

*Full Length Research Paper*

# A No-Shape-Substance as the propagating medium of light

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Accepted 19 August, 2014

**This paper proposes that there exists a special kind of substance, No-Shape-Substance which is also called “dark matter”, in the natural world. It first introduced the ‘No-Shape-Substance’ which is an actual substance with mass in a special state and is inseparable with the laws of physics. The new idea of ‘No-Shape-Substance’ can make people be acquainted with nature more fully as well as understand physics more objectively, naturally and logically. Secondly, the paper discusses the issue of the transmission of light based on the thought of “No-Shape-Substance”, and explains some famous physics experiments, such as Fizeau’s Experiment, Michelson-Morley Experiment, Millar Experiment, Light Aberration Phenomenon and the Sagnac Effect. Through analyzing a variety of physical phenomena, it is believed that this matter is the medium through which light propagates and the foundation on which all laws of motion can be built.**

**Key words:** No-shape-substance, Fizeau’s experiment, Michelson-Morley experiment, Millar experiment, light aberration phenomenon, Sagnac effect.

## INTRODUCTION

People think that light and other volatile both require a transmission medium and the transmission medium of light is “ether”. During the period of classical physics, this is a logical assumption; however, “ether” and absolute space are bound together which makes “ether” lost materiality completely. So it produces a lot of contradictions in explaining many physics experiment (Ji, 2006, 2008; Guangjiong and Hongfang, 1979).

For example, it is concluded that the speed of “ether” is 30 km/s when the frame of reference is the earth’s surface in aberration phenomenon. However, it can still be concluded that the speed of “ether” is “zero” relative to the earth’s surface in Michelson-Morley’s experiments. It was found that “Etherne” can be driven by water in a convinced experiment. Nevertheless, the facts are just the opposite to that of Airy. These contradictions make the classical physics to face great difficulties. Under this background, Einstein put aside the “ether”, gave up the

classic physics concept and created the theory of relativity.

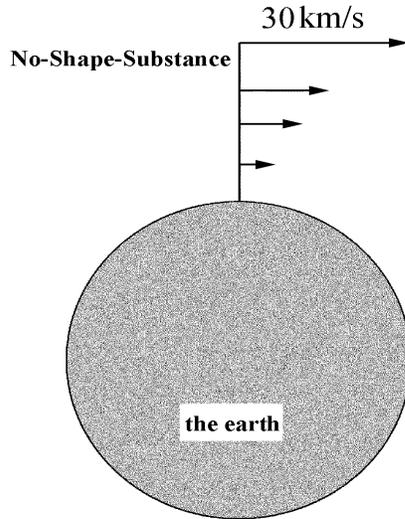
The author thinks that “ether” is a substance and should not be tied with ‘absolute space’, and all experimental phenomena won’t have any contradiction in the framework of classical physics as long as the materiality return to “ether”.

In order to avoid the wrong understanding of “ether”, this paper puts forward the thought of “No-Shape-Substance” which is a quality material in special state and also can be called “dark matter”.

This paper discusses the issue of the transmission of light based on the thought of “No-Shape-Substance”, and explains some famous physics experiments, such as

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**Figure 1.** The velocity distribution of the No-Shape-Substance relative to the earth.

Binary Phenomenon, Aberration Phenomenon, Convinced Experiment, Airy Experiment, Michelson-Morley Experiment, Millar Effect, and Sagnac Stark Effect.

**THE EXISTENCE OF NO-SHAPE-SUBSTANCE AND ITS INFLUENCE ON THE LAWS OF PHYSICS**

**Occupying the space by “No-shape-substance”**

In the natural world, apart from all kinds of known substances, there exists largely a special kind of substance - a No-Shape-Substance. A Shape-Substance is visible while a No-Shape-Substance is invisible. A Shape-Substance has its structure and is tangible, but a No-Shape-Substance has a contrary structure (Ji, 2006, 2008).

For example, an atom or an electron is a Shape-Substance. If an electron is analogous to a big tree, a No-Shape-Substance is analogous to the air that flows at will among the branches of the tree. Different from the commonly known matter, a No-Shape-Substance exists in another special state and is much tinier than the common matter.

The universe is a huge ocean full of No-Shape-Substance and all the Shape-Substance exist in the same ocean. Since the No-Shape-Substance exists on a dispersed state, it logically has density, which is usually denoted by S. (The SI unit for density is kg/m<sup>3</sup>).

**Velocity distribution on the surface of the earth**

This study exemplifies velocity distribution in a familiar manner. When pulling a small ball in the glycerin, the

glycerin on the surface of the ball can be carried, while the glycerin attached closely to the surface of the ball can be carried completely. If the small ball is displaced by a basketball or the earth, the influence on it will be different. Thus the bigger the body is, the greater the influence is.

