Photon density theory: an alternative to Einstein's special relativity

Xianming Meng

Email: mxmbox@yahoo.com

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Abstract

By linking photon density to relative mass, this paper presents an alternative to the special relativity theory. The new theory uses only a few intuitive assumptions and reveals the cause and mechanism for relativistic phenomena – the speed of the object alters the average density of the photons and thus changes the relative mass. With this mechanism, the photon density theory discards Lorentz transformation, length contraction and time dilation, and restores the separate universal space and time. Some predictions from the new theory are the same as those from the special relativity theory, such as the unmatchable speed of light, mass increasing with speed, the mass-energy equation, the high-order Doppler effect, and the equivalence of the inertial reference frames; however, the photon density theory suggests that the Doppler effect of light is also asymmetric and that the mass energy equation works only from mass to energy.

Key words: photon density; relative mass; relativistic Doppler effect; mass energy equation

1. Introduction

The reader may wonder why we need a substitute for a very popular theory like the special relativity theory, which is routinely proved by experiments. The short answer is that all theories need progress, either by upgrading or by replacement. Moreover, the special relativity theory is not a complete, consistent theory with deep understanding of relativistic phenomena.

First, even if a theory is supported by some experiments, not everything in the theory is correct. This point has been proven time and time again in the history of science. History also shows that successful challenges to mainstream theories lead to a giant leap in scientific advances, for example Galileo's challenge to Aristotle, Einstein's challenge to Newtonism and the electromagnetic wave theory, and Bohr's challenge to Einstein on quantum mechanism. While we should keep an open mind on the counterintuitive assumptions and results proposed by Einstein when the relativity theory was still on the horizon, we should also keep an open mind to new theories that may replace the special relativity theory.

Second, many predictions from the special relativity theory are proved by experiments or observations, but some are not. For example, an increase in rest mass during an inelastic collision at low speed has never been observed. Although there are claims of increases in rest mass during a high-speed collision, these claims are based on the calculations following Einstein's assumption of energy conservation during an inelastic collision. Despite a number of claims of creation of positrons and electrons from high-energy photon collision, there is no clear evidence showing any rest mass is created from energy.

For example, Burke et al (1997)[i] claimed an experimental confirmation of positron production in multiphoton light-by-light scattering, but their experimental result was achieved by scattering a laser with an electron beam. Even if the laser beam was off, positrons were detected. With laser beam on, more positrons were detected. This increased positrons detected were viewed as the results of photon collisions and the pair production equation of Breit and Wheeler (1934)[ii] was used to explain the result. An alternative explanation can be simply that the photon-electron collision (i.e. with laser beam on) enhanced the positron creation in the electron beam (i.e. with laser beam off). If so, this is not a process of creating positrons purely from energy. Some physicists designed and implemented experiments to smash high-energy photons to create electrons (Wilson, 2014[iii]; Starr, 2018)[iv], but so far, these experiments have not been successful.

Meanwhile, the temperature increase that results from an inelastic collision is not explained by the relativity theory. Although some may regard the heat generated as an increase in rest energy and thus in rest mass, this explanation apparently contradicts the definition of rest energy. Based on the energy equation $E_0=m_0c^2$, rest energy is solely related to rest mass and thus should not be affected by temperature.

Third, the special relativity theory lacks physical underpinning. The whole theory is based on the Lorentz transformation, which manifests the assumption of the constant speed of light regardless of the speeds of both the light source and the observer. The Lorentz transformation formulas reveal no underlying physical reasons. One may argue that length contraction and time dilation are the physical underpinnings, but these two phenomena are proposed as being the necessary consequence rather than the underlying factors of the Lorentz transformation. In this paper, some alleged evidence for time dilation and length contraction is discussed.

Just as Kepler's laws of planetary motion was an important step for Newtons' gravitational law, the Lorentz transformation and the relativity theory should be advanced to a higher level in order to improve our understanding of the physical world. An advanced theory that demonstrates the physical underpinning should be able to answer questions such as what causes the Lorentz factor to be in the form of $\gamma=1/(1-v^2/c^2)^{1/2}$? The proposed photon density theory provides an answer and derives the Lorentz factor. From the discussion above, the reader should perceive that the theory being proposed is not a regression back to the classical physics of Newtonism, but rather an upgraded classical physics that contains not only the valid elements of classical physics but also a new development that explains and clarifies the relativistic effect.

2. Assumptions

The proposed theory requires the following intuitive assumptions.

(1) Light (photon) speed is independent of the speed of the source.

This assumption is supported by observations and experiments such as stellar aberration, the Doppler effect of light, the observation of the movement of binary stars, the speed of γ rays from mesons, and the one-way Michelson and Morley experiments.

(2) All material objects emit photons evenly in all directions, and the number of photons emitted per second is proportional to the amount of mass at rest.

Photon emission or light is the common phenomenon and we observe that the emission intensity of a light source is the same in all directions. It seems that some objects do not emit photons, which may be because the emission frequency is too low to be detected by the current technology. Other things being equal, a light source from a larger mass tends to produce a proportionally higher light intensity, which indicates that the photon emission rates are proportional to the magnitude of the rest mass.

