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Posted Date: 4 February 2026

doi: 10.20944/preprints202602.0268.v1

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Article

From Michelson–Morley to Sagnac in Causal Lorentzian Theory (CLT) Global Time, Reciprocity, and the Failure of the $c \pm v$ Interpretation

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Abstract

The Michelson–Morley and Sagnac experiments are often portrayed as being in conceptual tension, leading to claims of ether drift, variable light speeds $c \pm v$, or the necessity of a global physical time. This paper shows that such claims arise from conflating coordinate time with physical (proper) time and from elevating kinematic closure relations into physical propagation laws. Within **Causal Lorentzian Theory (CLT)**, spacetime remains locally Minkowskian, light propagates locally at invariant speed c , and observable time differences arise from **conformal time scaling and causal holonomy** rather than from variable light speed. CLT eliminates global physical time by construction and thereby resolves Dingle-type paradoxes, reciprocity confusions, and the misuse of expressions such as $t_{\pm} = L/(c \mp v)$. Michelson–Morley probes local inertial structure, while Sagnac reveals the global failure of simultaneity in non-inertial motion. Both experiments are naturally unified within CLT.

Keywords: causal lorentzian theory; global time; relativity of simultaneity; causal holonomy; conformal spacetime; Sagnac effect; Michelson–Morley experiment; reciprocity; proper time; coordinate time; γ^2 time scaling; Lorentz transformation reinterpretation; $c \pm v$ fallacy; ether theory; GPS relativity; dingle paradox; vacuum energy–dependent gravity

1. Introduction

The Michelson–Morley (MM) experiment historically ruled out ether-drift models based on Galilean kinematics. By contrast, the Sagnac effect has repeatedly been invoked to argue for variable light speed, preferred frames, or the reintroduction of an ether. This perceived tension persists despite the overwhelming experimental success of relativistic technologies such as the Global Positioning System (GPS).

This work argues that the tension between MM and Sagnac is not physical but conceptual. It arises from three persistent confusions: (i) identifying coordinate time with physical time, (ii) mistaking reciprocity of description for symmetry of physical clock rates, and (iii) interpreting kinematic closure relations as physical light-propagation laws. **Causal Lorentzian Theory (CLT)** provides a framework in which these confusions are structurally excluded.

2. Time in Causal Lorentzian Theory

A foundational postulate of CLT is that **there is no global physical time parameter**. Time is local, causal, and path-dependent. Each physical clock measures its own proper time along its worldline, and observable time differences arise only through causal comparison or reunion.

The spacetime structure in CLT is described by a conformally scaled Minkowski line element

$$ds^2 = \Omega^2(x, v)(c^2 dt^2 - d\mathbf{x}^2),$$

where $\Omega(x, v)$ is a conformal factor encoding gravitational, kinematic, and vacuum-energy-dependent effects. The coordinate time t serves only as a chart parameter; it does not represent a globally shared or physically observable time.

3. CLT Coordinate Transformation and the γ^2 Law

In CLT, spacetime transformations are interpreted as **causal readout relations**, not as symmetric exchanges between equivalent inertial observers. For a boost along the x -direction with relative velocity v , the full CLT coordinate transformation is

$$\begin{aligned} t' &= \gamma^2 \left(t - \frac{v x}{c^2} \right), \\ x' &= \gamma^2 (x - v t), \\ y' &= \gamma y, \\ z' &= \gamma z, \end{aligned}$$

with $\gamma = (1 - v^2/c^2)^{-1/2}$.

This transformation exhibits the characteristic CLT scaling: time and longitudinal coordinates transform with a factor γ^2 , while transverse coordinates transform with a factor γ . The simultaneity term $-vx/c^2$ is retained explicitly, ensuring causal consistency.

The inverse transformation is correspondingly simple:

$$\begin{aligned} t &= t' + \frac{v}{c^2} x', \\ x &= x' + v t', \\ y &= \frac{1}{\gamma} y', \\ z &= \frac{1}{\gamma} z'. \end{aligned}$$

These relations make explicit that CLT does not admit a global physical time shared between frames; time transformation depends on position, and distant clock comparisons are inherently causal and path-dependent.

