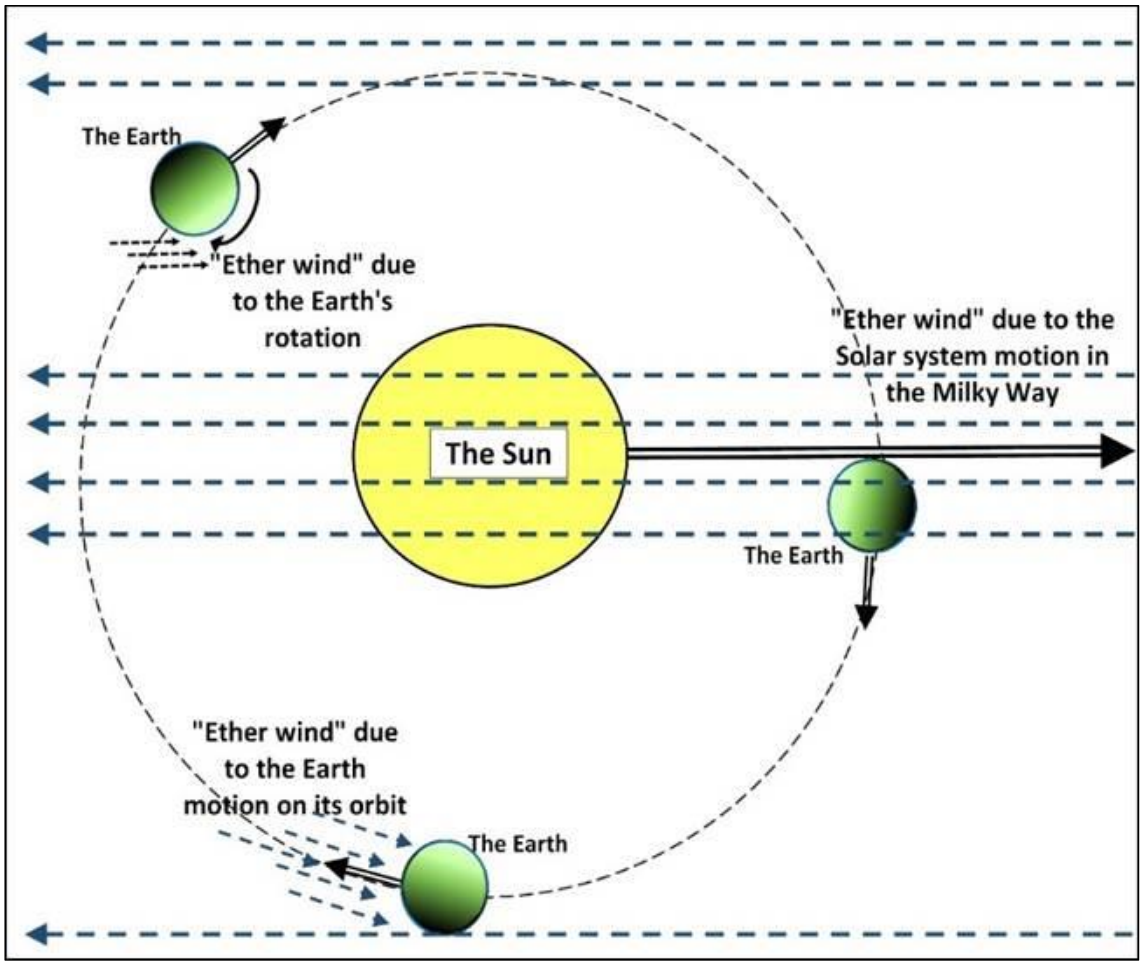

Figure 2. The Earth's motion around the Sun and the alleged "ether wind"

We can call the vector projection of the velocity vector ***"ether wind"*** onto the vector of the light beam velocity – ***"ether headwind"*** (see *Figure 3* below).

Therefore, according to the expectations, the resulting speed of the light would be different, depending on the direction of the light beam, and would be different at night and during the day, when the direction of the *"ether headwind"*, caused by the movement of the Earth in its orbit around the Sun, is opposite. The difference of the speed of light for different seasons of the year (at various points of the trajectory of the Earth in its orbit around the Sun), was expected to be an indication of the velocity of motion of the Solar System in the stationary luminiferous ether.

