

The Dynamics of the Constancy of Light Speed

China Kang

Contact e-mail: kangstudy@outlook.com

Abstract

By re-examining the simultaneity (measured by light and sound) within different inertial frames, the electrostatic field dragged by moving charges, the gravitational field (Hill sphere) dragged by rotating and translating celestial bodies, and the Casimir effect of a vacuum (not empty), this paper presents that all non-zero-mass objects possess their respective static vacuum fields, and reintroduces the vacuum medium model in which the constancy of light speed in a vacuum follows continuum mechanics. This result shows that a simply modified classical theory can more intuitively explain everything special relativity can explain, and that a slightly revised Newtonian cosmic model can exactly predict the cosmological redshift, the cosmic microwave background, and the relevant cosmological constants, thereby affording the theoretical possibility to quantize the vacuum and unify quantum-level and macroscopic systems.

keywords: light speed; special relativity; spin; cosmological redshift; cosmic microwave background (CMB); large-scale structure

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1. Introduction

The vacuum with absolute permittivity is not empty (where photons and electromagnetic waves do not propagate in empty space), which has been proved by the Camille effect [1] and vacuum phonon heat transfer [2]. In particular, the vacuum, once called the ether, was used not only as a medium by Newton to explain the propagation of light and the non-contact interaction of gravitational and electromagnetic forces, but as a continuum model with great success in Huygens-Fresnel optics and Faraday-Maxwell electromagnetism. Furthermore, Einstein continued to ponder the dynamic properties of the ether (vacuum) until the last years of his life [3]. So, would reintroducing the medium model for the vacuum make the relevant physics principles more natural? Of course, this would give a more intuitive understanding of the Michelson-Morley experiment and the constancy of light speed, clarify some of the puzzling inferences of special relativity, and reveal a concise large-scale structure of the universe.

2. Discussion and Results

We will first re-examine “the relativity of simultaneity”, the constancy of light speed in a vacuum, and the relevant experiment, then explain the propagation mechanism of light (or photons) and some relativistic concepts by re-introducing the medium model of vacuum and reviewing the motion laws of photons. Finally, we will discuss the cosmological redshift and cosmic microwave background radiation.

2.1 *The simultaneity between equal-weighting inertial frames*

In *Relativity: The Special and the General Theory* (whose 15th edition was published in 1952), Einstein discussed “the relativity of simultaneity”. Undoubtedly, whether two events are simultaneous in a stationary inertial frame can be judged by the propagation distance and time of the corresponding signal, which can be either light in a vacuum or a mechanical wave in a homogeneous medium. Observed on the railway embankment, two lightning stroke events occur simultaneously at the head and tail of a traveling train. In Einstein’s view, because the passenger sitting in the middle of the train is “hastening towards the beam of light coming from B (the head of the train)” and not stationary on the railroad embankment (what happens if the lightning stroke location remains relatively resting with the passenger?), he will first see the lightning stroke in the front and think that the front lightning stroke occurred earlier.

Leaving aside whether Einstein’s argument disregarded **the equidistant emission** of the two lightning stroke flashes in the inertial reference frame of the train and **the invariance (“which is independent of the state of motion of the emitting body”) of the light speed** in the vacuum of an inertial frame, let’s examine the following two questions:

- (1) According to the principle of relativity, the passengers can think that the two lightning hit at two fixed locations on the stationary train, and that light without the Doppler effect and light with the Doppler effect take the same amount of time to travel the same distance in the train’s inertial frame. Suppose there are surveillance cameras outside the head and tail of the train and the monitoring display is located in the middle of the carriage, or there are powerful laser lamps controlled by lightning strokes on the insides of the head and tail of the train (with all the doors between its carriages open). Thus, the observer sitting in the middle of the train will remain stationary concerning the relevant signal source of the lightning and not hasten “towards the beam of light coming from B”, so can he judge the simultaneity of the two lightning strokes?
- (2) The air sealed in the carriage moves in synchrony with the uniform-motion train, which can be considered a stationary rigid reference system relative to the passengers. Inside the train, the simultaneity measured by sound signals (without Doppler effect, not propagating in the ground air) and the simultaneity measured by light signals (without Doppler effect, cannot be directly observed from the ground) have equal weighting independent of observation coordinate systems. Also, the passengers will observe that the train being struck by lightning is an event that occurs at a fixed location inside the train’s inertial frame. So, can the observer sitting in the middle of the train hear that the two lightning bolts simultaneously hit the train’s head and tail?

If we endeavor to devise negative answers to the above two questions in order to defend “the relativity of simultaneity”, that would deviate from the constancy of the measurable light speed (independent of the relative motion of the railroad) in the passenger’s inertial frame. Actually, because of **the absolute status of the Minkowski metric** (whose space world line is a geodesic, such as the earth-center stationary reference frame within the earth’s Hill sphere), there is no time dilation between equal-weighting inertial frames (whose world lines are not geodesics and **they have the**

same kinematic effect relative to a local Minkowski metric space) with relative motion (see Ref. [4] and Eq. 13), and naturally, there is no relative length contraction between them. (**Note:** Absolute inertial frames do not exist, and the kinematic effects between different approximate inertial frames are not necessarily equal-weighting. For example, the timing periods of the same atomic clock or pendulum are not exactly the same at low and high latitudes.)

