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The Truth of the Experiments of Invariable Speed of Light in Special Relativity

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Abstract

It is pointed out that the most experiments on the invariant speed of light in special relativity proves the round-trip invariant speed of light, not one-way invariant. This paper makes a distinction between them. The Michelson-Morley experiment and the experiment of high-energy particles emitting photons and so on are the round-trip experiment of light's speed, showing that the average speed of light is a constant. But the Sagnac effect experiment, the Michelson-Gale's experiment that the earth's rotation effects the speed of light, and the satellite signal propagation between China and Japan are the one-way experiments of light's speed, showing that the speed of light is variable, satisfying the Galilean velocity addition rule. The orbit shape changes of binary stars and the phenomenon of charm stars cannot be observed due to that the calculated observing directions are different from the practical observing direction for the observers on the Earth. The Fizeau water flow experiment and the Sagnac experiment are combined to prove that the rotation of optical fiber would affects the speed of light. The problem that the Sagnac effect is independent of the refractive index of optical fiber is explained well. It is proved that the Sagnac effect formula derived from special relativity is consistent with that derived from classical mechanics when the optical fiber's refractive index $n=\sqrt{2}$. When $n=1$, there is no the Sagnac effect according to special relativity. While according to classical mechanics, there is the Sagnac effect. The original experiment of Sagnac effect in 1913 was carried out in atmosphere with $n\approx 1$. Therefore, the original Sagnac experiment became a judgment experiment. It certainly jugated that the velocity of light satisfied the Galilean addition rule rather than the Lorentz transformation formula.

Keywords: special relativity, invariable principle of light's speed, Galilean velocity addition rule, Lorentz velocity transformation, Michelson-Morley experiment, Michelson-Gale experiment, Sagnac experiment, Fizeau water flowing experiment

1. Introduction

It is well known that the most important experimental basis for Einstein's special relativity is the Michelson-Morley experiment (M-M experiment). In order to explain the zero result of the experiment, Lorentz proposed the famous Lorentz coordinate transformation. Then Einstein put forward the principle of special relativity and the invariable principle of light's speed in 1905, establishing special relativity.

However, the authors published two papers in Applied Physics Research in 2023, to prove that the Michelson-Morley experiment was invalid and denied the legitimacy of the Lorentz transformation formula. The most important theoretical and experimental basis of Einstein's special relativity are falsified (Mei Xioachun, Yuan Canlun, 2023).

It is pointed out in the first paper that the calculation of the M-M experiment was wrong. Michelson fixed the light source on the absolutely stationary reference frame of the universe (or the ether reference frame) in the calculation of the M-M experiment. However, in the actual experiments, the light source was fixed on the earth motion reference frame and moved and rotated with the interferometer, leading to the invalidity of the M-M experiment's experiment.

If the light source is fixed on the moving reference frame of the earth and the Galilean velocity transformation formula is adopted, the zero result of the M-M experiment can be explained and the Lorentz transformation formula is unnecessary at all.

If Michelson had done his calculation correctly in early years, there would have been neither the first dark cloud in the history of physics, no Einstein's special relativity, and there would be no later general relativity!

The second paper proves that the mass velocity formula of special relativity cannot be derived by using the Lorentz velocity transformation formula, and therefore Einstein's famous mass-energy relationship cannot be obtained. All deductions of the mass velocity formula in special relativity are cobbled together artificially and meaningless. The mass-velocity formula can only be regarded as an empirical formula, not be deduced theoretically.

Therefore, the most important two equations of Einstein's special relativistic dynamics, the mass- velocity formula and the mass-energy formula actually have nothing to do with relativity. If they are correct, Einstein's special relativity is wrong.

This paper goes on to discuss the experiments of special relativity on the invariable speed of light, as well as the experiments that special relativity cannot explain. According to the observation facts of cosmic microwave background radiation, the absolute rest reference frame of the universe is introduced, and the speed of light in the absolute rest reference frame of the universe is defined as the light's speed c in vacuum.

When measured on the earth's surface, one-way speed of light is related to the Earth's moving speed, which is not a constant, satisfying the Galilean addition rule of velocities. But the round-trip speed of light has nothing to do with the earth's motion speed and is still an invariant.

In this way, all the experiments in special relativity, such as the Michelson-Morley experiment, the speeds of photons radiated by high-energy particles, can be reasonably and uniformly explained without using the Lorentz velocity transformation formula. It can also explain experiments that special relativity cannot explain, such as the Sagnac experiment, the M-G experiment and the time difference experiment of satellite signal transmission between China and Japan.

As for the invisibility of the deformation of visual orbit of binary star and the charmed star, it is due to that the calculated observing directions on the x-y plane are different from the practical observing direction on the z axis for the observer on the Earth, all of them are not observable.

The Fizeau flow experiment is also connected with the Sagnac effect experiment, and it is proved that the rotation of fiber medium will affect the speed of light. A history left problem that the change of interference fringe of light in the Sagnac effect has nothing to do with the refractive index of fiber is explained.

According to the current theory, the Sagnac effect experiment is a non-inertial system, which cannot be explained by special relativity so that general relativity is needed. Based on Lorentz velocity transformation formula, the Sagnac effect formula of special relativity in optical fiber medium is derived in this paper. It is proved that the result is the same with that derived from classical mechanics when the Fizeau effect is considered and the refractive index of fiber is $n=\sqrt{2}$, general relativity is unnecessary.

However, when $n\neq\sqrt{2}$, the calculation results of classical mechanics and special relativity are different. We can distinguish them through experiments. Especially, when $n=1$, there is no the Sagnac effect according to special relativity. While according to classical mechanics, there is the Sagnac effect. The original Sagnac effect experiment in 1913 was performed in air with $n\approx 1$ and the optical loop formed by several mirrors. So, the original Sagnac experiment becomes a judgment experiment to prove that the speed of light satisfies the Galilean addition rule rather than the Lorentz transformation formula.

In 1925, Michelson and Gale carried out an experiment on the effect of the Earth's rotation on the speed of light (the M-G experiment) in the suburbs of Chicago, USA. The experiment measured the Earth's rotational angular speed, or the tangential motion speed of the Earth's surface. The results of the experiment, contrary to the Michelson-Morley experiment, proved that the rotation speed of the earth could be measured, and the speed of light was not constant on the earth's surface. But because it was contrary to special relativity, the existing textbooks and literature do not mention this experiment.

It is pointed out in this paper that the M-G experiment is actually an amplified Saganc effect experiment which also measures the one-way variable speed of light. The result is fundamentally different from the M-M experiment.

The M-M experiment is compared with the Sagnac effect experiment. It is pointed out that the M-M experiment is a round-trip experiment, showing that the average speed of light is a constant. However, the Sagnac effect is a one-way experiment, showing the variable speed of light. In the experiment, two beams of light moving in opposite directions travel a complete circle and return to the starting point for interference. Before returning to the starting point, the direction of circular motion does not change.

This perfectly explains why the basic principle and the measurement method of two experiments are the same, but the M-M experiment has no the change of interfere fringes, while the Sagnac experiment has the change of interfere fringes.

Therefore, this paper further proves that physics requires neither the Lorentz coordinate transformation formula nor the Einstein's principle of invariable speed of light.

