

Perhaps We Have Misunderstood the Maxwell' s Theory and the Galilean Transformations

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Abstract

The Einstein' s theory of special relativity is based on his two postulates. The first is that the laws of physics are the same in all inertial reference frames. The second is that the velocity of light in the vacuum is the same in all inertial frames. The theory of special relativity is considered to be supported by a large number of experiments. This paper revisits the two postulates according to the new interpretations to the exact solutions of moving sources in the laboratory frame. The exact solutions are obtained using the classic Maxwell' s theory, which clearly show that the propagation velocity of the electromagnetic waves of moving sources in the vacuum is not isotropic; the propagation velocity of the electromagnetic waves and the moving velocity of the sources cannot be added like vectors; the transverse Doppler effect is intrinsically included in the fields of the moving sources. The electromagnetic sources are subject to the Newtonian mechanics, while the electromagnetic fields are subject to the Maxwell' s theory. We argue that since their behaviors are quite different, it is not a best choice to try to bind them together and force them to undergo the same coordinate transformations as a whole, like that in the Lorentz transformations. Furthermore, the Maxwell' s theory does not impose any limitations on the velocity of the electromagnetic waves. To assume that all objects cannot move faster than the light in the vacuum need more examinations. We have carefully checked the main experiment results that were considered as supporting the special relativity. Unfortunately, we found that the experimental results may have been misinterpreted. We here propose a Galilean-Newtonian-Maxwellian relativity, which can give the same or even better explanations to those experimental results.

Full Text

Preamble

Perhaps We Have Misunderstood Maxwell' s Theory and the Galilean Transformations

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Abstract Einstein' s theory of special relativity rests on two postulates: first, that the laws of physics are identical in all inertial reference frames; and second, that the velocity of light in vacuum is constant across all inertial frames. While special relativity is widely considered experimentally validated, this paper re-examines these postulates through new interpretations of exact solutions for moving sources in the laboratory frame. These solutions, derived from classical Maxwell' s theory, reveal that: (1) the propagation velocity of electromagnetic waves from moving sources in vacuum is not isotropic; (2) the propagation velocity of electromagnetic waves and the velocity of their sources cannot be added vectorially; and (3) the transverse Doppler effect is intrinsically contained within the fields of moving sources. Electromagnetic sources obey Newtonian mechanics, while electromagnetic fields obey Maxwell' s theory. Since their behaviors differ fundamentally, we argue that binding them together and forcing them to undergo identical coordinate transformations—as the Lorentz transformations do—is not optimal.

Furthermore, Maxwell' s theory imposes no limitation on the velocity of electromagnetic waves. The assumption that no object can exceed the speed of light in vacuum requires further scrutiny. We have carefully reexamined major experimental results previously interpreted as supporting special relativity and found that these results may have been misinterpreted. We propose a Galilean-Newtonian-Maxwellian relativity that can provide equivalent or superior explanations for these experimental findings.

Introduction

In the coordinate system $\mathcal{O}(t, \mathbf{r})$, Maxwell' s equations in vacuum can be expressed as $[\mathbf{E}, \mathbf{H}, \rho, \mathbf{J}]$ where \mathbf{E} is the electric field intensity, \mathbf{H} is the magnetic field intensity, $\rho(t, \mathbf{r})$ is the charge density, and $\mathbf{J}(t, \mathbf{r})$ is the corresponding current density. The fields are generated by the sources. In vacuum, the current density is caused by the motion of charges, i.e., $\mathbf{J} = \rho\mathbf{v}$, where \mathbf{v} is the velocity of $\rho(t, \mathbf{r})$. The permittivity ε_0 and permeability μ_0 are constants.

The scalar potential $\phi(t, \mathbf{r})$ satisfies the wave equation where S is the excitation source and c_0 is also a constant. Conventionally, c_0 is considered the wave velocity since this equation has the same form as the wave equation in classical mechanics.

However, it is crucial to note that Maxwell' s theory does not state that the velocity of electromagnetic waves in vacuum is always c_0 . For a single pulse

charge existing at point \mathbf{r}_1 and time instant t_1 , its fields at point \mathbf{r} and time t are determined by the Green's function [?, ?, ?]. This can be considered an electromagnetic field pulse whose propagation velocity is isotropic and remains c_0 in all directions in vacuum. For time-harmonic, motionless sources within a bounded region, the far electric field may be expressed as where ω_0 is the angular frequency of the fields and r is the radial distance. In this case, it is a spherical wave propagating with constant velocity c_0 in all directions.

