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Physical Essence of Michelson-Morley Experiment

Prof. Zeng Qingping
sciencesum@yahoo.cn

Air Force Radar Academy of Chinese People's Liberation Army

[Abstract] This article restudies physical essence of Michelson-Morley experiment, and the result is: 1.Use Einstein's special relativity to calculate interference experiment, but the result is not consistent with experiment conclusion. 2. Use Galilean principle of relativity to calculate interference experiment, and the result is totally consistent with experiment conclusion. This means that Einstein's principle of constancy of light velocity loses the evidence. This article challenges relativity, it deserves the readers to read and it has significant physical significance.
[Keywords] interference experiment, hypothesis of constancy of light velocity, Galilean principle, vector of light velocity

1 Foreword

Article 1 points out: relativity uses text language to state that light velocity is constant, from the appearance, principle of constancy of light velocity explains the zero conclusion of interference experiment, but in fact there are some flaws. When we use relativity its own mathematical language (velocity transformation formula of relativity) to calculate Michelson-Morley experiment, we can find that there still exists optical path difference $\delta = d\beta^2$ in relativity. So, what is the true reason of Michelson-Morley experiment? This article will study its physical essence. Based on the basic property that light velocity is a vector and the principle of vector superposition, this article proves and states that Galilean principle of relativity is not only suitable to particle movement, but also suitable to the light movement. So it denies the principle of constancy of light velocity.

2 Introduction of Michelson-Morley Experiment

Michelson-morle experiment was carried out in 1881. Science background is: through Fizeau's light velocity experiment, it gets the conclusion that light velocity has relations with the movement of propagation medium. So, Michelson-morle thought: interferometer moves with the earth at the velocity of $\boldsymbol{v}$, this is equal to that interferometer is still and the Ether-medium flows through the interferometer at the velocity of $-\boldsymbol{v}$, as shown in figure 1. The interferometer moves to right, this is equal to that interferometer is still (static) and the Ether-medium moves to left (dynamic). The result is as below.

The route of light beam b_1 is $M \to M_1 \to M \to e$, and that of b_2 is $M \to M_2 \to M \to e$. Because light wave is propagated in the Ether-medium due to oscillation, and Ether-medium moves at the velocity of $-v$, propagation velocity of light wave in moving Ether-medium is c_0, when the light beam points to left, interferometer (static) detects that the light velocity is $c_0 - v$, when the

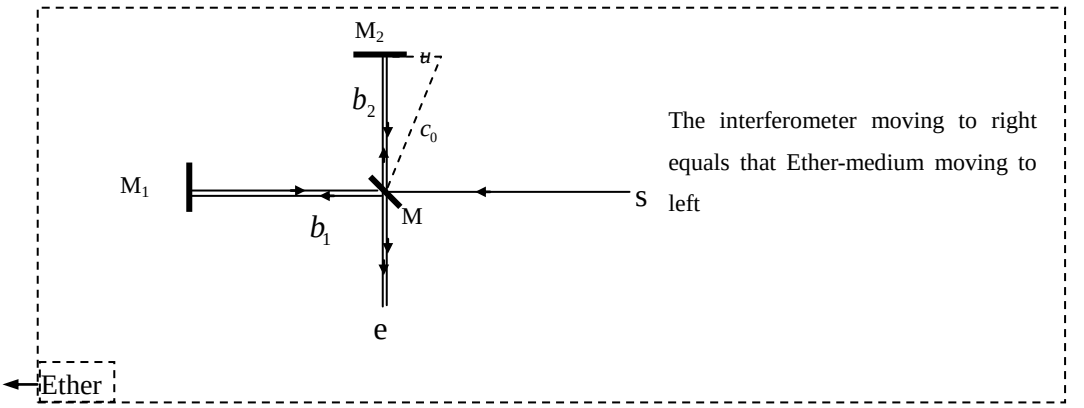


Figure 1 Equal to that Ether-medium flows through the interferometer at the velocity of $-v$

light beam points to right, interferometer (static) detects that the light velocity is $c_0 + v$. The result is:

1) Light beam b_1: the velocity on the route of $M \to M_1$ is $c_0 - v$ (because light beam points to left), and the velocity on the route of $M_1 \to M$ is $c_0 + v$ (because light beam points to right), the required time of back and forth is:

$$t_1 = \frac{d}{c_0 - v} + \frac{d}{c_0 + v} = \frac{2d}{c_0} \frac{1}{1 - \beta^2} \tag{1}$$

2) Light beam b_2: velocity component on the route of $M \to M_2$ is $\sqrt{c_0^2 - v^2}$, and velocity component on the route of $M_2 \to M$ is $\sqrt{c_0^2 - v^2}$, required time of back and forth is:

$$t_2 = \frac{2d}{\sqrt{c_0^2 - v^2}} = \frac{2d}{c_0} \frac{1}{\sqrt{1 - \beta^2}} \tag{2}$$

Time difference between the two light beams passes into the eye is $\Delta T = t_1 - t_2$, relative optical path difference is $\delta \approx d\beta^2$. But the experiment conclusion is "zero" result. It means that the experiment conclusion is no interference fringe existing. The above is experiment and analysis conclusion of Michelson-Morley experiment.

3 Special Relativity is not Consistent with Experiment Conclusion

Article 1 points out that the basis of constancy of light velocity is Michelson-morle experiment, that is: principle of constancy of light velocity explains this experiment. But article 2 considers that

there are defects in the principle of constancy of light velocity. From the word language of relativity, there seems to be no doubt, but the situation is quite bad if mathematical language is used to calculate.

Special relativity points out: static and dynamic systems of relativity are both assumed arbitrarily. Considering that Michelson used the calculation method of "Ether-medium flows through the interferometer at the velocity of $-\boldsymbol{v}$", so the view of relativity includes: interferometer can be static system, and the light velocity detected by it is c_0; Ether-medium moving at the velocity of $-\boldsymbol{v}$ is dynamic system, and the light velocity detected by it is also c_0. It means: Ether-medium coordinate system moving at the velocity of $-\boldsymbol{v}$ is dynamic coordinate system xoy', and interferometer coordinate system is static coordinate system XOY. It is consistence with original calculation method, and suitable to the view of "all the light velocities detected by inertial system are c_0" of special relativity.

Velocity transformation formula of relativity[2] is:

$$u_x = \frac{u_x' + v}{1 + \frac{\beta}{c_0} u_x'}, \quad u_y = \frac{u_y' \sqrt{1-\beta^2}}{1 + \frac{\beta}{c_0} u_x'}, \quad u_z = \frac{u_z' \sqrt{1-\beta^2}}{1 + \frac{\beta}{c_0} u_x'} \tag{3}$$

This is velocity transformation between dynamic and static relativity.

Now, we calculate the optical path of horizontal light beam and vertical light beam according to the mathematical language of relativity.

We notice that: Fizeau experiment is about the movement of light medium (water), so Michelson-morle adopts Ether-medium moving left, that is dynamic. According to relativity, Ether-medium moving at the velocity of $-\boldsymbol{v}$ is dynamic, and the light velocity is $c' = c_0$. The coordinate selections of the two experiments are totally consistent and suitable to the relativity. So,

$$u_x' = c_0, \quad u_y' = 0, \quad u_z' = 0 \tag{4}$$

1) For horizontal beam b_1.The velocity of light beam detected by dynamic system (Ether coordinate system moving at the velocity of $-\boldsymbol{v}$) is:

While using velocity transformation formula (3) of relativity to calculate, the light velocity detected by static system (interferometer) is:

$$u_x = \frac{u_x' + v}{1 + \frac{\beta}{c_0} u_x'} = \frac{c_0 + v}{1 + \frac{\beta}{c_0} c_0} = c_0, \quad u_y' = 0, \quad u_z' = 0 \tag{5}$$

From formulas (4) and (5), we can see that the light velocities detected by dynamic system and static system are both c_0 (light velocity of relativity). This is also the result of article 1, which states that it is consistence with Einstein's hypothesis. It is amazing! Hypothesis of constancy of light velocity gets the mathematic prove in the calculation of horizontal wave velocity. We once cheered for it! So, in the horizontal direction, $d = \Delta t_1 c_0$, no matter $\boldsymbol{u}$ is in $+x$ direction or $-x$

direction, $d = c_0 \Delta t_1$, and the time difference between back and forth is $t_1 = \Delta t_1 + \Delta t_1 = \frac{2d}{c_0}$.

