Wilhelm Wien

Article Talk

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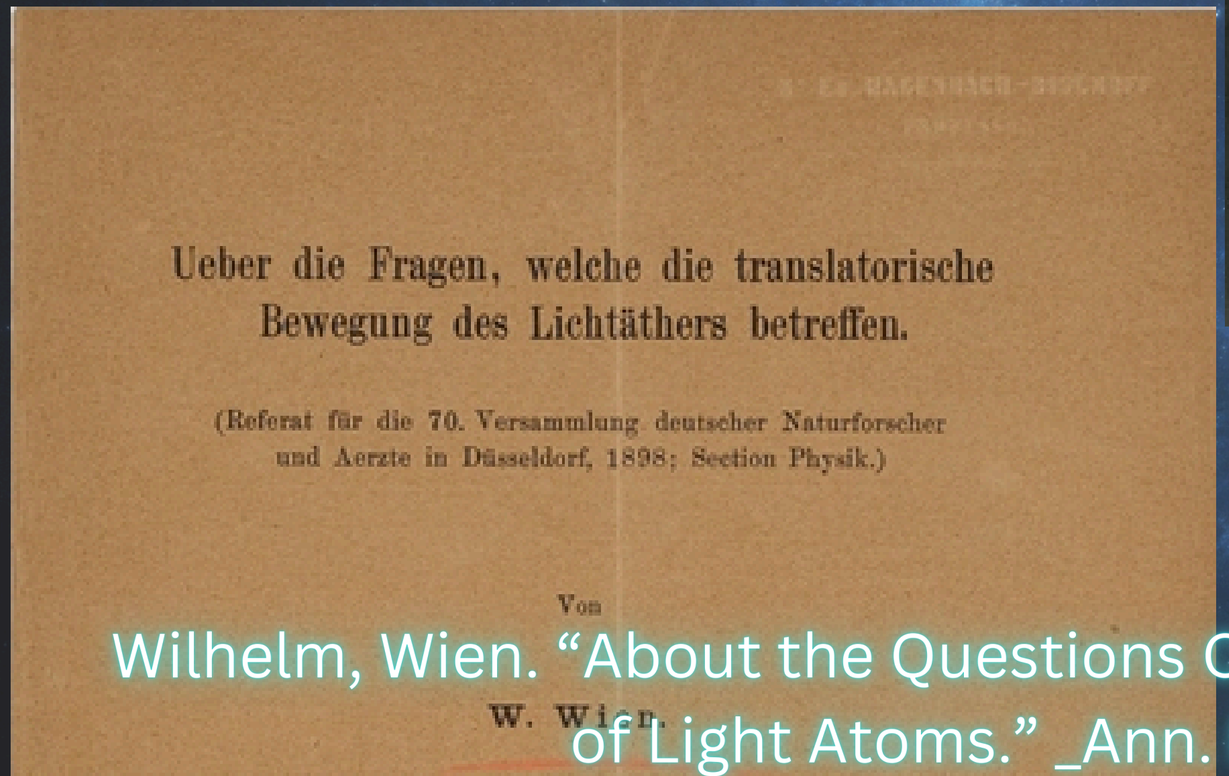
Wilhelm Carl Werner Otto Fritz Franz Wien (German pronunciation: [ˈvɪlhɛlm ˈviːn] ; 13 January 1864 – 30 August 1928) was a German physicist who, in 1893, used theories about heat and electromagnetism to deduce Wien's displacement law, which calculates the emission of a blackbody at any temperature from the emission at any one reference temperature.

He also formulated an expression for the black-body radiation, which is correct in the photon-gas limit. His arguments were based on the notion of adiabatic invariance, and were instrumental for the formulation of quantum mechanics. Wien received the 1911 Nobel Prize for his work on heat radiation.

He was a cousin of Max Wien, inventor of the Wien bridge.