It is conceivable that the spatial location of the event of an inertial frame remains relatively static with this inertial frame. For example, a bolt of lightning hitting a train that travels at a constant speed is, whether observed inside the carriage or on the railway embankment, an event that happens at a fixed spatial location within their respective inertial frames. Thus, Einstein's thought experiments on lightning hitting a train should, in fact, be used to prove that the simultaneity between equal-weighting inertial frames is absolute (which is mainly embodied in the fact that their precise atomic clocks have the same timing frequency when observed in a particular "absolute" reference frame), not to argue "the relativity of simultaneity". As for the so-called time dilation, although it appears to be experimentally verified, it essentially reflects the change in a certain motion state (or period) of an object after the variation in forces (see Ref. [4] and Eqs. 8, 9, 10, 11, 12, 13, 14).

The following discussion is based on experimental facts and the underlying theory, unconstrained by the relativistic light-speed invariance postulate and the relativistic space-time view. We will clarify the physical mechanism of light speed more intuitively and give a clearer physics picture of several relativistic concepts.

2.2 Vacuum (field) waves and the speed of photons

As is known to all, a uniformly moving point charge always drags its independent electrostatic field in the reference frame with which it stays stationary, and the sun always drags its static gravitational field and all things belonging to the solar system. Similarly, all objects with non-zero mass should drag (intrinsically possess) their respective vacuum media that present a compounded static field ($|\mathbf{E}_r| = \left| \frac{1}{4\pi\epsilon_0} \sum_{i=1}^N \frac{q_i}{|\mathbf{r}-\mathbf{r}_i|^3} (\mathbf{r}-\mathbf{r}_i) \right| \geq 0$ and $|\mathbf{g}_r| = \frac{Gm}{r^2} > 0$ are the components of the object), which possesses the absolute permittivity ϵ_0 and gravitational constant G , **remains "absolute rest" relative to the object it belongs to**, and can transport quantized energy (photons) at light speed. Therefore, the **Michelson-Morley experiment** did not and should not detect the relative motion between the earth and the ether; namely, there is no relative motion between an inertial system and the static vacuum medium it is dragging.

Just as the different magnetic fields induced by the same point charge in different-motion-state reference frames do not influence each other, and just as numerous laser beams in a vacuum intersect at will without scattering, the vacuum media dragged by different objects should also be able to overlap infinitely. A critical issue to consider is that, unlike the motion of electric charges, when a photon is propagated directly in the vacuum medium of one inertial system, its action with a vacuum of other reference frames is paltry—this is somewhat similar to the fact that stable satellite orbits inside the earth's Hill sphere, where the gravitational perturbation from an outside celestial body is weak, even when its gravitation to the satellite is strong.

It should be noted that **light propagation along a straight line is only an approximation inside a local inertial system** (local stationary vacuum)—for example, straight-motion trajectories in different directions inside the earth's inertial system are typically curves with different shapes when viewed in the sun's or Milky Way's static Hill sphere. **Thus, photons with regular propagation laws only have direct observable meaning when interacting with the static vacuum dragged by the observer's inertial system**, like the sound from the inside of a traveling train that can only be heard directly from the ground when it vibrates the air outside. Furthermore, the velocity of a given photon

propagating inside one inertia system relative to another still follows the Galilean transformation (see Eqs. 8, 9, 10, 11, 12, 13, 14 for the relativistic energy-momentum relation and time dilation).

In essence, the vacuum should be an isotropic, non-dispersive, and homogeneous linear medium whose plane waves (propagating a certain strength $f(x, t)_{dx/dt=\pm c}$) follow

$$\frac{\partial^2 f(x, t)}{\partial t^2} = \frac{dx}{dt} \frac{\partial}{\partial x} \left[\frac{dx}{dt} \frac{\partial f(x, t)}{\partial x} \right] = c^2 \frac{\partial^2 f(x, t)}{\partial x^2}. \quad (1)$$

Obviously, the wave equation of the vacuum (field) is completely consistent with the wave equation of mechanical waves in mathematical form, showing that the propagation mechanism of electromagnetic waves transporting energy in the vacuum is unified with that of mechanical waves that transport energy in isotropic homogeneous linear media (such as air in resting laboratories and air in uniform-motion trains).

Corresponding to mechanical waves, the propagation of electromagnetic waves logically requires a medium, and that medium is the electromagnetic field itself. More conclusively, the vacuum is not empty; it is none other than a medium that contains overlapping electromagnetic fields induced by innumerable electric charges. Technically speaking, **the traveling wave of electromagnetic field oscillations necessarily transports energy (photons), but the photon is an energy particle with an intrinsic spin rather than the electromagnetic wave.**

Since the elliptical polarization of light resembles the projection of its helical motion (onto the traveling direction), its linear polarization is similar to the projection of its cycloidal motion (spin angular momentum S_γ perpendicular to translational momentum p_γ), and its diffraction ability is negatively correlated with the frequency (ν_γ), we can conclude that **the spin of photons is a light-speed circular motion** (for a spin system moving translationally at light speed) and the spin angular momentum S_γ (spin momentum p_s , spin circle radius r_s) obeys

$$|S_s| = |r_s \times p_s|_{r_s \perp p_s} = \left| r_s \times \frac{h\nu_\gamma}{c^2} c \right|_{r_s \perp c} = \frac{h}{2\pi} = \hbar, \quad (2)$$

where h and \hbar are the Planck constant and reduced Planck constant, respectively.