Since there is an attracting force between the Shape-Substance and the No-Shape-Substance, the movement of the Shape-Substance can also carry the No-Shape-Substance. The bigger the Shape-Substance is, the greater its influence on the No-Shape-Substance existing in the space. The nearer to the body the No-Shape-Substance is, the greater the influence from the body on the No-Shape-Substance existing in the space.

Considering the Earth at a macroscopic angle, the Earth is in an ocean of No-Shape-Substance. The movement of the Earth can carry the No-Shape-Substance near it. Moreover, the No-Shape-Substance is carried by the Earth on the Earth’s surface while in the far distance from the Earth, the No-Shape-Substance cannot be carried by the Earth at all. As shown in Figure 1, the velocity of the No-Shape-Substance relative to the earth increases from “zero” to 30 Km/s gradually as the increase in the distance from the earth.

The earth is not likely to bring completely the No-shape-substance on its surface, due to its translational movement. But when it rotates, it is not easier to bring completely No-Shape-Substance on the earth’s surface. Because the speeds of all the points on the surface are completely different, a point is different at different times, when the earth rotates.

**The density of “No-shape-substance”**

The densities of the No-Shape-Substance are different in the whole universe. Because there is some attracting force between the Shape-Substance and the No-Shape-Substance, the density of the No-Shape-Substance is greater to some extent in the place where the Shape-Substance has more accumulation. That is, the density of the No-Shape-Substance on the earth’s surface is greater than that of far away from the earth.

The No-Shape-Substance can be superimposed. The total density of the No-Shape-Substance in space equals the algebraic sum of that of all objects. The total density of the No-Shape-Substance in space is:

$$S = S_1 + S_2 + S_3 + \dots \tag{1}$$

**The object’s influence on “No-shape-substance” on the surface of the earth**

No-Shape-Substance is carried completely by the earth. For example, when a train passes by us, the No-Shape-Substance cannot be driven obviously in the place because the train is much smaller than the earth. Whether or not the train exists, it puts little influence on the state of the space. The influence that the train exerts

on the No-Shape-Substance in the space can be neglected completely and it is the same in the carriage. But it is a problem of another level to the inside of the matter, such as in water or in glass, since it is much nearer to the molecule or the atom. The density of the No-Shape-Substance inside a body cannot be neglected.

Inside water, the total density of the No-Shape-Substance is the superposition of that of the vacuum in the earth's surface and that corresponding to the water.

$$\text{That is: } S = S_E + \bar{S}_W.$$

We know that it needs to establish a spatial reference system to discuss a physical question. The Shape-Substance has a velocity relative to a spatial reference system, and it is the same with respect to the No-Shape-Substance, too.

The velocity of the total No-Shape-Substance equals the full-weighted superposition of the velocity and the density of every object in space. That is:

$$\vec{v} = \frac{S_1\vec{v}_1 + S_2\vec{v}_2 + S_3\vec{v}_3 + \dots}{S_1 + S_2 + S_3 + \dots} \quad (2)$$

Still we take the flow of water for example. Assuming that the water has a velocity of  $\vec{v}_W$  relative to the spatial reference system on the earth's surface, we probe into the velocity of the No-Shape-Substance inside the water relative to the spatial reference system on the earth's surface.

The velocity of the No-Shape-Substance corresponding to the earth is zero relative to the earth's surface. The No-Shape-Substance corresponding to the flow of water moves together with the water, and its velocity relative to the earth's surface is  $\vec{v}_W$ . So the velocity of the total No-Shape-Substance relative to the earth's surface can be expressed as follows:

$$\vec{v} = \frac{\bar{S}_W \cdot \vec{v}_W + S_E \cdot 0}{\bar{S}_W + S_E} = \frac{\bar{S}_W}{\bar{S}_W + S_E} \vec{v}_W$$

**Absence of “No-Shape-Substances” in vacuum**

Considering the case in a vacuum, it has been thought for a long time that there was nothing in an ideal vacuum, but it is not the actual case. What the vacuum lacks is only the atmospheric molecules. In fact, there exists a large amount of No-Shape-Substance in the vacuum space. And the wall of a vacuum container will not block the move of the No-Shape-Substance.

If the vacuum is on the earth's surface, what permeates in it is the same No-Shape-Substance on the earth's surface; wherefore the density of the No-Shape-Substance in the vacuum is the same as that on the earth's surface. However, if the vacuum is in the cosmic

space, what is dispersing in it is the No-Shape-Substance of its corresponding cosmic space; therefore the density of the No-Shape-Substance in the vacuum is the same as that in the relevant cosmic space.

**Physical laws connected with “No-Shape-Substance”**

The space in which the No-Shape-Substance exists is called the No-Shape-Substance Space or the Substance Space for short. Conversely to the No-Shape-Substance Space, the virtual and flat space is called the Mathematical Space. All the motion laws of all bodies depend on the total No-Shape-Substance space where it exists instead of the absolutely mathematical space.