Considering that matter emits photons evenly in all directions, we focus on the photon emission rates in one representative direction. The number of photons emitted in any direction can be calculated as:

$$N=f*e*m_0 \qquad (1)$$

where m_0 is mass at rest, N is the number of photons emitted per second in one direction by total mass m_0, e is the number of photons of one emission in one direction emitted by one unit of mass as determined by the property of the matter, and f is emission frequency.

(3) Inertia of matter is determined by the density of the photons.

Photon density results in the inertia of the emitter through photon pressure or photon matter interaction. This assumption is a natural extension of the common wisdom that mass at rest is the measurement of the inertia of a matter. Since the density of photons is proportional to the amount of mass at rest, it can serve as a measurement of mass and thus a measurement of inertia. For the purpose of measuring inertia and momentum, only the photon density in and opposite to the direction of the speed matters.

Photon density may change when an object starts to move, so the inertia of the object may also change. We use the concept of relative mass as the indicator for the changing inertia of the object. For an object at rest, its relative mass equals its rest mass, m_0. The corresponding photon density is denoted d_0. When the object starts to move, the relative mass m is different from m_0, and the photon density d is different from d_0. By utilizing these notations, assumption (3) can be crystalized as:

$$m = m_0 d/d_0 \qquad (2)$$

(4) Emission frequency is proportional to the inverse of photon density.

Photon pressure can adversely affect the further emission of photons, so photon density and emission frequency are inversely related to each other. This assumption can be expressed as:

$$f \propto \frac{1}{d}$$

Or

$$fd = constand$$

If the rest mass m_0 has the emission frequency of f_0 and the photon density of d_0, the assumption can be further expressed as:

$fd= f_0d_0$ *or*

$f= f_0d_0 /d$ (3)

3. Basic physical quantities and concepts

(1) Mass

We formally define rest mass as the mass measured when the matter is stationary, denoted as m_0. When the matter is moving, the measured mass is called relative mass, denoted as m. Given the emission frequency f_0 for the matter at rest, its photon emission rate N_0 can be obtained by applying equation (1) to the case:

$N_0=f_0em_0$ (4)

Given the speed of light in vacuum c as shown in the panel (a) of Figure 1, the line density of photons in any direction can be calculated for the object at rest:

$d_0=N_0/c$ (5)

When the matter is moving, the structure of the photon density will change. As shown in the panel (b) of Figure 1, a light source of speed v will have denser photons in the front and sparser photons behind. The change in photon density structure may also affect the average photon density and thus affect the photon emission frequency. Based on equations (1) and (4), we have:

$N=fem_0=(f/f_0) (f_0em_0)=N_0f/f_0$ (6)

The photon density ahead can be calculated as:

$d_1=N/(c-v)$

Similarly, the photon density behind the source is:

$d_2=N/(c+v)$

and the average line density of the light source can be expressed as:

$d=(d_1+d_2)/2=Nc/(c^2-v^2)$

Plugging equations (6) and (5) into the above equation, we have:

$$d=(N_0f/f_0)c/(c^2-v^2) = d_0(f/f_0)c^2/(c^2-v^2) \qquad (7)$$

Plugging equation (3) into equation (7), we have:

$d^2=d_0^2c^2/(c^2-v^2)$

Solving the equation, we obtain:

$$d = d_0/\sqrt{1-\frac{v^2}{c^2}} \qquad (8)$$

$$f = f_0\sqrt{1-\frac{v^2}{c^2}} \qquad (9)$$

Using equations (2) and (8), we have relative mass:

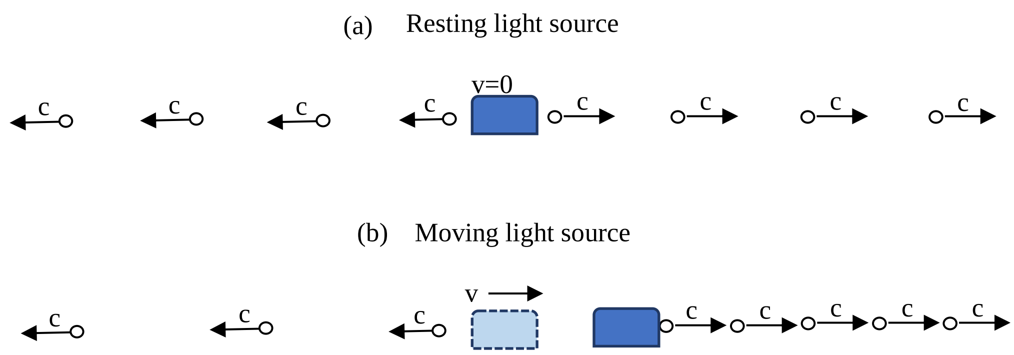
$$m = m_0 d/d_0 = m_0/\sqrt{1-\frac{v^2}{c^2}} \qquad (10)$$

and the difference between relative mass and resting mass can be calculated as:

$$m_k = m - m_0 = m_0/\sqrt{1-\frac{v^2}{c^2}} - m_0 \qquad (11)$$

Since this increased mass stems from the redistribution of photon density due to the speed of the light source, we give it a name: kinetic mass.