2) For vertical beam b_2. The velocity of light beam detected by dynamic system (Ether coordinate system moving at the velocity of $-\boldsymbol{v}$) is:

$$u_x^{'} = 0, \quad u_y^{'} = c_0, \quad u_z^{'} = 0 \tag{6}$$

While using velocity transformation formula (3) of Einstein to calculate, the light velocity detected by static system (interferometer coordinate system) is:

$$u_x^{'} = 0, \quad u_y = \frac{u_y^{'}\sqrt{1-\beta^2}}{1+\frac{\beta}{c_0}u_x^{'}} = \frac{c_0\sqrt{1-\beta^2}}{1+\frac{\beta}{c_0}0} = c_0\sqrt{1-\beta^2}, \quad u_z^{'} = 0 \tag{7}$$

The problem is revealed. The motto of relativity is "Physical essence which is vertical to the direction of movement is unchangeable". But now there happens a problem: light velocity which is vertical to the direction of movement changes to $u_y = c_0\sqrt{1-\beta^2}$. So the result is $\Delta t_2 = \frac{d}{c_0\sqrt{1-\beta^2}}$, and required time of back and forth is $t_2 = \frac{2d}{c_0\sqrt{1-\beta^2}}$.

3) Relativity is not consistence with zero result of the experiment. According to special relativity, time difference of the two light velocities on the interferometer is:

$$\Delta t = t_2 - t_1 = \left[(\frac{2d}{c_0\sqrt{1-\beta^2}}) - (\frac{2d}{c_0}) \right] = \frac{2d}{c_0}\left[\frac{1}{\sqrt{1-\beta^2}} - 1 \right] \approx \frac{d}{c_0}\beta^2 \tag{8}$$

So the optical path difference watched by interferometer is $\delta = d\beta^2$. Relativity states that "All the light velocities detected by inertial system are c_0" by word language, from the appearance, it explains the zero result of Michelson-Morley experiment, but it can not explain it when using mathematic language (velocity transformation formula of two coordinates) to calculate.

Our well-loved Einstein, you said that light velocities detected by either two inertial systems were c_0, but you did not mention the static system, according to our will: suppose light velocity detected by Ether coordinate system (moving at the velocity of $-\boldsymbol{v}$) is $u_x^{'} = c_0$, the parallel light velocity is $u_x = c_0$. We once were excited and happy, but when we use the same idea and theory as yours to calculate vertical light beam, the zero result of interferometer experiment can not be explained by your idea and theory.

4 Galilean Principle of Relativity is Consistent with Experiment Conclusion

Article 2 proves the principle of light velocity superposition: in the vacuum, light wave doesn't have any oscillation medium to propagate and the mass of light field is zero, the movement of light field need not any force, so light movement is a kind of radiation, it is a constant $\boldsymbol{c}_0$ relative to radiation velocity of light source. It's a relative velocity, not an absolute velocity. It complies with the principle of light velocity superposition, when there is a relative velocity $\boldsymbol{v}$ between light

source and observer, the relative velocity detected by observer is $\boldsymbol{c} = \boldsymbol{c}_0 + \boldsymbol{v}$.

Article 2 re-explains the zero result of Michelson-Morley experiment.

4.1 Parallel movement condition of light beam b_1 is shown in figure 2 and figure 3

In order to clear the concept, we analyze one by one, as shown in figure 2 and figure 3. Dotted scale is absolute static system, and observer in the absolute space is selected as the static system person; because the earth is always moving, so measuring instrument in the earth is selected as the dynamic system person. The analysis is as follows.

1) Velocity of light source movement is contrary to light velocity, as shown in figure 2. Static system person (Ether person) watches the earth and interferometer moving at the velocity of v in the absolute space.

When $t = 0$, light source o launches a photon (or the first wave), suppose the radiation velocity of wave crest relative to light source is c_0, because the light source is moving, so the light velocity measured by static system person (Ether person) is c_1. According to Galilean principle of relativity, the absolute light velocity watched by static system person is:

$$c_1 = c_0 - v \tag{9}$$

Where c_0 is the relative light velocity watched by instrument, light source and observer. c_1 is the light velocity measured by static system person (Ether person).