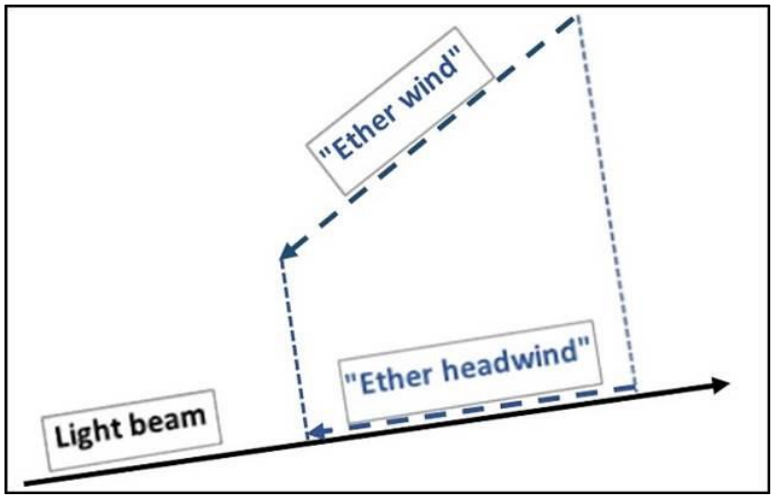

Figure 3. The expected influence of the "ether headwind" on the speed of a light beam in vacuum.

So, if the hypothesis of the existence of the "stationary ether" is true, the created "ether wind" by the Earth's motion through the stationary ether should increase or decrease the speed of the light beam (depending on the direction and magnitude of the ***"ether headwind"***).

But now let us reveal the "defect" of the fatal for the physics of the 20th century Michelson-Morley experiment, whose erroneous explanation of the result (that the speed of light is constant for all reference frameworks) continues to be supported by the modern physics.

2.2. The First Michelson's Experiment.

Albert Michelson designed an experimental construction (later known "Michelson interferometer", and made his first experiment in 1881, in order to determine the change of the speed of light due to the motion of the Earth in its orbit around the Sun through the "stationary luminiferous ether" (see *Figure 2*).

Michelson's expectations.

Michelson's expectations were also such, that if the "stationary luminiferous ether" exists, the motion of the Earth through the ether would result in an effect of the "ether wind" on the speed of a light beam. Above, we have called the projection of the three-component vector sum *"ether wind"* on the direction of the light beam *"ether headwind"* (see *Figure 3*).

In other words, Michelson has expected that the speed of the light beam to be different:

- *firstly*, depending on the direction of the arms, on which the light beams spread;
- *secondly*, the speed of the light beam (in the case of a fixed direction in relation to the Earth's surface) was expected to be different at night and during the day, when the direction of the *"ether headwind"*, caused by the Earth's motion in its orbit around the Sun is opposite in relation to the direction of the fixed light beam (see below *Figure 4*).

On this basis, Michelson made his first experiment in 1881 with an interferometer constructed by him – see the scheme of the interferometer below in *Figure 5*. Michelson used a monochromatic light beam, split (in order the two coherent light beams to be perfectly the same), on two arms in two mutually perpendicular directions. The two light beams propagate along two mutually perpendicular arms, each beam reflected in the opposite direction by a mirror. After reuniting of the two reflected beams at the place of splitting, the Michelson expected to ascertain:

> ***displacement of interference lines*** *which is consistent with the expected difference in the speeds of the two light beams, caused by the "ether wind" due to the movement of the Earth in its orbit around the Sun.*

Subsequently, the construction of the experiment "Michelson-Morley" was improved – the light beams are reflected repeatedly, but the same idea is used again – the usage of two coherent light beams in two directions, from the splitter of the monochromatic beam to the mirrors and backward. The fact that the same beam is used in opposite directions (one reflected) on the same arm, means that ***each of them travels exactly the same distance*** - from the monochromatic beam splitter to the mirror (the straight beam), and back (the reflected beam)... ***This, however, means that if the speed of the two opposite light beams, moving in opposite directions is changed by the "ether wind", the change will be the opposite, and the difference will be completely compensated, because the path of the two beams (the straight and the reflected) is perfectly the same!***

Thus, on the base of the speed of the Earth in its orbit around the Sun, which is approximately 30 km/s, the expectations of Michelson had been that the displacement of the interference fringes (the bright or dark bands caused by beams of light that are in phase or out of phase relative to each other), will be different at night and during the day and will correspond to the calculations made.