Fig.1 Speed of the light source, photon density, and relative mass



(2) Momentum

Since relative mass changes with speed, the definition and calculation of the formula for momentum in classical physics needs to be upgraded to reflect the changing relative mass.

p=∫Fdt=∫d(mv)=∫(mdv+vdm)=mv

Using equation (10), one can easily verify that this general formula holds for relative mass:

$$p = \int (mdv + vdm) = \int \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} dv + \int vd \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} m_c$$

$$= \int \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} dv + v \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} - \int \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} dv = mv$$

(3) Energy

The calculation of kinetic energy also needs to be based on relative mass:

$K=\int Fdx=\int Fdt(dx/dt)=\int vd(mv)=\int(mvdv+v^2dm)$ (12)

Differentiating equation (10), we have:

$c^2dm-v^2dm-mvdv=0$

or

$v^2dm= c^2dm -mvdv$ (13)

Plugging equation (13) into equation (12), we have:

$$K = \int c^2 dm$$

Equation (10) shows that when the speed increases from zero to v, the mass increases from m_0 to m. The above calculus in this range can be evaluated as:

$K= mc^2-m_0c^2$

The term m_0c^2 indicates the amount of energy related to rest mass, so we call it rest energy or internal energy, E_0:

$E_0=m_0c^2$

Similarly, the term mc^2 indicates the energy related to relative mass, so we call it relative energy:

$E=mc^2$

The difference between relative and rest energy is kinetic energy, which is related to kinetic mass:

$K= m_kc^2 =(m-m_0)c^2=E- E_0$

(4) Space, time and speed

As will be seen later, the change in photon density can explain all seemingly unusual phenomena in classical physics, such as the unmatchable speed of light, the mass increase with velocity, the relativistic Doppler effect, etc., so most features of classical physics are preserved, including absolute space, universal time, and Galilean relative speed. As such, the Galilean transformation works well. For example, the distance between the photon and the source can be obtained through the Galilean transformation:

$x=(c-v)t$

Here, the speed of the object (v) cannot be greater than the speed of light (c). This limit is not addressed by the Galilean transformation, but it is mandated by the relative mass formula. As shown in equation (10), if speed v approaches the speed of light c, the relative mass m approaches infinity, so no force can push an object of infinite mass to reach the speed of light.

4. Inelastic collision and reference frame

Physicists devote significant effort to making sure the physic laws are the same in different reference frames. Galileo proved that the law of motion is the same for any inertial reference frames. Later, it was proved that the choice of inertial reference frame does not affect the laws in classical physics. To some extent, the creation of the Lorentz transformation and the special relativity theory aim to keeping the physics laws invariant under different reference frames. It is of interest to see how the photon density theory works with different reference frames.

In the case of elastic collision, it is easy to verify the conservation of momentum and energy for any reference frames, so this case is not interesting to us. In the case of an inelastic collision, the concept of photon density plays a crucial role in understanding the change in momentum and energy with changing reference frames. In this section, the inelastic collision is used as an example to show how and why a general law like momentum and energy conservation is invariant for any inertial frames.

(1) Inelastic collisions in a rest frame

We start with two inelastic collision experiments in a rest frame, as shown in Figure 2.

In the left panel, two balls, A and B, with the same resting mass 'm_0' and the same speed 'v' move towards each other. The inelastic collision causes the two balls to stick together, forming a bigger ball, C, and becoming stationary. In classical physics, the change in momentum and kinetic energy can be calculated as:

$\Delta p=0-(m_0v-m_0v)=0$

$\Delta K=0.5*2m_0*0 -0.5m_0v^2*2= - m_0v^2$

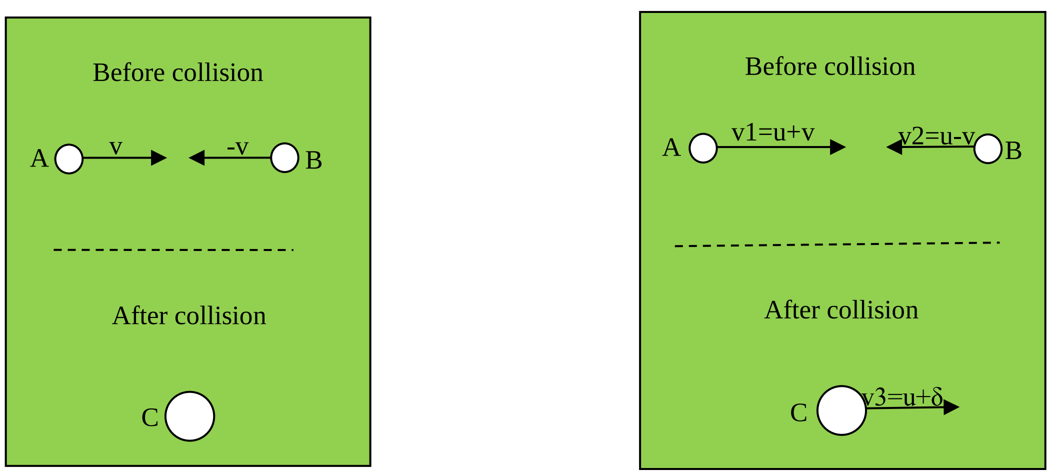
When taking into account the relative mass caused by the change in photon density, the change in momentum and kinetic energy before and after the collision are:

$$\Delta p = 2m_0 * 0 - \left(\frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} \right) = 0$$

$$\Delta K = 0.5 * 2m_0 * 0 - 0.5 \left(\frac{m_0 v^2}{\sqrt{1-\frac{v^2}{c^2}}} + \frac{m_0 v^2}{\sqrt{1-\frac{v^2}{c^2}}} \right) = \frac{-m_0 v^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

If v is negligible compared to light speed c, $\Delta K \approx -m_0 v^2$. The result is therefore consistent with classical physics.

