the general science journal

When Light Reveals the Reality We Cannot See

A Modern Reassessment of First-Order Experiments: From Bradley's Observations to Einstein's Relativity, an Old Question Re-emerges.

Aimé Savouret

aimesavouret@protonmail.com

Original language: French

Created November 30, 2025

Updated March 12, 2026

Contents

1 Introduction

For more than two centuries, the way light propagates through space has remained one of the deepest and most debated questions in physics. From the bold ideas of Arago to the insights of Einstein, through the intuitions of Fresnel, the measurements of Fizeau, and the equations of Lorentz, each step has reshaped our perception of reality.

Light, an elusive messenger, guided the very birth of relativity. Yet a sense of paradox remains. Between theory and intuition, something still resists. When traveling through a moving medium, light sometimes appears to defy attempts to reduce it to simple laws. The experiment proposed here follows the lineage of the great foundational experiments.

Are we facing an illusion of perspective or a flaw in the foundations of our understanding of reality?

2 Historical Context

2.1 From the aberration of light to the idea of a dragged ether

In 1728, James Bradley turned his telescope toward the sky, determined to capture the hidden signature of Earth's motion around the Sun. Observing Gamma Draconis with patience and precision, he hoped to detect the slightest displacement due to stellar parallax. Instead of the expected shift, an unusual phenomenon appeared: the star seemed to trace a small perfect circle in the sky, a subtle and regular motion repeating over the course of a year. Bradley measured this celestial motion with remarkable precision: 20.5 arcseconds, small yet sufficient to reveal an invisible truth, light is not stationary; it is overtaken by Earth's motion. Thus emerged the discovery of the aberration of light, a first-order effect in $\frac{v}{c}$, revealing, like a faint whisper, the continuous motion of our planet through space.

In 1810, Dominique-François Arago also turned to the stars, prism in hand, to investigate a fundamental mystery: is light, this cosmic messenger, carried along by the Earth in its celestial motion? Inspired by Bradley's discovery of stellar aberration, his experiment aimed to determine whether the motion of our planet alters the direction of light rays passing through a prism.

But the sky remained silent. No measurable deviation, no sign that light obeys Earth's motion. A paradox then emerged: how can the Earth move without leaving any imprint on the light it receives?

This challenge to contemporary theories led Augustin Fresnel, in 1818, to propose a bold answer: the ether, this hypothetical fluid, would be only partially dragged, precisely according to the factor $1 - \frac{1}{n^2}$, where n is the refractive index of the medium.

Thus emerged the unsettling idea of a universe where motion may remain invisible, a world in which light seems indifferent to the motion of matter, as if keeping for itself the secret of its own journey.

2.2 Fizeau and experimental confirmation

In 1851, Hippolyte Fizeau undertook a bold experiment: measuring the speed of light not in vacuum but within a moving fluid. In a carefully designed setup, two light beams traveled through water flowing in opposite directions, like two travelers following contrary currents.

At the output, a subtle result appeared: the shift of the interference fringes, a delicate trace of their journey, testified to a profound truth. The fluid influenced the light, but only according to the fraction predicted by Fresnel.

This precise and intriguing result confirmed an intuition emerging from theoretical considerations: light is not entirely insensitive to the motion of the medium it traverses, yet it is not completely governed by it either, as if retaining a degree of independence.

However, a question remained: what about the absolute motion of the entire system? If the apparatus as a whole moves through the ether or any privileged reference frame, does light retain any trace of it?

In the Fizeau experiment, everything relies on symmetry: two light beams traverse