Let θ ($0 \leq \theta \leq \pi$) be the angle between the spin angular momentum S_γ of a photon and its translational momentum p_γ , and one can imagine **the correspondence between the polarization and spin:**

$$\left. \begin{aligned} \text{linear polarization} &\iff \theta = \frac{\pi}{2}, S_\gamma \perp p_\gamma; \\ \text{circular polarization} &\iff \theta = \{0, \pi\}, S_\gamma \parallel \pm p_\gamma; \\ \text{elliptical polarization} &\iff \theta \neq \frac{\pi}{2}. \end{aligned} \right\} \quad (3)$$

In this way, **the energy of a photon, an energy carrier, is contributed jointly by its spin and translation kinetic energies, which follows König's theorem** and can be represented as

$$E_\gamma = h\nu_\gamma = \frac{1}{2}p_s c + \frac{1}{2}p_\gamma c = p_\gamma c \quad \left(|p_s| = |p_\gamma| = \frac{h\nu_\gamma}{c} \right). \quad (4)$$

Naturally, the wavelength of a photon is equal to its spin perimete, and its frequency is the spin frequency, as shown in

$$\left. \begin{aligned} \lambda_\gamma &= 2\pi r_s = cT_\gamma, \\ \nu_\gamma &= \frac{c}{2\pi r_s} = \frac{1}{T_\gamma}. \end{aligned} \right\} \quad (5)$$

Now it is possible to imagine that photons, when they combine zero-mass charges and transform into positrons and electrons (or muons, protons, and other particles), still keep the light-speed circular spin (that bound-state spin

angular momentum no longer follows $|\mathbf{r}_s \times \mathbf{p}_s|_{\mathbf{r}_s \perp \mathbf{p}_s} = \hbar$) and translate back and forth inside the “spherical shell” of charges at light speed, **thus behaving as a mass in the form of a standing wave and the corresponding mass-energy equivalence**. For an electron (ignoring its translational or rotational movements), the translation oscillation of the photon (energy $E_{\gamma \rightarrow e} = m_e c^2$) providing it with mass m_e appears as a back-and-forth cycloidal motion, where an arch span $2\pi r_c$ is the charge radius r_e (that is, classical electron radius $r_e = \alpha \hbar / m_e c = 2\pi r_c$) at which the electron’s electromagnetic energy converges to $m_e c^2 = \frac{1}{2} \frac{e^2}{4\pi\epsilon_0 r_e} + \frac{1}{2} \frac{(\mu_0 e c)^2}{4\pi\mu_0 r_e} = \frac{e^2}{4\pi\epsilon_0 r_e}$; the charge of an electron also moves in the same cycloidal motion but with a delay of one period. At this point, it is easy to obtain the mass-energy equivalence of the electron and **the self-energy correction term of electron spin magnetic moment**:

$$\left. \begin{aligned} E_e &= E_{\gamma \rightarrow e} = E_k^{spin} + E_k^{translation} = \frac{1}{2} m_e c^2 + \frac{1}{2} m_e c^2 = m_e c^2, \\ \mu'_e &= -\frac{e}{2\pi r_c / c} (\pi r_c^2) = -\frac{1}{2} |\mathbf{r}_c \times e\mathbf{c}| = -\frac{1}{2} \frac{r_e e c}{2\pi} = -\frac{1}{2\pi} \frac{\alpha \hbar e c}{2m_e c} = -\frac{\alpha}{2\pi} \frac{e \hbar}{2m_e} = -\frac{\alpha}{2\pi} \mu_B. \end{aligned} \right\} \quad (6)$$

Later, we will discuss the specific mass-energy relationship in subsection 2.4 (see Eqs. 9 and 10).

The translation of photons in a vacuum must be accompanied by the oscillation of vacuum media (where the observable phenomenon is the quantized photon whose energy and momentum meet the observable threshold), so it is easy to understand that Paul Dirac mentioned “each photon go partly into each of the two components” when explaining the double-slit interference of photons (see Dirac’s *The Principles of Quantum Mechanics*, Chap. 1.3).

Considering the medium nature of the vacuum and the particle properties of light, it can be believed that **the constancy of light speed in a vacuum only means that the wave speed of a vacuum medium is the light speed, i.e., the traveling speed of one photon in the static vacuums with which it interacts closely (rather than in any reference frame) is the same constant**. Based on this understanding, it is reasonable to infer that the relative motion of light sources will cause the deflection of light (which has been confirmed by stellar aberration), thereby intuitively clarifying a few inferences of relativity.

2.3 The light deflection induced by relative motion

The tangential speed of light (ignoring the spin) in a vacuum remains constant (ignoring the propagation of light before interacting with the vacuum of observation reference frames), but the direction of light can be deflected by gravity, manifesting that the effective acceleration acting on photons is embodied in the normal direction of their trajectories. From the deflection of starlight in stellar aberration phenomena (where the star that is approximately stationary in the sun’s gravitational field can be viewed as a moving light source relative to the earth), it can be deduced that the light emitted by a moving light source will be deflected towards the motion direction of the light source when interacting with the static vacuum of stationary inertial frames (ignoring for now the influence of the **Hill sphere** on observations).