Fig.2 Inelastic collisions in a rest frame



The right panel of Figure 2 shows the collision of the two balls A and B with speed v1=u+v and v2=u-v, respectively. Based on the principle of conservation of momentum, we have:

$$p = \frac{m_0 v_1}{\sqrt{1-\frac{v_1^2}{c^2}}} + \frac{m_0 v_2}{\sqrt{1-\frac{v_2^2}{c^2}}} = \frac{2m_0 v_3}{\sqrt{1-\frac{v_3^2}{c^2}}}$$

Or

$$p^2 = \left(\frac{m_0 v_1}{\sqrt{1-\frac{v_1^2}{c^2}}} + \frac{m_0 v_2}{\sqrt{1-\frac{v_2^2}{c^2}}} \right)^2 = \frac{4m_0^2 v_3^2}{1-\frac{v_3^2}{c^2}} \tag{14}$$

Based on the pre-collision momentum, we can calculate:

$$p^2 = \frac{m_0^2 v_1^2}{1-\frac{v_1^2}{c^2}} + \frac{m_0^2 v_2^2}{1-\frac{v_2^2}{c^2}} + \frac{2m_0^2 v_1 v_2}{\sqrt{1-\frac{v_1^2+v_2^2}{c^2}+\frac{v_1^2 v_2^2}{c^4}}}$$

$$\approx m_0^2 v_1^2 \left(1+\frac{v_1^2}{c^2}\right) + m_0^2 v_2^2 \left(1+\frac{v_2^2}{c^2}\right) + 2m_0^2 v_1 v_2 \left(1+\frac{v_1^2+v_2^2}{2c^2}\right)$$

$$= m_0^2 (v_1+v_2)^2 + \frac{m_0^2}{c^2}(v_1^4+v_2^4+v_1^3 v_2+v_1 v_2^3)$$

$$= m_0^2 (v_1+v_2)^2 + \frac{m_0^2 (v_1+v_2)}{c^2}\left[(v_1+v_2)^3 - 3v_1 v_2 (v_1+v_2)\right]$$

Letting v1=u+v and v2=u-v, we can calculate:

$$p^2 = m_0^2 (2u)^2 + \frac{m_0^2 (2u)}{c^2}\left[(2u)^3 - 3\left(u^2 - v^2\right)(2u)\right] = 4m_0^2 u^2 + \frac{4m_0^2 u^2}{c^2}(u^2+3v^2)$$

Plugging the above equation back into equation (14), we have:

$$v_3^2 = \frac{p^2}{4m_0^2 + \frac{p^2}{c^2}} = \frac{u^2 + \frac{u^2}{c^2}(u^2+3v^2)}{1+\frac{u^2+\frac{u^2}{c^2}(u^2+3v^2)}{c^2}}$$

$$\approx \left[u^2 + \frac{u^2}{c^2}(u^2+3v^2)\right]\left[1 - \frac{u^2+\frac{u^2}{c^2}(u^2+3v^2)}{c^2}\right]$$

$$\approx \left[u^2 + \frac{u^2}{c^2}(u^2+3v^2)\right] - u^2\left[\frac{u^2+\frac{u^2}{c^2}(u^2+3v^2)}{c^2}\right]$$

$$\approx u^2 + \frac{3u^2v^2}{c^2} - \frac{u^4}{c^4}(u^2 + 3v^2)$$

For u<<c, the last item is much smaller than the second term, so v_3 will be greater than u. This is expected. If v is very small compared with u, the relative mass of two balls is almost the same, so the expected speed of the merged ball is u. Due to the uneven photon distribution before the collision, the ball moving at the higher speed (e.g. u+v if u and v have the same sign) has more relative mass than the other ball, so the momentum caused by the extra relative mass of the ball of higher speed will add extra momentum to the merged ball, and thus v_3 will be greater than u.

The change in kinetic energy can be calculated as:

$$\Delta K = \frac{1}{2}\left(\frac{2m_0v_3^2}{\sqrt{1-\frac{v_3^2}{c^2}}} - \frac{m_0v_1^2}{\sqrt{1-\frac{v_1^2}{c^2}}} - \frac{m_0v_2^2}{\sqrt{1-\frac{v_2^2}{c^2}}}\right)$$

$$\approx \frac{1}{2}m_0\left[2\left(1+\frac{v_3^2}{2c^2}\right)v_3^2 - \left(1+\frac{v_1^2}{2c^2}\right)v_1^2 - \left(1+\frac{v_2^2}{2c^2}\right)v_2^2\right]$$

$$= \frac{1}{2}m_0\left[2v_3^2 - v_1^2 - v_2^2 + \frac{2v_3^4 - v_1^4 - v_2^4}{2c^2}\right]$$

$$\approx m_0\left[u^2 + \frac{3u^2v^2}{c^2} - \frac{u^4}{c^4}(u^2+3v^2)\right] - m_0(u^2+v^2) + m_0\frac{2\left(u^2 + \frac{3u^2v^2}{c^2}\right)^2 - v_1^4 - v_2^4}{4c^2}$$

$$\approx m_0\frac{3u^2v^2}{c^2} - m_0\frac{u^4}{c^4}(u^2+3v^2) - m_0v^2 + m_0\frac{u^4 + \frac{6u^4v^2}{c^2} - (u^4 + v^4 + 6u^2v^2)}{2c^2}$$

$$= -\frac{m_0\,v^4}{2c^2} - \frac{m_0u^6}{c^4} - m_0v^2$$

The result is negative for all values of u and v, so the kinetic energy decreases for all case. This is expected because during an inelastic collision, some energy is converted to thermal energy.