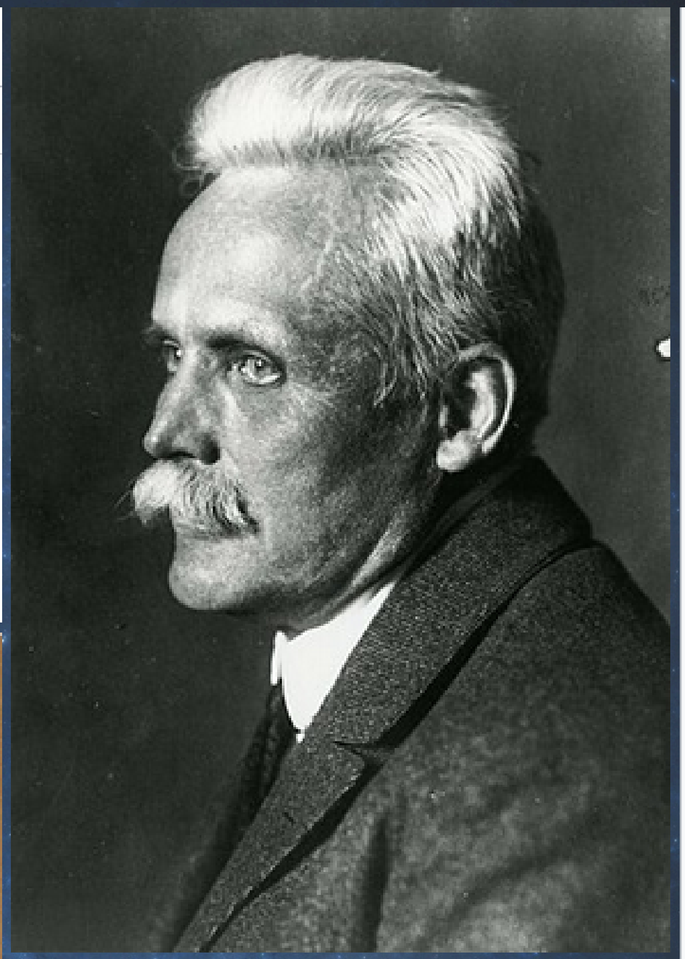


Ueber die Fragen, welche die translatorische Bewegung des Lichtäthers betreffen.

(Referat für die 70. Versammlung deutscher Naturforscher und Aerzte in Düsseldorf, 1898; Section Physik.)

Von

W. Wien.



Born	Wilhelm Carl Werner Otto Fritz Franz Wien 13 January 1864 Gaffken, Province of Prussia
Died	30 August 1928 (aged 64) Munich, Germany
Alma mater	University of Göttingen University of Berlin
Known for	Blackbody radiation Wien filter Wien's displacement law Wien's distribution law
Spouse	Luise Mehler (1898) (1877-1961)
Awards	Guthrie Lecture (1925) Nobel Prize for Physics (1911)
	Scientific career
Fields	Physics
Institutions	University of Giessen University of Würzburg University of Munich RWTH Aachen
Doctoral advisor	Hermann von Helmholtz
Doctoral students	Gabriel Holtsmark Eduard Rüchardt

Wilhelm, Wien. “About the Questions Concerning the Translational Movement of Light Atoms.” _Ann. Phys. Chem._ 65 (1898).

A) Experiments with positive results.

1. The aberration of the light of the fixed stars. As is well known, the aberration found a simple explanation through the emission hypothesis of light.The difficulties in the undulation theory have only recently been eliminated by HA Lorentz by assuming a ether at rest.

2. The Doppler principle is of general kinematic importance in its nature, but must still be taken into account when considering the question of moving or resting aether.

3. Fizeau 's experiment and its repetition by Michelson and Morley . A ray of light passing through flowing water in the direction of movement experiences an acceleration of the passage in proportion 1 + v (1 − (1 / n^2)) , where v denotes the speed, n denotes the refractive index of the water. This result finds its complete explanation in the assumption of resting aether.

B) Experiments with negative results.

1. Arago's experiment as to whether the movement of the earth influences the refraction of the light coming from the fixed stars.

2. Ketteler’s interference experiment. The two beams of an interferential refractor are sent through two tubes filled with water and inclined towards each other in such a way that one beam hits one tube after the first reflection (on one glass plate), the other beam hits the second tube after the second reflection (on the other glass plate), i.e. runs in the opposite direction. Although both tubes are carried along by the earth's movement, there is no change in the interference fringes, although one beam is accelerated and the other is delayed.

3. Klinkerfues' experiment to determine whether the absorption line of sodium vapor was influenced by the movement of the earth.

B) Experiments with negative results.

10. The Michelson and Morley experiment . If the aether is at rest, the time it takes for a ray of light to travel back and forth between two plates of glass must change as the plates move. The change depends on the size v^2 A^2 but should be observable when interference is used.

The negative result is incompatible with the assumption of resting aether. This assumption can only be maintained by the hypothesis that the length dimensions of solid bodies are changed in the same proportion by the movement through the resting ether in order to compensate for the lengthening of the path of the light ray.

The assumption of moving aether would give rise to the possibility that the aether is carried along by the movement of the earth and rests relative to it. This would explain all negative test results. But then the explanation of the aberration would remain.

ART. XXXVI.—*On the Relative Motion of the Earth and the Luminiferous Ether*; by ALBERT A. MICHELSON and EDWARD W. MORLEY.*

THE discovery of the aberration of light was soon followed by an explanation according to the emission theory. The effect was attributed to a simple composition of the velocity of light with the velocity of the earth in its orbit. The difficulties in this apparently sufficient explanation were overlooked until after an explanation on the undulatory theory of light was proposed. This new explanation was at first almost as simple as the former. But it failed to account for the fact proved by experiment that the aberration was unchanged when observations were made with a telescope filled with water. For if the tangent of the angle of aberration is the ratio of the velocity of the earth to the velocity of light, then, since the latter velocity in water is three-fourths its velocity in a vacuum, the aberration observed with a water telescope should be four-thirds of its true value.†