Suppose a laser transmitter (whose stationary orthogonal plane coordinate system is $X'O'Y'$) moves with velocity \mathbf{v} along the X -axis of an plane coordinate system XOY (which lies in the same plane as $X'O'Y'$), and the angle between its laser beam (parallel to the XOY plane) and the X' -axis is α . For the XOY coordinate system, the laser photon will deflect towards the moving direction of the laser transmitter with an angle β ($\sin\beta \approx (v \sin\alpha)/c$ when $v \ll c$) due to the particle inertia or initial normal-direction impulse $\mathbf{p} \cdot \sin\alpha$. When the laser beam is emitted perpendicular to the X' -axis ($\alpha = \pi/2$) and interacts with the static vacuum of the XOY reference system, its deflected angle β satisfies

$$\sin\beta = \frac{v}{c} \quad (0 \leq v < c), \quad (7)$$

which has been confirmed by the observation of stellar aberration, showing that the velocity (including direction) of light in a vacuum is **not strictly “independent of the state of motion of the emitting body”**.

For a star directly above an observer on the earth ($\alpha = \pi/2$), the speed of the starlight parallel to the tilted lens barrel of the observation telescope is c , and its component (or projection) perpendicular to the ground is $c \cdot \cos\beta = \sqrt{c^2 - v^2}$ (where v is the earth’s revolution speed). In this case, the composition of the velocity of a photon (particle) still seems to obey the parallelogram law of classical mechanics, except that its speed is a constant in the vacuum with which it interacts. When a photon emitted from a moving emitter interacts with the vacuum dragged by an inertial system, its interaction with the vacuum of a stationary reference frame where the emitter resides is negligible; thus, even if its speed relative to the emitter is no longer the constant c , this does not violate the constancy of light speed in a vacuum.

2.4 Photon-mass-energy and the Newtonian view of special relativity

Since the coordinate transformation keeps space-time distances invariant (similar to the vector-module invariance of Euclidean-space rotation), the Lorentz transformation can be considered an orthogonal mapping (a microscopic rotation related to vortices and energy) of the quantum-level motion system of particles with non-zero mass in three-dimensional space. To explain the “transformation of time” (see *Feynman Lectures on Physics Volume I*, Chap. 15-4), Feynman also took the photon emitted perpendicular to the moving direction of an atomic clock as an example: “the distance the light travels in the same time is proportional to c , and the vertical distance is therefore proportional to $\sqrt{c^2 - v^2}$ (that is the source of the square root expressions in our equations).”

Although experiments have shown that a vacuum is not empty, that there is not necessarily the so-called time dilation between inertial frames keeping relative motion, and that straight-line motion is only an approximation within a local reference system, physics textbooks on special relativity have always clicked to the complicated postulations: One photon moves relative to any inertial reference frame at the same speed, space can shrink, time is dilatable, and the “interval” remains invariance...from which to derive the Lorentz transformation. Indeed, upon reexamining relevant experimental phenomena and identifying the postulation unified with classical theory, we can concisely draw several conclusions deduced under the Lorentz transformation.

When the initial emitted direction of a photon (or other light-speed particles, e.g., neutrinos) is orthogonal to the velocity v of the emitted particle, its deflection angle β follows

$$\cos\beta \approx \sqrt{1 - \frac{v^2}{c^2}} = \frac{m_0 c}{\sqrt{m_0^2 c^2 + p^2}} = \frac{m_0}{\sqrt{m_0^2 + m_p^2}} > 0 \quad (m_0 > 0), \quad (8)$$

where $v = \frac{p}{\sqrt{m_0^2 + (p/c)^2}} < c$ now can be considered an empirical formula (although it is also an inference of relativity); $m_p = \frac{p}{c} = \sum \frac{h\nu_i}{c^2}$ can be understood as the energy-momentum factor of bound-state photons that contribute momentum p ($p = m_p c = \sqrt{m_0^2 + m_p^2} v$) to the particle with mass m_0 , as Newton’s *Optics* (Quest. 30) conjectured, “**Bodies receive much of their Activity from the Particles of Light which enter their Composition**”— which is embodied in the relativistic energy-momentum relation. In essence, however, **the total energy E_v (or m_v) of a moving system** (mass m_0 , speed v , momentum $p = m_p c = m_v v$) **possesses a Newtonian differentiable and integrable property:**

$$\left. \begin{array}{l} \frac{dE_v}{d(m_p c^2)} = \frac{m_p c^2}{E_v}, \\ p = m_p c = m_v v, \end{array} \right\} \Rightarrow \left\{ \begin{array}{l} E_v = \sqrt{m_p^2 + m_0^2} c^2 = m_v c^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}; \\ m_p = \frac{v}{c} \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad v = \frac{m_p c}{\sqrt{m_p^2 + m_0^2}} < c. \end{array} \right. \quad (9)$$

The system of equations (9) intrinsically characterizes the energy and velocity of moving particles, in which the emergence of **the Lorentz factor** $\frac{1}{\sqrt{1-v^2/c^2}}$ completely does not require the relativistic light-speed invariance and space-time view. It is evident that **equation** $E_v = \frac{m_0 c^2}{\sqrt{1-v^2/c^2}} = \sqrt{m_p^2 + m_0^2} c^2$ **also applies to describing zero-mass photons**, which shows that the energy of a photon ($m_0 = 0$, $v = c$, $E_v = pc = m_p c^2$) originates from itself and that a free photon need not and cannot be accelerated by the momentum of other light-speed particles.