When $t = \Delta t$, the first wave crest (photon) hits the reflector M_1. At this moment, the absolute route of reflector M_1 and light source o in the static system is $L = v\Delta t$, but the absolute route of the first wave crest (photon) in Δt is:

$$L_O = d - L \tag{10}$$

Where d is the relative route watched by instrument, light source and observer.

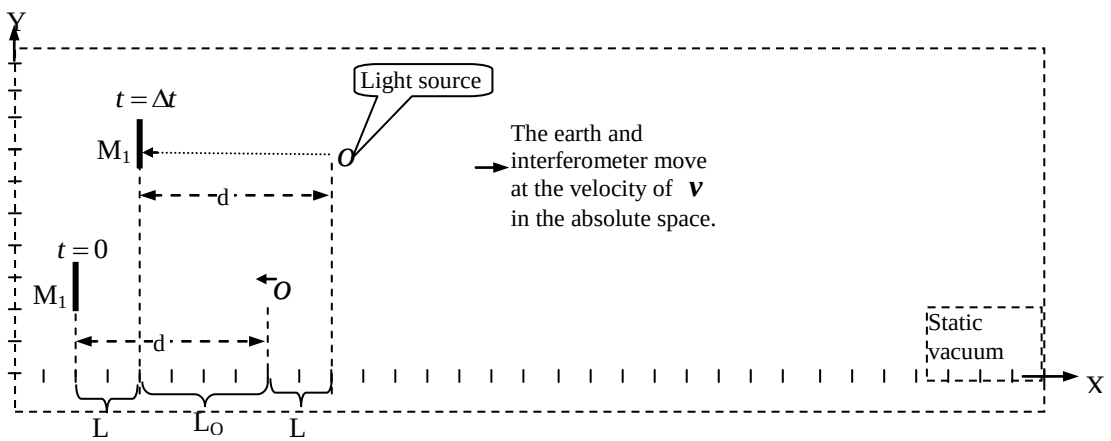


Figure 2 The movement direction of light radiation and light source is opposite, and static system person calculates the light velocity

Multiplying formula (9) by Δt gets the result $c_1\Delta t = c_0\Delta t - v\Delta t$, and comparing it with formula (10) gets the result:

$$\begin{aligned} L_o &= c_1\Delta t \\ d &= c_0\Delta t \\ L &= v\Delta t \end{aligned} \tag{11}$$

So the result measured by dynamic system person (instrument, light source and observer) is $d = c_0\Delta t$. This is Galilean principle of relativity, and c_0 is the relative radiation velocity.

2) Velocity of light source movement is contrary to light velocity, as shown in figure 3. Static system person (Ether person) watches the earth and interferometer moving at the velocity of v in the absolute space.

When $t = 0$, light source o launches a wave crest, suppose the radiation velocity of wave crest (relative velocity) relative to light source is c_0, because the light source is moving, so the light velocity measured by static system person (Ether person) is c_2. According to Galilean principle, the absolute light velocity watched by static system person (Ether person) is:

$$c_2 = c_0 + v \tag{12}$$

When $t = \Delta t$, the first wave crest (photon) hits the reflector M_1. At this moment, the absolute route of reflector M_1 and light source o in the static system is $L = v\Delta t$, but the absolute optical path of the first wave crest (photon) in Δt is $L_O = L + d$. Although the light velocity watched by Ether person is c_1, the result measured by interferometer is:

$$d = \Delta t \cdot c_0 \tag{13}$$

So, although the light velocity watched by Ether person is c_1, the light velocity measured by interferometer is c_0, optical path is still d.