2. The Propagation Speed of Light

2.1 The Images of Invariable Speed of Light in Special Relativity

The most basic formula of special relativity is the Lorentz coordinate transformation, which has a perfect symmetry. As shown in Figure 1, the reference frame K is assumed to be stationary in vacuum, and the reference frame K' moves along the $x-$axis to the right side at a uniform speed V relative to the reference frame K. Suppose that at the initial moment $t_0=0$, when the origins O and O' of two reference frames coincide, a light wave is emitted from the origins of coordinate system with the propagation speed c. For the reference frame K', the Lorentz coordinate transformation formula is

$$x'=\frac{x-Vt}{\sqrt{1-V^2/c^2}} \qquad y'=y \qquad z'=z \qquad t'=\frac{t-Vx/c^2}{\sqrt{1-V^2/c^2}} \tag{1}$$

But for the reference frame K, the Lorentz coordinate transformation formula is

$$x=\frac{x'+Vt'}{\sqrt{1-V^2/c^2}} \qquad y=y' \qquad z=z' \qquad t=\frac{t'+Vx'/c^2}{\sqrt{1-V^2/c^2}} \tag{2}$$

The Lorentz speed transformation formula is

$$u'=\frac{u-V}{1-uV/c^2} \qquad \text{or} \qquad u=\frac{u'+V}{1+uV/c^2} \tag{3}$$

According to Eq.(3), for the both reference frame, the speed of light is a constant c, or the speed of light has nothing to do with the speed of light source.

For an observer at rest in the reference frame K, the wave front of light wave arrives at the spherical surface with radius $R=ct$ at arbitrary moment t as shown in Figure 1. At this time, the origin O' of the reference frame K' moves to the position O'. Thus, according the observer at rest in K, the wave front of light observed by the observer in K' is not a spherical surface.

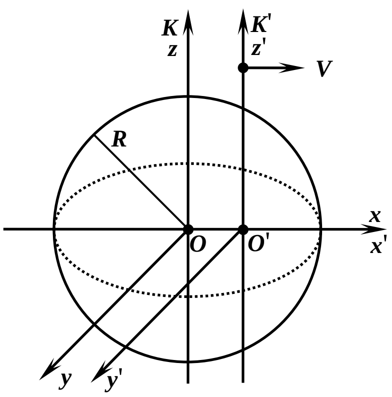

Figure 1. Image 1 of invariable speed of light

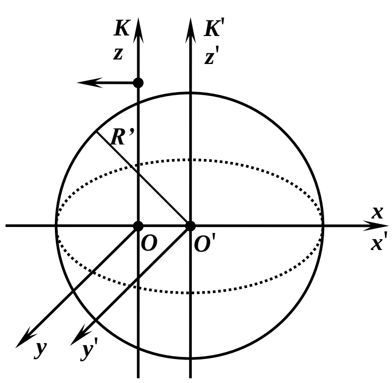

Figure 2. Image 2 of invariable speed of light

However, for the observer at rest in K', the situation is just opposite. The wave front of light arrives at the spherical surface with radius $R' = ct'$ at time t' as shown in Figure 2. At this time, the origin O of K moves to the position O. Thus, according the observer in K', the wave front of light observed by the observer in K is not a spherical surface.

This picture of special relativity is very grotesque and completely odd with human common sense and basic logic. In order to explain this picture, Einstein had to propose the hypothesis of simultaneous relativity, which declared that what appeared simultaneously to an observer in the reference frame K (the wave front is a spherical surface) did not appear simultaneously to another observer in the reference frame K' (the wave front is not a spherical surface).

The viewpoint of other observer in the reference frame K' was opposite. He thought that the wave front of light was a sphere surface, but the observer in the reference frame K thought that the wave front of light was not a spherical surface.

It is proved in the author's paper that Lorentz coordinate transformation is not only unnecessary but also impossible (Mei Xiaochun, Yuan Canlun, 2023), the images in Figure 1 and Figure 2 cannot be true.

In fact, as Qi Ji had pointed out that if the speed of light in Eqs.(1), (2) and (3) were replaced by the speed c_w of water wave or sound wave, there were the similar Lorentz transformation formula of water wave or sound wave with (Qi Ji, 1993).

$$x' = \frac{x - Vt}{\sqrt{1 - V^2 / c_w^2}} \qquad y' = y \qquad z' = z \qquad t' = \frac{t - Vx / c_w^2}{\sqrt{1 - V^2 / c_w^2}} \tag{4}$$

$$x = \frac{x' + Vt'}{\sqrt{1 - V^2 / c_w^2}} \qquad y = y' \qquad z = z' \qquad t = \frac{t' + Vx' / c_w^2}{\sqrt{1 - V^2 / c_w^2}} \tag{5}$$

As well as the Lorentz velocity transformation formula for water wave or sound wave

$$u' = \frac{u - V}{1 - uV / c_w^2} \qquad \text{or} \qquad u = \frac{u' + V}{1 + uV / c_w^2} \tag{6}$$

Where V is the speed of the source of water wave or sound wave. It can also be concluded from Eqs.(4) ~ (6) that the speed of water wave and sound wave are also invariable and limited. The speed of an object cannot exceed the speed of water wave and sound wave, as well as there are the time delay and the length contraction related to water wave or sound wave. The relativity theories of water wave and sound wave can also be established. It is obvious that all of these are absurd.

2.2 The Speed of Light in the Absolutely Stationary Reference Frame of the Universe

We know that sound wave and water wave need a medium for propagation. According to modern physics, light is considered to have wave-particle duality. According to classical electromagnetic theory, light is electromagnetic wave, but it can travel through vacuum without the involvement of medium. In physical history, the ether was considered to exist as a medium through which light traveled. The existence of the ether, however, cannot be verified experimentally and would cause serious problems in physics.

The ether theory was abandoned since Einstein proposed special relativity, but this did not mean that the absolutely stationary reference frame did not exist. The cosmic microwave background radiation (CMB) was discovered in the 1960s. After that, it has been observed to deviate from the black-body radiation spectrum. Because CMB is measured on the Earth's reference frame, based on the deviations from the black-body spectrum, physicists calculates that the reference frames of the sun or the Earth are moving in the direction of right longitude $1^h.5 \pm 0^h.4$ and declination $0.^0 2 \pm 7^0$ in the celestial reference frame at a speed about $390 Km/s$ (Tan Zhansheng, 2007). This velocity can be regarded as the absolute motion velocity of the solar or the Earth reference frame relative to the absolute stationary reference frame of the universe (called the cosmic absolute reference frame).

It is known that the propagation speed of light in vacuum is a constant c. The refractive index of atmosphere on the earth surface is 1.0003, and the light’s vacuum refractive index $n = 1$. The motion of light in the cosmic reference frame is equivalent to the motion of light in vacuum with $n = 1$. In the non-vacuum condition, the speed of light is less than c. We need to discuss the motion of light in various non-vacuum media. Especially in the Fizeau flow experiment and the Sagnac effect in optic fiber, it is necessary to consider the influence of the motion state of medium on the speed of light.

2.3 The Relationship Between the Speed of Light and the Speed of Observer

According to the light speed invariant principle of special relativity, the propagation speed of light is not only independent of the speed of light source, but also independent of the speed of observer. In fact, Eq.(3) does not consider whether V is the speed of light source or the speed of observer. According to special relativity, it is indistinguishable for both situations that light source is stationary and observer is moving, or observer is stationary and light source is moving.

In classical physics, however, these two cases are different. There are two ways to observe the speed of a wave. One is that the observer is stationary and the wave source is moving. The other is that the wave source is moving and the observer is stationary. In these two cases, the propagation speed of wave may be different. For example, when the observer is at rest, the speeds of water wave and sound wave are independent of the speeds of wave sources. If the source is stationary and the observer is moving, the observed propagation speed of wave is related to the speed of observer.