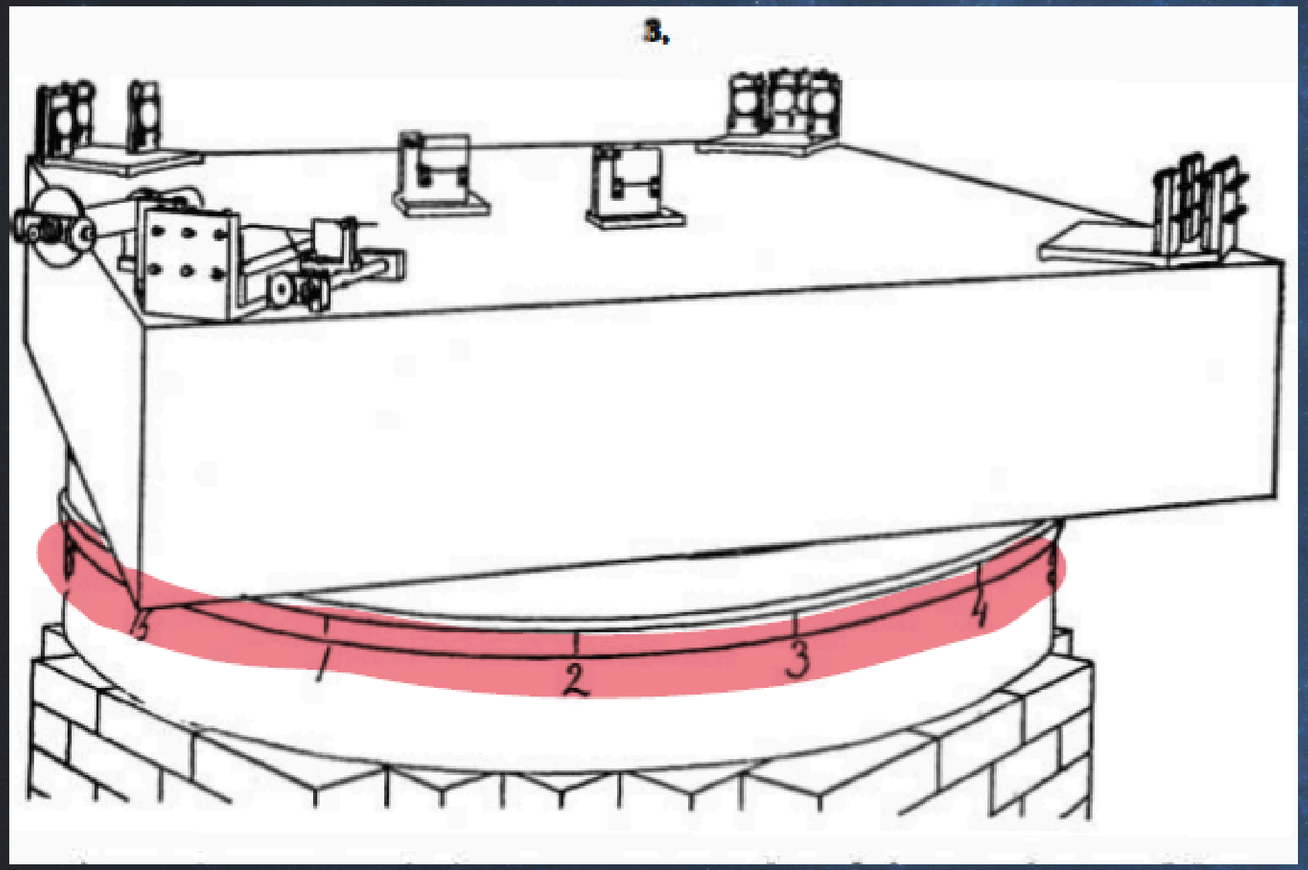
* This research was carried out with the aid of the Bache Fund.