Here, this study considers the following case that a fish swims in a river and the water flows in relation to the bank. The force acting on the fish and its law of motion are closely related to the flow of water, but not to the mathematical reference system based on the bank. A body is analogous to the fish while the No-Shape-Substance is analogous to the water. The motion laws of all bodies depend on the No-Shape-Substance Space where it exists but not directly on the Mathematical Space.

The universal gravitation between any two objects travels through the No-Shape-Substance; and also the Coulomb force between any two electric charges also travels through the No-Shape-Substance. A No-Shape-Substance is the propagation medium of light, and the propagating velocity of light relative to the No-Shape-Substance is constant.

**THE CONCEPT OF SPACE-TIME**

Before analyzing any physical laws, the basic concepts of this study would be cleared first.

Newton has said,

*“The absolute space is essentially independent of any outside body and remains equivalent and motionless forever.” “The absolute, real or mathematical time, itself and to the extent of its nature, always lapses uniformly, having nothing to do with any outside body (Ji, 2006, 2008; Guangjiong and Hongfang, 1979).”*

Time and space are the standards and scales for people to learn the world, and meanwhile they are also the unshakable cornerstones of physics. The view of space-time in this paper is compatible with that of Newton's classical physics. Time exists objectively and it always lapses uniformly having nothing to do with any outside body. The mathematical space is essentially independent of any outside body and remains equivalent and motionless forever. The speed follows the superposition principle of Galileo. Both mass (gravitational mass) and energy are conservative and cannot be converted into

each other. But the unique viewpoint in this paper with Newton's classical physics is what the laws of motion of a body depend on is not the mathematical space but the total No-Shape-Substance Space in which the body exists.

As mentioned above, this study has given an example about the fish swimming in water and the water flowing with reference to the bank. A body is analogous to the fish while the No-Shape-Substance is analogous to the water. The motion laws of all bodies depend on the No-Shape-Substance Space where it exists but not directly on the Mathematical Space.

**NO-SHAPE-SUBSTANCE AS THE PROPAGATING MEDIUM OF LIGHT**

The view of this paper is that there is no essential distinction between the light wave and other waves. The light wave has all the properties as the other waves do. A No-Shape-Substance is the propagation medium of light, and the propagating velocity of light relative to the No-Shape-Substance is constant.

Based on these views, this study discussed about the relationship between the velocity of light and the density of "No-Shape-Substance" as follows. From the wave theory, the propagating velocity of a wave  $u$  can be gotten as:

$$u = \sqrt{\frac{G}{\rho}} \text{ or } u = \sqrt{\frac{E}{\rho}} \text{ or } u = \sqrt{\frac{K}{\rho}}$$

where  $G$  and  $E$  are the shear modulus and the elastic modulus of a solid respectively,  $K$  is the volume modulus of a liquid or a gas, while  $\rho$  is the density of the medium.

In a nutshell, it does not matter whether it is in a solid or in a liquid, the propagating velocity of a wave is always in direct proportion to the square root of the modulus of the medium and is inversely proportional to the square root of the density of the medium. Because the No-Shape-Substance is the propagation medium of light, the following relation can be obtained between the speed of light  $c$  and the density of the No-Shape-Substance  $S$  :

$$c = \sqrt{\frac{W}{S}} \tag{3}$$

Where,  $W$  and  $S$  are the modulus and density of the No-Shape-Substance respectively. The SI unit of modulus is Pa (namely  $N/m^2$ ).

As it is known by all, the speed of light in other medium such as glass and water is lower than that in a vacuum. However, there is no good explanation to this problem in physics. But, if it is looked at from the viewpoint of the

No-Shape-Substance, it will become quite easy for a person to understand.

In the vacuum near the earth's surface, the density of the No-Shape-Substance is that of the earth's surface  $S_E$ . Then the velocity of light in the vacuum near the earth's surface is:

$$c = \sqrt{\frac{W}{S_E}} \tag{4}$$

In the water, the total density of No-Shape-Substance is the sum of the density of the No-Shape-Substance in the vacuum near the earth's surface and the density of the No-Shape-Substance relating to the water. That is:

$$S = \bar{S}_W + S_E$$

Then the speed of the light in the water is:

$$c_W = \sqrt{\frac{W}{\bar{S}_W + S_E}} \tag{5}$$

In such medium as the glass or the water, because the density of the No-Shape-Substance is larger than that in the vacuum, the speed of light is naturally lower than that in the vacuum.

**REINTERPRETATION OF FAMOUS PHYSICS EXPERIMENTS BASED ON THE VIEWPOINT OF "NO-SHAPE-SUBSTANCE"**

Many famous experiments in the physics history are hard to explain in classical physics and they create many contradictions. These experiments and phenomena mainly include: the Binary Star Phenomenon, the Aberration Phenomenon, Fizeau's Experiment, Airy's Experiment and Michelson-Morley Experiment, Millar Experiment, and The Sagnac Effect (Guangjiong and Hongfang, 1979; Brace, 1905; Ji, 2007, 31 (3): 142-143; Shujie and Hua, 1987). Subsequently, these experiments and phenomena will be explained from a completely new point of view such that the experiments and phenomena will no longer have any conflict between them.