In fact, the speed of light is related to whether the essence of light is a particle or a wave. If light is essentially a particle, then according to the theory of light emission, the speed of light is related to the speed of light source. No matter what the essence of light is, this paper mainly points out that the speed of light must be related to the speed of observer. The assertion of special relativity that the speed of light is independent of the speed of observer is impossible to hold.

3. The Experiments of Round-trip Invariable Speed of Light

3.1 The Invariable Round-trip Speed and the Variable One-way Trip Speed of Light

According to the current understanding of special relativity, the constant speed of light has been fully verified in experiments. However, as Zhang Yuanzhong pointed out (Zhang Yuanzhong, 1994), what these experiments tested were the round-trip speed of light, rather than the one-way trip speed. Whether or not the speed of light is a constant in one-way trip is still an unsolved problem.

The reason is that for the measurement the one-way trip speed of light, we first have to calibrate two clocks at different places. However, calibrating clocks requires light signals, which requires knowing the speed of light in advance, so it gets stuck in a logical loop. If we measure the round-trip speed of light, in principle we only need a clock and a mirror to realize light. However, because the speed of light is so fast, it is difficult to make a one-way trip measurement of light's speed within a limited distance on the Earth's surface.

As discussed above and shown in Figure 3, assuming that the source of light is fixed on the cosmic absolute reference frame, the speed of light measured in the cosmic absolute reference frame is $\vec{c}$. The Earth's reference frame is moving at a velocity $\vec{V}$. When observed in the Earth's reference frame, the velocity of light is $\vec{c}'$.

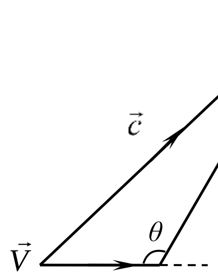

Figure 3. The light's velocities in the cosmic absolute reference frame and the Earth's moving reference frame

According to the Galileo's addition rule of velocity, there is a relation $\vec{c}' = \vec{c} + \vec{V}$. Suppose that the angle between $\vec{c}'$ and $\vec{V}$ is θ, we have

$$c^2 = c'^2 + 2c'V\cos\theta + V^2 \tag{7}$$

When $\theta = 0$, we have $c' = c - V < c$ .When $\theta = \pi$, we have $c' = c + V > c$. So the velocity of light measured on the Earth's surface is not a constant, but superimposed by the velocity of the Earth's reference frame.

As measured on the Earth's surface, the speed of light is $c' = 299792500 \pm 100 s/m$, and physics defines the speed of light in vacuum as $c' = 299792458 m/s$. This value does not take into account the absolute velocity of the Earth in the cosmic absolute reference frame, so the true vacuum speed of light needs to be corrected according to Eq.(7).

Regard $\vec{V}$ be the velocity of light's source relative to the Earth's surface, $\vec{c}'$ be the light's velocity when the light's source is at rest, and $\vec{c}$ be the velocity when the light's source is moving. The around-trip speed of light is to equal to take θ and $\theta + \pi$ in Eq.(7). Due to $c' >> V$, we can write Eq.(7) as

$$c \sim c_1 = c'\sqrt{1 + \frac{1}{c'}V\cos\theta + \frac{V^2}{c^2}} \approx c'\left(1 + \frac{1}{2c'}V\cos\theta\right) \tag{8}$$

and

$$c \sim c_2 = c'\sqrt{1 - \frac{1}{c'}V\cos\theta + \frac{V^2}{c^2}} \approx c'\left(1 - \frac{1}{2c'}V\cos\theta\right) \tag{9}$$

The average value of two measurements is

$$\frac{c_1 + c_2}{2} = c' \tag{10}$$

The measurement of round-trip speed of light cancels out the effect of the Earth's speed and gives a fixed value of $c' = 299792500 \pm 100 m/s$.

3.2 The M-M Experiment

The authors have proved that Michelson's calculation on the M-M experiment was wrong (Mei Xiaochun, Yuan Canlun, 2023). He fixed the light source on the cosmic reference frame. However, in the practical experiments, the light source was always fixed on the motion reference frame of the Earth rotating with the Michelson's interferometer, resulting in the failure to explain the zero result of the M-M experiment.

The M-M experiment is obviously a round-trip experiment of light, in which the light source is fixed on the interference in the Earth laboratory. Two beams of light are sent from the center point of the spectroscope, travel some distance, are reflected by the mirrors and then return to the center point of the spectroscope in the opposite directions. This is equivalent to measuring the time for light to travel at an average speed. The result is equivalent to that the speed of light is a constant so that no change of interference fringes is founded.

According to the authors' calculations (Mei Xiaochun, Yuan Canlun, 2023), for the observer at rest in the cosmic absolute reference frame, the Galilean velocity addition rule $c = c' \pm V$ is considered. Here c' is the speed of light measured by the Earth observers when the light source is stationary in the Earth lab, c is the light's speed measured in the cosmic absolute reference frame. If the arm length of the interferometer is l, and the light propagates along the transverse arm of the interferometer, the time in the round-trip of light is $\Delta t_1 = 2l/c'$.

When light travels along the longitudinal arm of interferometer, it is calculated that time in the round-trip of light is $\Delta t_2 = 2l/c'$, so we have $\Delta t_1 = \Delta t_2$. When the interferometer is rotated 90 degrees, there is no shift of interference fringe. Although the Earth's motion speed V is taken into account in the calculation, it does not appear in the final time difference formula, which indicates that the M-M experiment precisely reveals that the round-trip speed of light does not change, and the average speed of light is c'.

The paper also proves that if the Galileo's principle of relativity holds, it is impossible for an observer on the Earth's reference frame to observe the Earth's moving velocity in the cosmic absolute reference frame through the Michelson experiment.

Because of the existence of the cosmic absolute reference frame, the relativity principle is also invalid. An observer at rest on the Earth's reference frame should also consider himself moving absolutely in the cosmic absolute reference frame. The calculation result on the cosmic absolute reference frame is also the observation result on the earth reference frame. The M-M experiment on the Earth's surface is unable to find the shift of interference fringe.

3.3 The Speeds of Photons Radiated by High-energy Particles

In the processes that high-energy charged particles traveled at high speeds and slowed down by bombarding the nucleus of medium, leading to Bremsstrahlung radiation (D. Luckey, J. W. Weil, 1952), electron annihilation (D. Sadch, 1963), and particle π^0 decay emitting photons (T. A., Fillippas, J. G. Fox, 1964), the measurements indicated that the speed of γ rays were independent of the speed of particles.

It was analyzed that this kind of experiments measured the round-trip speed of light, and did not prove that the one-way speed of light was a constant (Zhang Yuanzhong, 1994). For example, in the Sadch experiment (D. Sadch, 1963) and the T. Alvager's experiment (T. Alvager, et., 1964), the path of ray and the path of detector device formed a closed loop, and what finally measured was the average speed of photon in the closed loop, and did not prove that the one-way speed of light was invariable.

In addition, we need to understand the mechanism of bremsstrahlung. The essence of bremsstrahlung is that the high-speed electrons in the nuclear electric field are rapidly decelerated by a force of positive charge, resulting in the release of energy. So, the speed of electron at the moment of radiation has actually been greatly reduced and can actually be considered to be moving at a low speed. The superposition of moving electron's speed can be ignored.

In the same way, when two electrons annihilate and particles decay to produce a ray, the speed of its mass center are very low, otherwise it would be impossible to radiate high-energy photons according to the conservation of energy, so we can ignore the effect of particle's speed on the speed of ray.