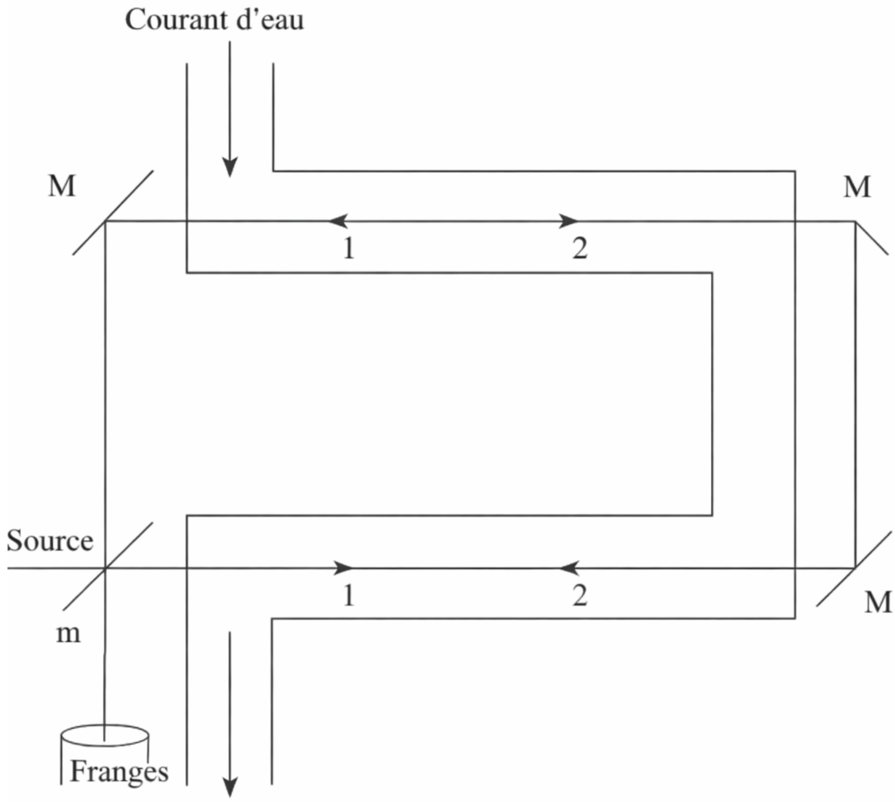

Figure 1: Diagram of the Fizeau experiment; m: semi-transparent mirror, M: mirror(s)

water flowing in opposite directions. This ingenious arrangement has a subtle consequence: it perfectly cancels any influence of an absolute motion of the laboratory. Even if the apparatus drifted through an invisible reference frame, no interference fringe would reveal it. The setup reveals only the relative effect of the fluid on light, never the trace of an absolute motion.

Nearly twenty years later, the Hoek experiment extended this investigation in a new configuration:

- A stationary glass cylinder guides two light beams in opposite directions.
- The apparatus is slowly rotated, as if exposing it to the hypothetical ether.
- Hoek sought to determine whether the orientation or apparent motion of the system modifies the propagation of light.

Once again, no interference shift, no asymmetry between the beams. The experiment remained insensitive to any absolute motion. In reality, the two beams traveling along opposite paths compensate each other, canceling any trace of a global displacement of the apparatus. In the Hoek configuration, a uniform motion automatically eliminates all terms proportional to v/c, so that observable effects appear only at second order. This is precisely the situation encountered in most classical experiments, from Michelson–Morley through Hammar to modern tests.

Both Fizeau and Hoek therefore reveal a clear conclusion: these experiments measure only relative velocities, never an absolute velocity of the system. This is not a limitation of reality itself but the consequence of experimental design: the setups are constructed so

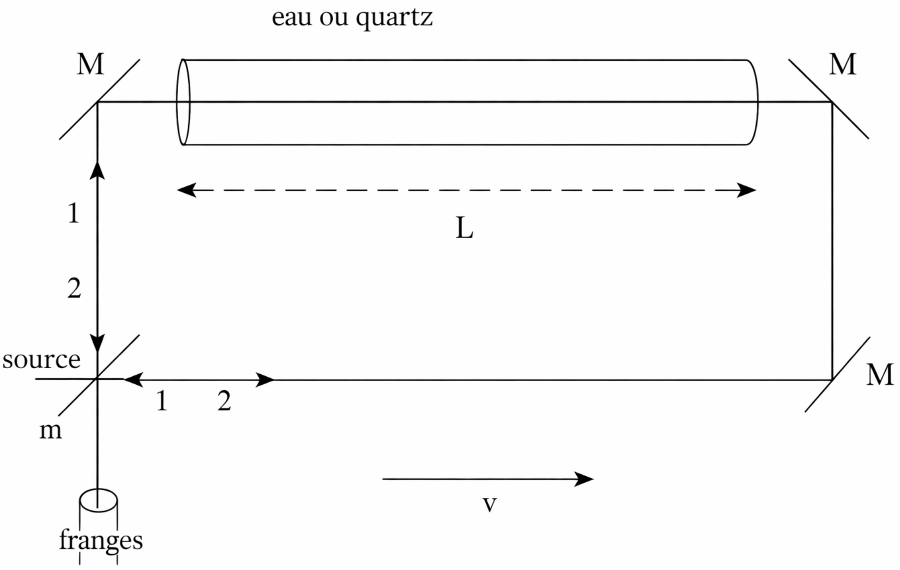

Figure 2: Diagram of the Hoek experiment

that any effect related to absolute motion cancels before detection. Reference documents 1 and 2 provide the demonstration. The result therefore remains identical regardless of the observer's viewpoint.