The mass of an object (including the energy of a neutrino) **is determined by the energy of photons bound within its electromagnetic system**. Meanwhile, photons, which convey energy in the form of kinetic energy, are in motion wherever and whenever. When a particle system with mass m_0 moves at the speed $v = m_p c / m_v$, its total energy E_v still follows König's theorem and can be expressed in kinetic energy as

$$E_v = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{2} \sqrt{m_p^2 + m_0^2} c^2 + \frac{1}{2} \sqrt{m_p^2 + m_0^2} v^2 + \frac{1}{2} \sqrt{m_p^2 + m_0^2} (\sqrt{c^2 - v^2})^2, \quad (10)$$

where $\frac{1}{2} \sqrt{m_p^2 + m_0^2} c^2$ is the spinning kinetic energy of the bound-state photons with total energy E_v inside the particle system, $\frac{1}{2} \sqrt{m_p^2 + m_0^2} v^2$ is the translational kinetic energy of the particle system traveling at the speed v , and $\frac{1}{2} \sqrt{m_p^2 + m_0^2} (\sqrt{c^2 - v^2})^2$ is the back-and-forth translational kinetic energy of the bound-state photons within the particle system.

Reviewed from a Newtonian perspective, the **relative translation speed** $\sqrt{c^2 - v^2}$ of light-speed particles bound inside a moving-particle system portrayed by Eq. (10) has substantive physical significance, showing that when a photon (and other light-speed particles) is confined to a particle system moving at speed v ($0 < v < c$), its translational momentum $\frac{h\nu_0}{c^2} c$ will remain a smaller magnitude $\frac{h\nu_0}{c^2} \sqrt{c^2 - v^2}$ after being transferred to the particle system (note that $\sum \frac{h\nu_i}{c^2} \sqrt{c^2 - v^2} \vec{e}_i = 0$), and it will take longer ($\lambda_0 / \sqrt{c^2 - v^2} > \lambda_0 / c$) to translate the distance of an original free-state wavelength λ_0 . Therefore, when the photon is released, its **Doppler shift** (ν / ν_0) that occurs in the vacuum of an observer's inertial system can be analyzed from both the energy-momentum and period-wavelength. Let the angle between the released direction of the photon and the velocity v be θ ($0 \leq \theta \leq \pi$), then its relative emitted speed is $v' = c - v \cos \theta$ (satisfying $v \cos \theta + v' = c$), and we have

$$\left. \begin{aligned} \frac{h\nu_0}{c^2} \sqrt{c^2 - v^2} &= \frac{h\nu}{c^2} (c - v \cos \theta) \implies \nu = \frac{\sqrt{c^2 - v^2}}{c - v \cos \theta} \nu_0, \\ c &= \lambda_0 \nu_0 = \lambda \nu = \frac{\lambda_0 (c - v \cos \theta)}{\sqrt{c^2 - v^2}} \nu \implies \nu = \frac{\sqrt{c^2 - v^2}}{c - v \cos \theta} \nu_0. \end{aligned} \right\} \quad (11)$$

According to the analysis of this equation system, we have a clear classical understanding of the physical process of the so-called relativistic time dilation.

In the Hafele-Keating experiment [4], whether an atomic clock is moving east or west, its "time dilation" depends on its speed relative to the resting earth's center, not relative to the resting ground. Also, the relativistic composition speed between two atomic clocks has no observable substantive meaning for the "time dilation" between them. Therefore, **the so-called relativistic synthesis velocity is unlikely to be rigorously applied to Eqs. (8), (9), (10) and (11)**.

Equations (8), (9) and (10) show that a particle with non-zero mass cannot be directly accelerated to light speed in a stationary inertial system. Even though the synthesis speed of two particles exceeds light speed (according to Galileo transformation), the "relativistic energy" of one particle relative to the other still equals the algebra sum (obeying Galileo transformation) of the "relativistic energy" of the two particles (moving below light speed) relative to a certain stationary reference frame.

Since the numerical calculation involving the factor $\sqrt{1 - v^2/c^2}$ looks like a geometric relation of an orthogonal transformation ($\cos\beta = \sqrt{c^2 - v^2}/c$), it is possible to describe the related inferences of special relativity in the projective invariance of several physical quantities. For example, the relativistic energy-momentum relationship and time dilation can be characterized as

$$\left. \begin{array}{l} \text{moving-system energy projection } E_v \cdot \cos\beta = m_0 c^2, \\ \text{light-speed-particle translation projection } ct \cdot \cos\beta = ct_0. \end{array} \right\} \quad (12)$$

Once again, as Eqs. (11) demonstrate, $t \cdot \cos\beta = t_0$ does not denote time dilation, but merely a change of the motion period of light-speed particles after being bound into moving particle systems.

2.5 Time dilation and Newtonian time

Of particular note is the Hafele-Keating experiment [4], which is thought to demonstrate the so-called time dilation. In fact, the experiment proved that the earth's center is approximately an **absolute reference system** within the earth's Hill sphere (like the special status of the Minkowski metric whose world line is a geodesic). There is no time dilation between equal-weighting reference frames relative to the earth's center (regardless of how they move relative to each other), and relative motion between observers does not necessarily generate time dilation effect.