The calculation converts to the classical case if u and v are negligible compared with the speed of light c.

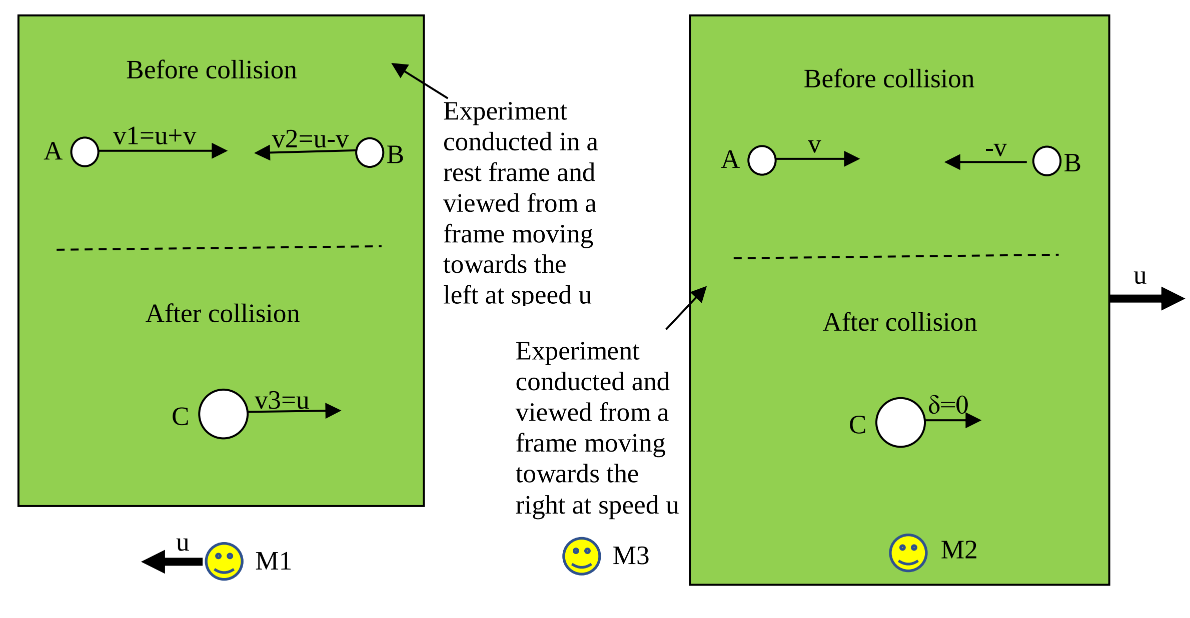
(2) Inelastic collisions in different reference frames

If the reference frame is not stationary, we must take into account the speed of the frame when applying the principle of momentum conservation. We consider the two cases as shown in Figure 3.

The left panel shows the two-ball collision that occurred in the rest frame but is observed by a person M1 moving to the left at speed u. The experiment in this case is essentially the same as that shown in the left panel of Figure 2, so the experimental outcome should be the same – the resulting ball C should be stationary in the rest frame. The momentum conservation that includes observer M1 can be written as:

$$p = \frac{M_1 u}{\sqrt{1-\frac{u^2}{c^2}}} + \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{M_1 u}{\sqrt{1-\frac{u^2}{c^2}}} \qquad (15)$$

Fig.3 Inelastic collisions in different reference frame



If the frame of observer M1 is used as a reference frame where the observer is stationary, using Galilean transformation we can conclude that the experimental frame M_F moves to right at speed u. The momentum conservation equation can be expressed as:

$$p = \frac{M_F u}{\sqrt{1-\frac{u^2}{c^2}}} + \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{M_F u}{\sqrt{1-\frac{u^2}{c^2}}} \qquad (16)$$

However, if observer M1 ignores the function of the experiment frame, he/she only registers that v1=u+v, v2=u-v, and v3=u. This will lead to a violation of momentum conservation because:

$$\frac{m_0(u+v)}{\sqrt{1-\frac{(u+v)^2}{c^2}}} + \frac{m_0(u-v)}{\sqrt{1-\frac{(u-v)^2}{c^2}}} \neq \frac{2m_0 u}{\sqrt{1-\frac{u^2}{c^2}}} \qquad (17)$$

The cause for violation of momentum conservation is not the Galilean transformation but the inappropriate application of the relative mass formula.

While it is appropriate to add the speed u to the two balls A and B through the Galilean relativity of speed, this added speed u does not change the photon density of A and B, thus it does not change the relative mass of A and B. As such, the inequality seen in equation (17) is a mis-calculation. To avoid this kind of mistake, we can calculate the total momentum by summing up the momentum of the frame and the additional momentum of the experimental objects, as shown in equations (15) and (16).