2.3 Lorentz and the end of the ether

At the end of the nineteenth century, Lorentz sought to reconcile the results of Fizeau and Michelson with a coherent electromagnetic theory. His model introduced length contraction and a local time, explaining the null result of the Michelson–Morley experiment while preserving a stationary ether.

2.4 Einstein and the relativistic revolution

In 1905, Einstein eliminated the ether concept and proposed two fundamental postulates:

1. All laws of physics are identical in inertial frames moving at constant velocity.
2. The speed of light in vacuum is the same for all observers, regardless of their relative motion.

Within this framework, the Fizeau experiment, where a fringe shift appears when light propagates through a moving liquid, naturally follows from relativity. The shift becomes a direct consequence of the relativistic composition of velocities derived from Lorentz transformations.

2.5 The Sagnac effect and the question of "rectilinear" motion at the Earth's surface

The Sagnac effect is generally presented as the sensitivity of an interferometric system to rotation. It is a first-order effect, similar in nature to the one demonstrated by Fizeau. In a ring laser gyroscope, two light beams travel along the same closed loop in opposite directions; in the presence of angular motion, the difference in travel time produces a measurable phase shift. This principle forms the basis of modern navigation gyrometers.

However, at the surface of the Earth, strictly rectilinear motion does not exist. Any point fixed on the ground continuously follows a curved trajectory resulting from Earth's rotation, inertial motions, and external forces. One may therefore ask whether an appropriately designed interferometric configuration could also reveal signatures associated with the linear velocity of a vehicle. The setup proposed here is based on this hypothesis.

3 A Revisited Experiment: Light Propagation in an Onboard Medium

3.1 General principle

The experiment compares the travel time of two light beams:

- One propagates through a refractive medium (a water-filled rod, $L = 1$ m, $n \approx 1.5$),
- The other follows a reference path in air.

The mirrors introduce a delay that allows the optical paths of the two beams to be equalized when the setup is at rest, ensuring that the path difference remains within the coherence length of the laser.

The entire system, laser source, refractive medium, detector, and mirrors, is mounted onboard a vehicle moving at speed v up to 130 km/h.

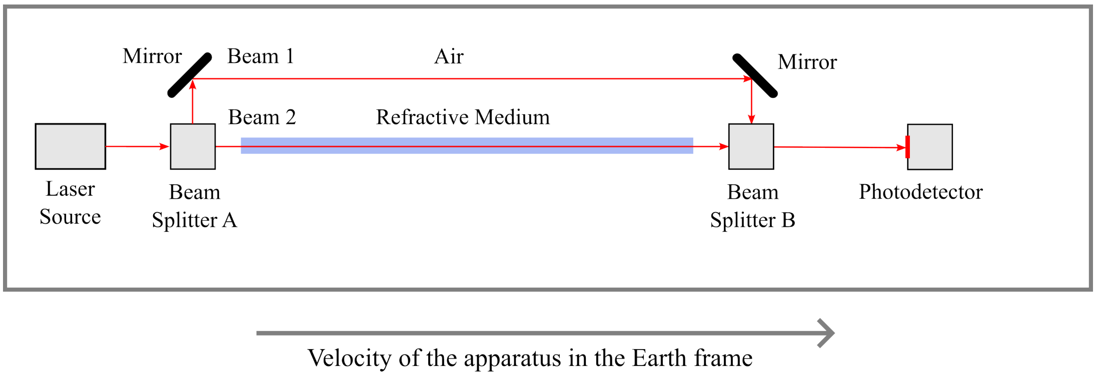

Figure 3: Diagram illustrating the proposed interferometric experiment

3.2 Conceptual objective

In strict relativity, uniform translation of the whole system should produce no fringe shift. However, within a pre-relativistic interpretation, light propagating through the refractive medium interacts with material electrons moving with the vehicle, potentially producing a velocity-dependent shift.

