Project Description

Introduction

Background

In the realm of physics, in the 19th Century, the theory of the Luminiferous Ether explained the nature of light as a wave in that medium. An experiment performed by Michelson and Morley in 1887 decisively falsified that ether theory. After a few decades, relativity theory, which was a better fit to this experiment and many others, flourished and became dominant in its place.

Michelson-Morley experiments continued to be performed over the decades. Over time, the results of most of these experiments approached the results expected by special relativity. However, as experimenters tried different approaches, certain patterns emerged that were not recognized until later.

One provocative but little recognized pattern was that Michelson-Morley experiments conducted in a vacuum showed no ether velocity and agreed with special relativity, while non-vacuum experiments did show an ether velocity, disagreeing with relativity. All these experiments disagreed with the Ether theory. Experimenters preferred the vacuum because they thought that air might cause disturbances in their observations. Therefore, later experiments were conducted mostly in vacuo. The agreement of the later, vacuum, experiments with relativity was attributed to improved experimental technique.

The focus of the present experimental project is to demonstrate that the agreement of modern Michelson-Morley experiments with relativity does not occur when a vacuum is not used.

Density Hypothesis

For the medium in the light path of the Michelson-Morley interferometer experiment:

1. *Very Low* Mass Density causes no measured ether velocity, *agreeing* with relativity.
2. *High* Mass Density does cause a measured ether velocity, *disagreeing* with relativity.

That is, the medium density is an independent variable in the Michelson-Morley experiment.

Research Gap

There is voluminous experimental support for Statement 1 of the Density Hypothesis. The support for Statement 2 exists but is sparse and disputed. This lack of experimental support for Statement 2 is the research gap targeted by this project's experiment.

Disagreement Among Past Experiments

The physics community does not consider the medium density as being an independent variable in the Michelson-Morley experiment. It therefore believes that Michelson-Morley experiments should all agree with or all disagree with relativity, without respect to medium density. Any discrepant experiment must somehow be wrong, even if a cause cannot be identified. An experiment by Dayton Miller was discrepant as described and was disregarded.

The Density Hypothesis is consistent with *all* Michelson-Morley experiments, including Dayton Miller's, as will be shown in the Literature Review. However, the Density Hypothesis implies special relativity does not apply universally, as assumed by the physics community.

Broad Impact on Physical Theory

Special relativity provides our fundamental view of space and time. If the Density Hypothesis is experimentally verified by new observations of an ether velocity, this will contradict the universality of special relativity. And since relativity is at the core of our understanding of nature, the contradiction upsets our fundamental understanding of space, time and nature.

There is voluminous experimental support for relativity theory, so it is inappropriate to simply characterize relativity theory as being wrong. But neither can relativity be considered universally correct if ether velocities are observed and the Density Hypothesis is supported by experiment.

Literature Review

The Michelson-Morley Experiment [MM]

A Michelson Interferometer splits a beam of light and projects it along two paths. Typically, one path is a reference and the other contains some material under test. It then recombines the light which may form interference patterns.

The Michelson-Morley interferometer is a Michelson interferometer that is adapted to measuring differences in the speed of light in two perpendicular directions, assumed to result from a purported moving ether. This interferometer has two perpendicular light paths in a horizontal plane. The medium in the light paths may be vacuum, air, or any other material transparent to light.

The apparatus is rotated around a vertical axis. The effect of this is to make first one arm then the other parallel then perpendicular to the ether velocity. The velocity of the purported medium within the plane of rotation can be deduced from changes in the interference pattern during a rotation. The patterns over a day, as the Earth rotates the interferometer axis about its own axis, give a three dimensional velocity. ????

Experiments Inconsistent With Relativity

Four Michelson-Morley experiments with high mass density are briefly described. Their results are inconsistent with relativity and satisfy Statement 2 of the Density Hypothesis,.

Dayton Miller’s Experiment

The Michelson-Morley experiment of Dayton C. Miller (1933) [DM] stands out because it comprises over 100,000 readings of interferometer phase shifts, enough to develop meaningful statistics. The experimental apparatus and procedures are also very well documented.