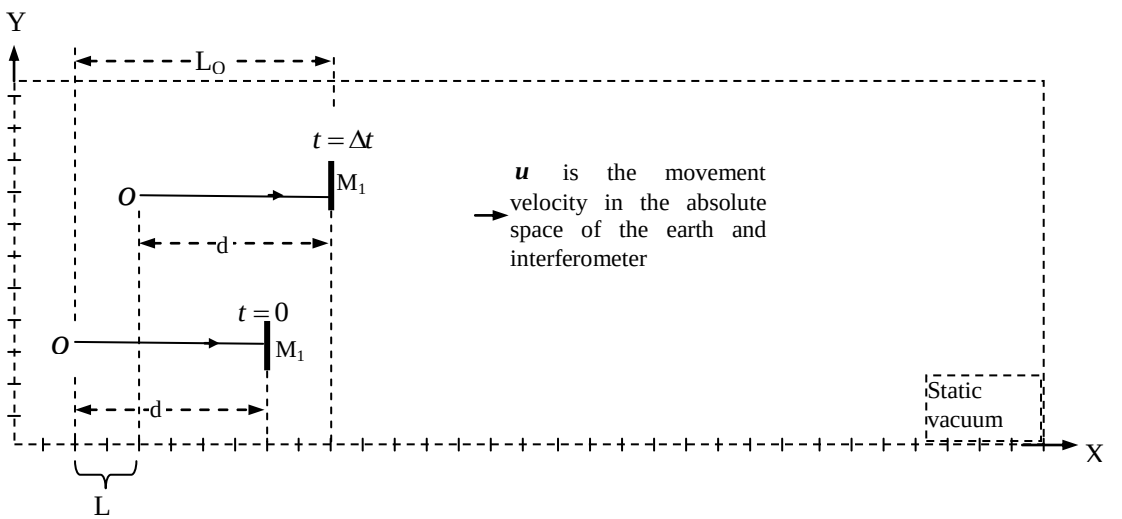


Figure 3 The movement direction of light radiation and light source is the same, and static system person calculates the light velocity

From figure 2 and figure 3, we can know it clearly: light velocity c_0 is a relative velocity relative to light source, but not the absolute velocity in the Ether-medium, when calculating, it complies with Galilean principle. For example, the time that a bullet fired at the stem hit the stern target is equal to the time that a bullet fired at the stern hit the stem target, this is Galilean principle of relativity.

4.2 Vertical movement condition of light beam is shown in figure 4 and figure 5

1) When light source moves in X direction, light wave radiates in +Y direction. When $t=0$, light source o launches a photon in +Y direction, as shown in figure 4. Because c_0 is the relative velocity relative to light source, but not the absolute velocity in the Ether-medium, so the light velocity watched by dynamic system person (interferometer) is c_0, but the vector of light velocity watched by static system person (Ether person) is $\boldsymbol{c}=\boldsymbol{c}_0+\boldsymbol{v}$ (light source is moving). Through parallelogram rule of the principle of vector superposition and Galilean principle of relativity, the amplitude of light velocity is:

$$c=\sqrt{c_0^2+u^2} \tag{14}$$

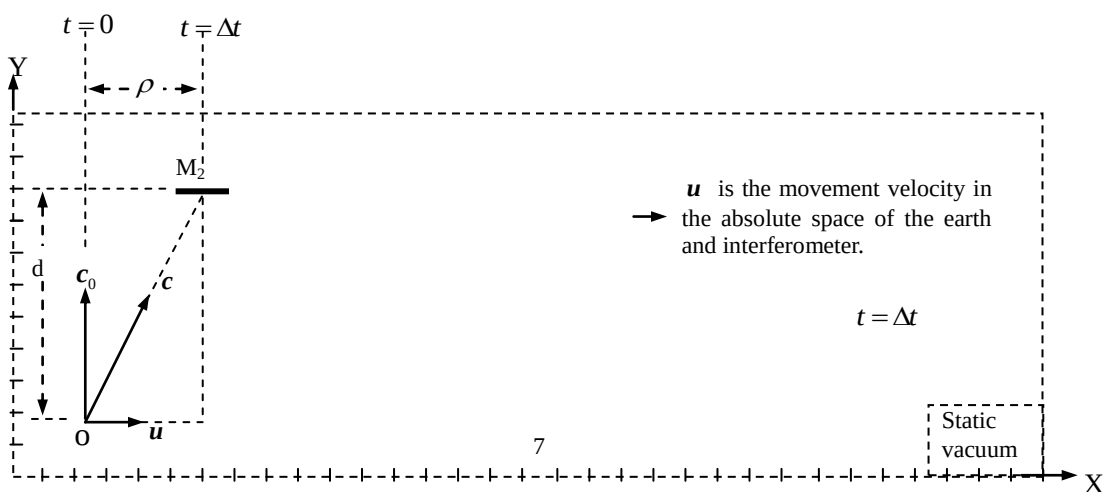
When $t=\Delta t$, the light wave hits the reflector M_1. At this moment, the route of reflector M_1 and light source o in the absolute space is $\rho=u\Delta t$, but the route of light wave crest in the absolute space is:.