However, in general situations with moving sources, electromagnetic fields represent superpositions of contributions from all sources at different positions and different time instants. The composed far fields become quite complicated. Consider a point source with time-varying charge oscillating at angular frequency ω_0 , moving uniformly in vacuum with velocity \mathbf{v} as shown in Fig.1. Its electromagnetic fields are rigorously solved from Maxwell's equations [?, ?]. The main component of the far fields can be generally expressed in the form where at time t_1 the source moves to position \mathbf{r}_1 , $\mathbf{R} = \mathbf{r} - \mathbf{r}_1$, and $\hat{\mathbf{n}} = \mathbf{R}/R$. The fields generated by the charge at time t_1 propagate to observation point \mathbf{r} with a time delay of R/c_0 .

[Figure 1: see original paper] Trajectory of a moving point source with time-varying charge.

The far field behavior is characterized by two key terms: $\omega_0(t - \mathbf{R} \cdot \mathbf{n}/c_0)$ describes the propagation property of the electromagnetic wave, while $1/R(1 - \mathbf{n} \cdot \beta)$ describes the variation of field amplitude, where $\beta = \mathbf{v}/c_0$. For the far field we have The electric far field expressed above can be rewritten as where the velocity c and angular frequency ω of the composed far field are, respectively [?]: The far field also represents a spherical wave, but both frequency and wave velocity vary with propagation direction.

According to these equations, propagation velocity depends on propagation direction. It can be seen that when the observer is on the source's path, regardless of source speed. The velocity reaches its maximum at $\theta = 0$ or π . Especially when $\theta = \pm\pi/2$, we have These equations clearly show that the propagation velocity of electromagnetic waves and the velocity of their sources do not satisfy vector addition. The claim that these velocities can be added vectorially according to classical physics rules represents a severe misunderstanding of classical physics. For convenience, we call this **Misunderstanding-1**.

The angular frequency ω of the far fields also depends on propagation direction, describing the Doppler effect. The normalized angular frequency is The relative Doppler shift can be expressed by $\Delta\omega/\omega_0 = \omega/\omega_0 - 1$. It is zero at angle θ_d satisfying Particularly, when $\theta = \pm\pi/2$, the transverse Doppler effect exists The Doppler effect is explicitly included in Maxwell's equation solutions far from moving sources. Conventionally, it is stated that no transverse Doppler shift exists in classical physics. This is another misunderstanding of classical physics, which we call **Misunderstanding-2**.

As an example, using results from [?], we plot the main component of the

electric fields of a moving Hertzian dipole at $\beta = 0.6$ and $\beta = 0.8$ in Fig.2, clearly demonstrating the Doppler effect.

[Figure 2: see original paper] The field patterns of a moving Hertzian dipole. The red arrows show the moving directions. (a) $\beta = 0.6$. (b) $\beta = 0.8$.

The wave velocity of the moving Hertzian dipole for $\beta = 0.8$ is shown in Fig.3(a), with maximum value about $1.67c_0$. The normalized frequency is shown in Fig.3(b), clearly depicting the transverse Doppler shift. The normalized radiation pattern appears in Fig.3(c), showing the forward beam is much larger than the backward beam. Recall that these beams are symmetrical for a motionless Hertzian dipole. In the figures, red arrows indicate moving directions and the blue arrow indicates the polarization direction.

[Figure 3: see original paper] A uniformly moving Hertzian dipole at $\beta = 0.8$. (a) Wave velocity. (b) Normalized frequency. (c) Normalized radiation pattern.

As a summary, we emphasize that: (1) ε_0 and μ_0 are constants. The propagation velocities of electromagnetic waves are determined by solutions to Maxwell's equations for given sources and are not necessarily c_0 for moving sources. (2) The transverse Doppler effect is intrinsically included in the far fields of moving sources. (3) The constant c_0 is fundamentally valid for electromagnetic systems obeying Maxwell's theory, not for objects obeying Newtonian mechanics.

Maxwell's theory provides no theoretical support for setting c_0 as the universal velocity upper limit. Conventionally, this velocity limitation is considered experimentally justified. We will show later that this is unconvincing because experimental results may have been misinterpreted.