Miller observed velocities of the assumed ether up to 10 km/s, three times his calculated error. Miller collected data at four times of the year, which he called epochs. Miller found systematic variations in hourly velocity observations within each epoch. Miller showed that these patterns are consistent with an ether velocity at a fixed direction in celestial coordinates. It is difficult to attribute these patterns to any terrestrial cause.

The observed velocities are inconsistent with special relativity, which predicts zero velocity for this experiment. Since the medium in the light path of Miller’s experiment was air and the results disagreed with relativity, this experiment satisfies Statement 2 of the Density Hypothesis.

Three critiques of Miller’s experiment follow.

Shankland's Analysis

The most famous critique of Miller was by Shankland, et al (1955) [RS]. The body of the report admitted that a correlation between the observations and the thermal conditions could not be established. Nevertheless, contradicting the body of the article, the conclusion attributed Miller's systematic results to these unestablished temperature effects. This contradiction speaks for itself.

Britannica

The consensus of the physics community regarding Dayton Miller's experiment is characterized by Britannica as follows.

> "It has been set aside and virtually forgotten … because … other tests of relativity theory supported it in so many different ways as to lead to the consensus that one discrepant set of observations cannot be allowed to weigh against the theory." [Brit]

Allais' Analysis

Nobelist Maurice Allais showed [MA] that there was a structure in Dayton Miller's ether velocity observations. Allais' analysis appeared in 2003, long after the consensus characterized by the Britannica had been reached.

The Figure 1 (after Allais) shows Miller's observations as dots in the 2D frame of the interferometer. Each dot is the average of the velocity in one sidereal hour. The 24 dots in each of four epochs are joined by a thin line.

An ellipse is fitted to the data for each of the four epochs. The correlations between the observed data and the fitted ellipses is shown in the plot as r. The mean of the four correlations is r=0.885. The nominal date of the multi-day epochs is also shown.

These very strong correlations were not calculated by Miller or anyone else for 70 years. These statistics and others, all calculated by Allais, are the strongest support for the validity of Miller's data.

If special relativity held, the observed velocities would be distributed near the origin based on experimental error.

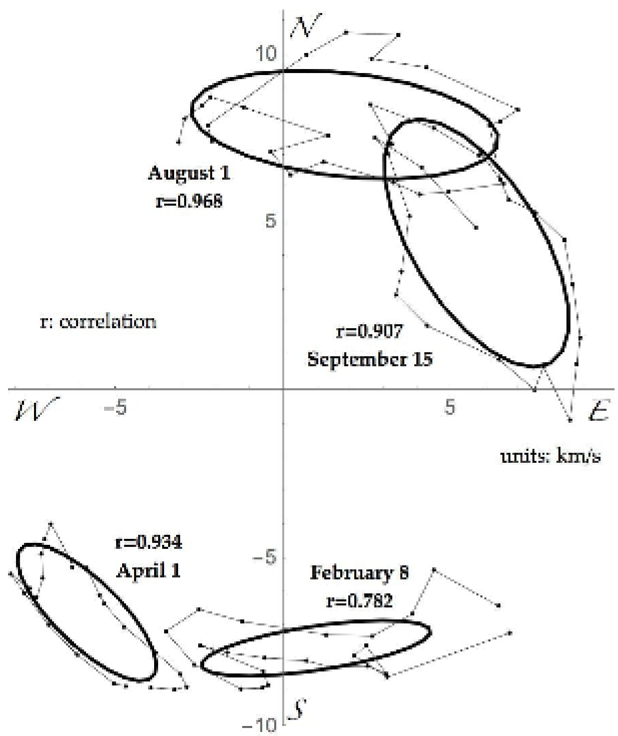

Figure 1. Miller's Ether Velocity Observations

Michelson and Morley's Experiment

The original experiment by Michelson and Morley was performed in 1887 [M&M]. Since at that time the ether theory was dominant, this experiment, which falsified the ether theory, was a shock to all. The results also contradict special relativity, not then conceived, and the medium of the experiment was air. Therefore, this experiment satisfies Statement 2 of the hypothesis. However, the small amount of data taken and the experimental error were such that the contradiction of relativity did not carry much weight.