$$\overline{OM_2}=c\Delta t=\sqrt{c_0^2+v^2}\cdot\Delta t=\sqrt{(c_0\Delta t)^2+(v\Delta t)^2} \tag{15}$$

Notice: $\overline{OM_2}$ is slope distance of the first wave crest in Δt, through Pythagorean theorem, we can get the result $\overline{OM_2}=\sqrt{d^2+\rho^2}$, so

$$d=c_0\Delta t \tag{15}$$

Where $d=c_0\Delta t$ is the result measured by dynamic system person (interferometer). They are different two concepts. [Notice: when $t=0$, M_2 is right above O in the figure; when $t=\Delta t$, light source is in the position of M_2.]



2) When light source moves in X direction, light wave radiates in -Y direction. As shown in figure 5, when $t=0$, light source o radiates a light wave in -Y direction, and the vector of light velocity watched by static system person (Ether person) is $\boldsymbol{c}=\boldsymbol{c}_0+\boldsymbol{v}$. Through the principle of vector superposition or Galilean principle of relativity, the amplitude of light velocity is:

$$c=\sqrt{c_0^2+v^2} \qquad (16)$$

When $t=\Delta t$, the light wave hits the reflector M_2. At this moment, the route of light source o and reflector M_2 is $\rho=u\Delta t$, and the route of light wave crest in the absolute space in Δt is:.

$$\overline{oM_2}=c\Delta t=\sqrt{c_0^2+v^2}\cdot\Delta t=\sqrt{(c_0\Delta t)^2+(v\Delta t)^2} \qquad (17)$$

Through Pythagorean theorem, we can get the result $\overline{OM_2}=\sqrt{d^2+\rho^2}$, and compare with formula (17):

$$d=c_0\Delta t \qquad (18)$$

Where $d=c_0\Delta t$ is the result measured by dynamic system person (interferometer). [Notice: when $t=0$, M_2 is right below O in the figure; when $t=\Delta t$, light source is in the position of M_2.]

From figure 4 and figure 5, we can know it clearly: light velocity c_0 is the relative velocity relative to light source, but not the absolute velocity in the Ether-medium. Although the light velocity watched by static system person (Ether person) is $c=\sqrt{c_0^2+u^2}$, the light velocity measured by dynamic system person (interferometer) is still c_0.

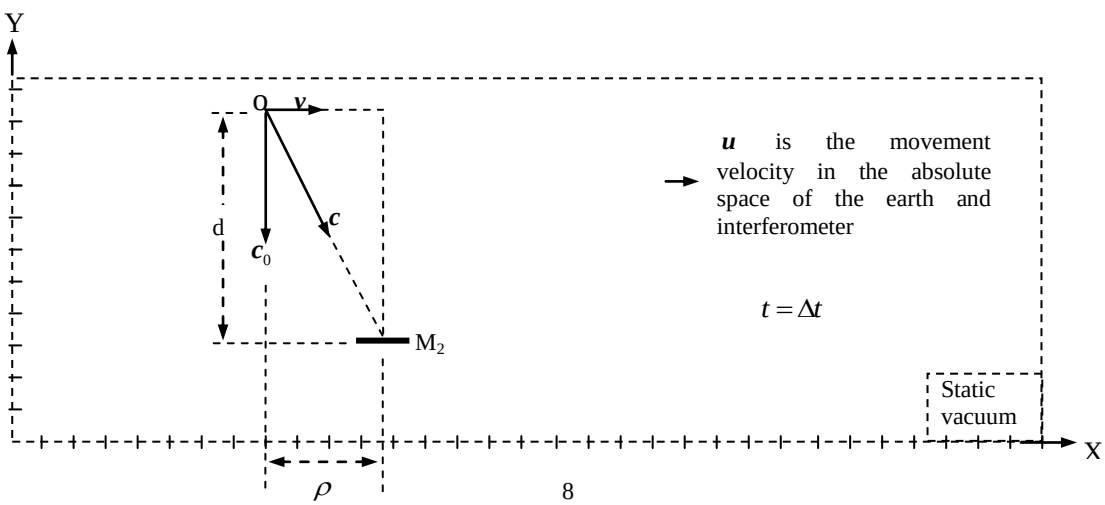


Figure 5 Light wave radiates in the -Y direction, and static system person calculates the light velocity