As shown in Eqs. (11) and (12), time dilation is nothing but the change in the motion time required for a bound light-speed particle within a moving particle system to translate an invariant distance. Because all motion is associated with the force state, the so-called time dilation (motion period variation) verified critically by electron transition or particle decay (not a pendulum that doesn't involve the motion of light-speed particles) can be expressed as

$$T \approx \frac{cT_0 \cdot \sqrt{1 - \frac{2R_0g_0 + r_0a_0}{c^2}}}{c \cdot \sqrt{1 - \frac{2Rg + ra}{c^2}}} = \frac{\sqrt{c^2 - (2R_0g_0 + v_0^2)}}{\sqrt{c^2 - (2Rg + v^2)}} T_0, \quad (13)$$

where $2R_0g_0 + v_0^2 \ll c^2$ (a correction term from the earth's gravity and rotation) can be ignored when the "absolute" speed v (sustainable, relative to the earth's center, or relative to a centrally directed force field that can ignore the earth's gravity) is close to light speed c . **Note:** When v is well above the third cosmic velocity, there must also exist an equivalent centrally directed force field (e.g., cyclotrons, or a point in the galaxy), where $ra = v^2$; when the surface gravity of a dense celestial body (whose internal gravitation follows Newton's shell theorem) satisfies $2Rg \geq c^2$, its constituent particles will have no discrete energy levels (no significant radiation from transition or decay, but there is still the spin motion of elementary particles and the conversion of energy and matter, and thus, **time never stops**).

For example, the timing period of an atomic clock (which keeps time by electrons capturing and releasing photons) on a GPS satellite is

$$T_G \approx \sqrt{\frac{c^2 - 2R_{\oplus}g_0 - v_0^2}{c^2 - 3R_Gg_G}} T_{\oplus}, \quad (14)$$

where $\sqrt{R_{\oplus}g_0} \approx 7905 \text{ m} \cdot \text{s}^{-1}$, $v_0 \approx 465 \text{ m} \cdot \text{s}^{-1}$, and $\sqrt{R_Gg_G} \approx 3885 \text{ m} \cdot \text{s}^{-1}$. So, is its timing speed faster by about 38 μs every day? Essentially, the atomic clock at different gravitational fields ticks at different rates [5], which is unified with the timing period variation $\frac{T_1}{T_2} \approx \frac{\sqrt{g_2}}{\sqrt{g_1}}$ of a pendulum clock at different gravitational potentials, reflecting the change in the motion state of objects under different forces rather than the change in the elapse speed of background time of isotropic cosmic space.

Based on the above analysis, there is reason to believe that the absolute, true, and mathematical Newtonian time is still the most consistent and natural view of time in physical logic.

2.6 The motion laws of photons and the large-scale structure of Universe

Undoubtedly, it is necessary to reintroduce the medium model of vacuum and classicize the space-time view of special relativity. After all, a clearer physical cognition of the constancy and normal-direction deflection of light speed is critical for us to further explore the fluid properties of the vacuum and the large-scale structure of the universe.

According to experiments, near-light-speed positrons and electrons are encircled by an ultra-strong circumferential magnetic field $\mathbf{H} = \frac{1-v^2/c^2}{(1-v^2\sin^2\alpha/c^2)^{3/2}} \frac{(\mu_0 e v) \times \mathbf{r}}{4\pi\mu_0 r^3}$ ($\alpha \rightarrow \pi/2$; we can define $q_m = \mu_0 q v$ as a **magnetic charge** — the so-called **magnetic monopole** is redundant in physics and should not exist in the universe), and their collisions can generate various leptons and hadrons [6]. Moreover, the vacuum electromagnetic field depends on electric charges rather than mass. Hence, the charges “disappearing” after energy released from particle-antiparticle annihilation (e.g., $e^+ + e^- \rightarrow 2\gamma_{m_e c^2}$) should have zero mass and will fuse into the vacuum dielectric in positive-negative pairs (which can be considered invisible **virtual electron** pairs $e_v^+ + e_v^-$). Besides, since photons have little interaction between them but easily interact with charged particles (including charged particles that are electrically neutral as a whole), photons are subjected to gravitation that should also be related to the vibration of virtual electrons in the vacuum.

Naturally, the vacuum dielectric composed of virtual electron pairs can present electromagnetic fields and provide electric charges to the resulting particles from positron-electron collisions. Such zero-mass virtual electron pairs (with non-zero energy close to cosmic background radiation) inevitably oscillate at light speed, where the single virtual-electron spin is a uniform circular motion obeying $|\mathbf{r} \times \mathbf{p}_{e_v}|_{r \perp p} = \hbar$ and the total spin of a virtual electron pair is $\mathbf{r} \times \mathbf{p}_{e_v^+} + \mathbf{r} \times \mathbf{p}_{e_v^-} = 0$. (It is reasonable to settle the spin of elementary particles as a circular motion based on the correlation of photon spin to polarization and the correlation of electron spin to its magnetic moment.) Now, we can imagine the inherent resonance frequency of virtual electron pairs (who else could it be?) endows the vacuum with absolute permittivity ε_0 (since the permittivity is related to the charge vibration).