Shamir and Fox's Experiment

A Michelson-Morley experiment by Shamir and Fox [S&F] used plexiglass as the medium in the light path. This was intended to test the hypothesis that a large optical density in the light path would give results consistent with the ether theory. The reported results falsified the ether theory, but the results were not zero. In fact, the reported upper bound on the result was the largest of any Michelson-Morley experiment save Miller's. So this high mass density light path experiment denied special relativity and satisfies Statement 2 of the hypothesis.

Kennedy's Experiment

A Michelson-Morley experiment by Kennedy [RK] used helium in the light path and yielded a non-zero result. This also satisfies Statement 2 of the hypothesis.

Experiments Consistent With Relativity

Many low mass density Michelson-Morley experiments have been done. They all agree with special relativity, satisfying Statement 1 of the Density Hypothesis. Two notable ones follow.

Joos' Experiment

Georg Joos' light path was enclosed by a vacuum chamber, whereas Miller's was open to air. Joos' results [GJ] were close to special relativity with an upper limit to the ether velocity of 1.5 km/s (vs. Earth's orbital velocity of 30 km/s.) This vacuum light path experiment supports special relativity, within experimental error, and satisfies Statement 1 of the Density Hypothesis.

Herrmann's Experiment

Hermann, et al. [SH] performed a Michelson-Morley experiment with a vacuum light path in very close agreement with relativity. It therefore satisfies Statement 1 of the Density Hypothesis.

Experimental

Proposed Experiment

In order to satisfy Statement 2 of the hypothesis, and thus address the research gap, the proposed experiment will be a Michelson-Morley experiment with the light path formed by optical fiber. The optical fiber inherently has the required high mass density. The optical fiber also does not require the accurate alignment of mirrors, nor the rigidity, nor weight of the traditional Michelson-Morley experiment. This is less onerous for the experimenter and less costly than the traditional approach based upon mirrors.

Prediction: the results will be of the same form as Miller's experiment but the magnitude of observed velocities will be larger. The larger predicted magnitude is due to the larger mass density of the optical fiber, versus air used by Miller.

Follow-on Experiment

A follow-on experiment has been identified. This will consist of a traditional, mirror based, Michelson-Morley experiment that is encased in a vacuum/pressure chamber. This will enable setting air pressure ranging from near zero to two or more atmospheres with corresponding mass densities.

The rationale for conducting this as a follow-on, rather than the primary experiment is that the apparatus is more expensive and requires repeated, fine adjustment by the experimenter.

Prediction: consistent with the Density Hypothesis, that when the experiment operates at low air pressure and thus low mass density, the results will be consistent with relativity; operated at high air pressure and thus higher mass density, the results will be inconsistent with relativity.

This allows the single experimental variable of mass density to be continuously varied while employing the *identical* location, environment, apparatus, instrumentation, data collection software, and data collection procedures. This will be a strong confirmation of both statements of the Density Hypothesis.

Both experiments are expected to yield results inconsistent with relativity. The follow-on experiment will be more difficult to refute than the primary experiment.

Equipment to be used

Overview

The body of the interferometer consists of two perpendicular tubular arms that contain the optical fiber that define the light path. The motor that rotates the interferometer about a vertical axis will be mounted on a fixed overhead support. The shaft of the motor will be extended to connect to the top of the interferometer body. Slip rings will transfer electrical power to the rotating body.

While this arrangement will be mechanically noisier than traditionally used, computational filtering will separate lower frequency signals from higher frequency noise.

Commercial Off-The-Shelf products will be used for all physical components. Software will be custom based on commercial and open-source software tools.