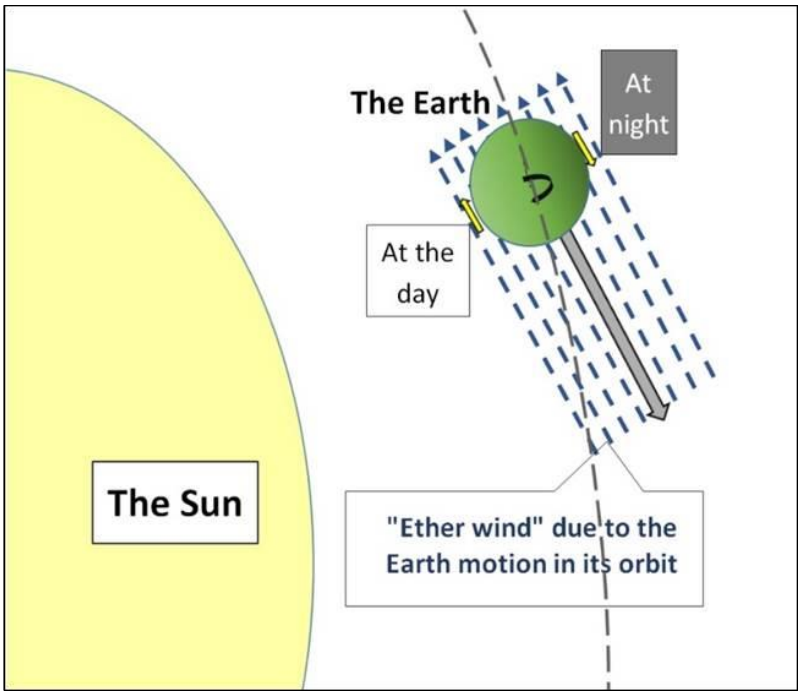

Figure 4. Schematic representation of the opposite directions of the expected "ether wind" at night and during the day due to the motion of the Earth along its trajectory around the Sun.

The yellow arrows show (see *Figure 4*), the direction of motion of the Earth's surface, where the interferometer is located. According to the presented image, the direction of surface motion during the day is in the direction of the hypothetical "ether wind", and at night - in opposite to the "ether wind" direction. The figure depicts a glimpse of the trajectory at which the Earth moves clockwise.

***Note**: The experiments were carried out in a short interval of time (the "Michelson-Morley experiment" was carried out from July 8 to July 12). This means that the Earth was located approximately in the same place on its trajectory around the Sun. That is why, the difference of speed of light due to the "ether wind" at different points of the Earth's trajectory around the Sun (which is an indication of the speed of motion of the Solar System in the Milky Way with about 220 km/s – see Figure 2), was not calculated by Michelson...*

The Michelson's interferometer

The experimental construction (the interferometer designed by Michelson), illustrated below in *Figure 5*, uses two-way light beam propagation (in the straight direction and in the opposite direction/ the reflected beam) in exactly the same path.

The interferometer consists of a monochromatic light source (with an accurate frequency); semi-silvered mirror separating the monochromatic light beam from the source along the two mutually perpendicular arms; two mirrors (A and B) reflecting the coherent light beams in opposite direction; and a detector depicting the interference fringes after reuniting of the two light beams. They are all located horizontally (i.e. on the same gravitational potential).