II. Maxwell's Equations under Coordinate Transformations

Vacuum is a three-dimensional Euclidean space described by coordinate system $\mathcal{O}(t, \mathbf{r})$, where \mathbf{r} denotes spatial position and t denotes time. Consider another inertial coordinate system $\mathcal{O}'(t', \mathbf{r}')$ moving with velocity \mathbf{V} , with coinciding origins at $t = t' = 0$ as shown in Fig.4. The Galilean transformations describe position changes between these frames: Obviously, we have $dt = dt'$, meaning time intervals between given events remain unchanged in all inertial frames. The Galilean transformations are valid for objects subject to Newtonian mechanics, such as stars, planes, tennis balls, and particles. The mass density $\rho_m(t, \mathbf{r})$ of all objects should remain unchanged under Galilean transformations.

[Figure 4: see original paper] Two inertial coordinate systems. \mathcal{O}' moves against \mathcal{O} with velocity \mathbf{V} .

Velocity and acceleration are physical quantities directly related to position \mathbf{r} and time t . They obey vector addition rules and change under Galilean transformations according to Galileo's seventeenth-century principle that laws of motion are identical in all inertial reference frames. All classical mechanical equations

maintain their forms under Galilean transformations—sometimes called the Newtonian principle of relativity [?].

Electromagnetic fields obey Maxwell's theory rather than Newtonian mechanics. Maxwell's equations in vacuum can be generally expressed as in (1). Importantly, Maxwell's equations describe electromagnetic fields generated by given sources $\rho(t, \mathbf{r})$, while the sources are determined by other mechanisms and unaffected by the fields they generate. Charge density is an intrinsic property of objects, like mass density. The mechanical behavior of charges obeys Newtonian mechanics and should remain unchanged under Galilean transformations. However, current density should include coordinate system motion effects: $\mathbf{J}' = \rho(\mathbf{v} - \mathbf{V})$. The current density changes in different inertial frames.

Maxwell's equations form the fundamental basis for electromagnetic systems and should not change form in any inertial coordinate system. However, early twentieth-century researchers found Maxwell's equations are not covariant under Galilean transformations. Taking the first equation in (1) as an example, under Galilean transformations the fields transform to $\mathbf{E}'(\mathbf{r}', t') = \mathbf{E}(\mathbf{r}' + \mathbf{V}t', t')$ and $\mathbf{B}'(\mathbf{r}', t') = \mathbf{B}(\mathbf{r}' + \mathbf{V}t', t')$. Using necessary vector identities, we obtain a form obviously different from the first equation in (1).

In 1904, Lorentz proved Maxwell's equations are covariant under Lorentz transformations (LT). Denoting \mathbf{r}_{\parallel} and \mathbf{r}_{\perp} as components parallel and perpendicular to \mathbf{V} , the Lorentz transformations can be written as where $\gamma = 1/\sqrt{1 - \beta^2}$. Since γ must be real, Lorentz transformations are only valid for $|\beta| < 1$. Any solutions of the original Maxwell's equations for $|\beta| > 1$ are prohibited by Lorentz transformations.

With Lorentz transformations, electromagnetic fields transform as [?, ?]. In 1905, Einstein reinterpreted these transformations, deriving them from his two postulates of special relativity: (1) physical laws are identical in all inertial reference frames, and (2) the velocity of light in vacuum is constant in all inertial frames.

The first postulate reasonably extends the Newtonian principle of relativity. The second appears strongly experimentally justified, as no contradictory observations have been formally confirmed. However, as shown in the previous section, this postulate may be unconvincing based on exact solutions for fields of moving objects. We re-examined these experiments and strongly believe that results supporting light velocity constancy may have been misinterpreted. It is also possible that we have misunderstood the Galilean transformations and Maxwell's theory.

III. The Natural Form of Maxwell's Equations under Galilean Transformations

In the Newtonian principle of relativity, laws of motion are identical in all inertial reference frames. The underlying principle is that the universe is homoge-

neous at macroscopic scales—observers in different locations or frames perceive the universe through identical physical laws. The most appropriate description appears to be that the distance $d\mathbf{r}$ between two given points and the time interval dt between two given events are unchanged in all inertial frames. We consider this the central rule of Galilean transformations. Choosing a reference point for position and time allows creation of a coordinate system for the universe. Position \mathbf{r} and time t are zeroth-level quantities for the universe.

