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Asymmetry Theory Derived from the Principle of Light-Speed Constancy: A Unifying Transformation for Classical and Relativistic Physics

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Abstract

Asymmetry Theory (AT) is derived from a single empirically validated principle: light propagates at constant speed *c* from its emission origin, addressing the foundational question: is STR's principle of relativity empirically necessary? AT transformation covers Lorentz and Galilean transformations as limiting cases while retaining absolute time. AT unifies classical and relativistic physics: In "Transverse Regime" — observer motion is perpendicular to the 'source-observer' line — AT is equivalent to Lorentz transformation, preserving Lorentz invariance and reproducing all validated predictions of STR, while naturally handling non-inertial frames. In "Longitudinal Regime", AT reduces to Galilean transformation. A central insight is that "Transverse Regime" is the natural equilibrium state of conservative systems in motion. This explains why established high-precision Lorentz invariance tests operate predominantly in the transverse regime and are therefore consistent with both AT and STR. The longitudinal regime is the untested empirical frontier where AT makes testable novel predictions distinguishing it from STR: (1) Sagnac phase shift in inertial frame; (2) momentum asymmetry for parallel acceleration versus deceleration. AT derives: (1) a light observed velocity formula explaining Sagnac effect, GPS one-way light speed, stellar aberration, and optical clock variation; (2) a unified formula encompassing both classical and relativistic Doppler effects, cosmological redshift, and Cherenkov radiation; (3) electrodynamics equations addressing particle acceleration, mass-energy equivalence, and matter waves; (4) a unified Maxwell's equations yielding classical and transverse Doppler and Sagnac effects as solutions.AT maintains consistency with all established empirical evidence: Michelson-Morley, optical cavity resonators, Hafele-Keating, optical clock, Ives-Stilwell spectroscopy, particle accelerators, muon decay, nuclear reactions and GPS Sagnac corrections. AT is also consistent with the anomalous Gezari lunar ranging and Thim microwave results, which remain unexplained within STR. A first-order sensitive motion-controlled interferometer is proposed for the decisive test of AT. In summary, AT is a mathematically rigorous, self-consistent and empirically supported framework that unifies classical and relativistic physics under a single derivable principle, with a decisive test proposed.

Keywords: Lorentz transformation; Lorentz invariance; QED; Maxwell's Equations; Sagnac effect; doppler effect; light speed invariance; special relativity; at transformation; ASR; time dilation; mass-energy; matter waves; cosmological redshift; Cherenkov radiation; Michelson-Morley; twin paradox; Hafele-Keating; Ives-Stilwell; optical clocks; muon lifetime; lunar range test; Galilean transformation

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I. INTRODUCTION

In 1905, Einstein introduced Special Relativity [1, 2, 3] with two postulates: (1) principle of relativity and (2) principle of the constancy of the velocity of light, which stated: "*in empty space, light is always propagated with a definite velocity V which is independent of the state of motion of the emitting body*". The second postulate has extensive empirical support: binary x-ray pulsar Her X1 timing signatures [8], gamma rays from fast pions [11], and moving optical element experiments [12] all confirm that light speed does not depend on source velocity. However, the additional derived from principle of

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relativity - that light speed is also independent of the observer's motion, has not been conclusively proven. All current tests can only provide an upper limit. Traditional Michelson–Morley interferometers establish only an upper limit of ~1 km/s [7, 43]; modern optical cavity resonators report a precision of order 10^{-17} [44, 45], but they involve confined light whose effective propagation may be locked to the cavity frame, complicating the interpretation. Several contested measurements — lunar laser ranging [27], GPS-based one-way tests [39], and rotational-microwave experiments [14] — have reported results that appear inconsistent with observer-side invariance, while the Sagnac effect in rotating frames [15, 16, 17] and the CMB dipolar asymmetry [47] suggest potential observer-dependent light-speed variations.

This empirical asymmetry motivates a foundational question: can the empirically successful predictions of relativistic physics be derived from the emitter-invariance principle alone, retaining classical absolute time? Previous attempts with classical principles include the ether theory (Lorentz 1904 [6]), which relies on the existence of ether, and the emission theory (Ritz 1908 [9]), which contradicts the principle of constant light speed [10]. Recently, anisotropic Special Relativity (ASR) has shown that relaxing observer-side invariance yields a mathematically consistent framework derivable from thermodynamic and kinematic considerations [49].

Asymmetry Theory (AT) Framework

Asymmetry Theory approaches the same foundational question from a different direction — deriving observer-dependent light velocity from the emission-origin constant light speed principle alone.

Define an emission event $(\mathbf{S}(t_s), t_s)$ of a photon $\mathbf{L}$, the principle of light-speed constancy is be represented as:

$$\mathbf{L}(t) - \mathbf{S}(t_s) = \boldsymbol{c}\,(t - t_s) \qquad \text{(Base Equation)}$$

All results are derived from this base equation through strict mathematics, summarized in **Table I.** step by step with supporting empirical evidence, and collectively termed as the "Asymmetry Theory" [23-25,35,40]. AT is based on the relations between light events, without the assumptions like the ether or universal preferred frames.

Two distinctions are foundational to interpreting AT correctly. First, the *light propagation velocity* $\boldsymbol{c}_{pro}$ — the velocity of the photon $\mathbf{L}(t)$ relative to its emission origin $\mathbf{S}(t_s)$ — must be distinguished from the *light observed velocity* $\boldsymbol{c}_{so}$, the velocity of the photon $\mathbf{L}(t)$ relative to an observer $\mathbf{O}(t)$. The former is invariant $\boldsymbol{c}$; the latter is observer dependent. Second, *absolute time t* — a universal coordinate independent of motion — must be distinguished from *physical clock time T*, which is the count of oscillation cycles measured by an atomic or optical clock and which depends on the clock's motion. AT retains absolute time while deriving the empirically observed clock-frequency variation as a physical effect of motion on oscillation rates.

Unification of Classical and Relativistic Physics

AT unifies classical and relativistic physics as limiting cases through AT transformation, which reduces to Lorentz transformation equivalent in “Transverse Regime” ($\phi = 90^\circ$), Galilean transformation in “Longitudinal Regime” ($\phi = 180^\circ$) and a mix in between.

AT preserves Lorentz invariance and hence reproduces all validated STR predictions in “Transverse regime”. A detailed comparison is summarized in **Table IV.** The distinction is conceptual: time never varies in AT, which preserves classical time synchronization, naturally eliminating temporal paradoxes like the twin paradox.

A key insight is that “Transverse regime” is the natural equilibrium state of a conservative system: the state that a conservative physical system in motion reaches and maintains. It has a revealing analogy in transverse interactions in physics, for example, electromagnetics, rotational momentum, Thomas Precession, Spin orbit coupling, Motional Stark effect, …. Notably, established high-precision Lorentz invariance tests operate predominantly in this regime, providing strong empirical support for AT.

Hence, in “Transverse regime”, AT is *empirically indistinguishable* from STR.

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AT Falsifiability: testable predictions

In "Longitudinal Regime", AT reduces to Galilean transformation and makes novel testable predictions that distinguish it from STR, including two-way light speed variation, generalized Sagnac effect in inertial frames and asymmetric momentum-to-acceleration ratios.

A first-order sensitive interferometer capable of detecting two-way light speed deviation by a lab-controlled motion of 0.1m/s is designed in [46] for a conclusive test of light speed invariance to moving observers.

Scope of Derivations

From the single base equation, AT derives:

1. Light velocity formula: explaining Sagnac effect [15, 16], stellar aberration, Michelson-Morley[7], optical clock variations [28], and GPS [39].

2. AT transformation: unifying Lorentz and Galilean transformations as limiting cases.

3. Unified Doppler/redshift formula: Encompass classical and relativistic Doppler effects [30, 36, 37], cosmological redshift [21], and Cherenkov radiation [34], all linked through the "time scaling factor" dt_o/dt_s. A single equation covers all scenarios of relativistic Doppler effect, explaining Ives-Stilwell experiments [30, 36]. Extends to time-varying velocities (novel). Predicts no frequency shift for circular motion, confirmed by experiments [13, 14].

4. Electrodynamics: Mass-energy equivalence and relativistic momentum, explaining particle accelerators [32] and nuclear reactions [33]; Novel prediction of momentum anisotropy; Formula linking mass-energy to de Broglie wavelength [41], suggesting potential quantum unification.

5. Unified Maxwell's equations: AT formulation of Maxwell's equations [40, 50] that directly yields classical and transverse Doppler and Sagnac effects and preserves classical velocity addition, eliminating the need for Galilean electrodynamics (GED).

Paper Organization

Section II derives the light velocity formulas. Section III presents how AT unifies classical and relativistic physics through AT transformation. Section IV. presents AT empirical evidence and explanations. Section V derives the unified Doppler/redshift formulas. Section VI presents the unified Maxwell's equations. Section VII derives electrodynamic formulas. Section VIII shows STR as a special case. Section IX presents falsifiable tests of AT. Section X provides discussion and conclusions.

Table I. Systematic derivation of AT framework from the base equation and supporting Empirical evidence.