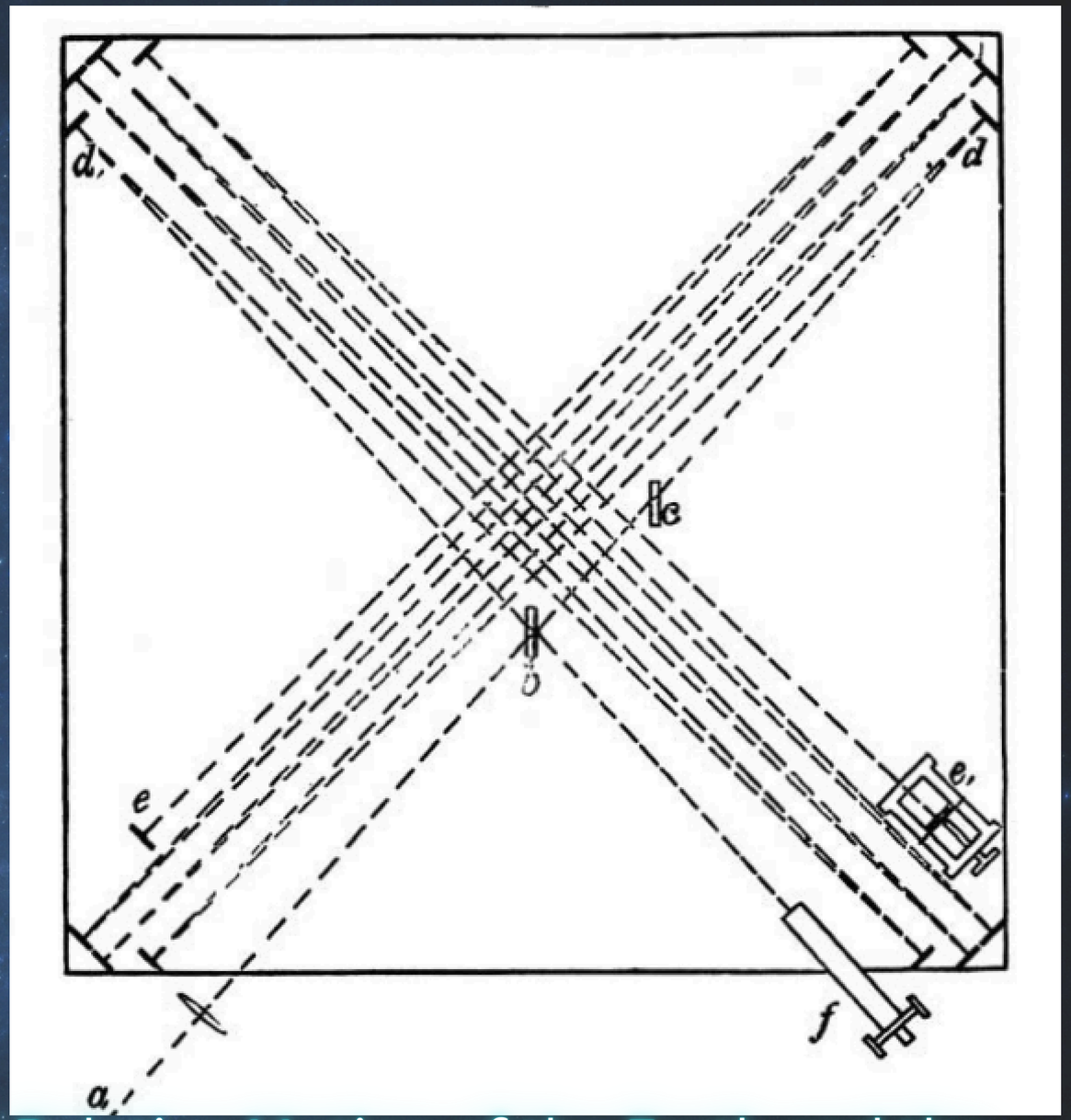
†It may be noticed that most writers admit the sufficiency of the explanation according to the emissiou theory of light; while in fact the difficulty is even greater than according to the undulatory theory. For on the emission theory the velocity of light must be greater in the water telescope, and therefore the angle of aberration should be less; hence, in order to reduce it to its true value, we must make the absurd hypothesis that the motion of the water in the telescope carries the ray of light in the opposite direction!

Let V = velocity of light.
v = velocity of the earth in its orbit.
D = distance ab or ac, fig. 1.
T = time light occupies to pass from a to c.
T' = time light occupies to return from c to a, (fig. 2.)

Then $T=\frac{D}{V-v}$, $T'=\frac{D}{V+v}$. The whole time of going and coming is $T+T'=2D\frac{V}{V^2-v^2}$, and the distance traveled in this time is $2D\frac{V^2}{V^2-v^2}=2D\left(1+\frac{v^2}{V^2}\right)$, neglecting terms of the fourth order. The length of the other path is evidently $2D\sqrt{1+\frac{v^2}{V^2}}$, or to the same degree of accuracy, $2D\left(1+\frac{v^2}{2V^2}\right)$. The difference is therefore $D\frac{v^2}{V^2}$. If now the whole apparatus be turned through 90°, the difference will be in the opposite direction, hence the displacement of the interference fringes should be $2D\frac{v^2}{V^2}$. Considering only the velocity of the earth in its orbit, this would be $2D\times10^{-8}$. If, as was the case in the first experiment, $D=2\times10^8$ waves of yellow light, the displacement to be expected would be 0·04 of the distance between the interference fringes.

A. A. Michelson and E. W. Morley. “On the Relative Motion of the Earth and the Luminiferous Ether.” American Journal of Science s3-34, no. 203 (1887): 333.

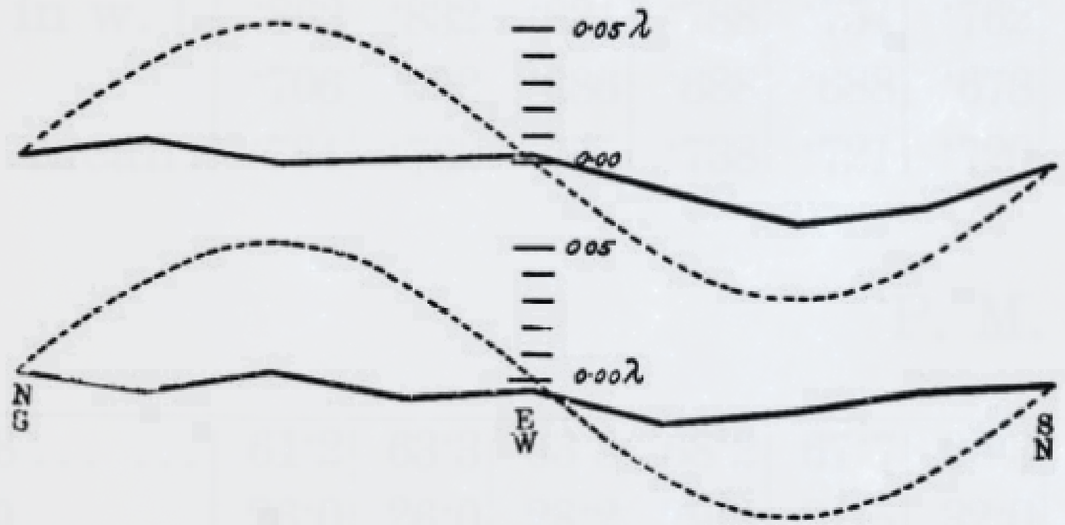




A. A. Michelson and E. W. Morley. “On the Relative Motion of the Earth and the Luminiferous Ether.” American Journal of Science s3-34, no. 203 (1887): 333.

