

Experimental Proposal: A Differential Test of One-Way Light Propagation Using a Macroscopic Accelerating Source in Vacuo

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1. Abstract

This paper proposes two complementary experimental configurations to rigorously test the independence of the one-way speed of light from source motion—a cornerstone of Special Relativity's second postulate. The key innovation is a *differential measurement method using stationary detector arrays that eliminates the need for absolute clock synchronization*, a persistent philosophical problem in traditional one-way speed tests.

Configuration A uses an accelerating macroscopic transmitter in vacuum with two stationary detectors, measuring how the arrival-time differential (Δt) varies with source velocity. Because both detectors remain at rest relative to each other, any synchronization offset is a static constant that cancels out when measuring *changes* in Δt —we never need to know the "absolute" time at either detector, only how their relative measurements shift with source motion. Configuration B inverts this approach: a stationary light source with accelerating detector arrays, eliminating ambiguities about light emission in moving frames while maintaining the synchronization-free differential advantage.

Critically, we examine the Ewald-Oseen extinction theorem's applicability to the emission process itself (rather than merely propagation through media), revealing that this commonly-cited objection may be overstated. By presenting both configurations, we provide a path to definitive testing regardless of how extinction applies at the emission level. Modern femtosecond timing and ultra-high vacuum technology make these experiments feasible.

2. Introduction

The second postulate of Special Relativity—that the speed of light is independent of the source's velocity—is a cornerstone of modern physics. However, a persistent philosophical problem has plagued attempts to measure the one-way speed of light: how do you synchronize distant clocks without already assuming a value for the one-way speed of light? This is the clock synchronization circularity problem.

Historical validations often relied on constant-velocity subatomic particles or two-way interferometry (which averages the speed in both directions). This proposal introduces differential measurement approaches that *directly sidestep the synchronization problem* by measuring *changes* in arrival-time differentials rather than absolute times.

By using two stationary detectors whose synchronization offset is a constant, we can observe how source motion affects the *difference* in their measurements. This difference changes predictably if emission theory ($c + v$) is correct, but remains constant if Special Relativity holds—without ever needing to solve the clock synchronization problem.

We present two complementary experimental designs, each addressing specific architectural limitations in traditional light-speed tests.

3. The Clock Synchronization Problem and How This Proposal Solves It

3.1 The Traditional Problem

The one-way speed of light cannot be measured without first defining how to synchronize clocks at different locations. Einstein's synchronization convention (the standard approach) involves sending a light signal from point A to point B and back, then assuming the one-way speed is the same in both directions. But this assumption is *precisely what we're trying to test*. This creates a logical circle: you cannot measure the one-way speed of light without assuming a value for the one-way speed of light.

Philosophers and physicists have long recognized this as a fundamental issue with one-way speed measurements (see Salmon, Ellis, and other philosophers of physics).

3.2 The Differential Measurement Solution

This proposal circumvents the synchronization problem by using *two detectors that are stationary relative to each other* and measuring only the *difference* in their arrival times (Δt). Because the detectors are stationary relative to each other, any synchronization offset between them remains a **static constant**. By taking multiple measurements at different source speeds, this constant is subtracted out. We are looking for a *shift* in the data correlated to the source's motion. If relativity holds, Δt will be a flat line across all velocities. If emission theory holds, Δt will decrease as source velocity increases in one direction, and increase if source velocity increases in the opposite direction.

3.3 How Source Motion Changes Δt

- Under Special Relativity: $\Delta t = L/c$ for all source velocities. The differential remains constant regardless of source motion.
- Under Emission Theory ($c \pm v$): $\Delta t = L/(c \pm v)$ changes with source velocity and direction. As the source accelerates toward the detectors, Δt decreases. As it recedes, Δt increases.

Rather than seeking an absolute value for c , we observe the **rate of change** of Δt with respect to the source's velocity (v), $\frac{\delta(\Delta t)}{\delta v}$. By measuring this sensitivity, we can definitively test between these theories *without ever solving the clock synchronization problem*.

3.4 Why This is Revolutionary

Previous attempts to measure the one-way speed of light have either:

1. Assumed a synchronization convention (circular reasoning)
2. Used two-way measurements (which average velocities and hide one-way anisotropies)
3. Relied on subatomic particles where quantum effects introduce ambiguities

This proposal uses a purely differential, empirical method that sidesteps the philosophical problem entirely. We do not need to define what "simultaneous" means at distant points—we only need to measure how the *difference* changes.

4. Experimental Configuration A: Accelerating Source with Stationary Detectors

4.1 The Source Assembly ("The Throne")

The transmitter consists of a high-speed pulsed laser or microwave emitter mounted on a rigid assembly. This assembly is capable of high-magnitude linear acceleration or is mounted on a high-velocity centrifuge to achieve varying instantaneous velocities (v).

4.2 The Detector Array

Two high-precision detectors (D_1 and D_2) are fixed at a distance (L) in the laboratory frame. They are connected to a common high-resolution timing system (femtosecond-scale).

Because both detectors are stationary relative to each other and share a common timing reference, any synchronization offset between them is a constant that cancels when computing $\Delta t = t_2 - t_1$ for various source motions.

4.3 The Vacuum Environment

To eliminate the **Ewald-Oseen Extinction Theorem** objection—which suggests that intervening matter "resets" light speed to c —the entire path (source and detectors) is housed in a single, continuous, windowless **Ultra-High Vacuum (UHV)** chamber ($< 10^{-10}$ Torr).