In addition, photons have the following physical properties: The photon is an elementary particle, specifically an energy quantum (see photoelectric effect and Compton effect); its escape from a gravitational field consumes energy (see gravitational redshift); its escape requires overcoming the gravitation of countless galaxies (see Newton’s shell theorem and Newton’s law of gravitation) and it will accumulate considerable redshifts on the escape path; it (as a free photon, the same below) does not get trapped in the Hill sphere of a star and is subject to the gravitation from numerous galaxies simultaneously at every moment; it can be deflected by gravitation, but its escape speed remains constant under gravitation (superposed gravitational acceleration can only act upon its normal direction); it has particle-like momentum $\frac{h\nu}{c^2}c$ and translational kinetic energy $\frac{1}{2} \frac{h\nu}{c^2} c^2$, but it is invariably weightless as it travels along the geodesic (escape path)... Consequently, one reasonable inference is that the escape of starlight is a uniform circular motion along the geodesic (great circle) of a large-scale spherically symmetric space. Based on the principle of least action, we can infer that starlight travels along one great-circle path (ignoring local gravitational lenses) from one galaxy to another within the great circle.

Suppose the maximum radius of the spherically symmetric space orbited by starlight is r_u and the vacuum pressure (or a specific modulus whose magnitude is equal to an energy density $\rho_{vac}c^2$) relative to photons is P_{vac} ($P_{vac} = \rho_{vac}c^2$), then the light speed c can be expressed as

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = \sqrt{\frac{P_{vac}}{\rho_{vac}}} = \sqrt{g_u r_u} = \frac{h/m_\gamma}{4\pi} \int_0^\pi \frac{\sin\theta d\theta}{r}, \quad (15)$$

where the last term is derived from the Biot-Savart law in fluid mechanics, and $m_\gamma = h\nu/c^2$ is an energy-momentum

factor of zero-mass vacuum particles whose spin follows $|\mathbf{r} \times m_\gamma \mathbf{c}|_{\mathbf{r} \perp \mathbf{c}} = \hbar = h/2\pi$. As for $c = \sqrt{g_u r_u}$, not only does it indicate that the orbiting speed of the spherically symmetric space with radius $r_u = \frac{G\rho_u V}{c^2} = \sqrt{\frac{3c^2}{4\pi G\rho_u}}$ (applicable to photons whose escape speed is constant and far exceeds the fifth cosmic speed) is light speed, but its expression is consistent with the surface wave speed $v = \sqrt{gd}$ of shallow water with an effective depth of d and an equivalent wavelength of $\lambda = 2\pi d$.

Evidently, Eqs. (1) and (15) hold out a natural and unified dynamical explanation for the constancy of light speed, and they also imply a large-scale structural model of an infinite universe (no Big Bang, no violation of the law of energy conservation, and no Earth-centricity to define cosmic size). Simply by measuring the average density ρ_u of the universe, we can directly calculate the observable cosmic radius (the so-called Hubble length) $R_U = 2r_u = \sqrt{\frac{3c^2}{\pi G\rho_u}}$, the observable cosmic mass $M_U = \frac{4\pi}{3}R_U^3\rho_u = \frac{4c^3}{G}\sqrt{\frac{3}{\pi G\rho_u}}$, and the Hubble time (the so-called cosmic age) $t_{H_0} = \frac{R_U}{c} = \sqrt{\frac{3}{\pi G\rho_u}}$.

Another key point is that from the translational kinetic energy $\frac{1}{2}h d\nu = -\mathbf{F} \cdot d\mathbf{r} \approx -\frac{G(\rho_u V)(h\nu/c^2)}{r^2} \frac{\sqrt{R_U^2 - r^2}}{R_U} dr$ (where $V = \frac{4}{3}\pi r^3$, $r = R_U \left| \sin \frac{ct}{R_U} \right|$) consumed by the escape of starlight, we can derive a classical cosmological redshift equation (ignoring all the factors that could increase the redshift extreme of starlight escape)

$$Z_U \approx \exp \left\{ \frac{8}{3} \left(1 - \left| \cos^3 \frac{ct}{R_U} \right| \right) \right\} - 1 < 13.4. \quad (16)$$

This formula clearly has a more adequate theoretical basis to replace the Big Bang model to account for the distance-dependent redshift of starlight, showing that a steady-state infinite universe can display a cosmological redshift that appears as if the universe once expanded (if one can only think of the Doppler effect, without ever imagining the escape of starlight) and the expansion is accelerating (since $\frac{dZ_U}{dt} \neq C$ is decreasing in the time interval $(0, \pi r_u/c)$ and the result is consistent with astronomical observations).

Of course, for a steady-state universe, the isotropic cosmic microwave background (CMB) can also be more reasonably explained by the blackbody radiation of ground-state hydrogen atoms in the vacuum inside the static Hill spheres dragged by different stars and galaxies (as well as galaxy groups and clusters). In the same (distant) region, the velocities of the Hill spheres of different galaxies relative to the detector inside the earth's Hill sphere must not be exactly the same, which undoubtedly leads to tiny fluctuations in the isotropic cosmic microwave background. By examining the elastic deformation (the lowest potential energy $-\mu_B B_{a_0}$) and precession (frequency $\frac{1}{2\pi} \frac{eB_{a_0}}{2m_e}$, ignoring nutation) of the electron spin magnetic moment, the “surface temperature” of an isolated ground-state hydrogen atom can be obtained from

$$T_0^H \approx \frac{2}{3k} \left(\frac{1}{2} \mu_B B_{a_0} \right) = \frac{2}{3k} \left(\frac{1}{2} \hbar \frac{eB_{a_0}}{4\pi m_e} \right) = \frac{2}{3k} \frac{1}{2} \left[\frac{1}{2} \frac{(\mu_0 e \alpha c)^2}{4\pi \mu_0 a_0} \right] \approx 2.80 \text{ K}, \quad (17)$$

