the general science journal

“The Interferometer Experiments Hinge ”

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Key Words: Michelson-Morley experiment, interferometers, Sagnac, Miller, Lorentzian special relativity, Einsteinian special relativity.

Abstract

In spite of the theoretical and empirical research cited in my previous papers (Wells 2023), luminiferous ether, another name for quantum vacuum energy, or QVE, is not accepted among the physics mainstream community. Prior to the late 19th century, this ether was widely accepted by most physicists due to the need for a medium through which light must propagate. This paper explores the details of these interferometer experiments and how they were interpreted. I then provide an interpretation by Lorentz, yielding what I believe to be the best understanding of the results.

Some Interesting Quotes

In 1904 Maxwell wrote:

> "Whenever energy is transmitted from one body to another, there must be a medium, or substance, in which the energy exists after it leaves one body and before it reaches the other" (Maxwell 1904)

In order to gain a better understanding of this concept, physicists began to experiment with interferometers to test hypotheses regarding the nature of the ether. The most famous of these experiments was performed by Michelson and Morley in the basement of a building in the campus of what is now Case Western University in Cleveland, Ohio. The results of this experiment were difficult to interpret. Several similar experiments followed for several years and although they progressively seemed to indicate the presence of ether, the mainstream physics establishment rejected the idea of ether. However, key contributors, such as Einstein later regretted moving in this direction.

In 1919 Einstein wrote to Lorentz:

> "It would have been more correct if I had limited myself, in my earlier publications, to emphasizing only the non-existence of an ether velocity, instead of arguing the total non-existence of the ether, for I can see that with the word ether we say nothing else than that space has to be viewed as a carrier of physical qualities." (Kostro 2000)

A year later, in an address at the University of Leyden, Einstein stated:

> "On the other hand there is a weighty argument to be adduced in favor of the ether hypothesis. To deny the existence of the ether means, in the last analysis, denying all physical properties to empty space. But such a view is inconsistent with the fundamental facts of mechanics." (Einstein 1920)

Had the physicists known what we know now about QVE perhaps results from the interferometer experiments would have been taken much more seriously rather than abandoning the ether theory altogether. Unfortunately, the replacement of ether with the theories of special and general relativity has taken physics from a science, based on physical mechanism causality, to a universe of mathematics with subsequent observations interpreted as to fit the equations and complex computer simulations.

Two Hypotheses

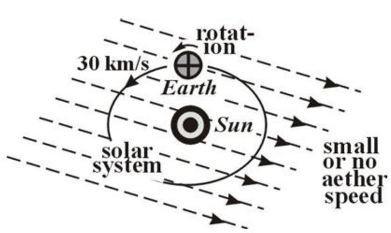

Figure 1. Ether wind (Fiennes 2020)

There were two prevailing hypotheses regarding the nature of the luminiferous ether. One, proposed by Fresnel assumed an "ether wind". For this hypothesis the ether exists in an absolute reference frame through which our solar system moves as illustrated in Figure 1. The other hypothesis, proposed by Stokes and others, treats ether as a medium that is entrained with, or "dragged" by the earth as it moves through its orbit and somewhat fixed to the surface as it rotates about its axis.

The Michelson Interferometer

In the 1880's, Albert Michelson, a physics professor at what is now Case Western Reserve University in Cleveland, Ohio, constructed an interferometer with which he sought to determine what effects a luminiferous ether would have on the measurement of light traveling in different directions through an apparatus on a stationary platform with respect to the earth surface yet moving in space at its orbital speed. Figure 2 (credit link) provides a simplified diagram of the Michelson interferometer. A beam of light emitted from a source is passed through a half-silvered mirror so that two orthogonal beams are formed. One of the two beams passes through the mirror in a straight line and is reflected back from Mirror B and then reflected at a 45 degree angle to a detector. The other beam reflects off the half-silvered mirror, strikes and reflects off Mirror A, where it is reflected back to and passes through the half-silvered mirror and on to the detector. Should the path lengths for both beams be identical, there will be constructive interference on the screen with no shift in the fringes. However, if the path lengths are not the same a shift in the fringe pattern will be observed.