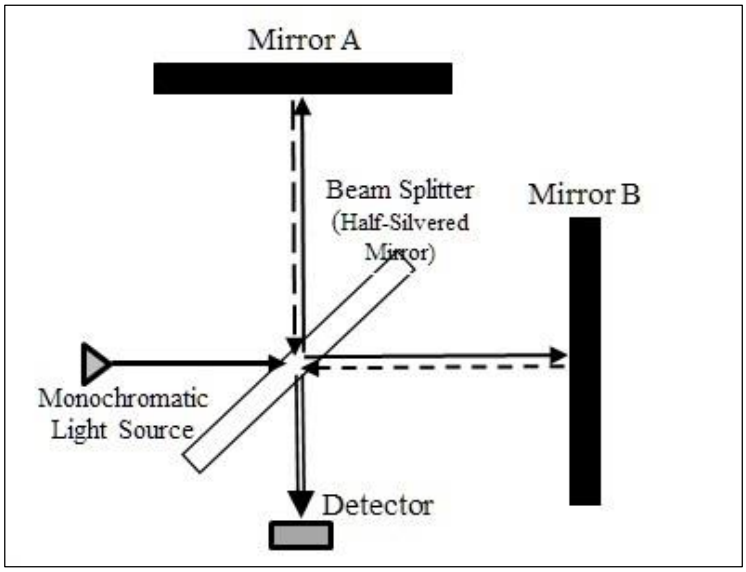

Figure 5. Scheme of the Michelson interferometer

As stated, the predicted change in the direction of the "ether wind" during the day and at night, in relation to the fixed arms of the interferometer to the Earth's surface, should have been led to a different change between the speeds of the two light beams, that should have been registered as a different displacement of the interference fringes. Using a wavelength of about 600 nm, Michelson has expected that there would have been a displacement of the interfering fringes, for which he made accurate calculations. The expected difference in the displacement of interference fringes during the day and at night has been sought in different directions of the two perpendicular arms of the interferometer.

However, the expected displacement of the interference bands was not ascertained.

The results reported by Michelson:

"The small displacements -0.004 and -0.015 are simply errors of experiment." (Michelson, 1881).

Michelson's conclusion was:

"The interpretation of these results is that there is no displacement of the interference bands… The result of the hypothesis of a stationary ether is thus shown to be incorrect, and the necessary conclusion follows that the hypothesis is erroneous." (Michelson, 1881).

2.3. The well-known "renowned" Michelson-Morley Experiment.

The famous Michelson–Morley experiment was performed in 1887. Albert Michelson, with the collaboration of Edward Morley, constructed a new improved interferometer. As in the first experiment, the improved interferometer used two-way paths of two light beams on two perpendicular arms. But by using multiple mirrors, the light path length of the two light beams was about 10 times longer. The light was repeatedly reflected back and forth along the arms of the interferometer, increasing the total light path length of each beam to 11 m. Thus, according to the intention, there was more than enough accuracy to detect the ether-hypothetical effect of the Earth's motion. At the path length of 11 m, the expected displacement should have been about 0.4 of the distance between the fringes. To eliminate thermal and vibration effects, Michelson and Morley's

interferometric apparatus was assembled on the top of a large block of sandstone, about a foot thick, which was then floated in a pool of mercury.

The results.

The result of the experiment was entirely unexpected and inexplicable again – the effect of the motion of the Earth around the Sun through the *hypothetical ether* on the speed of light was practically zero at any time of day or night, at all times of the year in different points of the Earth's orbit. The reported results were given by Michelson:

"It seems fair to conclude that if there is any displacement due to the relative motion of the earth and the luminiferous ether, this cannot be much greater than 0.01 of the distance between the fringes." (Michelson & Morley, 1887).

Although repeated many times with even greater precision, this experiment proves the same negative result.

2.4. Conclusion.

As grounded in Chapter 8 *"Fundamentals of the model of physical reality in the Universe"* of the book (Sharlanov, 2018), *the speed of light* ***in vacuum*** is a local constant and depends on the intensity of the gravitational field in the time-spatial domain. The *speed of light in vacuum* "on the surface of the Earth" is determined by the Earth's gravity and remains constant in the motion of the Earth in its orbit around the Sun and with the Solar system in the galaxy, because the intensity of the gravitational field near the Earth's surface is constant and is determined above all by the Earth.

However, the measured speed of light ***in different frames of reference*** *is different in the local region "near the Earth's surface".* As it turns out, in *the one-way measurement of the speed of light* between two points on the same latitude:

• *the measured velocity of light in the "West to East" direction in the reference system related to the Earth's surface is (c-V);*

• *the measured velocity of light in the "East to West" direction in the reference system related to the Earth's surface is (c+V);*

, where ***c*** is the local constant *"speed of light in vacuum"*, and *V* is the *linear velocity* of the Earth's surface at the respective latitude.