**Fizeau's experiment**

In 1851, Fizeau conducted a very sensitive experiment. It shows that water could slow down the motion of light. Light in water would move at a lower velocity. As shown in Figure 2, the light emitted by the lamphouse S is divided into two beams of light when passing through M. One is reflected subsequently by  $M_3, M_2, M_1$ , and then is reflected again by M into T. Meanwhile, the other beam permeates M and then is reflected subsequently by  $M_1, M_2$  and  $M_3$ , and at last arrives at T permeating M. When traveling through the flowing water in the level tube, the

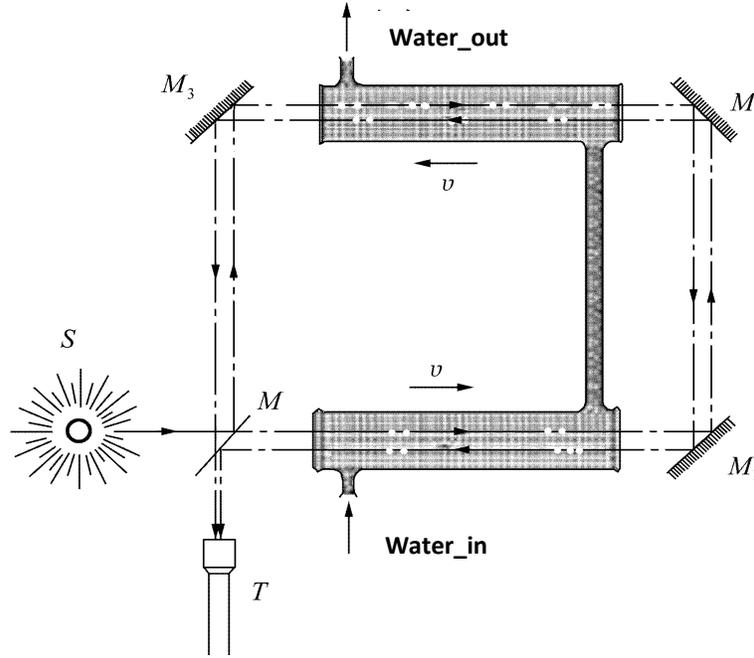


Figure 2. Fizeau's experiment.

former travels in the direction opposite to the direction of the flowing water, while the latter travels in the same direction as that of the flowing water. At last, the two beams of light interfere in T.

At the beginning of the experiment, the speed of the flowing water is designated in the level tube as zero. Because the two beams of light have the same traveling distance, the interference fringes are bright. Then when the speed  $v$  of the flowing water is increased in the level tube gradually, it will be observed that the interference fringes changed alternatively between bright fringes and dark ones, which shows that the speed of light in the flowing water changes when the light propagates in different directions from that of the flowing water. Furthermore, the velocity of the light propagating in the water relative to the earth can be established. Note that the velocity of the light propagating in the water relative to the earth in Fizeau's experiment is:

$$c' = \frac{c}{n} \pm f v_w \tag{6}$$

where,  $n$  is the refractive index of water, the plus sign "+" implies the condition that light travels in the same direction as that of the flowing water in the tube, and the subtraction sign "-" implies the condition that light travels in the opposite direction to that of the flowing water in the tube.

The dragging coefficient of water obtained from Fizeau's experiment is  $f = 0.434 \pm 0.002$ , with its value

smaller than 1. It shows that water can carry light but not completely (Ji, 2006, 2008; Guangjiong and Hongfang, 1979; Brace, 1905; Ji, 2007, 31 (3): 142-143; Shujie and Hua, 1987; Yiling and Huijun, 1991).

Now, Fizeau's experiments can be explained on why the water can drive the light based on the viewpoint of "No-Shape-Substance". It is the water that carries the No-Shape-Substance. So water can also carry light. In the vacuum near the earth's surface, the total No-Shape-Substance has no motion relative to the earth reference system and its density, denoted by  $S_E$ , which is uniform.