The right panel of Figure 3 shows the two-ball collision experiment conducted in an environmental frame moving towards the right at speed u. Observer M2, who is in the same environmental frame, is unaware of the movement of the frame and thus naturally obtains the momentum conservation equation:

$$\Delta p = 0 - \left(\frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} \right) = 0$$

This is the same result that would occur if the experiment is conducted in a rest frame, as shown in the left panel of Figure 2. This result indicates that the experimental result does not depend on the speed of the environmental frame if the observer is in the same environmental frame.

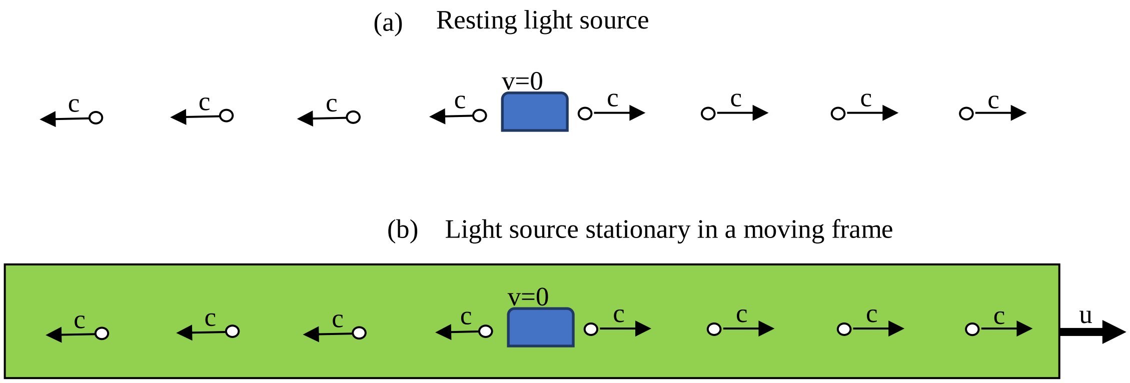
For observer M3 who is staying in the rest frame, the correct way to examine the change in momentum is to consider the frame first and then take care of the balls, so he/she will arrive at equation (16). However, if he/she ignores the moving experimental frame and focuses only on the movement of two balls, he/she would register that the observed speeds of the two colliding balls are v_1=u+v and v_2=u-v, respectively. Based on the same calculation as that used for the right panel of Figure 2, he/she may conclude that v3≠u, which contradicts the observation based on the Galilean principle of relative speed.

The problem in this calculation is that from the perspective of photon density, the experiment shown in the right panel of Figure 2 is different from that shown in the right panel of Figure 3. Experimental frames of different speeds lead to different photon densities of the experimental environment, which may affect the photon density of an experimental object. However, we cannot simply add the photon density of the experimental frame to the photon density of the object in the frame due to photon matter interaction.

The interference between the photon densities of the environment and the experiment is realized through photon matter scattering in the environment. In a separate paper, it can be shown that photons can pick up the full speed of the environment through photon matter scattering[1]. As such, an object that is stationary with the experimental frame has a speed u, its photons have a speed c+u, and the relative speed between the object and its photons is c. Consequently, the photon density in and opposite to the direction of the movement of the frame is the same (d1=d2=N/c) and the relative mass equals the rest mass, just like the case where the object is stationary in the rest frame (see Figure 4). Similarly, if an object moving at a speed of v with respect to the experimental frame, the relative mass is determined by the speed v, not the speed of the frame u .

[1] This is not the same as totally dragged aether theories by Stokes (1845[1]) and Hertz (1890[1]) which could not explain the result of Fizeau water tube experiment.. The photon matter scattering can explain all key experiments such as Fizeau (1851), Hoek (1868), Michaelson-Morley (1887), Kennedy-Thorndike (1932), and Sagnac (1899).

Fig.4 Inertial frame, photon density, and relative mass



In summary, the photon interaction with the inertial frame shields the photon density of the object in the frame, so the experimental results are the same as those conducted in the rest frame. This photon matter scattering results in the equivalence of the inertial frames. When the experiment is conducted in an inertial frame that is different from the reference frame, we need to consider the experimental frame first and then consider the experimental elements in the frame.

5. Predictions and evidence

The proposed photon density theory can explain all the evidence predicted or explained by the special relativity theory. There are many predictions from the special relativity theory, so it is impractical to examine all of them in the limited space. Instead, we focus on the following two areas.

(1) The relationship between velocity, mass, and energy

A key outcome of the photon density theory is the phenomenon that mass increases with velocity. The phenomenon was observed as early as 1897, when the electron particle was discovered, so this is a commonly accepted fact. Equation (10) in this paper describes quantitively the behaviour of the mass increase, and is exactly the same as the formula from the special relativity theory:

$$m = \gamma m_0,$$

$$where\ \gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

This formula has been verified repeatedly by experiments so we conclude that it is beyond doubt.

The other key outcome of the photon density theory is the energy mass equation, which is also the same as that in the relativity theory and is proven by nuclear energy generation. It seems that the two theories have no differences on this front. However, while the relativity theory views energy and mass as interchangeable, the photon density theory suggests that the equation works only from mass to energy.

