

# New Direct Test Proposed for Einstein's Velocity Addition Formula

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When the group velocity, as opposed to the phase velocity of light is measured, Einstein's predictions for one-way light velocities in a transparent medium differ from Fresnel's predictions by substantial amounts even at speeds as low as our speed relative to the Cosmic Microwave Background Radiation (365,000 m/s). Calculations show that if Einstein is wrong, then a measurable light round-trip time difference will be found between clockwise and counterclockwise fiber optic light paths, where each light path has synthetic fused silica fiber in one direction and air-core fiber in the other direction. The magnitude of the difference will be a function of velocity of the experiment and observer (both the same) relative to a presently unknown preferred reference frame (i.e. a frame preferred by physics not by physicists for convenience). If the light round-trip time difference is measured on an oscilloscope and the length of the loops is about 1,000 m, then a speed as low as 365,000 m/s relative to the preferred reference frame can be detected.

## 1. Introduction

There is currently a widespread belief within mainstream science that Special Relativity Theory requires little, if any further testing. Most recent experiments are repeats of prior experiments with an attempt, not always successful, to improve accuracy. Also, most of these experiments are not able to distinguish between the Lorentz-Poincare point of view and the Einstein point of view as to whether separated clocks are actually synchronized or desynchronized when an attempt is made to synchronize them using a light signal (i.e. these experiments are no help in deciding whether or not a preferred reference frame exists where the speed of light is truly isotropic.)

On the other hand, there are a growing number scientists who believe that a more productive approach to advance physics is to assume that the vacuum is not empty and that the gravitational and/or electric fields of all matter in the universe, and their relative motion determines the local preferred reference frame where the speed of light is isotropic along with the magnitude of that speed. There is evidence to support a preferred reference frame theory. Michelson-Morley-Miller type experiments, for example, do not, as is commonly stated, report null results [11, 12]. In fact, they report positive periodic results which are smaller than expected. In 2004, a Michelson-Morley experiment, where rotation of the experiment was accomplished by earth's rotation, was performed in Bogota Colombia [13]. Again, positive periodic results were reported. If a preferred reference frame viewpoint is to gain the upper hand, however, more evidence is required. Experiments which distinguish between the Lorentz-Poincare and Einstein viewpoints must be performed, and our proposed experiment accomplishes this goal.

## 2. Brief Description of Proposed Experiment

Figure 1 depicts the proposed group light speed experiment, where  $v$  is the velocity of the experiment and observer relative to a currently unknown preferred reference frame (PRF). Light pulses from a pulsed laser are split by a fiber optic splitter as

shown below. Half of a split pulse travels clockwise (left-to-right in silica fiber and then right-to-left in air-core fiber) while the other half travels counterclockwise (left-to-right in air-core fiber and then right-to-left in silica fiber). Each half of the pulse is displayed on an oscilloscope when it arrives. Although only one loop is shown, the length of the experiment can be greatly reduced by using multiple loops each with silica followed by air-core fiber.

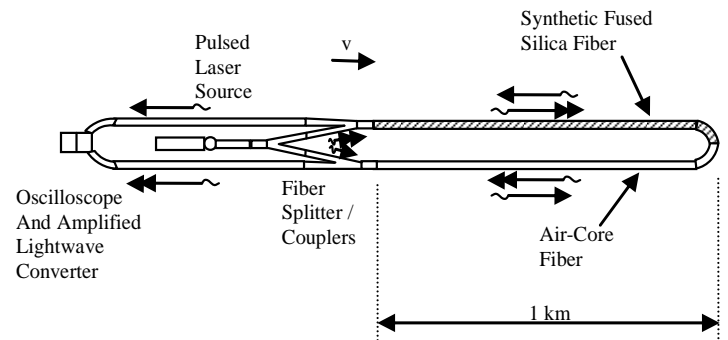


Fig. 1. Proposed group light speed experiment

## 3. Background

In 1818 A. Fresnel published the theory that light is partially dragged by a moving transparent medium through which it travels. Fresnel's formula was confirmed by H. Fizeau in 1851 in an experiment with moving water, shown in Figure 2, and no experiments to date have conclusively proven it wrong.

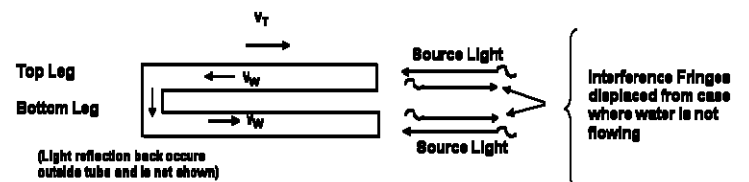


Fig. 2. Fizeau Experiment (where  $v_T$  is the speed of the tube, relative to an unknown preferred reference frame, and  $v_W$  is the speed of the water relative to the tube.)