The results of the observations are expressed graphically in fig. 6. The upper is the curve for the observations at noon, and the lower that for the evening observations. The dotted curves represent *one-eighth* of the theoretical displacements. It seems fair to conclude from the figure that if there is any displacement due to the relative motion of the earth and the luminiferous ether, this cannot be much greater than 0·01 of the distance between the fringes.

6.



displacement should be $2D\frac{v^2}{V^2}=2D\times10^{-8}$. The distance D was about eleven meters, or 2×10^7 wave-lengths of yellow light; hence the displacement to be expected was 0·4 fringe. The actual displacement was certainly less than the twentieth part of this, and probably less than the fortieth part. But since the displacement is proportional to the square of the velocity, the relative velocity of the earth and the ether is probably less than one sixth the earth's orbital velocity, and certainly less than one-fourth.

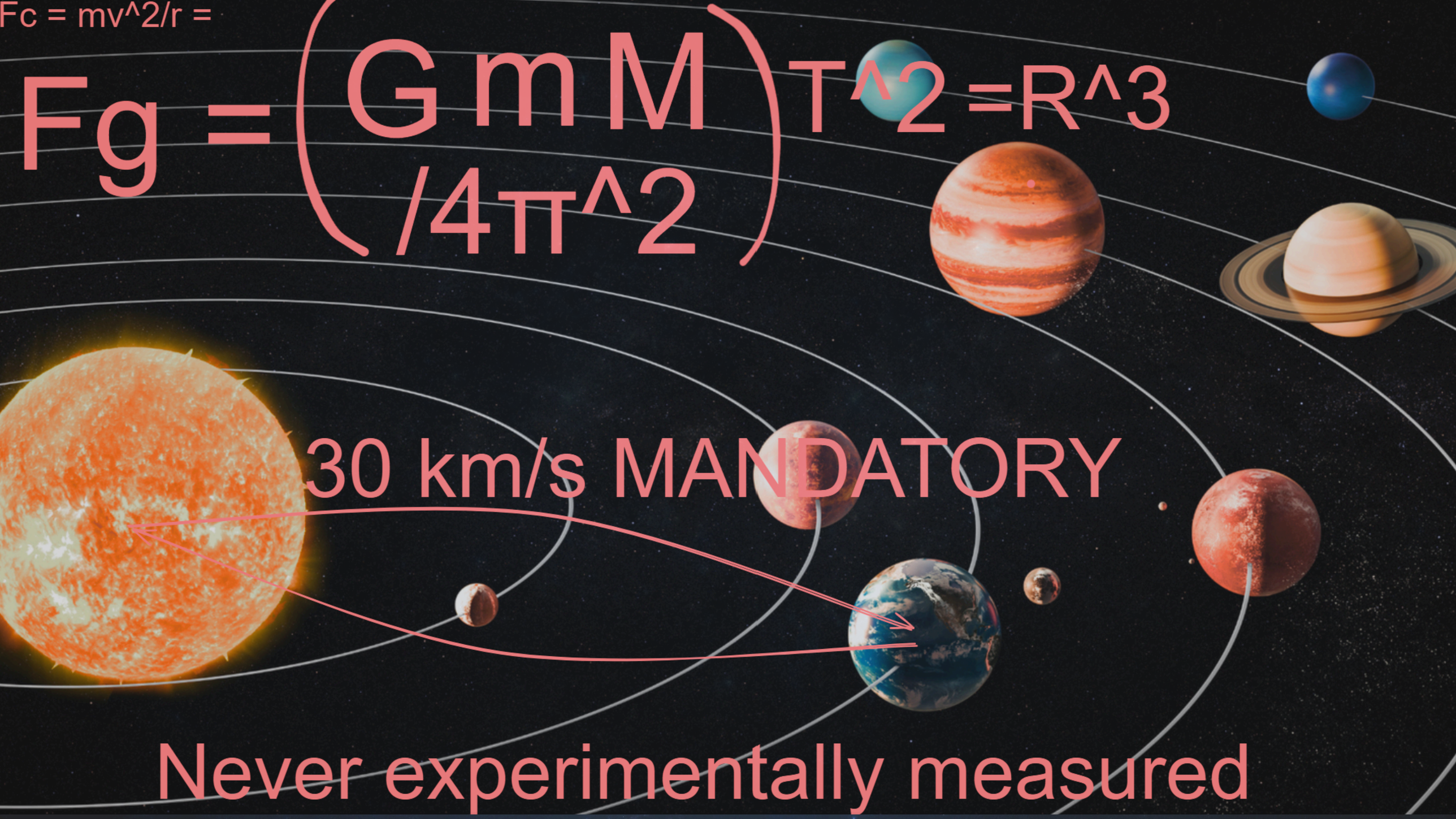
In what precedes, only the orbital motion of the earth is considered. If this is combined with the motion of the solar system, concerning which but little is known with certainty, the result would have to be modified; and it is just possible that the resultant velocity at the time of the observations was small though the chances are much against it. The experiment will therefore be repeated at intervals of three months, and thus all uncertainty will be avoided.