3.4 The Cedarholm Experiment, the Ciladea Experiment and the Mossberg Experiment Did Not Measure the Speed of Light Actually

The Cedarhole's experiment measures the ether drift velocity by measuring the flight of molecular beams in the ammonia cavity (T. Alvager, et., 1958). In the Ciladea's experiment, two lasers were mounted on opposite sides of a rotating table to measure the drift speed of the ether (R. Cialden, 1972). The Mossbauer's experiment measured the velocity of the Earth's reference system with respect to the ether by placing ray and ray absorber at the center and the edge of the rotor (D. C. Champeney, P. B. Moon, 1961; 1972). The results of these three experiments are close to zero, which proves that the ether drift velocity is negligible.

These experiments do not actually measure the speed of light, but rather the second-order Doppler effect, i.e., the effect of relativistic time delay factor on the frequency of light (Zhang Yunazhong, 1995). The experiments indicated that the second-order effects caused by the Lorentz transformation formula were so small that they could actually be considered non-existent by taking into account the experimental errors.

4. The Problems of the Visual Orbit Deformation of Binary Stars and the Charm Stars

4.1 The Main Reason That the Visual Orbit Deformations of Binary Stars and the Charm Stars Are Not Observable

The visual orbital deformation of binary star and the charm star are the problem of one-way speed of light. It is proved below that because the angle of calculation is different from the angle of observation, they are not observable and cannot be taken as the evidences that the speed of light is unrelated to the speed of light source.

As shown in Figure 4, assume that the binary stars S_1 and S_2 move around their center in circle with a speed V. If the speed of light is related to the speed of light source, according to the Galilean speed addition formula, the speed of light emitted from the star S_1 is $c+V$, and the speed of light emitted from the star S_2 is $c-V$ relative to the observer on the $x-y$ plane.

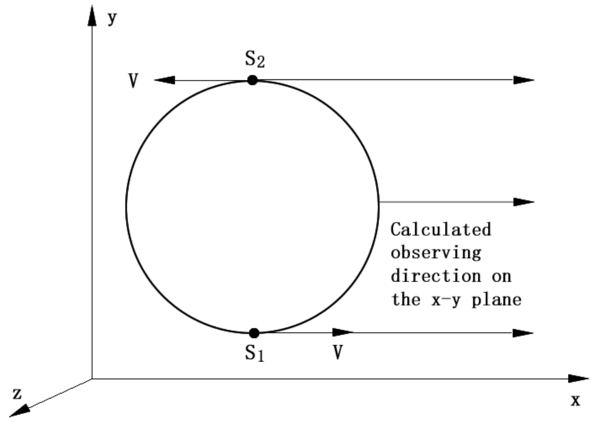

Figure 4. The calculated observing direction and practically observing direction are different resulting in non-observable of orbital shape's change of binary stars

According to the calculations (W. de Sitter, 1913; W. Zurhellen, 1914), the orbit of binary star will no longer be a circle but an ellipse to the observer, and an elliptical orbit would be severely deformed. However, the actual observations show that the eccentricity of binary star's orbit was very small, and the phenomenon that the circular motion becomes the elliptical motion had not been founded, indicating that the speed of light had nothing to do with the speed of binary stars.

The reason why the visual orbit deformation of binary stars cannot be observed is actually very simple, for it is just a problem of visual angle. For an observer viewed in the direction of the x and y axis, the speed of light is related to the speeds of binary stars. But what observed in these two directions are only the side of circular orbit along which stars move up and down along the x or y axis or a straight line. It is hard for the distant observers to consider them as a binary system, which are ignored in astronomical observations.

In fact, an observer on the Earth would need to place a telescope in the direction of the z axis as shown in Figure 4 to observe the front side of circular orbits of a binary system. Since the light from the binary star along the direction of z axis is perpendicular to the directions of moving speed of binary star, there is no speed superposition. The speed of light observed by the earth observer is still c rather than $c \pm V$, so no deformation of binary orbit can be observed.

4.2 The Concrete Calculation for the Charm Stars

As for the problem of charm stars in binary orbit, Bergman's "book Introduction to Relativity" simply mentioned that if the speed of light was related to the velocity of light's source, there would be charm stars. Landsberg's book "Optics" explained this phenomena, but it was not detailed enough. Until 1957, Zhao Daming and Yin Shimin published an paper in Physics Bulletin in Chinese, giving a detailed calculation of charm star problem (Zhao Daming, Yin Shiming, 1957). It is briefly cited below to prove that the calculation of charm star was also based on the observation directions of the x and y axes as shown in Figure 4, and the calculation of visual deformation of binary star orbit is the same.

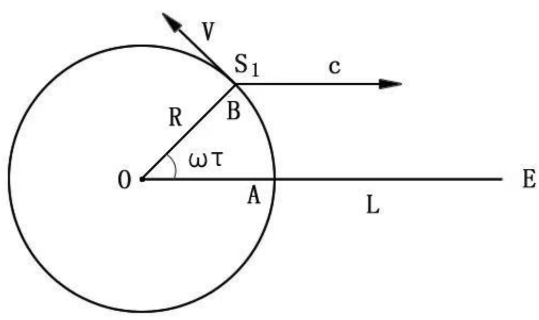

Figure 5. The Schematic Picture of Calculating Charm Star

As shown in Figure 5, assume that one of binary stars S_1 is moving around the center of a circular orbit, the orbit radius is R, the circular speed is V, the angular speed is ω, and the distance between the circular center O and the observer E is L. The star starts from the point A, and the time it takes to reach any point B in the circle is τ. So, when a star stats from the point A, reaches the point B and then omits a beam of light, when the light arrives at E, the time it takes is (Zhao Daming, Yin Shiming, 1957).

$$t = \tau + \frac{L - R\cos\omega\tau}{c - V\sin\omega\tau} = \tau + \frac{L(1 - R\cos\omega\tau / L)}{c(1 - V\sin\omega\tau / c)} \tag{11}$$

Due to $V / c << 1$, Eq.(11) can be approximately written as

$$t \approx \tau + \frac{L}{c}\left(1 - \frac{R}{L}\cos\omega\tau\right)\left(1 + \frac{V}{c}\sin\omega\tau\right)$$

$$= \tau + \frac{L}{c}\left(1 - \frac{R}{L}\cos\omega\tau + \frac{V}{c}\sin\omega\tau - \frac{R}{L}\frac{V}{c}\sin\omega\tau\cos\omega\tau\right) \tag{12}$$

Because the binary stars are far from the observer with $R / L << 1$and $R / L << V / c$, the second and fourth items in the bracket of Eq.(12) can be ignored, we get

$$t = \tau + \frac{L}{c} + \frac{LV}{c^2}\sin\omega\tau \tag{13}$$

Plotting t and τ gave that the multiple different τ satisfied an identical t, meaning that when viewed at E, the lights of multiple stars were observed at different circular points at the same time, and the charm star appeared. For example, for binary star α'GeM, $L = 44.6$ light years, $V = 3.19 \times 10^4 m / s$, according to Eq(13), there were three charm stars.

The problem is that what the observers see at the direction of E is only the linear orbits of stars, rather than the elliptical orbits, so observers may not actually consider them as binary star systems. If observed at the direction of the z axis, the speed of light emitted by binary stars was still c, not $c \pm V$, there were no charm stars.

4.3 The Other Explanations

The extinction method of light proposed by Erval and Oseen could also explain why the orbital deformation of binary stars were imperceptible (J. G. Fox, 1962). According to the theory, when the light emitted by a moving light source at a distance in the universe entered the stationary refracting medium, it would be absorbed and re-emitted by the medium, resulting in the erasure of information related to the moving speed of light source, and it is impossible to observe the visual deformation of binary star orbit caused by the moving speed of light source.