Physical principle	Mathematical Derivation of formulas	Empirical support
Light velocity constancy	$\mathbf{L}(t) - \mathbf{S}(t_s) = \boldsymbol{c}\,(t - t_s)$	**Base equation**
0. AT transformation	$x' = 1/\gamma(v_\perp)\, x + v_\parallel t\,; y' = y;\ z' = z;\ t' = t$	Galilean & Lorenz transf.
1. Light velocity	***base*** ⇒ $\boldsymbol{c}_{so}(t) = \boldsymbol{c} - \boldsymbol{v_o}(t)$	Her X1 [8], Fast pion [11]
1.1 One way light speed	**1.** ⇒ $c_{so} = c/\gamma(v_\perp) - v_\parallel$	GPS measurement [39]
1.2 Generalized Sagnac effect	1.1 ⇒ $\Delta t \approx 2vL/c^2$	Sagnac effect [15, 16]
1.3 Stellar aberration	**1.** ⇒ $sin(\theta_o - \phi) = v_o/c\, sin(\phi)$	Stellar aberration
1.4 Two-way light speed	1.1 ⇒ $c_{sor} = c * (1 - v_o^2/c^2)$	M-M interferometer [7] Cavity Resonator [44,45]
1.5 Two-way moving reflector	1.1 ⇒ $c_{sor} \approx c + v_r$	Lunar range light speed [27]
1.6 $\boldsymbol{v_o} \perp \overrightarrow{\boldsymbol{S}(t_s)\boldsymbol{O}(t_s)}:\ \phi = 90^o$	1.1 ⇒ $c_{so} = c/\gamma$	Lorentz factor
1.7 Optical Clock time dilation	1.6 ⇒ $f/f_0 = c_{so}/c = 1/\gamma$	Hafele-Keating [28], Optical clock [29], muon decay [31]
2. Electrodynamics		
2.1 Particle acceleration	**1.** ⇒ $\Delta P/c * \lvert\boldsymbol{c} - \boldsymbol{v_o}\rvert = m * \Delta v_o$	Kaufmann [32]
2.2 Mass energy relationship	2.1 ⇒ $\Delta E = \Delta m * c^2$	Nuclear reaction [33]
2.3 Matter waves relationship	2.1&2.2 ⇒ $\Delta E = h * c/\lambda$	De Broglie matter waves
3. Unified Doppler/redshift	***base*** ⇒ $\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s) = \boldsymbol{c}(t_o - t_s)$	Classical velocity addition

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3.1 Time dilation factor	**3.** ⇒	$\frac{dt_o}{dt_s} = \frac{c - v_s(t_s)\cos(\theta_s)}{c + v_o(t_o)\cos(\theta_o)}$	Doppler effects
3.2 Traditional Doppler effect	3.1 ⇒	$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c - v_s(t_s)\cos(\theta_s)}{c + v_o(t_o)\cos(\theta_o)}$	Rotational microwave [14]
3.3 Relativistic Doppler effect	3.2&1.6 ⇒	$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c - v_s cos\theta_s}{c + v_o cos\theta_o}\frac{\gamma(v_s)}{\gamma(v_o)}$	Ives-Stilwell [30, 36] (covers all scenarios in STR)
3.4 Cosmological redshift	**3.** ⇒	$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c/a(t_s) - v_s(t_s)\cos(\theta_s)}{c/a(t_o) + v_o(t_o)\cos(\theta_o)}$	Cosmological redshift [21]
3.5 Cherenkov emission angle	**3.** ⇒	$\cos(\theta_e) = c/n * v_p$	Cherenkov radiation [34]
4. Maxwell's equations	**0.** ⇒	$\frac{c^2}{\gamma^2}\frac{\partial^2 E}{\partial x'^2} - 2v cos\phi \frac{\partial^2 E}{\partial x' \partial t'} - \frac{\partial^2 E}{\partial t'^2} = 0$	Solves for classical & transverse Doppler and Sagnac effects

II. LIGHT VELOCITY

This section establishes the mathematical foundation of Asymmetry Theory by deriving light velocity formulas from the single principle of light speed constancy.

A. Foundation: Light Origin and Base Equation

Let a photon $\mathbf{L}$ be emitted at the spacetime event

$$\mathcal{E}_s \equiv (\mathbf{S}(t_s), t_s), \qquad \mathbf{S} \in \mathbb{R}^3, t_s \in \mathbb{R},$$

where $\mathbf{S}(t_s)$ is the spatial position of the emitter at emission time t_s, which defines the **light origin** for that photon. The fundamental principle governing light propagation is:

Principle 1: In empty space, the light always propagates with a velocity c. independent of the state of motion of the emitting body [1].

Let $\mathbf{L}(t) \in \mathbb{R}^3$ be the photon's trajectory, we have:

$$\mathbf{L}(t) - \mathbf{S}(t_s) = \boldsymbol{c}\,(t - t_s), t \geq t_s, \tag{1}$$

where $\boldsymbol{c}$ is the photon propagation velocity, see Figure 1. This relation (1) expresses one-way propagation invariance of photon relative to the origin event, which makes no assumption of the ether, a universal preferred frame or clock synchronization.

**Note: $\boldsymbol{S}(t_s)$ *differs from the emitter's position; they match at* t_s *but are independent after emission,* $t > t_s$.

Now, let a photon be observed at the spacetime event

$$\mathcal{E}_o \equiv (\mathbf{O}(t_o), t_o), \qquad \mathbf{O} \in \mathbb{R}^3, t_o \in \mathbb{R},$$

where $\mathbf{O}(t_o)$ is the spatial position of an observer $\mathbf{O}$ detecting the photon at time t_o, which means: $\mathbf{O}(t_o) = \mathbf{L}(t_o)$

Combining with Eq. (1), we have:

$$\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s) = \boldsymbol{c}(t_o - t_s) \tag{2}$$

All results in this paper are mathematically derived from Eq. (1) without additional postulates.

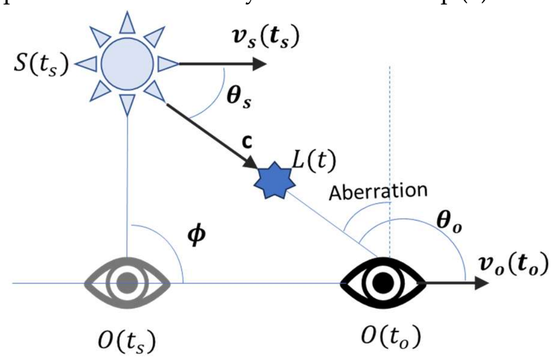

Figure 1. Light emission Timing, Velocities and Key angles.

Figure 1 shows $\boldsymbol{v_o}(t)$ as the velocity of observer $\boldsymbol{O}$ relative to $\boldsymbol{S}(t_s)$ and $\boldsymbol{v_s}(t)$ as the velocity of light source relative to $\boldsymbol{S}(t_s)$. Three key angles are: $\boldsymbol{\theta_s}$ (between $\boldsymbol{v_s}(t_s)$ and the line of

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sight), $\boldsymbol{\theta_o}$ (between $\boldsymbol{v_o}(t_o)$ and $\boldsymbol{c}$) and $\boldsymbol{\phi}$ (between $\boldsymbol{v_o}(t_s)$ and the line-of-sight). The transverse regime corresponds to ϕ = 90°; the longitudinal regime to ϕ = 180°. The aberration angle is $\boldsymbol{\theta_o} - \phi$.

B. Propagation Velocity vs. Observed Velocity

It is fundamental to distinguish between two velocities:

Define the **light propagation velocity** $\boldsymbol{c_{pro}}(t)$ as the relative velocity between photon $\mathbf{L}(t)$ and light origin $\mathbf{S}(t_s)$:

$$\boldsymbol{c_{pro}}(t) = \frac{d}{dt}\big(\boldsymbol{L}(t) - \boldsymbol{S}(t_s)\big) \tag{3}$$

Define the **light observed velocity** $\boldsymbol{c_{so}}(t)$ as the relative velocity between photon $\mathbf{L}(t)$ and observer $\mathbf{O}(t)$:

$$\boldsymbol{c}_{so}(t) = \frac{d}{dt}\big(\boldsymbol{L}(t) - \boldsymbol{O}(t)\big) \tag{4}$$

Note: *This distinction is analogous to the propagation frequency vs. observed frequency in Doppler effect.*

Theorem 1: The light propagation velocity is always $\boldsymbol{c}$.

Proof: Combining Eq. (1) and Eq. (3), we have:

$$\boldsymbol{c_{pro}}(t) = \frac{d}{dt}\big(\boldsymbol{c}\,(t - t_s)\big) = \boldsymbol{c}. \qquad \blacksquare$$

Theorem 2: The observed velocity of a light emitted from $\boldsymbol{S}(t_s)$ as to an observer $\boldsymbol{O}$ is

$$\boldsymbol{c}_{so}(t) = \boldsymbol{c} - \boldsymbol{v_o}(t) \tag{5}$$

Proof:

$$\boldsymbol{c}_{so}(t) = \frac{d}{dt}\big(\boldsymbol{L}(t) - \boldsymbol{O}(t)\big) = \frac{d}{dt}\big(\boldsymbol{L}(t) - \boldsymbol{S}(t_s)\big) - \frac{d}{dt}\big(\boldsymbol{O}(t) - \boldsymbol{S}(t_s)\big) = \boldsymbol{c_{pro}}(t) - \boldsymbol{v_o}(t)$$
$$= \boldsymbol{c} - \boldsymbol{v_o}(t). \qquad \blacksquare$$

****Note:** AT does not posit an Ether or universal privileged frame. It posits that each emission event has its own origin from which light propagates at c — the ECI frame in GPS is simply the empirically determined origin frame for the satellite emission events because $\boldsymbol{c}_{so} = \boldsymbol{c}$ in ECI, not a claim about the structure of the universe. See [48] for some methods of empirically determining the emission origin.

In summary,

1. Light propagation velocity $\boldsymbol{c_{pro}}(t)$ is always $\boldsymbol{c}$.

****Note:** *Hence, by default throughout the paper, "light velocity" refers to the observed velocity* $\boldsymbol{c}_{so}(t)$.