It appears, from all that precedes, reasonably certain that if there be any relative motion between the earth and the luminiferous ether, it must be small; quite small enough entirely to refute Fresnel's explanation of aberration. Stokes has given a theory of aberration which assumes the ether at the earth's surface to be at rest with regard to the latter, and only requires in addition that the relative velocity have a potential; but Lorentz shows that these conditions are incompatible. Lorentz then proposes a modification which combines some ideas of Stokes and Fresnel, and assumes the existence of a potential, together with Fresnel's coefficient. If now it were legitimate to conclude from the present work that the ether is at rest with regard to the earth's surface, according to Lorentz there could not be a velocity potential, and his own theory also fails.

A. A. Michelson and E. W. Morley. “On the Relative Motion of the Earth and the Luminiferous Ether.” American Journal of Science s3-34, no. 203 (1887): 333.

Fc = mv^2/r =

$$Fg = \left(\frac{G\,m\,M}{/4\pi^{\wedge}2}\right) T^{\wedge}2 = R^{\wedge}3$$



Examples of this sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the "light medium," suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.[1] We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a "luminiferous ether" will prove to be superfluous inasmuch as the view here to be developed will not require an "absolutely stationary space" provided with special properties, nor assign a velocity-vector to a point of the empty space in which electromagnetic processes take place.

Einstein, Albert. "On the Electrodynamics of Moving Bodies," 1905.

From this there ensues the following peculiar consequence. If at the points A and B of K there are stationary clocks which, viewed in the stationary system, are synchronous; and if the clock at A is moved with the velocity v along the line AB to B, then on its arrival at B the two clocks no longer synchronize, but the clock moved from A to B lags behind the other which has remained at B by $\frac{1}{2}tv^2/c^2$ (up to magnitudes of fourth and higher order), t being the time occupied in the journey from A to B.

It is at once apparent that this result still holds good if the clock moves from A to B in any polygonal line, and also when the points A and B coincide.

If we assume that the result proved for a polygonal line is also valid for a continuously curved line, we arrive at this result: If one of two synchronous clocks at A is moved in a closed curve with constant velocity until it returns to A, the journey lasting t seconds, then by the clock which has remained at rest the travelled clock on its arrival at A will be $\frac{1}{2}tv^2/c^2$ second slow. Thence we conclude that a balance-clock[7] at the equator must go more slowly, by a very small amount, than a precisely similar clock situated at one of the poles under otherwise identical conditions.

Einstein, Albert. “On the Electrodynamics of Moving Bodies,” 1905.

γ

30 km/s

$$\Delta t = 2vl/c\lambda$$

$$\Delta t = 4\Omega A/c\lambda$$

MMX

Sagnac

v/c

Relativity: How do we know if it’s true?

The Principle of Relativity of Simultaneity: As a consequence of the intertwining of space and time in relativity, two spatially separated events cannot be universally synchronized to a single timeline. The perception of the order of events depends on the observer's frame of reference

First Postulate) Any frame where Newton’s Laws hold true, the same is true for Relativity Theory

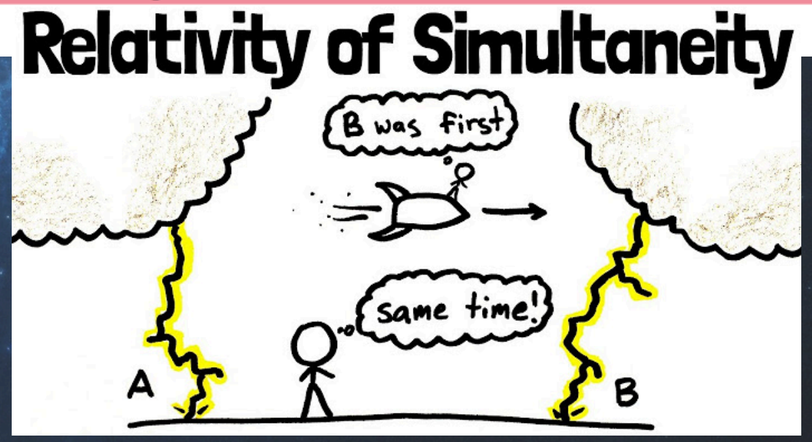
Second Postulate) The velocity of light is constant in a vacuum and propagates independently of the motion of the source emitter or inertial observer.

Experimental Test of Relativity's Core Principle

Global simultaneity vs. the relativity of simultaneity.

In any debate about the speed of light, the problem of simultaneity is always a focus. Special Relativity claims the relativity of simultaneity which states that two events occurring at two different places which are viewed as simultaneous for an observer in a system, usually will not be simultaneous if viewed for an observer in another system. But contrary to this, simultaneity is the key to GPS operations. GPS is a Timing – Ranging system: it does not directly measure the distance between two places where two events, i.e. signals transmitting and receiving, occur. It measures the difference of the two instants when these two events happen and then, the distance is calculated using the range measurement equation. GPS, especially its space segment and control segment, makes a huge effort to establish and maintain a GPS system time, or simply, GPS time [4]. In a scope where GPS is applied, roughly a scope with diameter of 50,000 km or bigger, if one is using GPS, one is using GPS time and therefore the concept of simultaneity of GPS: two events happened at two different places, (x_1, y_1, z_1, t_1) and (x_2, y_2, z_2, t_2), are simultaneous if $t_1 = t_2$. This is true no matter who the observer (receiver) is, where the receiver is, what its status is, or what its speed is. This is the basic operational principle of GPS. We can call it Global Simultaneity.

