

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 a definitive experimental setup to test the independence of the one-way speed of light from the motion of its source. By utilizing a macroscopic transmitter (the "source assembly") undergoing controlled acceleration within an ultra-high vacuum, and two stationary detectors, we can measure the variance in arrival-time differentials Δt . This configuration specifically addresses and eliminates the Ewald-Oseen extinction bias and the synchronization circularity inherent in traditional one-way speed of light measurements.

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, historical validations often rely on constant-velocity subatomic particles or two-way interferometry. This proposal introduces a **differential measurement** approach. By observing how the time interval between two stationary points changes as a source accelerates, we can test for source-velocity dependency ($c + v$) without the need for absolute clock synchronization or the assumptions of round-trip constancy.

3. Experimental Configuration

3.1 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).

3.2 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).

3.3 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).

4. Methodology and Logic

4.1 Differential Measurement

We define the arrival time at each detector as t_1 and t_2 . The measurement of interest is:

$$\Delta t = t_2 - t_1$$

Rather than seeking an absolute value for c , we observe the **rate of change** of Δt with respect to the source's velocity (v):

$$\frac{\delta(\Delta t)}{\delta v}$$

4.2 Handling Synchronization

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 accelerations, 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.

5. Addressing the Ewald-Oseen Extinction

The Ewald-Oseen theorem states that light entering a medium is extinguished and re-emitted at c relative to the medium. This proposal bypasses this by:

1. **Removing the Medium:** Using a vacuum ensures no molecules are present to re-emit the wave.
2. **Windowless Design:** Most experiments fail by shining light through a stationary glass window. In this setup, the source is *already inside* the vacuum, ensuring the light never interacts with a stationary boundary before reaching the detectors.

6. Mathematical Hypothesis

The objective of this experiment is to distinguish between the predictions of Special Relativity and those of Galilean Emission Theory by observing the behavior of the time interval Δt .

6.1 Predicted Variance in Δt

According to Emission Theory, the velocity of the light pulse is additive with respect to the source's instantaneous velocity (v_s). The predicted arrival time difference across a fixed distance L is:

$$\Delta t(v) = \frac{L}{c \pm v_s}$$

- **Approaching Source (v_s):** As the "throne" accelerates toward the detectors, the light speed is $c + v_s$. Consequently, the time taken to cross the distance L will **decrease**, leading to a measurable reduction in Δt .
- **Receding Source ($-v_s$):** If the source accelerates in the opposite direction (away from the detectors), the light speed is $c - v_s$. The propagation time will **increase**, leading to a measurable rise in Δt .

6.2 The Null Hypothesis (Special Relativity)

Conversely, Special Relativity's second postulate maintains that the speed of light is invariant. Under this framework, the derivative of the arrival time with respect to source velocity must be zero:

$$\frac{\delta(\Delta t)}{\delta v} = 0$$

Regardless of the direction or magnitude of the source's acceleration, Δt is predicted to remain a constant value ($\frac{L}{c}$).

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:** This experiment utilizes a **macroscopic, accelerating source** (the "source assembly") in a **windowless Ultra-High Vacuum (UHV)** environment. By keeping the entire path inside a vacuum and avoiding reflections or windows, this setup provides a much higher level of experimental control. It isolates the **one-way** propagation time and allows for a direct observation of how source-acceleration affects arrival times.

8. Conclusion

Modern advancements in femtosecond timing and ultra-high vacuum technology make this experiment feasible. By focusing on the differential arrival time of light from an accelerating macroscopic source, we can provide a rigorous, transparent test of the second postulate of Special Relativity that is immune to the standard criticisms of one-way light speed measurements.

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