Fiber Optic Sensors

The sensors are two identical lengths of optical fiber, called arms. The arms are perpendicular to each other and set in a horizontal plane. According to the ether theory, light passing through an arm is slowed down if the supposed ether is moving past the arm. By that theory, for a given ether velocity, the light is slowed twice as much if the ether flows parallel to the arm than if ether flows perpendicular to the arm.

Fiber Optic Interferometer

Coherent light originates in a distributed feedback solid state laser. It is coupled to the two arms, which are terminated by Faraday Reflectors. The recombined light goes to a high speed photoelectric detector.

The coupling to one of the arms goes through a piezoelectric fiber stretcher, which enables alteration of the length of one arm. This enables hundreds of wavelengths to be detected where, without this component, only less than half of one wavelength could be unambiguously detected. This large range of wavelengths minimizes manual realignment and increases tolerance of mechanical noise, acoustic noise, and the effects of temperature change.

Mechanical

The tubular body will be constructed from four one-meter lengths of roughly square profile extrusions. One end of each tube will be attached to a hub and the tubes will extend radially, resulting in a cross. The hub will support the fiber optic and electronic components.

Electronic

The electrical output of the photodetectors goes to analog-to-digital (A/D) converters on the data-logging computer.

Temperature sensors will be arranged along the arms and wired to the computer. (Critics claimed that Dayton Miller misinterpreted temperature effects as valid velocities.)

The data-logging computer will be a Beaglebone Black. A real-time clock will be used for data-logging. An integrated circuit package comprising a magnetometer, a gyroscope, and an accelerometer will determine the orientation of the interferometer as it rotates. The computer will connect via a WiFi client and server to the Internet.

Software

The data-logging computer will be programmed in Python to collect the interferometer readings, temperature and other environmental data, and time. This raw data will be encoded, formatted and transmitted directly, via WiFi and the Internet, to a public data repository. The software also controls the fiber stretcher to extend interferometer readings to hundreds of wavelengths.

The local computer, an iMac, will be used to debug and monitor the collection process. It will set parameters, such as sensor polling frequency. It will also provide a real-time picture of recent observations.

A public website will be maintained with links to the collected data and to the data collection software versions. Statistical analysis software will be run against the data and those results will also be available on the site, as well as the statistical software itself.

The data-logging computer will receive commands from the local computer via a public website. Commands from the local computer will be logged. Also responses and other status data from the data-logging computer will be logged.

Dual Interferometer Configuration

There is a great advantage to observing with two interferometers versus a single interferometer. If a data pattern is observed by only one interferometer, it can be interpreted as noise local to that interferometer. However, if observed in both interferometers at an appropriate time delay, it can be interpreted as signal. This strategy is used in LIGO.

Methodology to be used

The experiment is observational, not a controlled experiment. The observed quantity is a time-sequence of samples of phase offsets of a rotating interferometer. The experiment does not affect these phase offsets. It samples the instantaneous phase offset, a timestamp, and the condition of the interferometer at that time. This raw data is sent immediately to a public repository to minimize the opportunity for data tampering and to enable independent analysis.

Controls on the instrument include the rotation rate of the interferometer and various sample rates, such as for temperature. This does not affect the character of the data.

Data will be collected at one sample/second continuously, 24 hours/day, for years.

A mathematical model will begin with two parameters, (1) the speed of the medium tangent to Earth's orbit, and (2) the magnitude and direction in galactic coordinates of the apex of a constant medium velocity. Miller derived values for both of these features from his data.

For each raw data point, the corresponding model value will be calculated and the differences taken and summed. A least squares fit algorithm will find the best fit for the model parameters.

The residuals will be examined and the model extended. Miller described a feature that he named Displaced Meridians. Allais found a simple way to treat this feature and it will be added to the above model.

Since variations from day to day are expected to be minimal, auto-correlations with time offset of one sidereal day will be calculated.

For dual interferometers, cross-correlations will be calculated to distinguish instrumentation and local noise from patterns in the velocity of the medium.