In the books about Special Relativity, the most commonly cited example about the relativity of simultaneity is the example about the railway platform and the moving train [5]. It says that two events (e.g., the two strokes of lightning A and B) which are simultaneous with reference to the platform are not simultaneous with respect to the moving train and vice versa. But now GPS receivers have been utilized extensively on railway platforms and moving trains, and lightning at two different places, A and B, conceptually is the same as the emissions of GPS signals from two satellites or two DGPS stations. In fact, if two signals are emitted from two satellites or two DGPS stations at the same GPS time, both the GPS receiver on the railway platform and the GPS receiver in the moving train would acknowledge the two events, the emissions of the signals, to be simultaneous. Without this basic acknowledgement, the GPS receivers can not function at all.



Missing Relativity Terms?

Oversimplifications such as in [4], which disseminated the mistaken notion that GPS time is calculated "in the ECI," ignoring the earth's rotation, misled Steven Deines, in his paper entitled, "Uncompensated relativity effects for a ground-based GPS receiver."[5] Deines argued that

> The current ...GPS relativity corrections were based on an Earth centered inertial reference frame. The derivation assumed [that] the receiver obtains inertial GPS coordinate

Eq. (17) "is just what one would expect by a Lorentz transformation from the center of rotation to the instantaneous rest frame of the accelerated origin" ([6], p. 23). Except for the leading γ factor, it is the same as the formula derived in classical physics for the signal travel time from the GPS satellite to the ground station. As we have shown, introducing the γ factor makes a change of only 2 or 3 millimeters to the classical result. In short, there are no "missing relativity terms." They cancel out.

CARROLL ALLEY (UNIVERSITY OF MARYLAND):

following. And that if one perhaps does the explicit recognition of the special relativistic effects – I mean, it took a long time to get general relativity down properly, but I think that is more or less correct now. But it's the absence of any explicit acknowledgment of special relativistic effects due to the speed of light being the same whenever measured by an observer, leading to the relativity of simultaneity and the associated Lorentz transformation physics – there's nothing of that at all modeled in the current system, and I think it should be. Thank you.

Fliegel, Henry F., and Raymond S. DiEsposti. "GPS and Relativity: An Engineering Overview," 189–200, 1996.

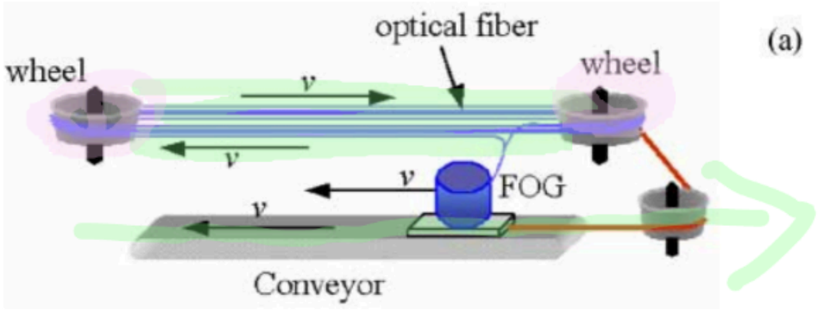
GPS Time Directly Refutes Relativity of Simultaneity

The second-order Relativistic effects of time dilation and length contraction cannot be physically manifested if time and space are absolute.

Time and space are shown to be absolute; there’s no justification to use a Lorentz Transformation as a replacement for what has to be acknowledged as a first-order measurement of velocity in v/c regarding all interferometry experiments

Generalized Sagnac Effect

To study the relationship between the motion of the fiber and the fiber orientation, we conducted an experiment in which the fiber zigzags and has an angle θ with respect to the direction of fiber motion. Thus, for a fiber segment having an actual length of Δl, its effective length is $\Delta l \cos\theta$, which is a projection of the fiber onto the motion direction. As shown in Fig. 2, our experiment demonstrates that the effective length contributes the phase difference, not the actual length; therefore, the phase difference $\Delta\phi$ is not $4\pi v \Delta l/c\lambda$, but