Einstein's first postulate reasonably extends the Newtonian principle of relativity. However, we believe the central rule mentioned above should not be abandoned. Basically, an observer can only perceive the universe in his own coordinate system with himself as origin. He cannot see the universe exactly as other observers do. When observers are close, their perceptions are naturally similar, like people on Earth seeing similar star patterns. Therefore, we may reiterate the second postulate as: all physical laws are identical for all observers. An assumption is hidden behind this statement: the observer has no impact on the physical systems being observed.

An essential concept requiring clarification is that physical laws describe how physical systems evolve under certain conditions. We must clearly distinguish between intrinsic quantities of physical systems' main bodies and physical quantities describing their behaviors. We treat mass density as an intrinsic property of mechanical systems and charge density as intrinsic to electromagnetic systems—these are first-level physical quantities. Position, velocity, and momentum are second-level quantities linearly dependent on coordinates; they are covariant under Galilean transformations. Acceleration, forces, potentials, fields, and energies are third-level supplemental variables describing main body behaviors within the frame, determined from lower-level quantities according to mechanical laws or Maxwell's theory. They need not be invariant under Galilean transformations.

In electromagnetic systems, charge dynamic behaviors obey Newton's laws. Charge densities remain unchanged under Galilean transformations, while current densities change according to (17). They are covariant under these transformations. However, electromagnetic field behaviors are subject to Maxwell's theory rather than Newtonian mechanics. Electromagnetic fields are determined from lower-level quantities in the frame according to Maxwell's equations in that frame. They are superpositions of fields from all sources generated at times $t_1 \leq t$, not just those at present time t , as are electromagnetic potentials, momenta, and energies. Moreover, electromagnetic wave propagation velocity and frame velocity cannot be added vectorially. Therefore, electromagnetic fields cannot be properly addressed with Galilean transformations. A natural approach is to find possible transformations in the whole space-time (\mathbf{r}, t) domain. It would be ideal to find a coordinate transformation under which all physical laws are covariant while simultaneously observing the central rule of Galilean transformations. However, this is extremely difficult. The Lorentz transformations achieve this only approximately, under the additional restriction that all

object velocities must not exceed c_0 , which obviously violates the central rule of Galilean transformations.

The Lorentz transformations were developed when researchers discovered Maxwell's equations were not covariant under Galilean transformations. They may have been influenced by the contemporary consensus—supported by experimental results—that light velocity in vacuum is constant. Initially mathematical considerations, they gained physical interpretation through Einstein. Scientists perceptively recognized the enormous merit of Maxwell's equations being covariant under Lorentz transformations, especially after Einstein's interpretation. Lorentz transformations rapidly replaced Galilean transformations as the foundation for unifying Newtonian mechanics and Maxwell's theory. The limitation imposed by Lorentz transformations was accepted and gradually evolved into consensus across physics.

Einstein's first postulate is widely accepted and physically sound. However, as discussed previously, requiring physical laws to be identical in all inertial frames does not require electromagnetic charges and fields to be covariant under the same coordinate transformations. Nor is it necessary for dynamic patterns of electromagnetic systems seen by observers in one frame to be directly mapped from patterns in other frames through transformations.

Based on these considerations, we propose applying Galilean transformations to mechanical and electromagnetic systems in the following modified way:

- (1) The mass of all objects remains unchanged under Galilean transformations. Positions, velocities, and accelerations are covariant, so momentum also changes covariantly.
- (2) Charge density $\rho(t, \mathbf{r})$ is treated like mass and remains unchanged under Galilean transformations. Current density changes covariantly according to (17). We can verify that the current continuity law is covariant: $\nabla' \cdot \mathbf{J}' + \partial\rho/\partial t' = 0$.
- (3) Maxwell's equations in $\mathcal{O}'(t', \mathbf{r}')$ have exactly the same forms as in $\mathcal{O}(t, \mathbf{r})$.