2. Light observed velocity $\boldsymbol{c}_{so}(t)$ depends on the velocity of observer $\mathbf{O}$, specifically, $\boldsymbol{c} - \boldsymbol{v_o}(t)$.

3. $v_o(t) = 0 \Leftrightarrow \boldsymbol{c}_{so}(t) = \boldsymbol{c}$, i.e. one-way light speed is $\boldsymbol{c}$ if and only if light origin is static in observer frame.

C. Composition of Velocity/Galilean transformation

Assuming two observers $\boldsymbol{O}$ and $\boldsymbol{O'}$ with velocity of $\boldsymbol{v_o}(t)$ and $\boldsymbol{v_{o'}}(t)$ respectively, and

$$\boldsymbol{v_{o'}}(t) - \boldsymbol{v_o}(t) = \boldsymbol{v}$$

Let $\boldsymbol{c}_{so}(t)$, $\boldsymbol{c}_{so'}(t)$ be the light observed velocities, from (5):

$$\boldsymbol{c}_{so'}(t) = \boldsymbol{c} - \boldsymbol{v_{o'}}(t) = \boldsymbol{c} - \boldsymbol{v_o}(t) - \boldsymbol{v} = \boldsymbol{c}_{so}(t) - \boldsymbol{v} \tag{6}$$

Hence, Asymmetry Theory maintains the classical addition of velocity across different observers.

D. Unification of Relativistic and Classical light speeds

Theorem 3: Let $v_\perp = v_o sin(\phi), v_\parallel = v_o cos(\phi)$ denote the transverse and longitude component of $\boldsymbol{v_o}$, the light observed speed c_{so} is:

$$c_{so} = c/\gamma(v_\perp) + v_\parallel \tag{7}$$

Proof: From (5), we have:

$$c^2 = c_{so}^2 + v_o^2 - 2c_{so}v_o cos\,(\phi)$$

Solving this equation, we have:

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$$c_{so} = c\sqrt{1 - v_o^2 sin^2(\phi)/c^2} + v_o cos\,(\phi) \quad \blacksquare$$

(7) clearly shows how AT unifies relativistic and classical light speeds. In Transverse regime: $\phi = 90^{\circ}$, (7) reduces to the relativistic formula:

$$c_{so} = c/\gamma \qquad (8)$$

In Longitudinal regime: $\phi = 180^{\circ}$, (7) reduces to the classical formula:

$$c_{so} = c - v_o$$

III CLASSICAL & RELATIVISTIC UNIF.

A. The unifying AT Transformation

Let $\mathbf{F}\,(\boldsymbol{r}, t)$ be the frame with the light origin $\mathbf{S}$ at rest in the origin. We can rewrite Eq. (1) as:

$$dr^2 - c^2dt^2 = 0 \qquad (9)$$

The plot of (9) is the well-known light cone.

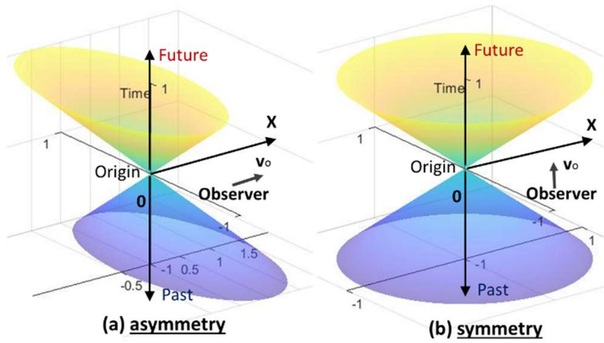

Figure 2. Light cones in Longitudinal and Transverse Regimes.

Let $\mathbf{F}'(r', t')$ be an observer $\mathbf{O}$'s inertial frame moving relative to $\mathbf{F}$ with velocity $\boldsymbol{v_o}$, and $t' = t$. Apply the law of cosines to the triangle of dr, dr' *and* vdt, we have:

$$dr^2 = dr'^2 - 2cos\phi vdtdr' + v^2dt^2$$

Solving this equation, we have:

$$dr' = 1/\gamma(v_\perp)dr + v_\parallel dt \qquad (10)$$

Let θ be the **aberration angle**, it is easy to see from the geometry in Fig. 1 that, $1/\gamma(v_\perp) = cos\theta$. Eq. (10) become:

$$dr' = cos\theta dr + v\,cos\phi t \qquad (11)$$

Note: *Using GPS as a practical example:* $\boldsymbol{F}$ *will be the ECI frame;* $\boldsymbol{E}$ *will be the satellite with velocity* $\boldsymbol{v_s}$ *relative to ECI;* $\boldsymbol{F'}$ *is the satellite frame.*

Let dr, dr' be in the $x,\ x'$ directions, from (10) we derived the **AT transformation** as:

$$x' = 1/\gamma(v_\perp)\,x + v_\parallel t \qquad (12)$$

$$y' = y$$

$$z' = z$$

$$t' = t$$

From (11), AT transformation (12) can also be written as:

$$x' = cos\theta x + v\,cos\phi t \qquad (13)$$

which clarifies its meaning as the combination of a rotation with light aberration angle θ plus a parallel motion $v\,cos\phi$.

B. Unification of Lorentz & Galilean Transformation

AT transformation unifies Lorentz and Galilean transformations as its limiting cases:

When $\phi = 180^o$, AT transformation Eq. (12) reduces to

$$x' = x - vt \qquad (14)$$

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which is exactly Galilean transformation.

When $\phi = 90^o$, AT transformation Eq. (12) reduces to

$$x' = 1/\gamma\, x \qquad (15)$$

Since *dr'* is in the direction of x', we have:

$$dr'^2 = dx'^2 = 1/\gamma^2\, dx^2 = 1/\gamma^2\, c^2 dt^2 \qquad (16)$$

Hence, in this "Transverse Regime", AT transformation preserves Lorentz invariance and is equivalent to Lorentz transformation but keeping the time constant. ****Note:** *While AT preserves Lorentz invariance mathematically, it differs from traditional concepts by retaining absolute time.*

Figure. 2(a) depicts the light cone in Longitudinal Regime, which is asymmetric/anisotropic. Figure 2(b) depicts the symmetric light cone in Transverse Regime, just like LT. (Interactive plot see: https://asymmetrytheory.netlify.app/)

C. Lorentz Invariance in "Transverse Regime"

A key insight is that "Transverse Regime", $\phi = 90^o$, has a revealing analogy in interactions in physics, such as, the magnetic force, Thomas Precession, Spin orbit coupling and Motional Stark effect.

In this "Transverse Regime", the conservative forces in classical, EM and quantum domains are all perpendicular to the motion, see examples in following table. Hence, the work created $\boldsymbol{F} \cdot \boldsymbol{v_o} = 0$, which means it is the natural equilibrium state of a conservative system in motion, i.e. the system will reach and maintain this state. Not surprisingly, it dominates the scenarios of high-precision LI tests. Understanding this correspondence explains AT's consistency with precision measurements while identifying the "Longitudinal Regime" as the untested frontier for empirical resolution.

Domain	Conservative Force
Classical orbit	Centripetal $\boldsymbol{F} \perp \boldsymbol{v_o}$
EM Lorentz magnetic	$\boldsymbol{F_B} = \boldsymbol{v_o} \times \boldsymbol{B} \perp \boldsymbol{v_o}$
Spin-orbit coupling	$\boldsymbol{F_{so}} = \boldsymbol{v_o} \times \boldsymbol{B_{eff}} \perp \boldsymbol{v_o}$

In summary, AT preserves Lorentz invariance in "Transverse Regime", which has a natural parallel in fundamental interactions and dominant presence in established Lorentz invariance tests.

D. Unification of Lorentz Force

We can explain AT's unification of relativistic and classical phenomena with Lorentz force [22], which describes how a charged particle P interacts with electromagnetic field. In **App. A.**, by analyzing the results of Barnett's experiment [18], we demonstrate that the $\boldsymbol{v}$ is the particle velocity relative to the magnetic field, i.e. $\boldsymbol{v_o}$, instead of the velocity in any reference frame as traditional belief:

$$\boldsymbol{F} = q(\boldsymbol{E} + \boldsymbol{v_o} \times \boldsymbol{B}) \qquad (17)$$

We further prove that Eq. (17) is invariant across different observer frames in **App. A**.

In Quantum Electrodynamics (QED), the electromagnetic force is viewed as virtual photon exchange, With the energy-momentum relation, we have:

$$d(\boldsymbol{P}c)/dt = \boldsymbol{F} \cdot \boldsymbol{c_{so}} \qquad (18)$$

where **P** is the applied momentum by photons, $\boldsymbol{c_{so}}$ is the light observed velocity of the particle. Decomposing the electric field into components perpendicular $\boldsymbol{E}_\perp$ and parallel $\boldsymbol{E}_\parallel$ to $\boldsymbol{v_o}$, it follows:

$$\frac{d\boldsymbol{P}c}{dt} = q\left(\boldsymbol{E}_\perp|\vec{\boldsymbol{c}}_\perp - \boldsymbol{v_o}| + \boldsymbol{v_o} \times \boldsymbol{B}|\vec{\boldsymbol{c}}_B - \boldsymbol{v_o}| + \boldsymbol{E}_\parallel|\vec{\boldsymbol{c}}_\parallel - \boldsymbol{v_o}|\right)$$

$$\frac{d\boldsymbol{P}c}{dt} = q(\boldsymbol{E}_\perp * c/\gamma + \boldsymbol{v_o} \times \boldsymbol{B} * c/\gamma + \boldsymbol{E}_\parallel * (c - v_o))$$

$$\frac{d\boldsymbol{P}}{dt} = \frac{1}{\gamma} * q(\boldsymbol{E}_\perp + \boldsymbol{v_o} \times \boldsymbol{B}) + \frac{c - v_o}{c} * q\boldsymbol{E}_\parallel \qquad (19)$$

Formula (19) explains how AT unifies classical and relativistic electrodynamics. For "Transverse Regime", we have:

$$\frac{d\boldsymbol{P}}{dt} = \frac{1}{\gamma} * q(\boldsymbol{E}_\perp + \boldsymbol{v_o} \times \boldsymbol{B}) \tag{20}$$

which is the same formula as relativistic electrodynamics. For "Longitudinal Regime", we have:

$$\frac{d\boldsymbol{P}}{dt} = \frac{c - v_o}{c} * q\boldsymbol{E}_\parallel \tag{21}$$

This is the classical formula and where AT distinguishes from relativity.