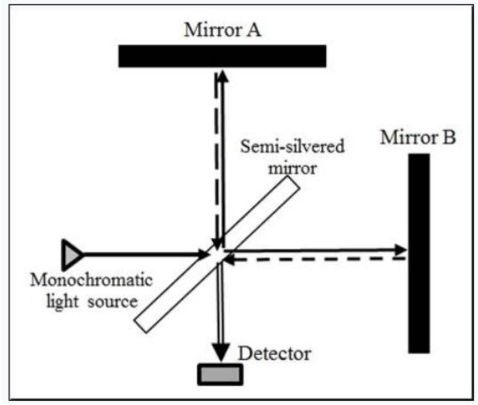

Figure 2. Simplified diagram of the Michelson interferometer.

The Michelson-Morley Experiments

In 1887, Albert Michelson, along with his colleague, Edward Morley, used the interferometer described in the previous section to prove or disprove the existence of the luminiferous ether. A photo of h**is** lab setup is provided in Figure 3. A few years earlier, Michelson attempted the same experiment with a smaller apparatus in Berlin, but accurate measurements were severely limited in accuracy due to city vibrations and small scale.

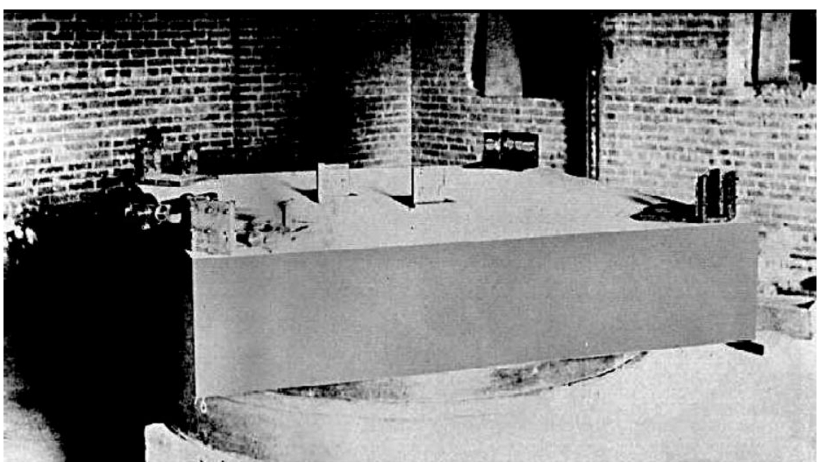

Figure 3 Photograph of the Michelson-Morley interferometer setup (credit Wikipedia).

In order to successfully mitigate the thermal and vibrational effects encountered in Berlin, Michelson directed the interferometer to be installed on a large sand stone block in the basement floor of a multi-floor stone building. The stone block was suspended and floated in a circular trough containing 275 kg of mercury (Fiennes 2020). The instrument was assembled in the closed heavy stone basement of a Case school dormitory. To maximize optical pathlength, both arms were effectively increased by a factor of ten by the utilization of multiple mirrors. Over the course of four days, Michelson and Morley executed over seventy sets of measurements, half at the noon hour and the other half at 6 pm over an hour. The expected values for the combined velocity were determined through knowledge of orbital mechanics. However, the motion of the solar system as a whole was not included. Effective distances for the two paths shown in Figure 9-2 would vary based upon the orientation of the apparatus with respect to the laboratory frame. By direct measurements of the constructive fringe pattern on the detector screen, the earth combined orbital and rotational velocity was computed as:

$$v = c\sqrt{\frac{\Delta x}{L}} \tag{1}$$

Where Δx was the difference between the two light paths, directly proportional to the shift in the fringe pattern due to earth's motion, and L was the nominal difference traversed for both paths.

After performing statistical analysis of all the observational data gathered from all 71 sets it was found the ether velocity was 6.22 km/s, only about 20% of the expected value of 30 km/s. Years later Munera, through the application of modern statistical analysis techniques to the Michelson-Morley data, confirmed the Michelson-Morley results for ether wind speed. He determined the ether velocity, at a 95% confidence level, to be an average of 6.22 km/s with 0.93 km/s standard deviation on the mean for the noon data sets and 6.80 km/s average with a standard deviation of 2.49 km/s for the evening data sets (Munera 1998).

The above results were not expected. They were far from conclusive as to which ether hypothesis is correct. A measured value of 6.22 km/s was too far from 30 km/s to demonstrate the Fresnel hypothesis and not close enough to 0 km/s to agree with the Stokes hypothesis. However, the experiment did not disprove the existence of ether. Michelson considered that, if the experiment would be performed at 3 month intervals over the course of one year, the accuracy would be enhanced. Unfortunately, he never got around to executing what he proposed.