The evidence presented in the analyses of the experiments "One-way measurement of the speed of light" and "Michelson-Gale-Pearson" in the book (Sharlanov, 2018), clearly ascertain the effect of the Earth's rotation around its axis on the speed of light, measured on the Earth's surface. They demonstrate with great accuracy the validity of Galilean transformations (which are a fact in our *local physical reality*), in the cases with the electromagnetic radiation.

In the "Michelson-Morley" experiment, however, no effect on the speed of light can be found, as a result of the Earth's rotation around its axis. The reason lies in the inappropriate conceptual design, embedded in the construction of the interferometer. When the "two-way measurement of the speed of light" is used, actually, the average speed of the two light beams is measured, propagating in two exactly opposite directions on exactly the same path. Therefore, the change of the speed of the two light beams for the two opposite directions, for each arm of the interferometer, in the reference system related to the surface of the Earth, completely compensates! If the resultant speed of the light beam in the direction *"from the semi-silvered mirror to the reflecting mirror (either mirror A or mirror B)"* is *(c+V)*, then the speed of the light beam in the opposite direction will be exactly *(c-V),* where *c* is the *speed of light in vacuum* and *V* is the *scalar projection* of the *linear velocity*

of Earth's surface on the arm of the interferometer (i.e. on the direction of the light beam propagation). The path of the light beam in both directions for each arm is absolutely equal, and the direction and the length of the arm are irrelevant, because, at any value of *V*, the differences in the speed will be completely compensated for each other. Thus, the resulting speed (measured for the two directions of the light beam in any arm) will always be equal to *c*: *[(c+V)+(c-V)]/2=c!* This means that the interference fringes will never be displaced, because the speed of each light beam for both directions of any arm ***will always be exactly equal to c, regardless of the length of the arm, regardless of arm's direction!***

So, in the *"one-way measurement of light speed experiments"* and the "*Michelson-Gail-Pearson experiment"*, the change of the speed of light as a result of the Earth's rotation in the reference system related to the surface of the Earth can be registered, but in case of using the inappropriate conceptual design of the Michelson's interferometer *("interferometer using two-way propagation of light beams")* – **this is impossible!**

The conclusion is:

"Actually, if even the "ether wind" exists (caused by the Earth's movement through the stationary luminiferous ether) – the difference in the speed of light between the two light beams, traveling in two opposite directions on the same arm, is completely compensated. This is true for any arm in any direction! In other words, if the projection of the velocity of the "ether wind" on the direction of one of the light beams is (+V), then the projection of the velocity of the "ether wind" on the direction of the reflected light beam (traveling in opposite), will be exactly (-V)." (Sharlanov, 2016).

Therefore, the poorly designed "Michelson-Morley experiment", can be classified as a huge fallacy, given what it means to physics *"more than a hundred years of delusion"*.

Over the past 100 years, too many variants of the Michelson-Morley experiment were carried out by many scientists from different famous universities and institutes of relativity and cosmology, with increasing sophistication and with increasing accuracy. However, the result cannot be other – the difference in the speed of light between the two light beams, traveling in two opposite directions on the same arm, is completely compensated if the construction of "*interferometer using two-way propagation of light beams*" is used.

An example of this continuing and nowadays delusion, is also a publication in ***"Physical Review Letters"*** and reported in ***"Physics World"*** (the membership magazine of the Institute of Physics, one of the largest physical societies in the world) – *"Michelson – Morley experiment is best yet"* from 14.09.2009: *https://physicsworld.com/a/michelson-morley-experiment-is-best-yet/*.

In summary. The "Michelson-Morley experiment" is actually the primary root cause for the great delusion that "the speed of light is the same in all inertial frames of reference", which is the core of the special theory of relativity.

The analysis of the article** "On the Electrodynamics of Moving Bodies" **shows exactly where and how the claim* "the speed of light is the same for all inertial frames of reference" *was applied, and actually reveals the essence of the special theory of relativity …

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