The difference arises from the different interpretation of rest energy. The photon density theory defines rest energy as $E_0=m_0c^2$, which indicates that the photon density theory relates rest energy only to the amount of rest mass, so the thermal energy contained in the mass is excluded from rest energy. In the case of an inelastic collision when two balls smash into each other and form a big ball at rest, the kinetic energy of the two balls is transformed into thermal energy, causing a temperature increase but leaving the rest mass unchanged. This explanation is consistent with the fact that, so far, no experiment has detected a change in rest mass during a collision.

On the other hand, the special relativity theory interprets rest energy as being all the energy embodied in the mass, and enforces the view of conservation of mechanic energy in an inelastic collision, thus the transformation of kinetic energy to thermal energy is counted as an increase in rest energy, E_0. Then the theory uses the energy equation $E_0=m_0c^2$ to conclude that there is an increase in rest mass, m_0. This interpretation is inconsistent: it regards thermal energy as part of rest energy but, in the meantime, it utilized the energy equation, $E_0=m_0c^2$, which explicitly shows that rest energy is independent of temperature or thermal energy. As a result, the special relativity theory simply views or treats the amount of thermal energy as rest mass.

Some experiments do generate new particles by smashing old particles or through a photon-nuclear interaction; however, due to our limited knowledge on subatomic particle structure, one cannot claim these new particles are transformed from energy rather than from old particles or existing matter. Since 2014, some physicists have started to design and implement experiments that smash high-energy photons to create electrons, but so far these experiments have not been successful. The outlook for these experiments is not optimistic because of the logic inconsistency of the special relativity theory regarding rest energy and rest mass. From another perspective, if energy can be transformed to mass, some direct or indirect evidence of this kind of transformation should have been observed in the numerous experiments that have been conducted so far.

(2) No length contraction or time dilation

Length contraction and time dilation are extremely counter-intuitive concepts that result from the Lorentz transformation. However, the confirmation of other predictions from the special relativity theory popularized these concepts. The photon density theory uses Galilean transformation, which assumes absolute and separate space and time, so length contraction and time dilation play no role in the theory.

There is no evidence on length contraction because it is not provable: any tool that measures length contraction will be contracted when it travels at the same speed of the object to be measured. Here we focus on evidence that is claimed to directly relate to time dilation.

It is generally accepted that the observed changes in atomic clocks on flying airplanes (Hafele and Keating, 1972[v]) are too tiny to be claimed as evidence for time dilation. The evidence of meson life (Rossi and Hall, 1941[vi], Crawford, 1957[vii]) is also regarded as inconclusive (Dingl, 1956[viii], Cochran, 1957[ix], Prokhovnik, 1978[x]). Now there seems to be two pieces of solid evidence for time dilation: the Ive and Stillwell (1938, 1941) experiments and the adjustment of GPS satellite clocks (Ashby, 1975[xi], 2003[xii], Allan et at, 1985[xiii], Ashby and Weiss, 1999[xiv]).

The GPS clock argument for time dilation is related to both the special and general relativity theories. The special relativity theory indicates that the clocks on the satellites should be slower due to the higher speed of the satellites, so these clocks should be adjusted to run faster in order to match the speed of clocks on the ground. However, the GPS clocks need to be slowed down before they are taken to the space, and this phenomenon is generally regarded as evidence of the relativistic effect of the general relativity theory. We will not discuss the general relativity effect in this paper, so we leave the explanation of GPS clock adjustment to another time.

The experiments by Ives and Stilwell examined time dilation in the Thomar-Lorentz theory. Since this theory is also based on the Lorentz transformation, its predicted time dilation effect is similar to that of the special relativity theory. As a result, the confirmation of time dilation predicted by the Thoma-Lorentz theory is generally viewed as confirmation of the relativistic Doppler effect in the special relativity theory. The explanation of the Ives and Stilwell experiments based on the time dilation argument can be shown briefly as follows.

The formula for the ordinary Doppler effect is:

$$\frac{\lambda}{\lambda_0} = \frac{c - v * cos\theta}{c} = 1 - \frac{v}{c} cos\theta \qquad (18)$$

where v is the speed of the moving light source and θ is the angle between v and the light ray towards the observer.

However, the Lorentz transformation necessitates that for the moving object, time slows down by the amount of the Lorentz factor γ, so the relativity theory predicts a high-order Doppler effect due to time dilation:

$$\frac{\lambda}{\lambda_0} = \gamma\left(1 - \frac{v}{c} cos\theta\right) = \frac{1 - \frac{v}{c} cos\theta}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (19)$$

The experiment of Ives and Stillwell (1938[xv], 1941[xvi]) involved a longitude Doppler effect of the opposite direction, i.e., θ=0 and π. For θ= π, the ordinary Doppler effect leads to a red shift and the introduction of γ enlarges this red shift because 0<γ<1. For θ=0, however, the ordinary Doppler effect leads to a blue shift, and the presence of γ partially offsets the ordinary Doppler effect. This asymmetric shift is called a relativistic or high-order Doppler effect.