Sagnac Experiments

The 1887 Michelson-Morley interferometer was designed for sensitivity to linear platform motion. In 1912, Georges Sagnac designed his interferometer for rotational sensitivity about an axis normal to the plane (Sagnac 1913). His concept is illustrated in Figure 4 (Experiments in Modern Physics credit link). As with Michelson's interferometer, a beam of light is split into two counter-rotating beams. Should each of these beams travel the same distance, there will be a maximum of constructive interference fringe in the center of the detected fringe pattern. Such a case results when the interferometer is not rotated. However, when rotation is applied, the pathlengths are no longer the same. Sagnac's measured shift in the fringe pattern was what he predicted based on the assumption of an entrained ether (i.e., at rest in the laboratory frame). Motion of the earth and solar system do not have an effect since for each path, they are canceled out by opposite sides of the loop. Consequently, only the controlled angular motion of the apparatus is observed. Such is the main feature of ring laser and fiber optic gyros. Sagnac concluded that what he observed confirms the existence of entrained ether due to a circular ether wind created by the rotational motion of the instrument. Another important conclusion from the Sagnac observations is that the

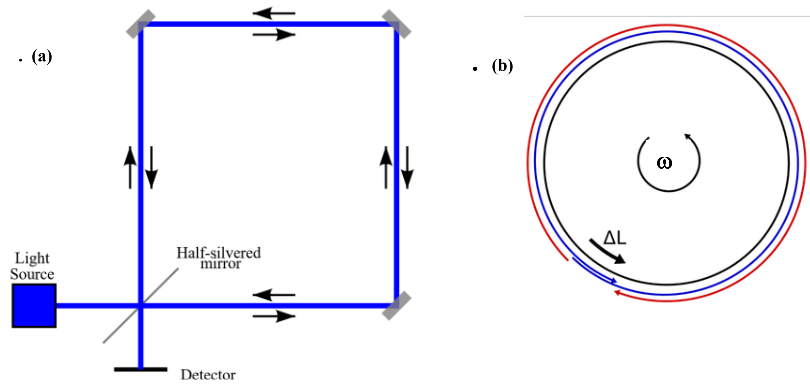

Figure 4 (a) Simplified diagram of Sagnac' interferometer concept showing how the input light is split into a clockwise and a counter-clockwise beam with the interference fringe pattern accumulated at the detector, (b) illustrates how a difference, ΔL, results due to a rotation of the instrument.

speed of light is not the same in all reference frames. An observer on the rotating platform, stationary with respect to the mirrors, light source, and detector sees identical distances for each path yet light travels further along one with respect to the other. Consequently, that light speed was higher for that path. It appears that light speed is additive and there must be an absolute rest frame for the luminiferous ether. Such interpretation was later challenged by Einsteinian relativists and that is discussed later in this paper.

Michelson-Gale Experiments

Sagnac's results inspired Michelson to take a similar approach. In 1925 Michelson and Gale repeated the Sagnac experiment. However, they devised a large interferometer with dimensions, 650m x 360m fixed to the ground. Then, using the Earth's surface as the platform and its rotation as the angular velocity, they performed the experiments. Based on the assumption that the luminiferous ether is essentially stationary in space, a fringe shift of 0.236 was predicted. The measured value of 0.230±0.005 was the result. Once again, the Sagnac interferometer approach reveals compelling evidence for the ether's existence.

Miller Experiments

A very respected and well established physicist, Dayton Miller, took Michelson's work to another level beginning in 1900 through 1933. First of all, he performed many more sets of interferometer measurements: 12,000 compared to the Michelson Morley 36 sets. These were also done at various points in the earth orbit around the sun. By doing so, the orbital velocity effects were all but eliminated, leaving the residual cosmic motion of the solar system through space. Miller's interferometer was also designed to include much longer arms than those of the interferometer used in the Michelson Morley experiment, resulting in a roundtrip optical path length of 64 meters, making it the largest and most sensitive instrument of its kind ever constructed (DeMeo 2014). To minimize ether entrainment, he installed his apparatus high atop Mt. Wilson, in California. It was used in the critical and defining set of ether experiments in 1925-1926. Miller also experimented with the light paths enclosed and filled with various gases. However, with all these improvements, the final cosmic velocity measurement was 8.22±1.39 km/s (DeMeo 2001). Although a positive observation, this was far from a dramatic improvement over the Michelson Morley measurement of 6.22 km/s. He believed this to be due to ether entrainment blocking the observability of the cosmic ether velocity (i.e., earth velocity with respect to an ether at rest). Miller concluded from all the data he collected and analyzed that the luminiferous ether exists and that the theory of special relativity has now been disproved.