It is important to note that mass, momentum, charge density, and current density are transformed from those in $\mathcal{O}(t, \mathbf{r})$. All electromagnetic fields do not undergo coordinate transformations like (20) in Lorentz transformations. Electromagnetic fields in $\mathcal{O}'(t', \mathbf{r}')$ are subject to Maxwell's equations (22) in \mathcal{O}' , determined by sources $\rho(t', \mathbf{r}')$ in that same inertial frame, i.e., $\rho'(t', \mathbf{r}') = \rho(t, \mathbf{r})$. They are not explicitly related to fields in $\mathcal{O}(t, \mathbf{r})$.

We use a point charge q at rest in $\mathcal{O}(t, \mathbf{r})$ to demonstrate the relationship between fields in two inertial frames. For the observer at rest in \mathcal{O} , the charge is at the origin, the magnetic field is zero, and the electric field is simply expressed by Coulomb's law. For the observer in \mathcal{O}' , the charge moves uniformly with velocity \mathbf{V} , so the sources are $\rho'(t', \mathbf{r}') = q\delta(\mathbf{r}' - \mathbf{V}t')$ and $\mathbf{J}'(t', \mathbf{r}') = q\mathbf{V}\delta(\mathbf{r}' - \mathbf{V}t')$. We use Liénard-Wiechert potentials in the same frame for these sources. The electric and magnetic fields derived in \mathcal{O}' are found to be [?, ?, ?]. The electric fields

expressed in the two frames are quite different and not easily mapped through coordinate transformations. Note that both are exact solutions to Maxwell' s equations in their corresponding frames. Modifying solutions to include special relativity effects would require modifying Maxwell' s equations themselves.

We hereafter call this modified theory the **Galilean-Newtonian-Maxwellian principle of relativity**. Its main points are:

- (1) The distance between two given points and the time interval between two given events are unchanged in all inertial frames. There is no time dilation or length contraction. Positions, velocities, and accelerations change between frames and obey vector addition rules.
- (2) For electromagnetic systems, charge density remains unchanged in all inertial frames, while current density changes due to charge velocity changes.
- (3) Maxwell' s equation forms remain unchanged in all inertial frames. Fields are determined by sources in that frame and obey Maxwell' s equations in that frame.
- (4) For mechanical systems, mass density $\rho_m(t, \mathbf{r})$ remains unchanged in all inertial frames. An object' s mass is always the same as its rest mass m_0 . Kinetic energy is $0.5mv^2$ and momentum is $m\mathbf{v}$. Newton' s law forms are covariant, and mechanical behaviors obey Newton' s laws in that frame.
- (5) Unlike mass and charge densities, system momenta and energies are conserved within a single frame.

Additionally: (6) The causality principle must be observed in all inertial frames: fields at time t cannot be generated by sources at time t_1 later than t . Explicitly, $t_1 \leq t$ is required.

In the Galilean-Newtonian-Maxwellian principle of relativity, we apply Einstein' s first postulate differently than in special relativity.

IV. Rechecking the Experimental Results

A. Light Velocity Constancy

Before reexamining historical experiments measuring light velocity constancy, we note the following facts:

- (1) The light velocity in Einstein' s second postulate refers to c_0 . This is verified by noting that in almost all such experiments, except those using high-energy particles [?, ?], interferometers detect interference fringe displacement caused by phase difference changes in light beams.
- (2) Most early conclusions supporting light velocity constancy were based on Misunderstanding-1, which incorrectly assumes that in classical physics, light velocity and source or observer velocity add vectorially. We must

re-evaluate experimental results using the correct relationship (9) as our reference.

- (3) In most early experiments, light waves were converted to light beams using lenses and collimators. Unfortunately, the side effects of using light beams have been largely ignored. Theoretically, a very thin light beam can be accurately described by Gaussian beam solutions under the paraxial limit [?]. Near the beam axis, the wavefront approximates plane waves, and light velocity nearly equals c_0 . Converting light waves to light beams may have destroyed the original wave structures. Experiments may have measured c_0 rather than $c(\theta)$. Therefore, the experimental system could not detect interference fringe displacements even with high accuracy.

We present several examples showing potential misinterpretation of experimental results [?, ?].

