MINKOWSKI INVARIANCE, TIME DILATION, AND LOGICAL ASYMMETRY: A PLEM-BASED REINTERPRETATION OF SPECIAL RELATIVITY

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MINKOWSKI INVARIANCE, TIME DILATION, AND LOGICAL ASYMMETRY: A PLEM-BASED REINTERPRETATION OF SPECIAL RELATIVITY

BABAK JABBAR NEZHAD

Abstract. While Special Relativity (SR) predicts a symmetric experience of time dilation between inertial frames, experimental evidence consistently supports a unidirectional dilation: the moving frame's clock ticks slower. In this paper, we reinterpret this asymmetry through the Parallel Law of Excluded Middle (PLEM), a logic-based framework introduced in our earlier works. We derive an identity linking asymmetric Lorentz factors and argue that the apparent invariance of the Minkowski interval is structurally protected—not because spacetime is truly rigid, but because experimental regimes suppress detectable deformation. Within the PLEM framework, SR reveals a hidden logical curvature in the subworld, explaining observed asymmetries without violating Lorentz covariance.

1. Introduction

Special Relativity proposes that time dilation is reciprocal: each inertial observer sees the other's clock running slower. Yet all real-world experiments consistently show that only the moving frame's time (denoted t') dilates. This structural asymmetry has no explanation within standard SR.

We propose that this is not a paradox, but a consequence of logical asymmetry in the subworlds, as outlined in our earlier work on the Parallel Law of Excluded Middle (PLEM) [4, 5]. In this view, inertial frames correspond to a logically distinct subworld, where the Law of the Excluded Middle (LEM) fails, and symmetry of logical form collapses. Thus, while velocity remains symmetric ($v \leftrightarrow -v$), the logical framework does not.

2. Asymmetric Gamma Factors: A Structural Identity

Let us denote:

- Frame A observes B moving at speed v, using Lorentz factor γ
- Frame B observes A moving at speed $-v$, using factor γ'
- We do not assume $\gamma = \gamma'$

Lorentz transformation ($A \to B$):

$$x' = \gamma(x - vt)$$
$$t' = \gamma\left(t - \frac{vx}{c^2}\right)$$

Inverse transformation ($B \to A$):

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$$x = \gamma'(x' + vt')$$
$$t = \gamma'\left(t' + \frac{vx'}{c^2}\right)$$

Substituting forward transforms into the inverse:

$$x = \gamma'\gamma\left[x - vt + v\left(t - \frac{vx}{c^2}\right)\right] = \gamma'\gamma\left[x\left(1 - \frac{v^2}{c^2}\right)\right].$$

Therefore:

$$x = \gamma\gamma'\left(1 - \frac{v^2}{c^2}\right)x \Rightarrow \boxed{\gamma\gamma' = \frac{1}{1 - \frac{v^2}{c^2}}}.$$

This identity reveals that even if velocities are symmetric, Lorentz factors can diverge logically due to subworld asymmetry.

3. Time Dilation in Experiments: t' Always Dilates

In Special Relativity's formalism, time dilation is reciprocal: each inertial observer sees the other's clock running slower. However, every experimental result to date confirms that only t' (the time in the moving frame) dilates — never t. This is not contrary to SR's mathematical predictions when one frame is considered stationary, but it is contrary to the symmetry assumption that both dilations are equally valid or observable.

3.1. **Muon Decay from Cosmic Rays.**

- Muons at 99.94% c should decay in < 1 km
- But reach Earth (10 km) due to dilated t'
- Earth frame: muons age slower $\rightarrow$ t' dilates [2]

3.2. **GPS Satellite Time Correction.**

- SR predicts satellite clocks run slower $\rightarrow$ correction needed
- GR predicts opposite effect (faster clocks)
- Combined corrections confirm SR time dilation of t' [1]

3.3. **Hafele–Keating Experiment.**

- Clocks flown around Earth ticked slower than those on the ground
- Direction-dependent due to velocity $\rightarrow$ confirms t' dilation [3]

3.4. **Particle Accelerators.**

- Fast-moving particles live longer than rest-frame lifetime
- This only makes sense if their internal t' runs slower [2]

In every case, the moving clock dilates—not both. SR's theoretical symmetry is not observed physically.

4. Minkowski Interval and Logical Deformation

The Minkowski metric:

$$ds^2 = -c^2t^2 + x^2.$$

Under Lorentz transformation with $\gamma \neq \gamma'$, we derive:

$$ds'^2 = \gamma^2(1 - \frac{v^2}{c^2})(-c^2t^2 + x^2).$$

Let $k = 1 - \frac{v^2}{c^2}$, so:

$$ds'^2 = \gamma^2 k \cdot ds^2.$$

But $\gamma\gamma' k = 1$. Then either $\gamma < 1$ or $\gamma' < 1$. Now assume t' dilates (as experiments show), so $\gamma > 1$ and then $\gamma k > 1$.

Conclusion:

- ds'^2 expands
- ds^2 contracts
- Logical asymmetry induces structural Minkowski deformation, though undetectable in experiments due to scaling

5. Why Minkowski Invariance Remains Hidden

All major experiments are logically asymmetric, but structurally suppress deviation due to scale:

Experiment	Velocity	Spacetime Scale	ds^2 Deformation
GPS	-0.000013c	20,000 km	Too small
Hafele-Keating	-0.000001c	40,000 km	Too small
Muons	-0.9994c	10 km/μs	Smoothed out
Accelerators	>0.999999c	km/μs	Hidden by γ-scale

Thus, while γ grows massively at high speeds, the spacetime interval is too large or too slow-changing to reveal deformation. Minkowski appears invariant due to measurement limitation, not true invariance.

6. PLEM Interpretation

As demonstrated in [4, 5]:

- A subworld is a logical frame where LEM fails
- Inertial observers occupy a distinct subworld
- There is no global decidability or logical symmetry

Therefore:

- γ and γ' need not be equal
- Time dilation is structurally one-sided
- Minkowski invariance is logically local, not absolute

7. Conclusion

The experimental asymmetry in time dilation—where t' consistently dilates—reveals a hidden logical curvature. This cannot be explained by SR's formal symmetry, but follows naturally from the PLEM framework, where the single subworld, due to logical undecidability and failure of LEM, encodes an asymmetric internal structure.

Future experiments with shorter displacement, ultra-high precision, and asymmetric detection frames may uncover subtle violations of Minkowski invariance.

Note. In traditional physics, the constancy of physical laws across inertial frames is taken as a foundational assumption. Instead, any true logical or physical consistency is found only in the global universe — the full layered logical structure that contains all subworlds. Even without acceleration, a single subworld may lack logical symmetry—rendering certain physical laws locally inconsistent or structurally incomplete. This means that Special Relativity's assumption of universal law invariance across inertial frames breaks down when viewed from within a logically layered universe. The failure of the Law of the Excluded Middle (LEM) in subworlds is not a merely logical defect—it signals a physical asymmetry in how laws manifest within localized observers.

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