E. Time sync. and Causality

Although AT's Eq. (16) is mathematically equivalent with Lorentz transformation, the crucial conceptual distinction is that $t' = t$ in AT; instead, the observed light speed becomes c/γ to preserve Lorentz invariance. As a result, AT maintains classical time synchronization and event causality.

STR [1] claims that time synchronization is impossible. Let a ray of light start at t_A from A towards B, and be reflected at t_B, and arrive again at A at t'_A, STR defines the two clocks synchronized if

$$t_B - t_A = t'_A - t_B$$

However, for an observer moving with speed v, we have:

$$t_B - t_A = \frac{r_{AB}}{c - v} \quad and \quad t'_A - t_B = \frac{r_{AB}}{c + v} \tag{22}$$

STR cannot resolve this contradiction and subsequently asserts that the clocks at A and B are not synchronized [1].

In contrast, Asymmetry Theory yields:

$$(t_B - t_A) - (t'_A - t_B) = 2v * r_{AB}/(c^2 - v^2) \tag{23}$$

which is exactly same formula as Sagnac effect [16]. Thus, AT avoids contradiction (22) in STR and instead predicts a generalized Sagnac effect as (23) for nonrotational frames, which can be experimentally validated with a novel first order M-M type interferometer in [46].

F. "Time Dilation": Absolute Time vs. Physical Clock

A critical point to understand "Time dilation": AT distinguishes between time itself and physical clock.

Absolute Time t: Universal coordinate, same for all observers, never varies.

Physical Clocks T (Atomic/Optical): A measurement counting atom/photon oscillations with frequency f.

We have a relationship between light speed and oscillation frequency as: $c = f * \lambda$, where λ is the wavelength. Let $f(v_o)$ be the frequency of a moving clock with v_o, we have:

$c_{so} = f(v_o) * \lambda$ and $c = f(0) * \lambda$

From Eq. (8), when the motion v_o is perpendicular to its measurement axis (typical geometry "Transverse Regime"):

$$\frac{f(v_o)}{f(0)} = \frac{c_{so}}{c} = \frac{1}{\gamma} \tag{24}$$

In summary, a moving clock physically ticks slower by factor γ —not because absolute time has changed, but because the internal process (frequency f) driving the clock is slowed by motion. It mathematically explains the clock "Time Dilation": Optical clocks [28], Hafele-Keating [29] and Muon lifetime [31] (muon decay rate "Clock frequency" depends on transverse Spin-Polarization).

IV. EMPIRICAL EVIDENCE

A. One-way light speed & GPS measurement

AT's light velocity formula (5) directly explains why one-way light speed measurement yield values different from *c*. From Eq. (5), the light observed speed is: $c_{so}(t) = |\boldsymbol{c} - \boldsymbol{v_o}(t)|$, which is the one-way measured light speed aligned with the GPS measurement like [39].

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STR argues that measuring one-way light speed is impossible due to clock synchronization errors. AT shows it is measurable and Sagnac effect is its direct result. In fact, GPS is a practical example of one-way light speed application with clock synchronization. The ground observers have velocity $\boldsymbol{v_o}$ in ECI frame. Hence, the one-way light speed is $c_{so} = |\boldsymbol{c} - \boldsymbol{v_o}|$. Current GPS must apply "Sagnac correction" to correct the timing error caused by using c as the light speed. AT calculates directly without the need of Sagnac correction: $\Delta t = d/|\boldsymbol{c} - \boldsymbol{v_o}|$.

B. Round-trip light speed & M-M interferometer

Theorem 4: The round-trip speed of light c_{sor} from $\boldsymbol{S}(t_s)$ to $\boldsymbol{O}$ with velocity $\boldsymbol{v_o}$ along the light path (static reflector):

$$c_{sor} = c * (1 - v_o^2/c^2) \tag{25}$$

Proof: The round-trip speed is the average of the forward and backward speeds. From (5), we have

$$c_{sor} = \frac{2}{\frac{1}{c - v_o} + \frac{1}{c + v_o}} = c * \left(1 - \frac{v_o^2}{c^2}\right) \qquad \blacksquare$$

In summary, the round-trip light speed $c_{sor} \approx c$ if $v_o \ll c$.

Explanation of Michelson Morley [7, 43]:

If we assume the ECI frame, $v_o = 460m/s$ for Earth's rotation. From (25), we have:

$$\Delta c = v_o^2/c \approx 0.7\ mm/s$$

which is below the detection threshold of traditional Michelson-Morley interferometer. Hence, the result is null. For a further test, a novel first-order sensitive M-M type interferometer is designed in [46] which can detect two-way light speed deviation caused by a lab induced motion as small as 0.1m/s.

C. Modern Cavity Resonator Experiment

The modern M-M experiments [44, 45] measure the frequency difference between cavity resonators with sensitivity better than 10^{-15}.

AT Explanation:

When light resonates inside a closed cavity, successive reflections from the cavity walls continuously re-establish the photon's light origin at each reflection event. In effect, the cavity walls act as periodic re-emitters, locking the photon into a resonant mode whose effective light origin is the cavity frame itself — not the original emission source. Under this interpretation, the observer velocity relative to the cavity's own light origin is v_o=0., and from Eq. (25), $c_{sor} = c$, consistent with the null result. This behavior is physically analogous to how a Fabry–Pérot resonator defines its own optical path length independent of external translation. We note that this interpretation — while physically motivated and consistent with AT's base equation — constitutes a proposed mechanism rather than a formal derivation from first principles, and a rigorous treatment is reserved for future work. The first-order sensitive interferometer proposed in [46], which uses free-space propagation rather than confined light, is specifically designed to avoid this ambiguity and will provide a decisive test.

D. Round-trip light speed with moving reflector

The contested Lunar laser ranging test (Gezari, 2009 [27]) measures the round-trip light speed at c+*200m/s*, in which the observatory moves along the line-of-sight of the reflector in moon at *200m/s* due to the earth rotation.

AT Explanation:

Let the observatory $\boldsymbol{O}$ velocities to the light origin and reflector be v_o and v_r. So, the reflector velocity to the origin is $v_o - v_r$. From (5), the round-trip speed c_{sor} is:

$$c_{sor} = \frac{2}{\frac{1}{c - (v_o - v_r)} + \frac{1 - v_r/(c - (v_o - v_r))}{c + v_o}}$$
$$= c(1 - v_o^2/c^2) + v_r(1 + v_o/c) \approx c + v_r \tag{26}$$

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We can also derive (26) from the composition of velocity (6). Imagine an $\boldsymbol{O}'$ static with the reflector, thus its velocity relative to $\boldsymbol{O}$ is $-v_r$. From (6) and (25):

$$c_{sor} = c(1 - v_o^2/c^2) - (-v_r) \approx c + v_r$$

In Lunar ranging: $v_r = 200m/s$, we have: $c_{sor} = c+200m/s$, which matches the result perfectly. While the Lunar laser range test is contested as anomalous in STR but follows naturally from AT.

E. Generalized Sagnac Effect

The Sagnac effect [15] shows that two light beams, sent clockwise and counterclockwise around a closed path, take different time to travel the path, which contradicted the assumption that the light velocity is independent of the motion of the observer. STR attributed this contradiction to the rotating/accelerating frame [4, 17]. The Sagnac effect can be extended to a FOG [16] with $\Delta t = 2vL/c^2$, where v is the speed of the detector, L is the length of the path.

Let v_o^+, v_o^- be the velocities of the detector to the origins of two light beams, then $v_o^+ - v_o^- = 2v$. According to (5), the light velocities as measured by the detector are $c - v_o^+$ and $c - v_o^-$, respectively. Therefore,

$$\Delta t = \frac{L}{c - v_o^+} - \frac{L}{c - v_o^-} = \frac{2vL}{(c - v_o^-)(c - v_o^+)} \approx \frac{2vL}{c^2} \tag{27}$$

In summary, AT predicts the generalized Sagnac effect as a direct consequence of the observer-dependent light velocity formula (5), applicable to non-rotational frames and resolving the time synchronization paradox (22) of STR. The AT calculation of $\Delta t = d/|\boldsymbol{c} - \boldsymbol{v_o}|$ is mathematically equivalent to the GPS "Sagnac correction" applied to a constant light speed c: both procedures yield identical numerical predictions, but AT derives the result directly from observer light speed rather than introducing an ad-hoc adjustment. This prediction can be experimentally validated with a novel M-M type interferometer in [46].