Tang Keyun also proposed a method to explain the binary orbit problem (Tang Keyun, 2016). He thought that de sitter's argument for the constant speed of light in the binary star orbits was a mathematical ideal that did not exist in nature. The natural reason for many observed binary stars with quasi-Kepleran orbits was not that the speed of light did not change, but that the binary stars constantly emitted photons. A large number of photons came from the right period and moved toward the telescope at the right speed at any given time, to replace those that were more seriously out of the Kepleran's orbit. This ensured that the binary stars image was always in a quasi-Keplerian orbit during light's propagation.

So, we can interpret the observation problem of binary orbits in a variety of ways. There is no need to assume that the speed of light is independent of the speed of light's source.

5. The Experiments of One-way Variable Speed of Light

5.1 The Time Difference Experiment of Satellite Signal Transmission Between China and Japan Is One-way Speed of Light

As shown in Figure 6, suppose that the reference frame K is at rest and the reference frame K' is moving in a uniform speed V. There are two light's sources fixed at two points x'_1 and x'_2 in K' with a distance

$l' = x'_2 - x'_1$ between them. At time t'_1, the light's source at point x'_1 emits a beam of light. At time t'_2, the light arrives at point x'_2. The light's source at point x'_2 emits a light at time t''_2, and the light arrives at point x'_1 at time t''_1.

According to the principle of relativity, the observer in K' thinks that himself is at stationary state, so the time for the light to spend traveling from x'_1 to x'_2 is the same as that the light traveling from x'_2 to x'_1. Let $\Delta t'_{1\to 2} = t'_2 - t'_1$ and $\Delta t'_{2\to 1} = t''_1 - t''_2$, we have $\Delta t'_{1\to 2} = \Delta t'_{2\to 1} = l'/c$.

On the other hand, relative to the observer in K, two light sources move. Suppose that the coordinates of two light sources are x_1 and x_2 at arbitrary moment, the distance between them is $l = x_2 - x_1$. Because the propagation direction of light emitted from point x_1 is the same as the motion direction of light source, the time spent for a light traveling from x_1 to x_2 is

$$\Delta t_{1\to 2} = \frac{l + V\Delta t_{1\to 2}}{c} \quad \text{or} \quad \Delta t_{1\to 2} = \frac{l}{c - V} \tag{14}$$

Because the propagation direction of light emitted from point x_2 is opposite to the motion direction of light source, the time taken for a beam of light traveling from x_2 to x_1 is

$$\Delta t_{2\to 1} = \frac{l - V\Delta t_{2\to 1}}{c} \quad \text{or} \quad \Delta t_{2\to 1} = \frac{l}{c + V} \tag{15}$$

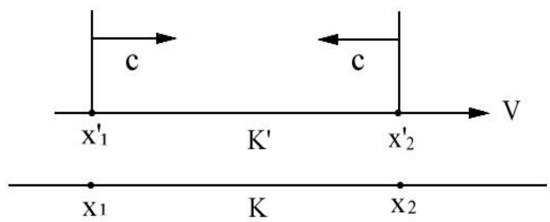

Figure 6. The time difference of two-way light signals

Therefore, we have $\Delta t_{1\to 2} \neq \Delta t_{2\to 1}$. That is to say, observed in the stationary reference frame K, the time taken for two beams of light to reach each other's luminous position is different. Light's velocity satisfies the Galileo addition rule $c \pm V$.

However, according to the invariable principle of light's velocity in special relativity, observed in K, light's speed is still c, rather than $c \pm V$. So observed in K, we still have $\Delta t_{1\to 2} = \Delta t_{2\to 1}$. Thus, in the case shown in Figure 6, does the time difference exist?

In cooperation with China's Shanxi Astronomical Observatory (CSAO) and Japan's Institute of Integrated Communications Research (CRL), the bidirectional satellite time comparison experiment (TWSTT) was conducted on October 31, 1998 to realize the synchronization of two countries' standard time. Because the signals passed through the same path with the same time, the influence of path factor on time synchronization could be decreased to the maximum loudness.

After several months of testing, the result was that the time difference between two places was 95ns, which was attributed to the Sagnac effect (Li Huanxin, Song Jinan, Li Zhigang, Liang Shuangyou, 2000). In the experiment, the accuracy of TWSTT clock was 0.2~0.2ns, and the measurement accuracy of time difference was 1~2ns.

Therefore, it is necessary to discuss the Saganc effect, which is also the focus of this paper, trying to reveal the essence of the Saganc experiment which shows the one way variable speed of light.

5.2 The Sagnac Effect Experiment

Since Sagnac completed the experiment in 1913, more than 110 years have passed, but special relativity had failed to explain it properly and had to regard it as the so-called effect of general relativity. The textbooks and literature of special relativity did not mention this effect, but it cannot avoid for special relativity.

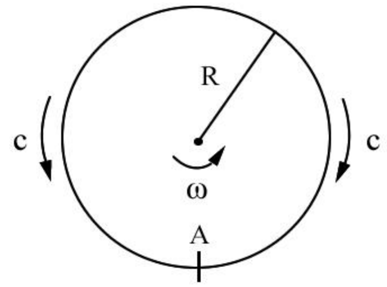

Figure 7. The experiment schematic of Sagnac effect

The Sagnac effect is actually just that the linear motion of light shown in Figure 6 is changed as the circular motion of light around a loop. The loop can be circular, square, or any other shape. Figure 7 shows a diagram of the Sagnac effect of circular interference, which is also the basic schematic diagram of a fiber optic gyroscope.

Make an optical fiber loop with radius R and refractive index n rotate at an angular speed ω around the center of circle. The perimeter of fiber loop is $l = 2\pi R$ and the circular area is S. A is the light source and a device is also fixed at point A through it interference fringes can be observed. According to the Galilean velocity addition rule of classical mechanics, when observed in the stationary reference frame, the propagation speeds of the light are respectively $c'_{\pm} = c \pm V$ with $V = \omega R$. Two beams of light travel in the opposite directions once around the circle and re-arrive at A, the experienced times are respectively

$$t_1 = \frac{l}{c/n + \omega R} \tag{16}$$

$$t_2 = \frac{l}{c/n - \omega R} \tag{17}$$

Due to $c >> \omega R$, the time difference is

$$\Delta t = t_2 - t_1 = \frac{2l\omega R}{(c/n)^2 - \omega^2 R^2} \approx \frac{4\omega S n^2}{c^2} \tag{18}$$

The optical path difference is $\Delta L = c\Delta t$, the wave length of light is λ, the number of interference fringe's change is

$$N = \frac{\Delta L}{\lambda} = \frac{4\omega S n^2}{c\lambda} \tag{19}$$

Observed at point A, N interference fringe's change would be found, that was the Sagnac effect. So according to classical physics, there is no problem in explaining the Sagnac effect. This effect has been used to make laser navigators, which are widely used in aerospace.

According to the calculation of Eq.(19), the Sagnac effect is proportional to the square of the refractive index of fiber. However, practical experiments show that the Sagnac effect has nothing to do with the refractive index of fiber (Wang Ruyong, 2004), so it should take $n = 1$ in Eq.(19). However, the refractive index of general optical fiber is $n = 1.4 \sim 1.6$ with $n^2 = 1.96 \sim 2.56$, the difference of both is not negligible.

To solve this problem, we need to consider the Fizeau experiment of flowing water. This experiment is often mentioned in the textbooks of special relativity, and it is used to study the dragging effect of the ether on light. Although the ether does not exist, it is useful for us to explain why the Sagnac effect is independent of the refractive index of optical fiber.