Because the distance between molecules inside the water is quite small, the density of the No-Shape-Substance in the flowing water cannot be ignored. Thus the density of the total No-Shape-Substance equals the sum of the density of the No-Shape-Substance on the earth and that in the flowing water. That is:

$$S = \bar{S}_w + S_E \tag{7}$$

The velocity of the No-Shape-Substance on earth with reference to the earth's surface is zero, while the velocity of the No-Shape-Substance in the flowing water is  $v_w$  relative to the earth's surface. Then the velocity of the total No-Shape-Substance that can be obtained moving relative to the earth's surface from Equation 2 is as follows:

$$v = \frac{\bar{S}_w \cdot v_w + S_E \cdot 0}{\bar{S}_w + S_E} \quad \text{If} \quad f = \frac{\bar{S}_w}{\bar{S}_w + S_E}$$

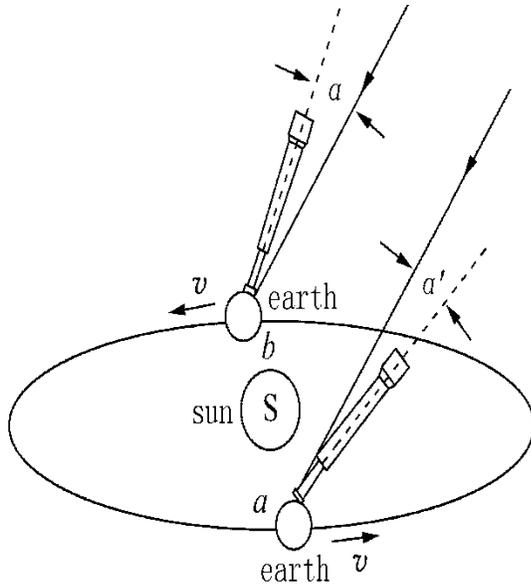


Figure 3. light aberration phenomenon.

$$v = f v_w \tag{8}$$

When light propagates in water, its velocity relative to the total No-Shape-Substance space is  $c/n$ , and its velocity relative to the earth is:

$$c' = \frac{c}{n} \pm v$$

$$c' = \frac{c}{n} \pm f v_w \tag{9}$$

It is water that carries the No-Shape-Substance. So water can also carry light. This perfectly reflects on Fizeau's experiment which showed that light was dragged by water.

Subsequently, the dragging coefficient of the water was quantitatively calculated. As was said before, when the light travels in a certain vacuum near the earth's surface, its velocity in the vacuum can be expressed as:

$$c = \sqrt{\frac{W}{S_E}} \tag{10}$$

When light travels in water, its speed is:

$$c_w = \sqrt{\frac{W}{S_E + \bar{S}_w}} \tag{11}$$

The study can easily get the following equation from equations (10) and (11):

$$\frac{c_w^2}{c^2} = \frac{S_E}{\bar{S}_w + S_E}$$

Since  $f = \frac{\bar{S}_w}{S_E + \bar{S}_w}$

Again replacing  $c/n$  for  $c_w$ , it follows that:

$$f = 1 - \frac{1}{n^2} \tag{12}$$

Since the refractive index of water is 1.33, the dragging coefficient is calculated theoretically as follows:

$$f = 1 - \frac{1}{n^2} = 1 - \frac{1}{1.33^2} = 0.4347$$

The dragging coefficient of water obtained from Fizeau's experiment is  $f = 0.434 \pm 0.002$ . Apparently, the theoretical value perfectly agrees with the experimental value.

**The Michelson-Morley experiment**

During the time between 1876 and 1887, Michelson and Morley conducted an experiment in an effort to find the speed of the "ether -wind" using the Michelson Interferometer. But the result showed that there was no so-called "ether-wind" on the earth's surface at all (Ji, 2006, 2008; Guangjiong and Hongfang, 1979; Shujie and Hua, 1987; Yiling and Huijun, 1991; Shankland, 1964; Ji, 2007, 31 (3): 144-145; Yuanzhong, 1979; Wenwei, 1999).

Now, the Michelson-Morley Experiment can be explained well. A No-Shape-Substance is the propagation medium of light, and the propagating velocity of light relative to the No-Shape-Substance is constant. As shown in Figure 3, in the space near the earth's surface, the total No-Shape-Substance has no relative motion to the earth's surface. Therefore the velocity of light measured on the earth's surface is obviously isotropic.

**Millar experiment**

From the year 1902 to 1904, Millar and Morley repeated the Michelson-Morley experiment with better instruments. The result of their experiment was closer to zero than what was got by Michelson and Morley in 1887. Later on, Millar obtained different results from those obtained in the experiment conducted rather than the space of the earth

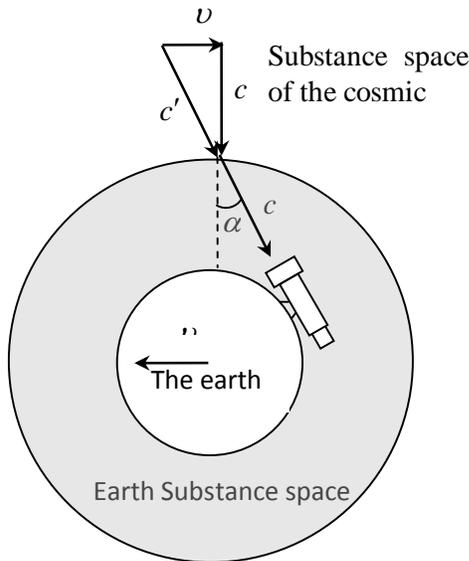


Figure 4. Light aberration phenomenon.

surface.