F. Key angles and stellar aberration

Aberration of starlight is a phenomenon of difference in the observed angle of starlight due to the velocity of the observer. FIG.1 shows key angles for the light velocity, θ_s, θ_o, ϕ. The stellar aberration is $\theta_o - \phi$. Assuming $v_o(t)$ is constant v_o, the relationship is determined from Fig.1:

$$sin(\theta_o - \phi) = \frac{v_o}{c} sin(\phi) \tag{28}$$

When $\phi = 90^{\circ}$, we have $cos(\theta_o) = -v_o/c$, which is the same as STR in [1], noting θ_o is ψ'.

V. UNIFICATION OF DOPPLER EFFECT

From the single Eq. (2), AT derives a unified framework for frequency shifts observed when sources and/or observers are in motion. We show that classical Doppler effect, relativistic Doppler effect, cosmological redshift, and Cherenkov radiation angle all emerge from a single mathematical formalism—the "time scaling factor" dt_o/dt_s. This unification provides compelling evidence for AT's foundational principles.

A. Time Scaling Factor and Observed Time

The foundation of observed light frequency shifts is the time scaling factor, defined as dt_o/dt_s. A light wave can be viewed as continuous emission events $(\boldsymbol{S}(t_s), t_s)$ and the corresponding observed events $(\boldsymbol{O}(t_o), t_o)$. From (2),

$$\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s) = \boldsymbol{c}(t_o - t_s)$$

Perform an inner product of both sides, we have:

$$(\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s)) \bullet (\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s)) = c^2(t_o - t_s)^2$$

Differentiate both sides as to t_s and reorganize:

$$\frac{(\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s))}{c(t_o - t_s)} \bullet \left(\boldsymbol{v_o}(t_o)\frac{dt_o}{dt_s} - \boldsymbol{v_s}(t_s)\right) = c\left(\frac{dt_o}{dt_s} - 1\right)$$

Let $\boldsymbol{i}_{os}$ denote the unit vector in $\overrightarrow{\boldsymbol{S}(t_s)\boldsymbol{O}(t_o)}$, we have:

$$\boldsymbol{i}_{os} \bullet \boldsymbol{v_o}(t_o)\frac{dt_o}{dt_s} - \boldsymbol{i}_{os} \bullet \boldsymbol{v_s}(t_s) = c\left(\frac{dt_o}{dt_s} - 1\right)$$

$$\left(c - \boldsymbol{i}_{os} \bullet \boldsymbol{v_o}(t_o)\right)\frac{dt_o}{dt_s} = c - \boldsymbol{i}_{os} \bullet \boldsymbol{v_s}(t_s)$$

Finally, the formula for time scaling factor is:

$$\frac{dt_o}{dt_s} = \frac{c - v_s(t_s)\cos(\theta_s)}{c + v_o(t_o)\cos(\theta_o)} \tag{29}$$

When constant v_o, v_s and $\theta_s = 0, \theta_o = \pi$, (19) reduces to:

$$\frac{dt_o}{dt_s} = \frac{c - v_s}{c - v_o} \tag{30}$$

To understand the physical meaning of "time scaling factor", let's consider the phenomenon of a moving observer watches a static clock ticking.

- When $v_o > 0$ (moving away from clock): $dt_o/dt_s > 1$, the clock appears to run slower.
- When $v_o < 0$ (moving toward clock): $dt_o/dt_s < 1$, the clock appears to run faster.
- When $v_o \to c$ (approaching light speed): $dt_o/dt_s \to \infty$, clock appears to stop.

Hence, "time scaling factor" describes how the motions of the observer/emitter impact the observer's "reading" of time. STR tried to use the same phenomenon to explain "time dilation". But since "dilation" means the clock always runs slower, STR can't explain the scenario when clock runs faster. It's important to note that the actual time never varies in AT, what varies here is the observed clock "reading".

B. Derivation of classical Doppler Effect

The classical Doppler effect describes frequency shifts between the light wave emitted frequency and the observed frequency without the relativistic clock effects.

Theorem 5: For a light source emitting at frequency $f_s(t_s)$, the observed frequency $f_o(t_o)$ satisfies the following formula:

$$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c - v_s(t_s)\cos(\theta_s)}{c + v_o(t_o)\cos(\theta_o)} \tag{31}$$

Proof: Because the total wave-number emitted during the period dt_s should be equal to that received during the period dt_o, we have

$$f_o(t_o) * dt_o = f_s(t_s) * dt_s$$

Hence, Eq. (31) follows directly from Eq. (29). ■

Traditionally, Doppler effect formulas are limited for constant velocity. AT's formula extends to time-varying velocity, a theoretical breakthrough. Assuming constant velocities v_o, v_s and $\theta_s = 0, \theta_o = \pi$, this general formula (31) reduce to the traditional Doppler Effect formula [20]:

$$\frac{f_s}{f_o} = \frac{c - v_s}{c - v_o}$$

C. Derivation of Relativistic Doppler Effect

For atomic clocks, we must account for the clock's internal frequency change due to motion from Eq. (24).

Theorem 6: For atomic clocks as sources/observers, the Doppler effect formula is:

$$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c - v_s(t_s)\cos\theta_s}{c + v_o(t_o)\cos\theta_o} * \frac{\gamma(v_s(t_s))}{\gamma(v_o(t_o))} \tag{32}$$

Proof: Note that $f_s(t_s)$, $f_o(t_o)$ are at rest. From (24), the actual clock frequencies during motion are: $f_s(t_s)/\gamma(v_s(t_s))$, $f_o(t_o)/\gamma(v_o(t_o))$. Apply (31), we have:

$$\frac{f_s(t_s)/\gamma(v_s(t_s))}{f_o(t_o)/\gamma(v_o(t_o))} = \frac{c - v_s(t_s)\cos\theta_s}{c + v_o(t_o)\cos\theta_o}$$

which follows the formula (32). ■

STR requires different relativistic Doppler formulas in different scenarios. Table II. shows a single formula (32) covers all scenarios, compelling evidence for its validity.

Table 2. AT formula covers all RDE scenarios in STR.

Scenario	Case	f_s/f_o
Relativistic longitudinal	$v_s = 0$, $\theta_o = \pi$	$\sqrt{1+\beta}/\sqrt{1-\beta}$
Transverse visual closest	$v_s = 0$, $\theta_o = \pi/2$	$1/\gamma(v_o)$
Transverse geometric closest	$v_o = 0$, $\theta_s = \pi/2$	$\gamma(v_s)$
Receiver circular motion	$v_s = 0$, $\theta_o = \pi/2$	$1/\gamma(v_o)$
Source circular motion	$v_o = 0$, $\theta_s = \pi/2$	$\gamma(v_s)$
Source & receiver circular motion	$\theta_o = \pi/2$ $\theta_s = \pi/2$	$\gamma(v_s)/\gamma(v_o)$
Receiver motion arbitrary direction	$v_s = 0$	$\frac{1}{\gamma(v_o)\,(1+\beta\cos\theta_o)}$
Source motion arbitrary direction	$v_o = 0$	$\gamma(v_s)(1-\beta\cos\theta_s)$

D. Thim rotational microwave vs. Ives-Stilwell

The Thim experiment [14] finds no frequency shift for rotational microwave devices, which is contended to contradict STR [19].

AT Explanation: In this test, both the emitter and detector are stationary and linked/synchronized, i.e. no clock time dilation of $1/\gamma$. (32) reduces to the classical Doppler effect formula (31). For circular motion, $\theta_s = \theta_o = 90^o$, from (31), we have:

$$f_s(t_s)/f_o(t_o) = 1$$

i.e. no frequency shift, which aligns with Thim's result.

The Ives-Stilwell spectroscopy experiments [30, 36] measured Doppler shifts from high-speed ions and results matched AT's relativistic Doppler prediction (32).

AT Explanation: Fast-moving ions are atomic systems (atomic clocks). Eq. (32) is applied. In a rotation, $\theta_s = \theta_o = 90^o$. Assume constant v_s and $v_o = 0$, (32) reduces to:

$$\frac{f_s}{f_o} = \frac{\sqrt{1 - v_s/c}}{\sqrt{1 + v_s/c}} \tag{23}$$

a standard transverse Doppler effect aligned with the result.

AT mathematically resolves the appearing conflict between Thim and Ives-Stilwell test results by separating the clock time dilation from classical Doppler effect - a further proof of AT's concept that the relativistic clock effect is a change of physical oscillation not the actual time.

E. Derivation of Cosmological red-shift formula

Cosmological red-shift [21] is traditionally believed to be unrelated to Doppler Effect. AT shows that it can be mathematically derived from the time scaling factor.

The cosmological red-shift formula is:

$$\frac{f_s(t_s)}{f_o(t_o)} = \frac{a(t_o)}{a(t_s)} \tag{34}$$

where $a(t)$ is the cosmic scale factor. Under the assumption of inflating Universe, equation (2) becomes:

$$\boldsymbol{O}(t_o) - \boldsymbol{S}(t_s) = \int_{t_s}^{t_o} \boldsymbol{c}/a(t)dt$$

Following the similar derivation of dt_o/dt_s in **A.** of this section, we derived the following formula in [24]:

$$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c/a(t_s) - v_s(t_s)\cos(\theta_s)}{c/a(t_o) + v_o(t_o)\cos(\theta_o)} \quad (35)$$

When $v_s(t_s), v_o(t_o) \ll c$, (35) becomes:

$$\frac{f_s(t_s)}{f_o(t_o)} \approx \frac{a(t_o)}{a(t_s)}$$

which is the same as (34).

Hence, cosmological redshift emerges naturally from the same time scaling factor framework in AT, which can be viewed as Doppler effect in expanding spacetime.