Twin star experiments: Comstock [?] and de Sitter [?] studied binary star orbits to prove light velocity independence from source motion. They expressed measured light velocity as $c = c_0 + v \cos \theta$, where v is the twin star velocity. Finding $\Delta c \approx 0$, they concluded light velocity is independent of source speed. However, their conclusions were based on Misunderstanding-1. Using the correct formula (9) to predict light velocity, we get $\Delta c/c_0 < 10^{-4}$ when the twin star rotates at velocities less than 1200 km/s—much faster than Earth's orbital speed (29.75 km/s). Even ignoring possible light beam effects, it is unconvincing to conclude that light velocity is constant and independent of sources in vacuum. Moreover, according to (9), the largest velocity change is caused by the transverse component of the twin star's velocity at $\theta = 90^\circ$, not the radial component at $\theta = 0^\circ$ as claimed.

High-energy particle experiments: Sadeh [?] measured gamma-ray velocities from positron annihilation in flight. The center-of-mass system moved at about $0.5c$. Two detectors were set at angles of 20° and 135° relative to the positron path. The experiment showed gamma-ray velocity independent of source velocity within $\pm 10\%$ error. According to (9), light velocity increases by 1.5% at 20° and 6.9% at 135° , both below experimental error. Therefore, rather than concluding light velocity is source-independent, it is more reasonable to conclude the experimental accuracy (10%) was insufficient to detect velocity changes (<6.9%) correctly predicted by (9).

Fillippas and Fox [?] measured relative velocities of two gamma rays emitted forward and backward along a decaying π^0 meson's direction. The neutral pion velocity was known to be about $0.2c$. The experiment gave an upper limit $k < 0.4$ with 90% confidence. For comparison, the result predicted by (9) is about $k \approx 0.02$, within the upper limit. Again, the experiment supports (9) but does not prove gamma-ray velocity independence from the π^0 meson's motion as claimed.

Michelson-Morley type experiments: These need not be re-checked because when observer and light source are at rest together ($\beta = 0$), there should

be no light velocity changes in vacuum, as correctly predicted by (9). The historical role of Michelson-Morley experiments may have been to prove no ether exists in vacuum—a goal they achieved convincingly.

Aberrations of nebulae experiments [?, ?, ?]: When light sources approach or recede from observers along a straight line ($\theta = 0$ or π), the velocity is exactly c_0 as predicted by (9). This explains nebulae aberration experiments. Annual aberrations are nearly constant even though nebulae may have large radial velocities up to 30,000 km/s, simply because radial velocity has no impact on light velocity as (9) indicates. For comparison, even assuming a nebula moves transversely at 30,000 km/s, the largest light velocity is only $1.005c_0$, producing aberration of about $20.37''$, not the $23''$ claimed based on Misunderstanding-1.

Effect of Earth' s orbital velocity: Earth' s orbital velocity is about 29.75 km/s, producing a maximum light velocity change of about 10^{-4} , much smaller than most experimental apparatus errors. In some experiments, converting light waves to beams may cause additional errors.

In summary, correctly interpreted, these experimental results cannot be considered true support for light velocity constancy. Conversely, they may support our proposed theory since all results can be reasonably predicted using (9).

Einstein' s Gedanken experiment: With our theory, we can explain Einstein' s thought experiment [?] differently from special relativity. As shown in Fig.5(a), mirror B moves uniformly with velocity \mathbf{V} . Observer A in the frame comoving with mirror B sends a light beam to the mirror, which reflects back to A along the same path. For the comoving observer, light travels at velocity c_0 with proper time $2t$. For the laboratory frame observer, the light beam travels path ABA' in time interval $2t'$. According to special relativity, time dilates in the laboratory frame: $t' = \gamma t$, as shown in Fig.5(b). We can verify that $c'_{0t} = \gamma c_{0t}$, which is Einstein' s explanation.

With our theory, the time interval between given events is identical in all inertial frames: $t' = t$. However, in the laboratory frame, light velocity along the path changes to $c(\theta)$, where $\cos \theta = V/c(\theta)$, as shown in Fig.5(c). It is straightforward to verify that $c_{0t} = c(\theta)t'$.

[Figure 5: see original paper] Einstein' s Gedanken experiment. (a) Light path in the rest frame. (b) In the laboratory frame, explained with time dilation. (c) In the laboratory frame, explained with anisotropic velocity.

B. Doppler Effect

The Doppler effect formula (11) is directly derived from Maxwell' s equations, with clear physical meaning: field frequencies may change due to superposition of fields from the same sources at different time instants.