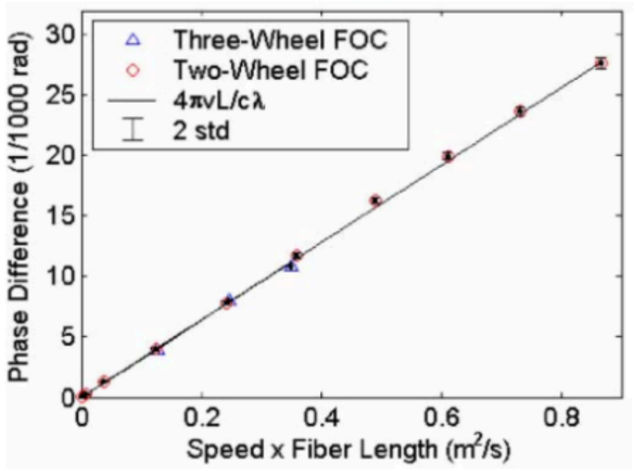
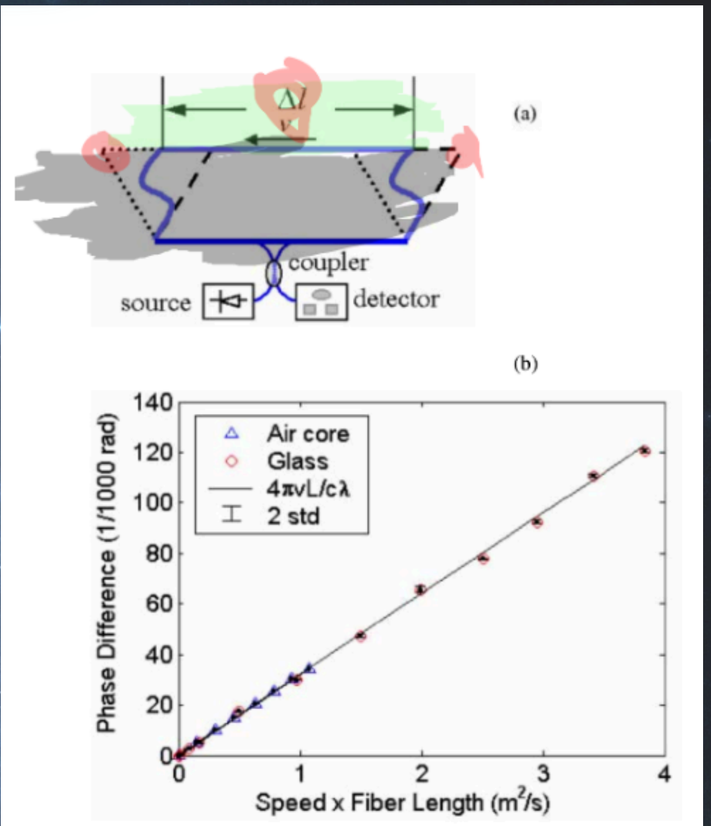


FIG. 1 Experiment for detecting the phase difference of two counterpropagating light beams in a moving fiber loop. (a) Experimental setup. The fiber loop is driven by the conveyor at a velocity v. The conveyor has a length of 1.5 m and can move from 0.001 to 0.25 m/s. The diameters of the wheels are 0.3 m. The FOG consists of a 1310-nm superluminescent light-emitting diode as the light source and a phase difference detector that has an output rate of 1162.6 mV per rad. (b) Phase differences of two counterpropagating beams in a moving air-core fiber.



According to our experiments, we can draw a conclusion about the generalized Sagnac effect that in a moving fiber loop or waveguide, a segment $\Delta \boldsymbol{l}$ with a velocity $\boldsymbol{v}$ contributes $\Delta\phi = 4\pi \boldsymbol{v} \cdot \Delta \boldsymbol{l}/c\lambda$ to the total phase difference between two counterpropagating beams in the loop. The contribution $\Delta\phi$ is independent of the refractive index of the waveguide, and the motion of the segment

Year	Creator	Title
1887	A. A. Michelso...	On the Relative Motion of the Earth and the Luminiferous Ether
1900	Drude	The Theory of Optics
1913	Sagnac	The Existence of the Luminiferous Ether Demonstrated by Means of the Effect of a Relative Ether...
1925	Michelson and ...	The Effect of the Earth's Rotation on the Velocity of Light, II
1925	Michelson and ...	The Effect of the Earth's Rotation on the Velocity of Light, II
1925	Michelson	The Effect of the Earth's Rotation on the Velocity of Light, I
1925	Miller	Ether-Drift Experiments at Mount Wilson
1929	Michelson et al.	Repetition of the Michelson-Morley experiment
1930	Miller	Ether Drift Experiments in 1929 and other Evidences of Solar Motion
1942	A. Dufour	On a Fringe Displacement of Fringes Recorded on a Platform in Uniform Rotation
1979	Brillet and Hall	Improved Laser Test of the Isotropy of Space
1984	Atwood et al.	Neutron Phase Shift in a Rotating Two-Crystal Interferometer
1993	Bilger et al.	Ring Laser for Precision Measurement of Nonreciprocal Phenomena
1993	Hasselbach an...	Sagnac Experiment with Electrons: Observation of the Rotational Phase Shift of Electron Waves i...
1993	Stedman et al.	Canterbury Ring Laser and Tests for Nonreciprocal Phenomena
1998	Allais	The Experiments of Dayton C. Miller (1925-1926) and the Theory of Relativity
2001	Galaev	Etheral Wind in Experience of Millimetric Radiowaves Propagation
2002	Galaev	Measuring Ether-Drift Velocity and Kinematic Ether Viscosity within the Optical Waves Band
2003	Müller et al.	Modern Michelson-Morley Experiment using Cryogenic Optical Resonators
2006	Múnera et al.	Observation During 2004 of Periodic Fringe-Shifts in an Adialeiptometric Stationary Michelson-...
2014	DeMeo	Does a Cosmic Ether Exist? Evidence from Dayton Miller and Others
2020	Bennett	Sagnac (1913) Completed by Dufour & Prunier (1942)