5.3 The Real Physical Meaning of the Fizeau Experiment of Flowing Water

According to the existing theories, the Fizeau's flowing water experiment indicated the dragging effect of flowing water on the ether (Zhang Yongli, 1980). According to the view of this paper, the essence of Fizeau's flowing water experiment is to reveal the influence of the velocity of moving medium on the propagation velocity of light.

As shown in Figure 8, G is the light source, S_i is the reflector, and T is the eyepiece. The pipe is filled with water, and the arrow indicates the direction of flowing water. The light from the source is divided into two beams by a spectroscope P, one traveling in the same direction as the flowing water, and the other traveling in the opposite direction of flowing water. Two beams of light traveling the same distance meet at the eyepiece, creating interference fringes.

As a general understanding, if water is not dragged by the ether, both beams of light travel at the same speed through water, whether the water is flowing or not. When water changes from a stationary state to a flowing state, the interference fringes do not move when viewed through an eyepiece. If the ether is dragged by the flowing water, the result is different.

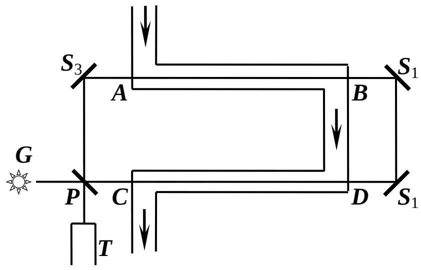

Figure 8. The Fizeau's flowing water experiment

Assume that the speed of water is V, the drag speed of water pulled by the ether is kV, k is the drag coefficient. When $k<1$, it is partial drag. When $k=1$, it is full drag. The total length of tubes $A-B$ and $C-D$ is $2l$. The refractive index of water is n. The speed of light in water is c/n. When the propagation direction of light is the same as the direction of flowing water, the time for a beam of light propagates through the water pipe is

$$t_1 = \frac{2l}{c/n + kV} \tag{20}$$

When the propagation direction of light is opposite to the direction of flowing water, the time for light propagates through the water pipe is

$$t_2 = \frac{2l}{c/n - kV} \tag{21}$$

When two lights arrive at the eyepiece, the time difference is

$$\Delta t = t_2 - t_1 = \frac{2l}{c/n - kV} - \frac{2l}{c/n + kV} = \frac{4lkV}{c^2/n^2 - k^2V^2} \tag{22}$$

Due to $V/c \ll 1$ and $k \le 1$, the term k^2V^2 in the denominator of Eq.(22) can be omitted, we get

$$\Delta t \approx \frac{4ln^2kV}{c^2} \tag{23}$$

Let light's wave length be λ, the optical path difference be $\Delta L = c\Delta t$, the number of interference fringe's change is

$$N = \frac{\Delta L}{\lambda} = \frac{4ln^2kV}{c\lambda} \tag{24}$$

In the Fizeau's original experiment, $l = 1.5m, V = 7m/s, \lambda = 5.893\times10^{-7}m$, the refractive index of water is

$n=1.333$. The number of interference fringe's change was $N=0.19$, relative to $k=0.46$. Michelson and Morley repeated the experiment after Fizeau, and the result was $k=0.434\pm0.02$. The conclusion was that the ether was partially dragged in the flowing water.

Long before Fizeau made his experiment, Fresnel had considered the action of material to drag the ether and summed that light's speed in the moving material was (Zhang Yongli,1980).

$$c'=\frac{c}{n}\pm V\left(1-\frac{1}{n^2}\right) \tag{25}$$

It corresponds to takes the drag coefficient as

$$k=1-\frac{1}{n^2} \tag{26}$$

Einstein's special relativity denied the existence of the ether. It was thought that light could travel through vacuum. The idea that the ether was dragged by flowing water makes no sense. Eq.(25) can also be derived by taking $c\to c/n$ in the Lorentz velocity transformation formula (Zhang Yongli, 1980). Therefore, the result of Fizeau's flowing water experiment was also considered as the effect of special relativity.

According to the author, the Fizeau's flowing water experiment reveals the influence of medium's moving speed on the speed of light, instead of the ether being dragged by the flowing water. When the medium is at rest, the speed of light moving through the medium is $c'=c/n$. When the medium is moving at speed V, viewed in the stationary reference frame, the speed of light becomes

$$c'=\frac{c}{n}\pm k'V \tag{27}$$

Where k' is the drag coefficient of common medium. In the following, we use this viewpoint to explain that the shift of reference fringes in the Sagnac experiment is independent of the refractive index of fiber medium.

5.4 The Interpretation That the Sagnac Effect Is Independent of Refractive Index of Fiber

Suppose the radius of optical fiber ring is R, the length is $l=2\pi R$, and the rotational linear speed is $V=\omega R$. Considering Eq.(26), when the propagation direction of light is consistent with the rotation direction of optical fiber, the time taken by the light to move around the optical fiber ring is

$$\Delta t_1=\frac{l}{c/n+k'\omega R} \tag{28}$$

Where k' is the drag coefficient of optical fiber. When the propagation direction of light is opposite to the rotation direction of optical fiber, the time taken by the light to move around the optical fiber ring is

$$\Delta t_2=\frac{l}{c/n-k'\omega R} \tag{29}$$

Due to $c>>V$ and $c/n>>\omega R(1-k)$, the time difference is

$$\Delta t=\Delta t_2-\Delta t_1=\frac{l}{c/n-k'\omega R}-\frac{l}{c/n+k'\omega R}$$
$$=\frac{2l\omega Rk'}{(c/n)^2-k'^2\omega^2R^2}\approx\frac{4\omega Sn^2k'}{c^2} \tag{30}$$

If the time difference is unrelated to the refractive index of fiber, let

$$n^2k'=1 \qquad\qquad k'=\frac{1}{n^2} \tag{31}$$

Eq.(30) becomes unrelated to the refractive index of optical fiber with

$$\Delta t\approx\frac{4\omega S}{c^2} \qquad\qquad N=\frac{4\omega S}{c\lambda} \tag{32}$$

The drag coefficient k' of optical fiber shown in (31) is generally different from the Fresnel formula as shown in Eq.(26).

For the common optical fiber with $n=1.4\sim1.6$, taking $n=1.414$ and $n^2=2$, according to Eq.(31), we have $k'=0.5$. According to Eq.(26), we also have $k=1-1/n^2=0.5$. Both are almost the same. This explains that the Sagnac effect is independent of the refractive index of fiber.

5.5 The Calculation of Special Relativity for the Sagnac Effect

It is well known that special relativity cannot explain the Sagnac effect. The current view is that the Sagnac experiment is a non-inertial rotating system which is not in the scope of special relativity discussion. Using general relativity, it is still possible to explain the Sagnac effect, but this is not the case in practice.

It is shown below that the Sagnac effect of rotating optical fibers can also be calculated by using the Lorentz velocity transformation of special relativity, without the need to consider general relativity. The problem is that the calculation result of special relativity is not the same as that of classical mechanics. Especially in the case of refractive index $n=1$, according to special relativity, there is no change of the interference fringes. According to classical mechanics, there is the change of interference fringes.