In special relativity, the Doppler effect is derived from the covariant principle that plane wave phase remains unchanged between laboratory and source rest

frames: $\mathbf{k} \cdot \mathbf{r} - \omega t = \mathbf{k}' \cdot \mathbf{r}' - \omega' t'$. This lacks the intuitive physical meaning of classical electromagnetic theory. The special relativity Doppler effect is [?, ?]: The second-order Doppler shift coefficient differs from that in (11).

Conventionally, the transverse Doppler effect is considered a pure relativistic effect directly related to time dilation, used as strong support for special relativity. However, with exact solution (11), this support is less convincing.

The transverse Doppler effect was experimentally detected in 1938 by Herbert E. Ives and G.R. Stilwell using longitudinal observation [?, ?]. Hasselkamp, Mondry, and Scharmann [?] measured the second-order Doppler shift of the H α line emitted by fast-moving hydrogen atoms, observing light emitted perpendicular to the source motion. These results show the second-order Doppler shift coefficient is about 0.5, close to special relativity predictions. However, in these experiments, source velocities were small ($\beta \ll 1$), making second-order shifts much smaller than first-order ones. Experimental errors are difficult to control and evaluate, including angular errors and Doppler broadening effects. Most importantly, source velocities were evaluated using relativistic equations $mc^2\gamma = \text{constant}$. It is unconvincing to use special relativity-based experiments to support special relativity [?]. Therefore, further experiments are needed to check this issue, especially when light source velocities are comparable to c_0 .

C. Superluminal Sources

We emphasize that Maxwell' s theory imposes no velocity limitation on electromagnetic waves, let alone on objects not obeying Maxwell' s theory. In our proposed Galilean-Newtonian-Maxwellian principle of relativity, we lift this velocity limitation for objects, including charges. We have shown in [?] that superluminal sources behave like electromagnetic black holes, generating electromagnetic shock waves. Amplitudes, frequencies, and velocities become unusually large at shock wave edges. That is, superluminal sources irradiate large amounts of high-energy rays with velocities much greater than c_0 at shock wave edges. Field distributions of shock waves generated by a Hertzian dipole moving at $2.0c_0$ are shown in Fig.6(a) and (b). Velocity and normalized frequency for $\beta = 1.5$ appear in Fig.6(c).

[Figure 6: see original paper] Electromagnetic shock waves of a moving Hertzian dipole. (a) Field pattern at $\beta = 1.5$. (b) Field pattern at $\beta = 2.0$. (c) Wave velocity and normalized frequency at $\beta = 1.5$.

Although superluminal sources have not been officially confirmed, some cosmological events may need revisiting [?, ?, ?].

Muon lifetime experiments: Muons were first discovered in cosmic rays. Their proper lifetime was measured as $\tau = 2.21\mu\text{s}$. Cosmic ray muons are generally produced in the atmosphere at high altitude, yet many travel over 10 km to sea level. Since $c_0\tau = 660\text{m}$, the travel distance is much longer than possible at light speed. Conventionally, there are only two possibilities: muons

travel faster than light in vacuum, or flying muon lifetimes increase due to special relativity time dilation. The first possibility is abandoned, and all experimental results are explained by special relativity.

Frisch and Smith [?] used muons produced atop Mt. Washington, descending about 6265 ft (\$ 1900m) toward sea level at speeds greater than $0.99c_0$. About 408/563 muons reached sea level, yielding an observed time dilation factor of 8.8 ± 0.8 , agreeing with the theoretical time dilation factor $mc^2\gamma = \text{constant}$. This experiment is used to prove time dilation.

In our theory, there is no time dilation, but also no muon velocity limit. Mass remains unchanged during flight. The only explanation is that muons can travel at superluminal speeds greater than c_0 . We evaluate muon velocity using Newtonian mechanics, where kinetic energy is $0.5mv^2$. Adopting the same parameters, muons can travel 5800m and reach sea level within their lifetime. By equating $0.5mv^2 = mc_0^2$, we estimate muon velocity at about $4.15c_0$. Most muons could also reach sea level if not absorbed by other particles. Hence, muon lifetime experiment results cannot be interpreted as supporting only special relativity—they can also be explained by our Galilean-Newtonian-Maxwellian principle of relativity.