F. Derivation of Cherenkov radiation emission angle

Cherenkov radiation [34] is electromagnetic radiation emitted when a charged particle passes through a dielectric medium at a speed greater than the light speed in that medium. It has a key emission angle θ_e determined by:

$$\cos(\theta_e) = \frac{c}{n}/v_p \quad (36)$$

where v_p is the particle speed and n is the refractive index.

Let's start derivation from (29). In this case, we have:

$$\frac{dt_o}{dt_s} = (\frac{c}{n} - v_p\cos(\theta_e))/\frac{c}{n} \quad (37)$$

Fermat's principle dictates the light path taking minimum time t_o. Minimizing t_o against t_s requires:

$$dt_o/dt_s = 0$$

Substitute to (37), we get the same formula as (36):

$$\cos(\theta_e) = (c/n)/v_p$$

The Cherenkov radiation angle emerges from the same time scaling factor combined with Fermat's principle. Again, a seemingly distinct phenomenon unifies under the AT framework.

VI. UNIFIED MAXWELL EQUATIONS

This section addresses a critical question: How do Maxwell's equations, which describe electromagnetic phenomena, relate to AT? In summary, AT provides a unified formulation of Maxwell's equations which directly solves the electromagnetic effects in moving systems: Classical and Relativistic Doppler effects, and generalized Sagnac effect. The solutions are consistent with both classical and relativistic results in AT — demonstrating self-consistency of AT's core results. We also show that AT formulation covers Galilean and Lorentz (equivalent) transformations as limiting cases, eliminating the need for modified Galilean electrodynamics (GED).

A. AT Formulation of Maxwell's Equations

Maxwell's standard wave equations [5] in a vacuum and charge-free space are:

$$\nabla^2 E(\boldsymbol{r}, \mathrm{t}) - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}E(\boldsymbol{r}, \mathrm{t}) = 0 \quad (38)$$

$$\nabla^2 B(\boldsymbol{r}, \mathrm{t}) - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}B(\boldsymbol{r}, \mathrm{t}) = 0 \quad (39)$$

The challenge is how does this standard form solve for the effect by system motion v. Traditional approaches include Lorentz transformation (only meaningful in high speed) and GED (modified equations for low-speed approximation).

AT transformation derives a unified formulation [50] which doesn't need Lorentz transformation or GED. Consider the simpler case where a polarized uniform plane wave propagates along the x direction, (38) becomes:

$$\frac{\partial^2 E(x,t)}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 E(x,t)}{\partial t^2} = 0 \quad (40)$$

The chain-rule operator substitutions under AT transformation are:

$$\partial/\partial x' = \gamma_\phi \partial/\partial x$$
$$\partial/\partial t' = \partial/\partial t + \gamma_\phi v cos\phi \partial/\partial x$$

Applying the substitutions, Eq. (40) becomes

$$\frac{c^2}{\gamma^2}\frac{\partial^2 E}{\partial x'^2} - 2vcos\phi\frac{\partial^2 E}{\partial x'\partial t'} - \frac{\partial^2 E}{\partial t'^2} = 0 \quad (41)$$

which is the AT formulation of Maxwell's wave equation. This formulation is mathematically equivalent to original Maxwell's equation and reduces to Galilean limit when $\phi = 180^o$ and Lorentz limit when $\phi = 90^o$ (See Table III.).

By solving the AT formulations, we derived [50]:

Galilean limit: Light phase speed is $c_{ph} = c - v$. Doppler effect is $f_o/f_s = c/(c-v)$. This is consistent with the classical results in AT.

Lorentz limit: Light phase speed is $c_{ph} = c/\gamma$. Doppler effect is $f_o/f_s = \gamma$. This is consistent with the relativistic results in AT.

Furthermore, the generalized Sagnac effect formula is derived from the solution.

In summary, AT formulation of Maxwell's equations directly solves both the classical and relativistic results for light velocity, Doppler effect and generalized Sagnac effect.

B. Generalized Formulation

For the general case when both the emitter and observer are moving, a generalized formulation was derived in [40], which distinguishes the motion of observer from that of emitter:

Table III. Reduced forms of at formulation of maxwell's equation and solutions (adapted from [50]).

Scenarios	AT formulation of Maxwell Equations	c_{ph}	c_{pro}	$f_o/f_s = c_{pro}/c_{ph}$
General	$\frac{c^2}{\gamma^2}\frac{\partial^2 E}{\partial x'^2} - 2vcos\phi\frac{\partial^2 E}{\partial x'\partial t'} - \frac{\partial^2 E}{\partial t'^2} = 0$	$c/\gamma_\phi + vcos\phi$	c	$\frac{c}{c/\gamma_\phi + vcos\phi}$
1. v=0 Original Maxwell	$\frac{\partial^2}{\partial x'^2}E - \frac{1}{c^2}\frac{\partial^2}{\partial t'^2}E = 0$	c	c	1
2. $\phi = 180^o$ Galilean Limit	$\frac{c^2}{\gamma^2}\frac{\partial^2 E}{\partial x'^2} + 2v\frac{\partial^2 E}{\partial x'\partial t'} - \frac{\partial^2 E}{\partial t'^2} = 0$	$c - v$	c	$\frac{c}{c-v}$
3. $\phi = 90^o$ Lorentz Limit	$\frac{c^2}{\gamma^2}\frac{\partial^2 E}{\partial x'^2} - \frac{\partial^2 E}{\partial t'^2} = 0$	c/γ	c	γ

$$(c^2\nabla^2 - (\boldsymbol{v_s}\cdot\nabla)(\boldsymbol{v_s}\cdot\nabla))\mathrm{E}(\boldsymbol{r},\mathrm{t_o}) + 2\frac{c - v_s \cos\theta_s}{c + v_o\cos\theta_o}(\boldsymbol{v_s}\cdot\nabla)\frac{\partial}{\partial t_o}\mathrm{E}(\boldsymbol{r},\mathrm{t_o}) - \frac{(c - v_s\cos\theta_s)^2}{(c+v_o\cos\theta_o)^2}\frac{\partial^2}{\partial {t_o}^2}\mathrm{E}(\boldsymbol{r},\mathrm{t_o}) = 0 \quad (42)$$

VII. ELECTRODYNAMICS

This section derives electrodynamics from AT's light velocity formula (5), showing how relativistic mass, mass-energy equivalence, and relation with matter waves emerge from observer-dependent photon velocity. Crucially, AT predicts momentum anisotropy—acceleration and deceleration require different momentum ratios—a testable distinction from STR that has not been investigated.

A. Momentum-to-speed change ratio

High-speed particles exhibit "resistance to acceleration" [32] — as particle velocity approaches *c*, the applied momentum produces diminishing acceleration. This phenomenon is traditionally attributed to "relativistic mass or momentum" in STR.

Momentum-Velocity Relationship

Consider a particle with mass m and velocity v_o, absorbing photons with momentum ΔP, is accelerated by Δv_o. From Eq. (5), the photon velocity relative to the moving particle is $\boldsymbol{c} - \boldsymbol{v_o}$. The equation of momentum conservation (perfectly inelastic collision) becomes:

$$(\Delta P/c) * |\boldsymbol{c} - \boldsymbol{v_o}| = m * \Delta v_o$$

$$\Delta P/\Delta v_o = c/|\boldsymbol{c} - \boldsymbol{v_o}| * m \qquad (43)$$

Eq. (43) mathematically explains "resistance to acceleration". When v_o=0, the momentum to acceleration ratio $\Delta P/\Delta v_o = m$; when v_o increases, the ratio increases; when v_o approaches c, the ratio approaches infinity.

Perpendicular Motion: Relativistic Mass/Momentum

When $\boldsymbol{v_o}$ is perpendicular to $\overrightarrow{\boldsymbol{S}(t_s)\boldsymbol{O}(t_s)}$, from Theorem 3., we have $|\boldsymbol{c} - \boldsymbol{v_o}| = c/\gamma$. Hence, (43) becomes:

$$\Delta P/\Delta v_o = \gamma * m \qquad (44)$$

which is in the same form as STR's "relativistic mass or momentum" formula. Kaufmann's electron deflection test [32] measured momentum-velocity relationships for electrons deflected perpendicular to their initial motion, supporting both STR and AT in this case.

Novel Testable Prediction: Momentum Anisotropy

One significant distinction of AT from STR is its novel prediction of anisotropic momentum to acceleration ratio.

When $\boldsymbol{c}$ and $\boldsymbol{v_o}$ are in the same direction, (43) becomes:

$$\Delta P/\Delta v_o = m/(1 - v_o/c) \qquad (45)$$

Let's assume $v_o = c/2$. For acceleration, $\Delta P/\Delta v_o = 2m$, a ratio >1 clearly explains the "resistance to acceleration". But for deceleration, $v_o = -c/2$ and $\Delta P/\Delta v_o = 2/3\, m$: a ratio <1 means "inclination to deceleration". This surprising prediction distinguishes AT from STR [1] and can be tested with an experiment designed in [23].

B. Mass-Energy relationship

We now derive the mass-energy relationship in AT analogous to the famous $E = mc^2$. Consider a particle with mass m and velocity v_o. It absorbs photons with momentum ΔP and gains mass of Δm. We have: the following equation for momentum conservation:

$$\Delta P + mv_o = (m + \Delta m) * (v_o + \Delta v_o)$$

$$\Rightarrow \Delta P + mv_o = mv_o + \Delta m v_o + m\Delta v_o + \Delta m \Delta v_o$$

Omit the second order $\Delta m \Delta v_o$ and substitute $m\Delta v_o$ with (45), we have:

$$\Delta P = \Delta m v_o + \Delta P(c - v_o)/c$$

$$\Rightarrow \Delta P * c = \Delta m * c^2 \qquad (46)$$

Hence, we derived the Mass-Energy relationship in AT:

$$\Delta E = \Delta m * c^2 \qquad (47)$$

This Mass-Energy relationship (47) is in harmony with STR [2]. Nuclear reactions [33] confirm mass changes Δm correspond to energy release ΔE with $\Delta E = \Delta m * c^2$.