In 1921, Millar repeated this experiment on Mount Wilson by using the same methods as before. As a result, a positive effect of 10km/s was found, which means light speed deviated by an amount of 10km/s (Ji, 2006, 2008; Yiling and Huijun, 1991; Ji, 2007, 31 (3): 144-145).

It can be said that Millar's experiment has undermined the theory of relativity (Wenwei, 1999; Hunan Science and Technology Publishing Company, 2002; Higher Education Press, 1991; Peking University Press, 2006). Now, this study can explain the experimental result well based on the viewpoint of "No-Shape-Substance". As shown in Figure 3, this study has analyzed previously that the Earth is not likely to bring completely the No-Shape-Substance on the earth's surface, when the earth is in translational movement.

The earth is also not likely to bring completely the No-Shape-Substance on the high mountain, when the earth is translational in movement. That means on the high mountain the No-Shape-Substance has higher speed relative to the earth. Therefore when the Michelson-Morley experiment was conducted there, the interference fringes produced the speed deviation.

### Light aberration phenomenon

When a far-away star is observed, there is need to change the direction of one's telescope when seasons change, that is, the telescope's angle is changed when the earth changes its position on its orbital course round the sun.

The maximum angle  $\alpha$  is about  $10^{-4}$  radian in the practical observation. Physicists used to explain the light

aberration phenomenon with the theory of ether. They said that the earth moves relative to ether at a speed of 30 km/s. That is to say that there is a "ether wind" moving at that speed on the earth's surface. But such an explanation is completely contradictory to the zero result of Michelson-Morley experiment conducted at the earth's surface (Ji, 2006, 2008; Guangjiong and Hongfang, 1979; Ji, 2007, 31(3): 144-145).

Now the light aberration phenomenon can be explained naturally. As shown in Figure 4, it is supposed that the light from a star is vertically incident upon the orbit-plane of the earth at the speed of  $c$  and the earth has a velocity of  $v$  relative to the cosmic space.

When light propagates in the cosmic space far from the earth, the influence on the total No-Shape-Substance in the far distance caused by the motion of the earth is so little that it can be ignored. The light from the star will still be vertically incident upon the orbit plane of the earth at the speed of  $c$  in the cosmic. Because the earth moves at a speed of  $v$  with reference to the cosmic space, if observed from the earth, the light is incident onto the orbit-plane of the earth at an angle of  $\alpha$  (to the original propagation).

We can learn from Figure 4 that the tangent value of angle  $\alpha$  which is the observed direction and the original propagation direction is:

$$\tan \alpha = \frac{v}{c}$$

In this equation, if we replace  $v$  and  $c$  respectively with the value of the earth's orbit-speed and the value of light speed, it will be followed that the maximum of angle  $\alpha$  is about  $10^{-4}$  radian. The above explanation is perfectly in accordance with the result of this study's observation.

### Airy's experiment

It is known that water can carry light in the Fizeau's experiment. People deduced that if the telescope was filled with water, there would be an aberration phenomenon different from the one when there is no water.

In 1871, Sir George Airy tried just that, but he still observed the same aberration phenomenon as the case that the telescope was not filled with water. It is contradictory with the result of light aberration phenomenon and Fizeau's experiment in the frame of ether (Ji, 2006, 2008; Guangjiong and Hongfang, 1979; Ji, 2007, 31(3): 144-145).

Now the Airy's experiment can be understood naturally. As shown in Figure 4, in this experiment the telescope was filled with water. Note that the water in the telescope has no relative motion to the earth, comparable to the absence of water, and that the water in the telescope just increases the density of the total No-Shape-Substance in

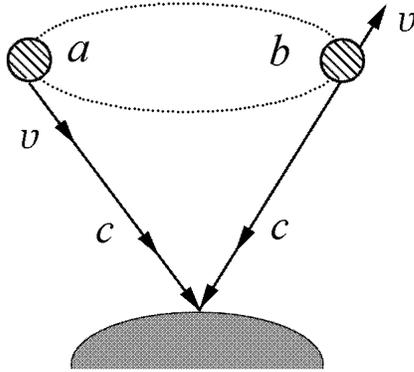


Figure 5. The binary star phenomenon.

the telescope, and that the total No-Shape-Substance in the telescope is still immobile relative to the earth.

After light has come into the No-Shape-Substance space near the earth surface, the water there will not affect the light's propagating direction. Therefore the same aberration phenomenon can still be observed as the case that there was no water in the telescope.

### Binary star phenomenon

From the observation of the remote binary star system, people can tell whether the speed of light would be affected by the light source. People have found that the observed binary star system is always quite natural. People have never observed the phenomenon of ghost stars. So they have concluded that the speed of light will not be affected by the motion of the light source (Ji, 2006, 2008; Guangjiong and Hongfang, 1979).

This study is of the opinion that the No-Shape-Substance is the propagating medium of light. The speed of light is independent from the motion of the light source.