However, the physics establishment at that time was already committed to both Einstein's special and general theories of relativity. Much of the rejection was exacerbated by a paper written by a team led by Robert Shankland in 1955 (Shankland et.al. 1955). Prior to Dayton Miller's death he was an avid debater with the most distinguished relativists of his time, including Einstein. His points, based on extensive theoretical and empirical data analysis, were never successfully rebutted. They were only rejected. Before he passed, Miller turned all his research documents over to Shankland, one of his students and head of the physics department at Case Western Reserve University. He asked Shankland, a friend of Einstein, to either analyze the work or burn it. According to scholars, including DeMeo, he led a team and in the process they scanned through the data, rejecting some analyses and magnifying others in such a way that did not do the research justice. The end product of their "analysis" was that Miller was not successful in demonstrating the existence of ether.

Length Contraction

During the years following the 1887 Michelson and Morley experiment leading up to the end of the 19th century, some interesting physics research was performed related to the phenomenon of nonrelativistic length contraction. In 1889 Oliver Heaviside demonstrated from Maxwell's that an object moving at a speed v, imparts a change in electric fields (Brown 2001) . The result is a physical change in the dimension along the direction of motion by the Lorentz factor, γ:

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \tag{2}$$

During that same time, George FitzGerald advanced this hypothesis considering that electrostatic intermolecular forces are the causal mechanism behind the contraction (Brown 2001). From this approach he was able to derive the same expression as in (2) for length contraction. Just five years later, in 1892, Hendrik Lorentz arrived at the same conclusion independently, after much rigorous effort. The conclusion was that

> "There will be a contraction in the direction of motion proportional to the square of the ratio of the velocities of translation and of light, such as to annul the effect of aether drift in the Michelson Morley experiment" – H. Lorentz (Fiennes 2020)

It is often misconstrued that, because there is a ratio of the objects speed related to the speed of light, it must be a relativistic effect. However, it is derived from the physical cause for the contraction, based on empirical observational data (i.e., interferometer experiments), not simply a mathematical expression derived from a thought experiment. To honor both physicists with equal credit, this phenomenon, defined by (2) is called the FitzGerald-Lorentz contraction, which was further confirmed by Joseph Larmor in 1900. He showed that a system made of two electrons in rotation about a common center with respect to each other, and moving through the ether, displayed a predicted deformation in the electric field that would result in the FitzGerald-Lorentz contraction (Larmor 1900).

It would not be until over a century later, in 2002, that Reginal Cahill, a physicist, would thoroughly examine the Michelson-Morley and Miller interferometer data. He discovered that neither applied the FitzGerald-Lorentz contraction into account. Cahill also recognized that although Miller made some attempt to consider the effects related to the index of refraction for air, such was not included in the Michelson-Morley experiment. By applying the FitzGerald-Lorentz contraction as illustrated in Figure 5, he was able to compute the velocities along the light beam paths. In the case of an ether headwind, v, the light speed is c-v on the outward portion and c+v on the return. Without length contraction, this would result in an average speed of c/γ^2. When the length contraction is applied, the apparent average speed is c/γ, a factor of γ greater. On the vertical path, light moves 90° with respect to the ether wind, the average light speed is also c/γ.

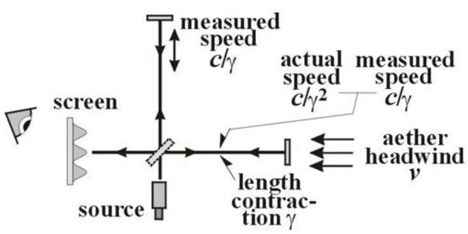

Figure 5 (a) Application of the FitzGerald-Lorentz contraction of the Michelson-Morley interferometer. (Fiennes 2020)