where $B_{a_0} \approx \mu_0 \frac{\mu_0 e(\alpha c)}{4\pi \mu_0 a_0^2} = \frac{\alpha^4 m_e c^2}{2\mu_B}$ ($|\mathbf{a}_0 \times m_e(\alpha c)|_{\alpha c \perp \mathbf{a}_0} = a_0 m_e(\alpha c) = \hbar$, $\mu_B = \frac{e}{2m_e} \hbar = \frac{1}{2} a_0 e(\alpha c) = \frac{e}{2\pi a_0 / \alpha c} (\pi a_0^2) = \frac{1}{2} |n \mathbf{a}_0 \times e(\frac{\alpha}{n} \mathbf{c})|$). As to why the radiation spectrum of the CMB corresponds to a blackbody at a temperature of about 2.725 K, it should be because the average kinetic energy of the magnetic-moment vibration or “magnetic-shell” (the lowest potential energy $-\frac{1}{2} \frac{(\mu_0 e \alpha c)^2}{4\pi \mu_0 a_0}$) elastic deformation of ground-state hydrogen atoms (like the breathing of neutral hydrogen) in the vacuum with an inherent vibrating frequency is slightly lower than $\frac{1}{2} \mu_B B_{a_0}$.

3. Conclusions

By investigating the physical mechanism of the constancy of light speed, this paper presents the medium nature of the vacuum, the classical counterpart of elementary-particle spin, the projection view of certain relativistic inferences, and the large-scale structure of the Newtonian universe (whose space is infinite and time elapses uniformly). Accordingly, such a plain universe can be fully explained by the modified classical mechanics without being described by the empirically counterintuitive Friedmann equations (which give an expanding cosmic model that both violates the law of energy conservation and is centered on the earth to define cosmic size) and special relativity (whose space-time view complicates physics concepts). Go to verify Eqs. (7) and (8) strictly in different inertial frames and simplify established theories from a unified perspective, which will bring us a little closer to the truth about nature.

Note: The main points of this paper have been discussed in a preprint analyzing the large-scale cosmic structure, in which the resulting average cosmic density is expressed as a constant $\rho_u = \frac{m_p^3}{m_e M_P^2} \frac{3m_p}{4\pi(\hbar/m_e c)^3} \approx 7.52 \times 10^{-26} \text{ kg} \cdot \text{m}^{-3}$ ($M_P = \sqrt{\hbar c/G}$), the relevant cosmological constants (e.g., substituting ρ_u into the calculated $M_U = \frac{4c^3}{G} \sqrt{\frac{3}{\pi G \rho_u}} = 8 \left(\frac{M_P^2}{m_p m_e} \right)^2 m_e \approx 7.04 \times 10^{53} \text{ kg}$, $R_U = \sqrt{\frac{3c^2}{\pi G \rho_u}} = 2 \left(\frac{M_P}{m_p} \right)^2 \frac{\hbar}{m_e c} \approx 1.307 \times 10^{26} \text{ m}$, and $t_{H_0} = \frac{R_U}{c} \approx 4.36 \times 10^{17} \text{ s} \approx 13.82 \text{ Gyr}$) agree nicely with the astronomical observations [7], and the corresponding cosmic model will be further verified by the James Webb Space Telescope (which will observe more and earlier mature regular galaxies that conflict with the Big Bang model).

Acknowledgements

I am grateful that Newton's thoughts on physics still resonate with me today.

References

- [1] S. K. Lamoreaux: Demonstration of the Casimir Force in the 0.6 to 6 μm Range. *Phys. Rev. Lett.*, Vol. 78, No. 1, 5 (1997). DOI: [10.1103/PhysRevLett.78.5](https://doi.org/10.1103/PhysRevLett.78.5)
- [2] K. Y. Fong, HK. Li, R. Zhao, et al.: Phonon heat transfer across a vacuum through quantum fluctuations. *Nature*, Vol. 576, 243–247 (2019). DOI: [10.1038/s41586-019-1800-4](https://doi.org/10.1038/s41586-019-1800-4)
- [3] A. Einstein: *Relativity: The Special and General Theory* (appendix 5, written in 1952), p 139-158. Routledge (2002)
- [4] J. C. Hafele, and R. E. Keating: Around-the-World Atomic Clocks: Predicted Relativistic Time Gains. *Science*, Vol. 177, No. 4044, pp 166-168 (1972). DOI: [10.1126/science.177.4044.166](https://doi.org/10.1126/science.177.4044.166)
- [5] T. Bothwell, C. J. Kennedy, A. Aeppli, et al.: Resolving the gravitational redshift across a millimetre-scale atomic sample. *Nature*, VOL 602, 420–424 (2022). DOI: [10.1038/s41586-021-04349-7](https://doi.org/10.1038/s41586-021-04349-7)
- [6] R. A. Briere, F. A. Harris, and R. E. Mitchell: Physics Accomplishments and Future Prospects of the BES Experiments at the Beijing Electron–Positron Collider. *Annu. Rev. Nucl. Part. S.*, Vol. 66, pp 143-170 (2016). DOI: [10.1146/annurev-nucl-102115-044802](https://doi.org/10.1146/annurev-nucl-102115-044802)
- [7] Planck Collaboration et al.: Planck 2018 results VI. A&A, Vol. 641, A6 (2020). DOI: [10.1051/0004-6361/201833910](https://doi.org/10.1051/0004-6361/201833910)