4. Proper Time Versus Coordinate Readout

The proper time measured by a physical clock in CLT is obtained from the invariant interval

$$d\tau = \Omega(x, v) \sqrt{dt^2 - \frac{d\mathbf{x}^2}{c^2}}.$$

Along the worldline of a moving clock, where $d\mathbf{x} = \mathbf{v} dt$, the CLT time readout becomes

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

This demonstrates explicitly that the CLT time readout t' is **not** identical to proper time τ . Coordinate-time holonomy and proper-time accumulation are distinct physical quantities. The appearance of the γ^2 factor follows from causal consistency and energy conservation rather than from symmetry arguments.

5. Michelson–Morley Experiment

The Michelson–Morley experiment probes uniform inertial motion. In CLT, spacetime is locally Minkowskian and the conformal factor Ω is uniform along both interferometer arms. Light propagates locally at invariant speed c , leading to equal round-trip travel times,

$$\oint dt = \frac{2L}{c}.$$

No preferred frame, ether, or global simultaneity is required. The null result of the Michelson–Morley experiment is therefore a direct consequence of local Lorentz invariance.

6. Sagnac Effect as Causal Holonomy

The Sagnac effect involves a rotating, non-inertial system. For a rotating platform with velocity field

$$\mathbf{v} = \boldsymbol{\Omega} \times \mathbf{r},$$

CLT predicts a nonzero time difference between counter-propagating light beams arising from the non-integrability of simultaneity. The effect is expressed as a holonomy integral,

$$\Delta t_{\text{Sagnac}} = \oint \frac{\mathbf{v} \cdot d\mathbf{x}}{c^2}.$$

Locally, light always propagates at speed c . The observed time difference reflects the impossibility of defining a single global simultaneity around a closed loop in a rotating frame. It is therefore a global causal effect, not a consequence of variable light speed.

7. The $c \pm v$ Fallacy

Expressions of the form

$$t_{\pm} = \frac{L}{c \mp v}$$

are kinematic closure relations describing catch-up times between moving endpoints. When such relations are interpreted as physical light-travel times, they implicitly assume a shared global time parameter ($t' = t$), absolute simultaneity, and Galilean velocity addition.

This reintroduces precisely the spacetime structure rejected by relativity. In CLT, such an interpretation is forbidden because no global physical time exists. The Sagnac effect arises from causal holonomy, not from light propagating at speeds $c \pm v$.

8. Reciprocity and Dingle’s Objection

Reciprocity in relativity refers to symmetry of descriptions, not symmetry of physical clock rates. Dingle’s paradox arises from assuming that distant clocks can be directly and symmetrically compared without reunion or causal exchange.

In CLT, clock rates are local and causal, determined by the conformal factor Ω . Observable differences are path-dependent integrals of proper time. As a result, statements such as “clock A runs slower than clock B and vice versa” are not physically meaningful and cannot be formulated within CLT.

9. GPS as Operational Confirmation

The Global Positioning System employs local proper times measured by satellite clocks together with a conventional coordinate time for computation. Relativistic corrections, including the Sagnac term, are essential precisely because simultaneity is not global. If light propagated physically at $c \pm v$, these corrections would be unnecessary and GPS would fail. CLT naturally reproduces the operational structure of GPS through causal holonomy and conformal scaling.

10. Conclusion

The Michelson–Morley and Sagnac experiments probe different aspects of spacetime. Michelson–Morley confirms local Lorentz invariance in inertial frames, while Sagnac reveals the global failure of simultaneity in non-inertial motion. Interpreting Sagnac via $c \pm v$ constitutes a regression to Galilean time. **Causal Lorentzian Theory** provides a unified causal framework with no

global physical time, invariant local light speed, and observable effects arising from holonomy rather than variable propagation speed.

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