The above discussion related to the application of the FitzGerald-Lorentz contraction would theoretically yield zero fringe shift, i.e., a null result. So, why did the interferometer experiments always resulted in some positive, non-zero value? The answer is that the light beams propagate through air and not a vacuum. Cahill derived the equation below, that relates the measured ether referenced velocity, v_m, to the index of refraction, n, for the medium in which the interferometer is emerged, to the proper velocity value, v:

$$v = \frac{1}{\sqrt{n^2-1}} v_m \quad (3)$$

Since the index of refraction is dependent upon air density, which depends on altitude, the cosmic velocity measurement from the Michelson-Morley experiment at Cleveland, Ohio, is understandably less than Miller's result on top of Mt. Wilson. When Cahill applied the necessary calibrations to the Michelson's, Miller's, and other similar experiments, he found they were all in fair agreement with respect to the cosmic ether speed as shown in Figure 6 (Cahill & Kitto 2002). It is further of interest that experiment sets 1 through 4 were not corrected for 30

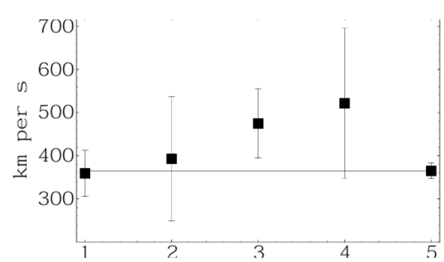

Figure 6 Ether speed measurements from various experiments. (1) Michelson-Morley noon observations, (2) Michelson-Morley 18 hr, (3) Miller experiments on Mt. Wilson, (4) Illingworth's results, and (5) COBE satellite observations of the CMB dipole. (Cahill & Kitto 2002).

km/sec due to earth orbital speed. When this is done, the match with the NASA COBE experiment is impressive, falling within measurement uncertainties. Here we have empirical evidence for the nature of the luminiferous ether.

Key Interpretations

Early results of related to Michelson interferometer experiments, such as that of Michelson-Morley in Cleveland in 1887, yielded ether wind velocities about 1/6th that of the expected value. Such an outcome led to a premature erosion in the establishment of ether theory. However, several experiments followed that increasingly contributed to compelling evidence that not only supports the existence of ether but that it also resides within an absolute stationary frame. Lorentz provided an explanation for the contraction in the pathlength that was making it appear as if there was not sufficient fringe shift, and therefore, ether velocity in the measurements. He believed that there was just enough ether force (I believe to be Van der Waals force from the virtual particle pairs) in the direction of motion on the molecular structure of the instrument to cause the contraction and that the force would only need to cause a shortening on the order of 1 nanometer per meter, a plausible ratio by anyone's standards (Lorentz 1927). Experiments such as the Casimir effect support this (Casimir 1948).

Einsteinian relativists, however, along with the mainstream physics establishment, have not conceded to the ether-existent interpretation. Although they admit not to have an explanation for the physical cause, their claim is that what is observed in the interferometer (both the Michelson and Sagnac types) is predictable by Einsteins theories of both special and general relativity. For example, by the application of the Mankowski spacetime approach in general relativity, Langevin was able to derive equations that predicted the same contraction as Lorentz (Langevin date unknown).

My reasoning in all of this is that relativity, used within its allowable constraints, can be a useful mathematical tool in predicting outcomes. But in the final analysis, it is only mathematics, a black box, that lacks any knowledge about what happens inside. However, Lorentzian relativity supports both the physical and mathematical understanding of the ether measurements in the interferometer experiments.

Conclusion

In this paper, key interferometer-based experimental data has been provided with the objective to reveal compelling evidence for ether, what we now call QVE (also known as quantum vacuum, quantum foam, quantum ether, and zero point energy). All of the experiments included here resulted in positive confirmation for the existence of ether. Unfortunately, the mainstream media at that time greatly distorted the news (as they still do) by stating there was no ether motion observed. The truth was that the observed fringe shifts were non-zero yet significantly less than expected. Regardless, with support of follow-on experiments, not only was there resulting evidence that the ether exists, but it is also at rest in an absolute frame, in agreement with Lorentzian but opposed to Einsteinian relativity. During the early 20th century, the intellectual and social culture was on the move away from absolute truth and towards subjectivity. I believe such a culture played a large role in the popular adoption of Einstein's theories of relativity, especially his special theory of relativity, from which is deduced the exclusion of an absolute inertial rest frame. The newspapers at that time portrayed Einstein as the greatest physicist of all time and anyone that disagreed with him was a fool. However, many great physicists at that time and since have questioned and even disagreed with some of his theories. More on this is covered in a follow-on paper that delves into the differences between the two schools of relativity.

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