V. Cosmology Hypotheses

Stellar-size black holes [?, ?]: Superluminal sources traveling faster than c_0 are not detectable if observers stay outside the shock wave zone. These sources are electromagnetic black holes to observers. Applying this hypothesis to the universe, we may imagine that stellar-size black holes are stars traveling faster than c_0 —superluminal stars. All stars traveling slower than c_0 are ordinary visible stars, as shown in Fig.7. Note that velocity is measured in the observer's rest frame. A black hole to Earth observers may be an ordinary star to inhabitants of other planets if its velocity in their rest frames is smaller than c_0 .

[Figure 7: see original paper] Hypothesis: stellar-size black holes are superluminal stars.

Birth of stars [?]: Superluminal stars may lose energy and slow down. To observers outside the shock wave zone, they are black holes. When they slow down enough to cross the electromagnetic barrier, they may become suddenly detectable: stars begin emitting light that can travel to and be detected by observers in the future. When crossing the electromagnetic barrier, they emit large amounts of high-energy rays, as shown in Fig.8. To observers, this may appear as a star being born from a black hole, emitting large amounts of high-energy rays like γ -rays. This is a possible mechanism for new star births: they are not practically born from black holes but have simply slowed down and crossed electromagnetic barriers.

[Figure 8: see original paper] Hypothesis: one possible way stars are born from stellar-size black holes. Superluminal stars slow down to cross the light barrier.

High-energy ray booms: When Earth is swept by the edge of an unknown superluminal star, we may receive a strong electromagnetic boom of high-energy rays. This may be one source of many unknown γ -ray bursts detected from the universe [?, ?].

Universe expansion: Since many superluminal stars and asteroids approaching Earth at velocities greater than c_0 are invisible to us, this may create an illusion that most stars are receding and that the universe is expanding [?], even though the universe may be practically homogeneous at macroscopic scales. Superluminal stars and asteroids may be part of the sources of dark matter and dark energy [?] in the universe.

VI. Discussions

By correctly interpreting exact solutions of electromagnetic fields from moving sources, three misunderstandings concerning classical physics can be clarified. It is clear that according to classical physics rules, wave velocity and source velocity cannot be added vectorially; light velocity in vacuum depends on propagation direction and relative velocity between source and observer through relationship (9); and the transverse Doppler shift is not a pure relativistic effect. Therefore, revisiting basic rules in classical mechanics and electromagnetic theory is necessary, as is revisiting Galilean transformations, Lorentz transformations, Einstein's two postulates, and thus Einstein's special relativity theory.

We have shown that light velocity constancy lacks solid theoretical support. By checking experimental results supporting light velocity constancy, we found almost all were interpreted using misunderstandings as comparison bases. Therefore, light velocity constancy also lacks solid experimental support. Einstein's second postulate is not an unquestionable natural law, and Lorentz transformations are not the optimal solution. In particular, since electromagnetic fields and sources obey different physical laws with quite different behaviors, it is unnecessary to bind them together and force them to undergo identical coordinate transformations, as Lorentz transformations do in special relativity, at the cost of imposing a velocity limit on all objects in the universe. Intuitively, under Lorentz transformations, the universe is bound by the slope of the velocity limit and packaged into a four-dimensional sphere. Spacetime itself is not bent; it is just distorted under Lorentz transformations.

Undoubtedly, understanding how main bodies are created in the universe is important. However, this paper discusses only mechanical and electromagnetic systems in vacuum, starting from given mass and charge densities independent of observers.

Although superluminal sources have not been officially confirmed, this does not discourage mathematical analysis of causal solutions for fields of sources moving faster than light in vacuum. Electromagnetic shock waves are naturally introduced by these solutions, enabling reasonable cosmological hypotheses such

as superluminal stars possibly existing in the universe and being sources of stellar-size black holes.

In our view, special relativity theory is an extremely powerful searchlight for scientific research, allowing scientists to see through the haze hanging over modern physics in its early stages. Without it, modern physics could not have achieved such great success. However, special relativity may have difficulty explaining some new findings in cosmology and particle physics. The light velocity limit has become a forbidden line. Many findings that may violate special relativity must be wrapped to fit its rules. We believe it may be time to abandon setting light velocity in vacuum as the universal velocity limit. It is unnecessary to use a searchlight when we can see the universe directly—a view perhaps closer to actual observations of our universe and time. If spacetime is indeed found to be bent in the future, we believe it will be bent under physics laws we have not yet discovered, not according to Lorentz transformations.

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