The high-order effect can be obtained quantitatively by applying binominal approximation to equation (19). For the direct light ray, equation (19) becomes:

$$\frac{\lambda 2}{\lambda_0} = \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}} \approx \left(1 - \frac{v}{c}\right)\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right) = 1 - \frac{v}{c} + \frac{1}{2}\frac{v^2}{c^2} - \frac{1}{2}\frac{v^3}{c^3}$$

For the reflected light:

$$\frac{\lambda 1}{\lambda_0} = \frac{1+\frac{v}{c}}{\sqrt{1-\frac{v^2}{c^2}}} \approx \left(1+\frac{v}{c}\right)\left(1+\frac{1}{2}\frac{v^2}{c^2}\right) = 1+\frac{v}{c}+\frac{1}{2}\frac{v^2}{c^2}+\frac{1}{2}\frac{v^3}{c^3}$$

Apparently, the wavelength shift for the two rays are asymmetrical. The average wavelength of the Doppler shifts of both rays can be calculated as:

$$\bar{\lambda} = \frac{\lambda 1+\lambda 2}{2} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\lambda_0$$

For $0<v<c$, the average is greater than the original wavelength λ_0, indicating that the spectrum line of the reflected ray shifts more than that of the direct ray. This asymmetric shift can be expressed explicitly by the difference between this average and the original wavelength, which consisted of the relativistic Doppler effect in Ives and Stilwell (1938):

$$\Delta\lambda = (\bar{\lambda}-\lambda_0) \approx \frac{1}{2}\frac{v^2}{c^2}\lambda_0$$

The positive relativistic Doppler effect $\Delta\lambda$ shows that time dilation will cause a red shift in addition to the ordinary Doppler effect. The Ives and Stillwell experiment confirmed the asymmetrical Doppler shift and also showed that the amount of relativistic shift from the original wavelength is consistent with the prediction of the time dilation effect shown in equation (19). As a result, this experiment is viewed as a confirmation of time dilation. However, as Christov (2010[xvii]) pointed out, the only problem with the analysis of Ives and Stilwell (1938) is that they assumed that the light frequency emitted by the atoms was independent of the speed of the atoms.

As discussed earlier, photon density around atoms can cause pressure on atoms and thus affect photon emission frequency. The photon emission frequency of moving atoms is described by equation (9). In terms of wavelength, the equation can be written as:

$$\lambda_M = \lambda_0 / \sqrt{1-\frac{v^2}{c^2}} \qquad (20)$$

where λ_0 is the wavelength from a stationary light source and λ_M is the wavelength from a moving light source.

The change in wavelength described by equation (20) will also be perceived by the observer, so the ordinary Doppler effect in equation (18) should be upgraded to:

$$\lambda' = \lambda_M * \frac{\lambda}{\lambda_0} = \frac{c - v*cos\theta}{c}\lambda_0 \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1-\frac{v}{c}*cos\theta}{\sqrt{1-\frac{v^2}{c^2}}}\lambda_0 \qquad (21)$$

Except the different notations for wavelength, this equation is exactly the same as equation (19), which is derived based on time dilation. Using equation (21), we can produce the same relativistic effect as that from the special relativity theory. As such, the photon density theory can explain the Ives-Stilwell experiment equally well, and this explanation makes the counter-intuitive time dilation redundant.

A possible experiment can examine if the relativistic Doppler effect detected by Ives-Stilwell is due to time dilation or due to a change in photon emission frequency at the light source. That is to examine if the moving observer or light detector can also cause high-order Doppler effect. According to the photon density theory, there should not exist such an effect because the emission frequency does not change. On the other hand, the special relativity theory suggests otherwise because time dilation equally applies to the moving observer. However, such an experiment is hard to implement at current technology because it is hard to accelerate the light detector to a high velocity while letting it stable enough to record the experimental results.

There is also alternative experiment to examine the claim of time dilation. If the claim is true, time dilation should also work for sound wave or water wave, so relativistic Doppler effect should also be observed and thus the Doppler effect of sound wave and water wave should also be symmetrical. The claimed relativistic Doppler effect is of 2^{nd} order (very small), so it may be hard to be detected. However, the common knowledge is that the Doppler effect of waves other than electromagnetic waves is asymmetric.

6. Conclusions

The paper presents a new theory to explain relativistic phenomena. Although most results from the new theory are the same as those from the special relativity theory such as the unmatchable speed of light, the mass velocity relation, the mass energy equation, the relativistic Doppler effect, momentum conservation in different reference frames, and the equivalence of inertial reference frames, the mechanisms driving these results are very different.

Based on the belief of superiority of Lorentz transformation over Galilean transformation and the belief of constant speed of light in vacuum regardless of the observer's speed, the special relativity proposed length contraction and time dilation as the causes of relativistic phenomena and claimed that energy and mass are interchangeable. The current paper shows that the Ives-Stilwell experiment, the key experiment supporting time dilation, can be explained by the change in light frequency when atoms are moving. The current paper also points out the logical inconsistence of treating thermal energy as rest energy/mass and thus casts doubt on the possibility of transforming energy to mass.

Compared with the special relativity theory, the photon density theory does not rely on the simplistic and sweeping claim about the speed of light in vacuum and does not involve the abstract and perplexing requirements of length contraction and time dilation. The new theory can explain quantitatively all relativistic phenomena. More importantly, the new theory reveals the cause or specific mechanism for the relativistic results: the change in photon density of moving objects and photon matter interaction. This mechanism reveals the physical underpinning and thus deepens our understanding of the relativistic phenomena. Further research on the behaviour of photons may push our understanding to a new level and usher in a new era of development in physics.

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