When the optical fiber is at rest, the speed that light travels in the optical fiber is $c'=c/n$. When the optical fiber rotates at tangential speed $V=\omega R$, the speed of light source rotating with the optical fiber is also V relative to the stationary reference frame. According to the Lorentz velocity transformation formula, observed in a stationary reference frame, the speeds of light propagating in two opposite directions become

$$c_{\pm}=\frac{c'\pm V}{1\pm c'V/c^2} \tag{33}$$

Therefore, the time for light propagating along the rotation direction of optical fiber for a circle is

$$t_{+}=\frac{l}{c_{+}}=\frac{l(1+c'V/c^2)}{c'+V} \tag{34}$$

The time for light propagating along the opposite rotation direction of optical fiber for a circle is

$$t_{-}=\frac{l}{c_{-}}=\frac{l(1-c'V/c^2)}{c'-V} \tag{35}$$

The time difference between two lights moving around the fiber a circle and coming back to the position A is

$$\Delta t'=t_{-}-t_{+}=l\left[\frac{1-c'V/c^2}{c'-V}-\frac{1+c'V/c^2}{c'+V}\right]$$

$$=\frac{2lV\left(1-c'^2/c^2\right)}{c'^2(1-V^2/c'^2)}=\frac{2lVn^2\left(1-1/n^2\right)}{c^2(1-V^2n^2/c^2)} \tag{36}$$

Due to $nV<<c$, we have

$$\Delta t'\approx\frac{2lVn^2\left(1-1/n^2\right)}{c^2}=\frac{4\omega Sn^2}{c^2}\left(1-\frac{1}{n^2}\right) \tag{37}$$

Eq.(37) is different from Eq.(30) which is deduced from classical method. If the time difference of fiber gyroscope is independent of the refractive index of fiber, according to Eq.(37), we have

$$n^2\left(1-\frac{1}{n^2}\right)=1 \qquad \text{or} \qquad 1-\frac{1}{n^2}=\frac{1}{n^2} \tag{38}$$

From Eq.(38), we obtain $n=\sqrt{2}$.Therefore, according to special relativity, we can still derive the Sagnac effect of fiber gyroscope. Comparing with Eq.(30) of classical mechanics, the calculation result Eq.(38) of special relativity corresponds to let

$$k = 1 - \frac{1}{n^2} \tag{39}$$

That is to say, according to special relativity, the drag coefficient of fiber medium is represent by the Fresnel formula (26). For common fiber, $n = 1.4 \sim 1.6$. Taking $n = \sqrt{2} = 1.414$, we have $k' = k = 0.5$. So, the results based on both classical mechanics and special relativity are the same. General relativity is unnecessary. But in general situations, if the refractive index of fiber $n \neq \sqrt{2}$, it is possible to determine whether classical mechanics is correct or special relativity is correct through optical fiber gyroscope.

We consider the original Sagnac experiment in 1913 carried out in the air with $n \approx 1$, the result is completely different. According to classical mechanics, the Saganc effect exists. According to special relativity, there is no Sagnac effect. We can then make a decision that the speed of light satisfies the Galilean additional rule rather than the Lorentz transformation formula.

5.6 The Original Sagnac Experiment in 1913 Was a Judgment Experiment

As shown in Figure 9, the original Sagnac experiment was carried out in air. The experiment used three mirrors B, C, D and a spectroscope A to form an optical loop. The light is divided into two beams through spectroscope A, travel in opposite directions, and come back to A. The optical path system rotates continuously. The change of interference fringes is observed at the eyepiece

Since the refractive index of air to light is $n \approx 1$, substituting it in Eq.(37) according to special relativity, we get $\Delta t' = 0$. There is no shifts of interference fringes and has no Sagnac effect after the rotation of the optical path system. But according to classical mechanics, taking $n \approx 1$ in Eq.(18), we have $\Delta t \neq 0$. The shifts of interference fringes exists. The result proves that the velocity of light satisfies the Galilean addition formula, rather than the Lorentz addition formula. The principle of constant speed of light are not valid.

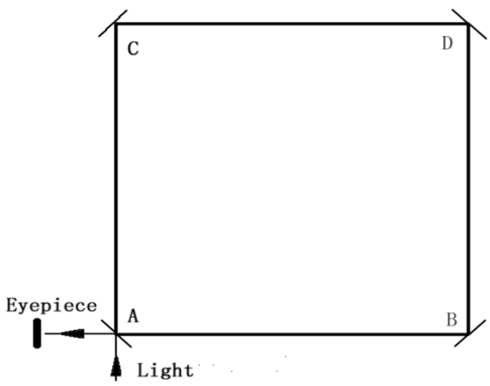

Figure 9. The schematic picture of original Sagnac experiment in 1913

The original Sagnac effect experiment is simpler and the experimental result is very clear. It makes a direct comparison between the Galilean velocity addition rule and the Lorentz velocity transformation rule to get a completely certain result. It directly decides that the speed of light is related to the speed of light's source, satisfying the Galilean addition rule rather than the Lorentz transformation rule.

5.7 Comparison Between the M-M Experiment and the Sagnac Effect Experiment in Air

The M-M experiment and the original Sagnac effect experiment were carried out in air. The experimental principles were exactly the same, but the results were completely opposite. In the M-M experiment the shift of interference fringes can be observed, but in the Sagnac effect experiment, it can be observed. These completely opposite results were confusing.

The reason is that the M-M experiment actually measures the time difference of light passing through round-trip path, while the original Sagnac effect measures the time difference of light passing through a one-way path. In the M-M experiment, two beams of light are emitted from the center point of spectroscope, travel some distances, and are reflected by the mirrors, and then return to the center point of spectroscope in the opposite direction. It is equivalent to measure the time when light travels at the average speed. The result is equivalent to that the speed of light is a constant, without producing the change of interference fringes.

In the original Sagnac effect experiment, as shown in Figure 5, both beams of light travel a complete loop, back to the starting point to intervene. Two beams of light traveling in opposite directions are always moving in the same direction of the rotation direction of the optical loop, or always moving in the opposite direction of optical loop's rotation until they return to the point A. The mirrors have not reversed the travel direction of light from the rotation direction of light loop. This is equivalent to the measurement of one-way speed of light, showing that the one-way speed of light is not a constant, related to the rotating speed of fiber loop.

These two opposite examples just show that the so-called constant speed of light is actually the round-trip average speed. The one-way speed of light is not a constant.

5.8 The Michelson-Gale Experiment Is an Amplified Sagnac Experiment

In order to measure the rotation speed of the Earth, Michelson and Gale completed an experiment called "The Effect of the Earth's rotation on the velocity of light" in 1925 (A. A. Michelson, H. G. Gale, 1925). The experiment detected the Earth's angular velocity, or the rotation speed of the Earth's surface. It actually indicted that the speed of light was not isotropic on the Earth's surface, or the speed of light was variable. Since this result is contradictory to the M-M experiment and negates special relativity, it has been neglected in current relativity literature and textbooks.

The principle of the M-G experiment is shown in Figure 10. It is basically the same as Figure 9 except there is a small loop marked by ABCD to calibrate the experimental parameters. Because the circuit area of ABCD is very small, the formed interference fringes can be neglected. Light from the source passed the spectroscope and separated into two opposite-direction beams and trivial along AEFD circuit, go back to the starting point of interference and is measured.

The length of AFED loop is 2010 feet and the wide is 1113 feet. The light propagated in the pipe. The air in the pipe was pumped out to make the light's propagation and the interference fringes stable.Obviously, the M-G experiment is an amplification of the Sagnac effect experiment carried out in air. The difference is only that the M-G experiment device is fixed and the changes of light's speed is through the rotation of the Earth. But the Sagnac experiment changes the speed of light by rotating the instrument itself.