3.3 Pre-relativistic analysis

The propagation velocity of light in the medium is given by Fresnel's formula:

$$c_{\text{medium}} = \frac{c}{n} - v\left(1 - \frac{1}{n^2}\right) \tag{1}$$

The propagation velocity in air is:

$$c_{\text{air}} = c \tag{2}$$

Let t_1 and t_2 denote the travel times of the two beams. The time delay is:

$$\Delta t = t_1 - t_2 \tag{3}$$

With path compensation:

$$\Delta t = \frac{L}{\frac{c}{n} - v\left(1 - \frac{1}{n^2}\right)} - \frac{L}{c} \tag{4}$$

$$\Delta t = \frac{L \cdot n^2 \cdot c - L \cdot n \cdot c - L \cdot v \cdot (n^2 - 1)}{n \cdot c^2 + v \cdot c \cdot (n^2 - 1)} \tag{5}$$

$$\Delta t = \frac{L \cdot c \cdot (n^2 - n) - L \cdot v \cdot (n^2 - 1)}{n \cdot c^2 + v \cdot c \cdot (n^2 - 1)} \tag{6}$$

For $v \ll c$:

$$\Delta t = \frac{L \cdot (n - 1)}{c} - \frac{L \cdot v \cdot (n^2 - 1)}{n \cdot c^2} \tag{7}$$

After compensation:

$$\Delta t = -\frac{L}{c^2} \cdot \left(n - \frac{1}{n}\right) \cdot v \tag{8}$$

The fringe shift is:

$$\Delta N = \frac{|\Delta t|}{\lambda} \cdot c \tag{9}$$

$$\Delta N = \frac{L}{\lambda} \cdot \frac{v}{c} \cdot \left(n - \frac{1}{n}\right) \tag{10}$$

4 The Role of the Light Source Reference Frame

Einstein states that the speed of light is independent of the motion of the source, but this independence applies only to propagation speed in vacuum, not to frequency or phase. In a refractive medium, a moving source introduces a classical Doppler modification:

$$\lambda_{\text{setup}} = \lambda_{\text{source}} \cdot \left(1 + \frac{v}{c}\right) \tag{11}$$

For $v \ll c$, the Doppler-induced fringe shift is:

$$\Delta N_{\text{doppler}} = \frac{\text{OPD}}{\lambda_{\text{source}}} \cdot \frac{v}{c} \tag{12}$$

where OPD is the optical path difference.

5 Experimental Implementation

The configuration considered is the onboard configuration, where the source, medium, and detector move together. A stabilized He–Ne laser is used, and interference fringes are detected with a high-sensitivity photodetector coupled to a digital phase analyzer capable of resolving shifts of approximately 0.01 fringe.

6 Experimental Expectations

The expected fringe shift is:

$$\Delta N = \frac{L}{\lambda} \cdot \frac{v}{c} \cdot \left(n - \frac{1}{n} \right) \tag{13}$$

For realistic parameters:

$$L = 1 \text{ m} \tag{14}$$
$$n = 1.33 \tag{15}$$
$$\lambda = 632.8 \text{ nm} \tag{16}$$
$$v = 36 \text{ m}\cdot\text{s}^{-1} \tag{17}$$

$$\Delta N = 0.11 \tag{18}$$

This predicted value is measurable but requires a highly stable interferometer capable of maintaining coherence despite mechanical vibrations and motion-induced disturbances.

7 Conclusion

The significance of this experiment extends beyond optics, touching the status of the reference frame of the light source itself. Most classical tests of relativity are second-order experiments, inherently insensitive to first-order velocity effects. The proposed onboard experiment specifically targets first-order effects proportional to the velocity of the vehicle.

If a velocity-dependent fringe shift is observed even when the entire apparatus moves together, it would indicate that light propagation in material media retains a dependence on the inertial status of its source. Even a null result would remain informative, as it would probe a regime rarely tested experimentally.

Two centuries after Arago, such an experiment could reopen the discussion on the role of the source reference frame and remind us that the behavior of light may still hold unexplored subtleties.

8 References

1. Hoek experiment by Doug Marett (2010):
`https://www.conspiracyoflight.com/Hoek/Hoek_Experiment.html`
2. Hoek experiment by Emil Falkner (22/01/2021):
`https://www.gsjournal.net/h/papers_download.php?id=1903`