5 Zero Result of Experiment is the Certain Result of Galilean Principle of Relativity

In short, we get the conclusion that no matter the radiation direction of light wave is vertical or parallel to the movement direction of light source, as long as reflector does not have relative movement with light source, the optical path is $d = c_0 \Delta t$, d is the distance from light source to reflector, c_0 is the relative velocity of light radiation relative to light source, Δt is the time that radiation of light source reaches to the reflector.

Notice: above exploded view 2 ~ 5 are Michelson-morle experiment figures. Now, let's check the time difference between two light beams, that is to analyze the physical essence of Michelson-morle experiment. Two light beams b_1 and b_2 will go through the same route $S \to M$ and $M \to \mathrm{e}$, so the same route need not calculated. Besides that, readers should notice: reflection is the second radiation launched by light source (hit the reflector), so the light source of reflecting light is reflector. According to the analysis of figure 2 ~ 5, we get:

1) Light beam b_1: although the movement direction of light source is parallel to the radiation direction of light wave and the light velocity watched by Ether person is $c_0 \pm v$, $\boldsymbol{c}_0$ is the relative velocity of light source but not the absolute velocity, so the single optical path measured by the dynamic system (interferometer) is still $d = c_0 \Delta t$, as shown in figure 2 and 3. The required time of back and forth is:

$$t_1 = \frac{d}{c_0} + \frac{d}{c_0} = \frac{2d}{c_0} \tag{19}$$

2) Light beam b_2: although the dynamic system (interferometer) moves in traverse direction of light beam (slope movement in absolute space) and the light velocity watched by static system (Ether) is $c = \sqrt{c_0^2 + v^2}$, because light source o and reflector M_2 move transversely with the earth, and the relative velocity of light source o and measurer M_2 is $v = 0$, so the single optical length measured by dynamic system (interferometer) is still $d = c_0 \Delta t$, as shown in figure 4 and 5. The required time of back and forth is:

$$t_2 = \frac{d}{c_0} + \frac{d}{c_0} = \frac{2d}{c_0} \tag{20}$$

Compare formula (19) and (20), time difference between the two light passes into the eye is $\Delta t = t_1 - t_2 = 0$, and the optical path difference measured by interferometer is $\delta = 0$. No matter which season is and how the interferometer rotates, because $\delta \equiv 0$, the optical path difference is always zero and interference fringes do not exist. This is the certain result calculated by Galilean principle of relativity.

Notice: $\boldsymbol{c}_0$ is the relative velocity of light source, but not the absolute velocity of Ether-medium oscillation and propagation. This is the key point. As long as there is no relative movement between light source and measurer, $d = c_0 \Delta t$, This is the certain result that light velocity obeys Galilean principle of relativity.

From this explanation, we have enough reason to understand the experiment: Michelson-morle experiment proves the suitability of Galilean principle of relativity. Besides it, the fact that light beam b_2 can hit the centre of M_2 further proves that light radiation has lateral stiffness. From another point, the fact that vertical light beam can hit the centre of M_2 proves that light wave is not dragged by Ether, which means Ether does not exist.

Pay special attention to: the light velocity measured by static system (Ether) is $\boldsymbol{c} = \boldsymbol{c}_0 + \boldsymbol{v}$, the optical path measured by dynamic system (interferometer) is $d = c_0 \Delta t$. Because there is no relative movement between light source and measurer, the light velocity measured by dynamic system (interferometer) is $\boldsymbol{c}_0$, and he light velocity measured by static system (Ether) is $\boldsymbol{c} = \boldsymbol{c}_0 + \boldsymbol{v}$. According to Galilean principle of relativity, the optical path measured by earth person (interferometer) is $d = c_0 \Delta t$.

6 Conclusion

This article points out: 1. Principle of constancy of light velocity can not explain the zero conclusion of Michelson-morle experiment, 2. Galilean principle of relativity is capable to explain the zero conclusion of Michelson-morle experiment, 3. Light velocity is relative to light radiation, it is a relative velocity, but not the absolute velocity in "Ether".

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