As shown in Figure 5, the total No-Shape-Substance around a celestial body will be influenced by the motion of the celestial body. Thus the two beams of light originating from point 'a' and point 'b' respectively have different velocities relative to the cosmic space, but the propagation time of light near celestial body is very short. However, in the remote cosmic space, the total No-Shape-Substance would not be influenced by the motion of the celestial body. When light travels in the broad cosmic space, the two beams of light originating from points 'a' and 'b' respectively have the same speed of propagation. Therefore the binary stars that we observed are a normal system.

### The Sagnac effect

In 1911, Sagnac invented a ring interferometer as shown in Figure 6. A beam of light is split into two beams by beam splitter, and the beams of light are made to follow a

trajectory in opposite directions. To act as a ring, the trajectory must enclose an area. On return to the point of entry, the light is allowed to exit the apparatus in such a way that the interference fringes are obtained on the viewing screen (Ji, 2006, 2008; Guangjiong and Hongfang, 1979; Ji, 2007, 31(3): 146-147).

The amount of displacement of the interference fringes in the Sagnac effect is proportional to the product of the angular velocity of the interferometer and the area enclosed by the trajectory.

As shown in Figure 7, to simplify the question, we suppose the trajectory is a circular loop of radius  $R$  and the interferometer is moving in the clockwise rotating direction around a fixed axle with an angular velocity of  $\omega$ . Because the motion of the interferometer has no effect on the total No-Shape-Substance on the earth's surface, the total No-Shape-Substance is motionless relative to the earth's surface. Then the speeds of the two beams of light are both  $c$  in the earth's surface reference frame.

The circumferential tangent speed of the loop is  $\omega R$ . Based on the superposition principle of speed of Galileo, we get the light speeds in the clockwise rotating direction and the counterclockwise rotating direction respectively in the reference system where the loop is as follows:

$$v_{co} = c - \omega R$$

$$v_{counter} = c + \omega R$$

The travel times of the two beams in the loop are:

$$t_{co} = \frac{L}{v_{co}} = \frac{2\pi R}{c - \omega R}$$

$$t_{counter} = \frac{2\pi R}{v_{counter}} = \frac{2\pi R}{c + \omega R}$$

Where  $L = 2\pi R$  is the perimeter of the loop. The difference between the travel times is:

$$\Delta t = t_{co} - t_{counter} = 2\pi R \left( \frac{1}{c - \omega R} - \frac{1}{c + \omega R} \right)$$

$$\Delta t = \frac{4\pi R^2 \omega}{c^2 \left( 1 - \frac{\omega^2 R^2}{c^2} \right)} \tag{13}$$

Ignoring the secondary lesser time, we get  $\Delta t = \frac{4\pi R^2 \omega}{c^2}$

, then substituting the  $S$  for  $\pi R^2$  which indicates the area enclosed by the loop, the equation will be:

$$\Delta t = \frac{4S\omega}{c^2} \tag{14}$$

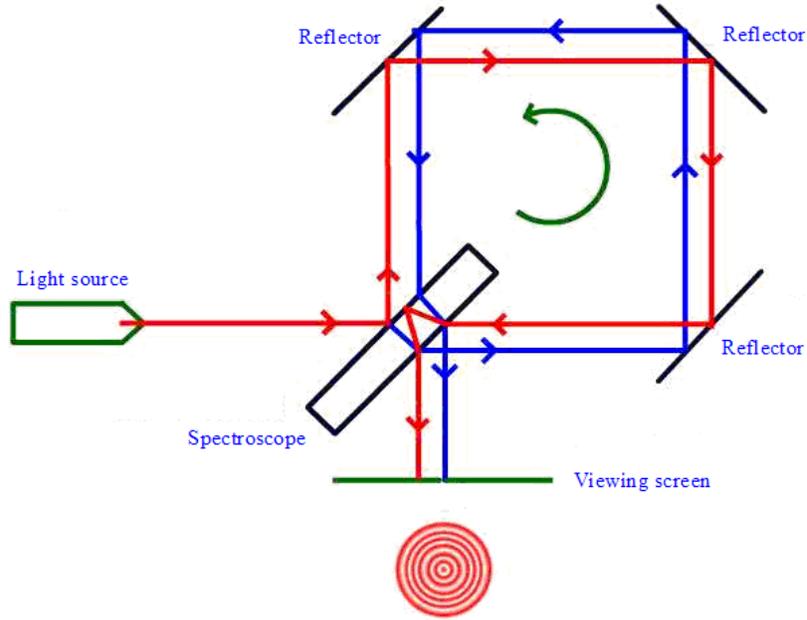


Figure 6. Sagnac Effect.