C. Mass-Energy and Matter waves relation

We extend the analysis to connect mass-energy with quantum matter waves. Consider a particle accelerated from $v_o = 0$ to v, by absorbing photons. From (46), we have:

$$P = c * \Delta m \qquad (48)$$

Applying De Broglie matter waves formula [41],

$$P = h/\lambda$$

where λ is the matter wave length, h is the Planck constant, (48) becomes:

$$c * \Delta m = h/\lambda$$

Applying (47), the relationship between mass-energy and matter waves is:

$$\Delta E = \Delta m * c^2 = h * c/\lambda \qquad (49)$$

It is interesting to note that (49) is analogous to the formula for photon energy:

$$E = h * f_{photo} = h * c/\lambda_{photon} \qquad (50)$$

This hints a potential pathway for AT to extend into quantum domain, which remains future work. AT's retaining of absolute time further resolves a potential roadblock.

VIII. AT COVERS & EXTENDS STR

This section demonstrates that AT reproduces all validated STR predictions in "Transverse Regime" because AT preserves Lorentz invariance in this limiting case. Despite the same predictions, AT has fundamental distinctions from STR: AT maintains classical principles, like absolute time; AT has a broader scope beyond inertial frame; AT provides simpler explanations of same phenomena and reconciles some experiments contradicting STR. The comparison is summarized in **Table IV.**

A. AT reproduced all validated STR Predictions

We now systematically show how AT reproduces each established STR prediction, i.e. empirically undistinguishable, in "Transverse Regime", i.e. $\phi = 90^{\circ}$.

1. Distance-Time Relationship

When $\phi = 90^{\circ}$, AT (Theorem 3.) and STR [1] provide the same equation governing distance *d* and *c*:

$$d = c/\gamma * t \qquad (51)$$

The distinction lies in time: STR changes time to t/γ to make (51) hold. In AT, (51) holds with invariant time t.

2. Stellar Aberration

When $\phi = 90^{\circ}$, AT formula (28) of stellar aberration is:

$$cos(\theta_o) = -v_o/c$$

which predicts same result as in STR [1], noting $\psi' = \theta_o$.

3. Optical Clock Frequency / "Time Dilation"

When $\phi = 90^{\circ}$, AT Eq. (24) predicts moving optical/atomic clock frequency change as:

$$f(v_o) = f(0)/\gamma$$

STR's time dilation formula [1] predicts:

$$t = \gamma\, t_0$$

Because clock frequency is inverse to clock time, AT and STR predict same reading for moving clock.

Both Hafele-Keating [29] and GPS show that clock measurement uses the specific velocity in ECI frame, challenging the equivalence of any reference frame in STR.

4. Relativistic Doppler Effect

Currently, STR [19] requires different formulas to predict relativistic Doppler effect in different scenarios.

Table II. shows a single AT formula (32) predicts same relativistic Doppler effect as STR in all scenarios and even extends to time-varying velocities, which suggests AT captures more fundamental nature of the phenomena. Ives-Stilwell [30, 36] spectroscopy validates both STR and AT.

5. Particle Acceleration

When $\phi = 90^{\circ}$, AT's momentum formula (43) becomes:

$$\Delta P = \gamma * m * \Delta v_o \qquad (52)$$

which is equivalent with the formula in STR [1]:

$$P = \gamma * m * v$$

Kaufmann electron deflection [32] and particle accelerators support the prediction.

In "Longitudinal Regime", AT predicts anisotropic momentum ratios—it is harder to accelerate a fast particle but easier to slow it down. An experiment is designed in [23] to test which prediction is right.

6. Mass Energy equivalence

AT establishes the mass-energy relation Eq. (47):

$$\Delta E = \Delta m * c^2$$

which parallels the widely recognized formula in STR [1]:

$$E = m * c^2 \qquad (53)$$

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If (53) holds, then (47) must be valid. Both formulas are empirically equivalent to practical applications. Nuclear reaction data [33] more closely corresponds to (47), showing that released energy ΔE relates to mass change Δm.

B. AT's Theoretical Progress Beyond STR

We highlight AT's theoretical progress beyond STR:

1. Unification of classical and relativistic physics

AT provides mathematical explanations for both classical and relativistic phenomena across fields like atomics, optics, electromagnetics and quantum: (1) It reproduces all established STR predictions; (2) It derives the classical and relativistic Doppler effect, Cosmological red-shift and Cherenkov radiation from the same time scaling factor, and covers all scenarios of relativistic Doppler effect with a single Eq. (32); (3) It solves Doppler and Sagnac effects directly from a reformulated Maxwell's equations.

2. Extend beyond the Inertial Frames

STR is strictly limited to inertial frames. Non-inertial motion (acceleration, rotation) requires GR or ad-hoc extensions.

AT makes no assumption of inertial frames. It naturally handles any phenomena in classical space and time, such as:

- AT directly derives generalized Sagnac effect from (5).
- Time-varying Doppler effect: STR only handles constant velocity. AT naturally handles time-varying velocity.

3. Maintain classical time synchronization & causality

By keeping absolute time, AT maintains classical time synchronization and causality. Hence, it naturally avoids temporal paradoxes (Twin, Grandfather) and makes simpler explanation of phenomena like Hafele Keating [29].

4. Reconcile contested experimental anomalies

Some contested experimental results appearing anomalous in STR are simply dismissed without the proof of repeated tests. AT provides consistent explanations for these results:

1. **Thim rotational microwave [14]:** No Doppler shift for rotational microwave devices.

STR predicts transverse Doppler shift for circular motion.

In AT, the classical formula (21) applies when there is no clock time dilation, predicting no shift for circular motion.

2. **GPS light speed [39]:** $c \pm v$ (v is earth rotation speed).

STR claims that one-way light speed is impossible to measure. In GPS calculation, a Sagnac correction is required to cancel out the error.

AT's one-way light velocity formula (5) $\boldsymbol{c} - \boldsymbol{v_o}(t)$ is consistent with the test result. Applying this formula in GPS calculation, the Sagnac correction is not needed.

3. **Lunar laser ranging [27]:** Round-trip light speed is $c + 200m/s$ (observatory speed along line of sight)

STR predicts the light speed to be invariant c.

AT's Eq. (16) prediction of $c + v_r$, matches the result.

Table IV. Comparison of Asymmetry Theory (AT) and Special relativity (STR) including empirical evidence.

	Asymmetry Theory	Special Relativity	Empirical Evidence
Part I. Empirical evidence supports both AT and STR (undistinguishable predictions)			
Distance equation	$d = c/\gamma * t$	$d = c * t/\gamma$	**Note:** when $\phi = 90^\circ$
Optical clock	$\frac{f}{f_0} = \frac{c_{so}}{c} = 1/\gamma$	$\frac{t}{t_0} = \gamma$	Muon life [31]; Optical clock [28]; Hafele-Keating [29]
Two-way light speed	$c_{sor} = c/\gamma^2 \approx c$	c	Michelson-Morley [7],

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			Cavity resonator [44, 45]
Stellar Aberration	$cos(\theta_o) = -v_o/c$	$cos(\psi') = -v/c$	Same prediction for aberration.
Relativistic Doppler effect (Atomic clock)	$\frac{f_s}{f_o} = \frac{c - v_s cos\theta_s}{c + v_o cos\theta_o}\frac{\gamma(v_s)}{\gamma(v_o)}$	$\frac{f_s}{f_o} = \frac{\sqrt{1+\beta}}{\sqrt{1-\beta}}$	Ives-Stilwell [30,36]; **Note:** AT formula covers all scenarios
Particle Momentum	$\frac{\Delta P}{\Delta v_o} = m * c/\lvert \boldsymbol{c} - \boldsymbol{v_o}\rvert$	$\frac{\Delta P}{\Delta v} = m * \gamma$	Kaufmann [32]
Mass-energy equivalence	$\Delta E = \Delta m * c^2$	$E = m * c^2$	Nuclear reaction [33]
Part II. Empirical evidence supports AT but not STR* or not explained in STR#			
One-way light speed	$c_{so} = \lvert \boldsymbol{c} - \boldsymbol{v_o}\rvert$	Not measurable	GPS test of light speed* [39]: $c \pm v$, supports AT.
Two-way light speed with relative motion	$c_{sor} \approx c + v_r$	c	Lunar ranging of light speed* [27]: $c + 200m/s$ supports AT
Sagnac effect	$\Delta t \approx 2vL/c^2$	Not applicable	Sagnac effect# [15,16]
Classical Doppler effect	$\frac{f_s(t_s)}{f_o(t_o)} = \frac{c - v_s(t_s)cos\theta_s}{c + v_o(t_o)cos\theta_o}$	$\frac{f_s}{f_o} = \frac{\sqrt{1+\beta}}{\sqrt{1-\beta}}$	Lack of Doppler shift* [14]; Cosmological redshift# [21]; Cherenkov radiation# [34].
Lorentz Force	$F = q^*(E + \boldsymbol{v_o} \times B)$	$F = q^*(E + \boldsymbol{v} \times B)$	Barnett* [18] supports AT.

Note: * Empirical evidence supports AT but contradicts STR; # Phenomena explained by AT but not by STR.