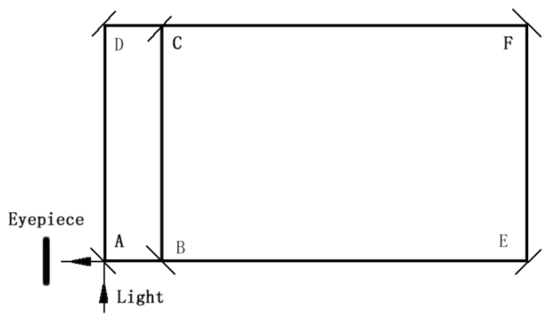

Figure 10. The schematic picture of the M-G experiment

Because there is no reverse of light propagation direction, the M-G experiment measures the one-way speed of light instead of the round-trip speed. Due to the superposition of the Earth's rotation speed, two beams of light traveling in opposite directions at different speeds. Therefore, the M-G experiment is different from the M-M experiment. It is inevitable to detect the rotation speed of the earth.

The formula for the calculation of the number of interference fringes in the M-G experiment is basically the same as that for the Sagnac effect (A. A. Michelson, H. G. Gale.1925)

$$N = \frac{4\omega S \sin\varphi}{c\lambda} \tag{40}$$

Where ω was the Earth's rotational angle speed, φ was the Earth's latitude. The experiment was carried out outside Chicago to took $\varphi = 41^0 36'$. The wave length of sodium light was $\lambda = 5700 \pm 50\,\mathring{A}$. According to Eq. (40), the calculation value was $N = 0.236 \pm 0.002$. In the experiments, 13 measurements had been made, and the average results were $N = 0.230 \pm 0.05$ in good agreement with the theoretical calculation.

Measuring the angular speed of the Earth's rotation was equal to measure the tangential rotation speed of the earth's surface. As shown in the Sagnac experiment, the speed of light and the rotation speed of the Earth meet the speed addition rule of Galileo.

5.9 Using General Relativity Cannot Explain the Sagnac Effect

Since the constant vacuum speed of light in special relativity cannot explain the Sagnac effect, some people believe that the optical fiber rotating around the center of a circle are not an inertial system, and the special relativity principle does not apply. But the Sagnac effect can still be explained by considering general relativity.

This is a common practice of special relativity, and when problems arise that cannot be explained, physicists habitually push them to general relativity. From the above discussion, it can be seen that the calculation result of special relativity in optical fiber medium is similar to that of classical mechanics, general relativity is not needed at all.

In fact, general relativity itself has serious problems. If special relativity does not work, general relativity cannot work too. In view of the importance of the Sagnac effect, we need to discuss this issue seriously.

To explain the Sagnac effect, the Schwarzschild metric of the spherically symmetric gravitational field of general relativity is considered. Under the approximate condition $\alpha / r << 1$, the Schwarzschild metric can be approximately written as (Fei Baojun, 2007)

$$ds^2 = c^2\left(1 - \frac{\alpha}{r}\right)dt^2 - \left(1 + \frac{\alpha}{r}\right)\left(dr^2 + r^2 d\theta^2 + r^2 \sin\theta^2 d\varphi^2\right) \tag{41}$$

By introducing the coordinate transformation

$$t' = t \qquad r' = r \qquad \theta' = \theta \qquad \varphi' = \varphi - \omega\, t \tag{42}$$

Represented by the rectangular coordinates, they are

$$t' = t \qquad x' = x\cos\omega\, t + y\sin\omega\, t \qquad y' = -x\sin\omega\, t + y\cos\omega\, t \qquad z' = z \tag{43}$$

Substituting them in Eq.(41), it becomes the metric of gravitational field of the earth's rotating reference frame

$$ds^2 = c^2\left[1 - \frac{\alpha}{r}\frac{(\omega\times\vec{r}')}{c^2}\right]dt'^2 - \left(1 + \frac{\alpha}{r}\right) \times\left[2(\omega\times\vec{r}')\cdot d\vec{r}'dt' + dr^2 + r^2 d\theta^2 + r^2\sin\theta^2 d\varphi^2\right] \tag{44}$$

Based on Eq.(44), the time difference shown in Eqs.(16) and (17) can be obtained. However, this method has following problems.

1. The strict solution of the gravitational field equation of a rotating sphere is the Kerr metric (Liu Liao, Zhao Zheng), not the static Schwarzschild metric. The Kerr metric is completely different from Eq. (41) and cannot be used to explain the Sagnac effect.

2. Eqs.(42) and (43) are the Galilean transformations of Newtonian mechanics, not the transformations of special relativity. So, this explanation for the Sagna effect is still Newtonian one, not real relativistic one. Since the Sagnac effect can be naturally induced by the Galilean coordinate transformation, there is no need to do so. Adding the Galilean coordinate transformation of Newtonian mechanics to the Schwarzschild metric to explain the Sagnac effect makes no sense.

3. Because of the spherical symmetry of Eq.(41), two beams of light propagate along the circumference of a concentric symmetric gravitational field in opposite directions, the gravitational field has the same effect on the speed of two beams of light. When two beams of light travel in opposite directions for a circle and meet again, it must take the same amount of time, not cause the change of interference fringes.

In short, it is impossible to explain the Sagnac effect according to the Lorentz velocity transformation and the principle of invariable speed of light of special relativity, combined with general relativity. The existence of the Sagnac effect proves that Einstein's principle of invariant speed of light is not valid.

6. Conclusions

So far, physical experiments have only proved that the speed of light is a constant in the round-trip processes, not in one-way processes. This paper makes a distinction between them. It is pointed out that the M-M experiment, the speed measurement of photons emitted by high-energy particles and so on are the experiments of round-trip speed of light, showing that the average speed of light is a constant.

However, the Sagnac effect experiment, the M-G experiment and the experiment that the satellite signal propagates between China and Japan, are the experiments of one-way speed of light. They indicate that the speed of light is variable, satisfying the Galilean velocity addition rule, rather than the Lorentz transformation ruler.

The change of orbit's visual sharp of binary and the phenomenon of charm stars cannot be observed due to that the calculated observation direction are different from the practical observing direction of the earth observers.

In this paper, the Fizeau's following water experiment and the Sagnac effect experiment are connected. It is proved that the rotation of optical fiber medium affects the propagation speed of light. Thus, the problem that the change of interference fringe has nothing to do with the refractive index of optical fiber in the Sagnac effect is explained.

Based on the Lorentz velocity transformation formula, the Sagnac effect formula of fiber gyroscope of special relativity is derived. It is proved that the result derived from special relativity is the same with the result derived from classical mechanics after considering the Fizeau effect of optical fiber rotation when the refractive index of fiber is $n = \sqrt{2}$.

However, in general case, the calculation results of special relativity are different from those of classical mechanics. Especially, when $n = 1$ in air, there is no Sagnac effect according to special relativity, but there is the Sagnac effect according to classical mechanics. The original Sagnac effect experiment was carried out in air with $n \approx 1$, which just proved that Lorentz velocity transformation formula was invalid. The speed of light was related to the speed of light source, satisfying the Galilean addition rule, rather than the Lorentz transformation formula.

Finally, by comparing the M-M experiment with the original Sagnac effect experiment in air, it is pointed out that the round-trip speed of light is involved in the M-M experiment but the one-way speed of light is involved in the Sagnac effect. It perfectly explains why these two experiments have exactly the same principle and the same measurement method, but lead to completely different results. The truth of the so-called constant speed of light in the experiments of special relativity is reveled.

The conclusion of this paper is that all problems of theory and experiment about light's speed in special relativity can be reasonably explained from the perspective of classical physics. Physics requires neither the Lorentz coordinate transformation nor the Einstein's principle of invariable speed of light.

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