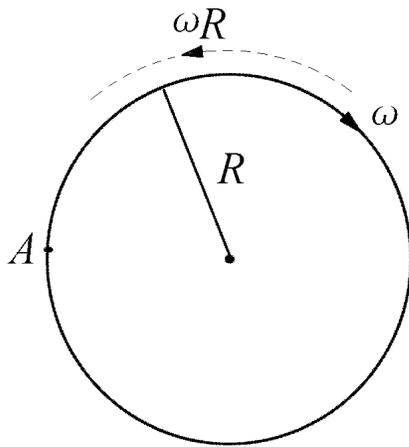


Figure 7. In a vacuum

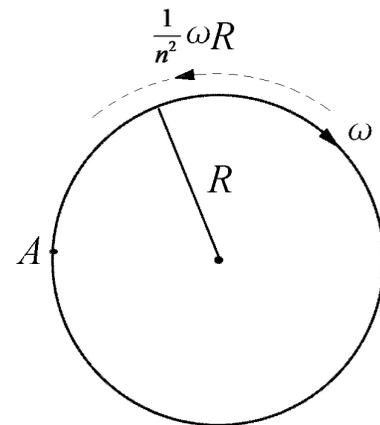


Figure 8. In a medium

The optical path difference is:  $\Delta = c\Delta t = \frac{4S\omega}{c}$

So the amount of displacement of the interference fringes corresponding to the optical path difference is:

$$\Delta N = \frac{\Delta}{\lambda} = \frac{4S\omega}{c\lambda} \quad (15)$$

This equation applies to any enclosed loop, not necessarily circular.

The Sagnac effect has been employed in many

practical ways. For example, a fiber gyroscope has been successfully utilized in the field of aviation and space flight. It was one of the highly developed gyroscopes in the last 20 years.

For the fiber gyroscope, when light propagates in the medium, its speed is relevant to both the refractive rate and the tangent speed of the medium. However, the Sagnac effect can still be well understood without changing the original formula.

As shown in Figure 8, the radius of the fiber coil is R. Both the light source and the detector are at point A. The device is moving in the clockwise-rotating direction with an angular speed of  $\omega$ , so the tangent speed of the coil is

$\omega R$ .

The total No-Shape-Substance inside the fiber will also move in the clockwise-rotating direction because of the carrying ability of the fiber. From the equation discussed in Fizeau's experiment, we get the tangent speed of the total No-Shape-Substance relative to the earth's surface as follows:

$$v = f\omega R = \left(1 - \frac{1}{n^2}\right)\omega R \tag{16}$$

But the total No-Shape-Substance is moving in the counterclockwise-rotating direction relative to the rotating reference system where the interferometer is, so its tangent speed relative to the rotating reference system is:

$$v' = \omega R - v = \frac{1}{n^2}\omega R \tag{17}$$

When the light propagates in the clockwise and counterclockwise direction, its tangent speeds relative to the interferometer are  $v_1$  and  $v_2$  respectively:

$$v_1 = \frac{c}{n} - \frac{1}{n^2}\omega R$$

$$v_2 = \frac{c}{n} + \frac{1}{n^2}\omega R$$

The time difference is:

$$\Delta t = \frac{2\pi R}{v_1} - \frac{2\pi R}{v_2} = \frac{4\pi R^2 \omega}{c^2 \left(1 - \frac{\omega^2 R^2}{n^2 c^2}\right)} \tag{18}$$

Ignoring the secondary lesser time, we get  $\Delta t = \frac{4\pi R^2 \omega}{c^2}$ , and doing the same substitution as before, we get the equation as follows:

$$\Delta t = \frac{4S\omega}{c^2} \tag{19}$$

It has the same form as equation (14) in vacuum. The corresponding phase difference is:

$$\Delta\phi = 2\pi \frac{\Delta t c_n}{\lambda_n} = 2\pi \frac{\Delta t c}{\lambda} = \frac{8\pi S\omega}{\lambda c} \tag{20}$$

Where  $\lambda$  is the wavelength of laser in vacuum,  $\lambda_n$  and

$c_n$  are the wavelength and the speed of laser light in the medium respectively. Thus, if the fiber coil has N circles, its phase shift is:

$$\Delta\phi = \frac{8\pi SN\omega}{\lambda c} \tag{21}$$

After measuring the value of  $\Delta\phi$  according to the phenomenon of interferometer of light, the value of the angular speed  $\omega$  can be calculated.

### CONCLUSIONS

This paper expounded a new physical concept that there exists a special kind of substance, No-Shape-Substance, in the natural world and it is the propagating medium of light. It probes into the problem of propagation of light, and well explains why the propagation velocity of light in materials such as glass and water is less than the speed of light in vacuum based on this idea.

On the same foundation, the article reinterpreted a lot of the contradictory phenomena in the history of physics, such as Fizeau's Experiment, Michelson-Morley Experiment, Millar Experiment, Light Aberration Phenomenon and the Sagnac Effect. Under the new ideas, the experimental phenomena no longer have any conflict between each other which can make people be acquainted with nature more fully, as well as understand physics more objectively, naturally and logically.

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