I. FALSIFIABLE TESTS OF AT

Asymmetry Theory makes three quantitative, falsifiable predictions (**Table V.**). The framework is structured so that any single experimental disconfirmation in the longitudinal regime decisively refutes AT —the falsifiability criterion. These predictions have not been experimentally tested to date, not because they are inaccessible, but because the framework of STR has not motivated the necessary first-order longitudinal-sensitivity measurements. This section presents detailed experimental proposals [23, 46] that pre-register specific outcomes for AT versus STR, providing a clear path to empirical resolution.

Table V. Testable Predictions of AT vs. STR.

Physical Effect	AT	STR
1. Round-trip light speed with relative reflector motion v	$c \pm v$	c
2. Sagnac effect with linear motion v in inertia system	$2vL/c^2$	0
3. Momentum to speed change: acceleration versus deceleration	Acc >1 Dec <1	Same >1

A. Two-Way Light Speed deviation

Two-way light speed formula Eq. (25) explains the null-results of traditional M–M interferometers due to second-order sensitivity, masking the deviations caused by earth rotation

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speed. Based on Eq. (26), a novel interferometer, Fig. 3, is designed in [46] with first-order sensitivity, i.e. $c \pm v_r$, detecting deviation Δc caused by v_r as small as 0.1 m/s — a 10^4-fold improvement over traditional M-M setups.

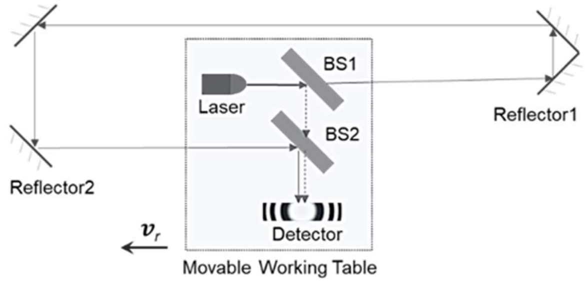

Figure 3. Interferometer detecting light speed deviation [46].

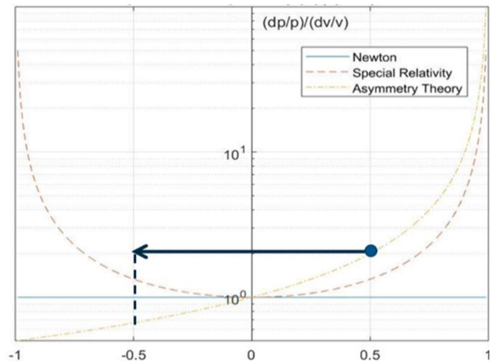

Figure 4. Asymmetry of momentum to acceleration ratio [23].

Moving the apparatus with a lab-controlled $v_r > 2\delta$, the experiment uncertainty, [46] proves the test will produce a definitive result no matter what the outcome of Δc.

Case 1: $\Delta c\ within \pm \delta$: Supports light speed invariance (STR) and conclusively rules out anisotropy (AT).

Case 2: $\Delta c - v_r\ within\ \pm \delta$: Supports light speed anisotropy (AT) and invalidates invariance (STR).

Case 3: $other$: Invalidates both AT and STR.

B. Generalized Sagnac effect in inertial frames

While STR attributes Sagnac effect to rotating frames, AT predicts generalized Sagnac effect in inertial frames as a direct derivation from the light speed formula (5).

Modifying the interferometer of Fig. 3 [46] by replacing the beam splitter BS2 with a reflector allows two light beams to travel the same path in opposite directions, we can test AT's prediction of a phase shift in inertial conditions.

- AT predicts the time difference from Eq. (27) as:

$$\Delta t = 2vL/c^2$$

- STR predicts no Sagnac effect in inertial frame: $\Delta t = 0$.

The result will confirm which prediction is correct.

C. Momentum to speed change ratio anisotropy

Unlike STR, AT Eq. (43) predicts anisotropy in momentum-to-speed-change ratios, which means when a particle is accelerated, it requires more momentum to accelerate further, i.e. "***resistance to acceleration***"; when decelerated, it requires less momentum, i.e. ***"inclination to deceleration"***. This asymmetry is illustrated in Fig. 4.

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An experiment was proposed in [23] to test this prediction. Keep a particle at a constant speed, say 0.5c. Apply a constant momentum to the particle and measure the resulting speed change. Repeat the test but change the direction of momentum each time.

- AT Eq. (43) predicts an anisotropic ratio $\Delta P/\Delta v_o$:

Accelerate: $2m$ versus Decelerate: $2/3m$.

- STR predicts a constant ratio for any direction.

The result will confirm if the momentum to speed change is anisotropic or isotropic, distinguishing AT from STR.

X. SUMMARY & FUTURE WORK

A. Summary of Contributions

Asymmetry Theory is derived from a single empirically validated postulate — that light propagates at constant speed c from its emission origin — without invoking an ether, a universal preferred frame, or the postulate of relativity. Four principal results follow, which are aligned with all established empirical evidence (**Table I.**).

First, the AT transformation (Eq. 12) provides a unified transformation retaining absolute time, recovering the Lorentz transformation in the transverse regime ($\phi = 90^{\circ}$) and the Galilean transformation in the longitudinal regime ($\phi = 180^{\circ}$) as limiting cases. AT reproduces each established STR prediction in transverse regime.

Second, the transverse regime is the natural equilibrium state of conservative systems in motion: in classical orbits, magnetic interactions, spin-orbit coupling, and Thomas precession, the conservative force is perpendicular to velocity, so $\boldsymbol{F} \cdot \boldsymbol{v_o} = 0$ and physical systems relax into and maintain $\phi = 90^{\circ}$. Consequently, all high-precision Lorentz invariance tests have been performed in the regime where AT and STR are empirically indistinguishable; the longitudinal regime, where they diverge, remains untested.

Third, AT provides a single mathematical origin for diverse phenomena: the time-scaling factor dt_o/dt_s unifies classical and relativistic Doppler effects, cosmological redshift, and Cherenkov radiation, while the AT formulation of Maxwell's equations yields the AT core results as solutions, removing the need for GED approximations.

Fourth, AT naturally extends beyond inertial frames (generalized Sagnac effect) and resolves results anomalous under STR — Gezari lunar-ranging, Thim rotational-microwave, and GPS one-way light-speed observations — through direct application of its observer-dependent light-velocity formula, without auxiliary assumptions.

B. Falsifiability and the Decisive Test

AT and STR are indistinguishable in the transverse regime (**Table IV.**) and yield three quantitatively distinct predictions in the longitudinal regime (**Table V.**): two-way light-speed deviation $\Delta c = \pm v_r$, generalized Sagnac shift $\Delta t = 2vL/c^2$ in inertial frames, and momentum-to-acceleration anisotropy. A first order sensitive motion-controlled interferometer [46] is proposed as a single-measurement decisive test; the framework is structured so that any disconfirmation refutes AT.

C. Scope and Future Work

AT does not posit a universal preferred frame — each emission event defines its own origin, empirically validated as ECI for GPS but potentially distinct for other phenomena (e.g., the CMB frame for cosmological observations). Systematic methods for determining emission-origin frames across physical contexts [48] are an open program.

The present framework is restricted to Euclidean space and absolute time without gravitation. Extension to gravitating systems and the relationship between emission-origin structure and the equivalence principle are reserved for future work. The mass–energy–wavelength relation $\Delta E = \Delta mc^2 = hc/\lambda$ parallels the photon energy formula and suggests a bridge to quantum mechanics via the de Broglie relation, a direction also reserved for future investigation.

D. Closing

Asymmetry Theory is mathematically rigorous, derived from a single postulate, consistent with all established empirical evidence, and falsifiable through specified experiments. Whether AT or STR provides the more fundamental description of nature is an empirical question — structured so that experiment can decisively answer it.

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Conflict Of Interest: the authors declare no conflicts of interest.

APPENDIX

A. Lorentz Force invariance across observer frames

The Lorentz force formula for particle P is

$$\boldsymbol{F} = q^*(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})$$

By analyzing the results of Barnett's experiment [18], we further demonstrate that the $\boldsymbol{v}$ in Lorentz force formula is the particle velocity relative to the magnetic field, i.e. v_o, instead of the velocity in any reference frame as traditional belief. In the experiment, a cylindrical capacitor with wire connecting inner/outer conductors is coaxial with a solenoid magnet:

Case 1: Capacitor rotates with angular velocity ω, Solenoid stationary - Lorentz force is detected.

Case 2: Capacitor stationary, Solenoid rotates with ω - No Lorentz force is detected.

If v is particle velocity in "any" frame, there should be force in both cases, contradicting the result.

In AT, the particle velocity is v_o, relative to the magnetic field. Hence, we have:

$$\boldsymbol{F} = q^*(\boldsymbol{E} + \boldsymbol{v_o} \times \boldsymbol{B})$$

Case 1: $v_o = \omega^* r$ (motion relative to field) – Force.

Case 2: $v_o = 0$ (stationary relative to field) – No force.

Hence, Barnett's results further confirm the light origin concept in AT.

Like the light origin, let S be the center of the magnetic field B. Hence, we have:

$$v_o = \frac{d(P-S)}{dt}$$

If we perform the Galilean transformation, P, S, E, B become P', S', E', B' after transformation. We should have the same Lorentz force after transformation. Hence,

$$q^*(E' + v_o' \times B') = q^*(E + v_o \times B) \quad (54)$$

Since

$$v_o' = \frac{d(P'-S')}{dt'} = \frac{d(P-S)}{dt} = v_o$$

for (54) to hold for any v_o, we have:

$$E' = E \;\; and \;\; B' = B \quad (55)$$

In summary, The Lorentz force law in AT is invariant for same observer across different frames and the EM fields don't change just because of different frame selection.

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