5. Experimental Configuration B: Stationary Source with Accelerating Detectors

This alternative configuration inverts the experimental approach, offering a conceptually cleaner test that sidesteps certain ambiguities while maintaining the synchronization-free differential advantage.

5.1 The Light Source

A stationary, high-precision pulsed laser or microwave emitter is fixed at the center (or edge) of an ultra-high vacuum chamber. The source remains at rest in the laboratory frame throughout the experiment. This eliminates any question about light emission from atoms in a moving frame.

5.2 The Accelerating Detector Arrays

Two detector assemblies are mounted on independent acceleration platform capable of controlled linear acceleration in opposite directions (or sequentially in the same direction at different times). Each detector is connected to synchronized atomic clocks with femtosecond resolution.

5.3 The Vacuum Environment

As in Configuration A, the entire experimental volume (source, detectors, and acceleration apparatus) is contained within a single **Ultra-High Vacuum (UHV)** chamber ($< 10^{-10}$ Torr), ensuring no intervening matter affects light propagation.

5.4 Methodology

The experiment measures the time difference Δt between photon arrivals at D_1 and D_2 as their reference frame (platform) is moving relative to the stationary light source. If Special Relativity holds, Δt

will remain constant regardless of detector motion. If emission theory ($c \pm v$) is correct, the relationship between detector motion and measured Δt would change in a predictable way.

Because the light source is stationary, there is no ambiguity about the speed at which photons are emitted—they propagate at speed c in the laboratory frame from the outset.

6. Critical Re-examination of the Ewald-Oseen Extinction Theorem

6.1 Classical Statement and Scope

The Ewald-Oseen extinction theorem is a rigorous result in classical electromagnetism: when an electromagnetic wave propagates through a medium, it is absorbed and re-emitted by the medium's electron clouds at speed c relative to that medium. This is mathematically derived from Maxwell's equations.

6.2 The Emission Problem

However, a distinction must be drawn between:

- Light *propagating through* matter (where extinction is well-established)
- Light *being created* by atomic transitions in a moving source (where extinction's applicability is less certain)

The extinction theorem describes how a pre-existing electromagnetic wave interacts with matter. Its application to the emission process itself—where photons are created *de novo* through quantum transitions—relies on less rigorous arguments.

6.3 Implications for This Proposal

Configuration A would directly test whether extinction applies to emission in an accelerating frame. If extinction truly "resets" light speed at the point of emission, the experiment would confirm this. If not, we would observe $c + v$ effects.

Configuration B sidesteps this ambiguity entirely by using a stationary source, where no question of emission in a moving frame arises.

6.4 A Note on Historical Precedent

Many papers invoke extinction as a definitive objection to one-way speed tests without carefully distinguishing between propagation and emission. This section suggests that the extinction objection, while theoretically sound for light passing through matter, may be overstated when applied to the emission process itself.

7. Comparison with Historical Precedent

This proposal is designed to address specific architectural limitations—primarily "round-trip averaging" and "medium interference"—found in historical light-speed validations.

- **Michelson-Morley (1887):** This is the most famous test of light's constancy. However, it utilized a **Two-Way (round-trip)** path where light was reflected back to its origin. This averages the speed in both directions, which can mask a one-way anisotropy. Furthermore, it tested light speed relative to the "aether," whereas this proposal tests speed relative to the **source**.
- **Alväger et al. (1964):** These researchers used constant-velocity subatomic particles (π^0 mesons). While their results supported relativity, the experiment is often debated by skeptics due to the "window" problem. The gamma rays passed through stationary material (detectors/windows) before being measured, potentially triggering the **Extinction Theorem** "reset."
- **Beckmann & Mandics (1964):** This experiment used moving mirrors to test the second postulate. Like Michelson-Morley, the use of mirrors introduces a "re-emission" bias. According to the Ewald-Oseen theorem, the mirror's atoms act as a new stationary source, effectively "extinguishing" any velocity boost the light might have had from the original source.
- **This Proposal**
 - **Configuration A:** Macroscopic, accelerating source in a windowless UHV environment, with differential timing measurements on stationary detectors. This *solves the clock synchronization problem through differential measurement*. It isolates one-way propagation time while avoiding reflections and windows.
 - **Configuration B:** Stationary source (avoiding emission ambiguity) with accelerating detectors, providing an alternative test path that is conceptually cleaner regarding light creation while maintaining the differential measurement advantage.

8. Conclusion

Modern advancements in femtosecond timing and ultra-high vacuum technology make these experiments feasible. By employing differential arrival time measurements, we solve a persistent philosophical problem in physics: *the clock synchronization circularity that has plagued one-way speed tests since Einstein*.

Configuration A directly probes light emission from accelerating sources using stationary detectors, while Configuration B uses a stationary source to cleanly isolate the effects of detector motion. Both maintain the synchronization-free differential measurement principle: we need only measure changes in Δt , not absolute times.

Together, these configurations form a comprehensive experimental program that:

1. Addresses the clock synchronization problem
2. Provides multiple experimental paths to testing the second postulate
3. Sidesteps standard objections about light extinction
4. Demonstrates that a definitive test of source-independence is experimentally achievable

The critical re-examination of the extinction theorem suggests that this commonly-invoked objection may require more rigorous justification than it typically receives in the literature. These experiments would help settle this question empirically.

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