The verified Fresnel Partial Drag equation is given by [1],

$$c'_m = c_m + \left(1 - \frac{1}{n^2}\right)v \quad (1)$$

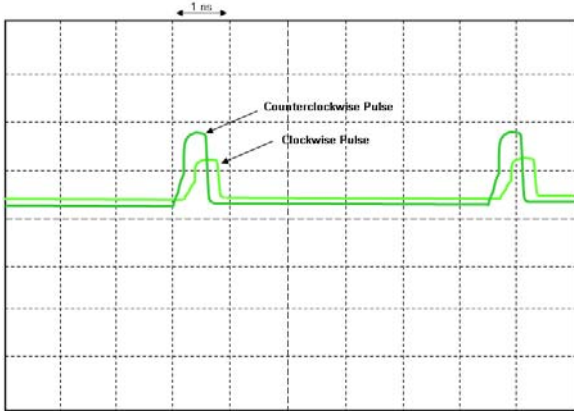
where  $v$  is the speed of a transparent medium relative to the PRF in which the speed of light is assumed isotropic for our region of space,  $n$  is the refractive index of the medium,  $c_m$  is the phase speed of light in that medium relative to the PRF when the medium is stationary in the PRF, and  $c'_m$  is the phase speed of light in that medium relative to the PRF when the medium is moving at speed  $v$  relative to the PRF. The phase speed of light,  $c'_{m-rel}$ , relative to the moving medium is then given by

$$c'_{m-rel} = c_m - \frac{v}{n^2} \quad (2)$$

Since  $c_m$  is equal to  $c/n$ , where  $c$  is the phase speed of light in the PRF vacuum, we have [2]

$$c'_{m-rel} = \frac{c}{n} - \frac{v}{n^2} \quad (3)$$

In addition to the phase velocity of light in a transparent medium there is also a very important 'group velocity' of light, which in general is quite a bit less than the phase velocity. The group velocity is important because it specifies how fast energy, and thus information, is transferred. **It is the group velocity that is measured in 'direct' experiments where the light path and time of travel are measured directly as in the experiment proposed in this paper** (see Figure 3).



**Fig. 3.** Oscilloscope Screen showing expected arrival times of laser pulses travelling at group light speed

The group velocity of light in a transparent medium has been demonstrated to lag behind the phase velocity of light by substantial amounts (e.g. by about 2,960,759 m/s for silica). The lag amounts, which vary by wavelength and change in refractive index with respect to wavelength, have been shown to be consistent with the group speed formula first deduced by Rayleigh in 1871 [3]. In a vacuum, the phase and group velocities are the same. It has been shown that air-core fiber behaves essentially like a vacuum for the speeds considered. The group speed of light,  $c'_{g-rel}$ , relative to the moving medium is derived in a manner similar to that used in deriving Eq. (3) and is given by [4].

$$c'_{g-rel} = \frac{c}{n} - \frac{v}{n^2} - G \quad (4)$$

Note that Eq. (4) is the same as Eq. (3) except that it includes an additional group subtraction term,  $G$ , which is determined, based on wavelength and change in wavelength with respect to refractive index, using empirical tables of refractive index vs. wavelength. Note also that when  $v$  is equal to zero we have the group speed of light in the medium when the medium is stationary in the PRF. Special Relativity Theory (SRT) must assume that the moving observer also measures this same speed when the medium is in motion relative to the PRF, regardless of the medium speed and direction of light. In order for an observer moving along with the medium to measure these unchanging group light speeds and for the stationary observer to measure group light speeds that are consistent with the phase speeds measured in the Fizeau experiment, the SRT velocity addition formula would need to be valid. That is, the velocity of the medium relative to the stationary observer and the velocity of the light relative to the moving medium would not be able to be simply be added. **It is important to understand that the SRT velocity transformation equation is not just the result of a Lorentz contraction and slow running clocks (both of which could be physically caused), but also of the de-synchronization of the moving observer's clocks when he uses a light signal to 'synchronize' them. Without this de-synchronization, the moving observer cannot measure the speed of light through the medium to be the same in either direction.**

In Fresnel's theory, the speed of light is considered to be isotropic in the partially dragged reference frame. The amount of dragging depends upon the refractive index of the transparent medium. Since our proposed experiment contains two different mediums (e.g. Synthetic Fused Silica and Air) we are dealing with two different reference frames in which the speed of light is isotropic. Recall that the original transformation equations as derived by Lorentz were designed to make light speed variations undetectable when moving relative to one preferred reference frame where the light and all measuring instruments were affected by that one reference frame (*i.e.* prior to Einstein's reinterpretation).

## 4. Predictions for Proposed Experiment

Predictions for the proposed experiment are based on the following assumptions;

1. That a PRF exists for our region of space (*i.e.* the local "vacuum") where the speed of light is isotropic at a value of  $c$ .
2. That this reference frame is partially dragged by a moving transparent medium, as described by Fresnel's drag theory, and that the speed of light in the partially dragged frame is isotropic at new value of  $c/n$ , where  $n$  is the refractive index of the medium.
3. That a physical Fitzgerald-Lorentz contraction of the medium occurs in the direction of motion, when the medium moves with respect to the PRF.
4. That the pulse rate of electromagnetic clocks slows down when they move with respect to the PRF, in accordance with the Lorentz transformation equations.

Calculations show that the effects of assumptions 3) and 4) are negligible and may therefore be neglected, specifically for the proposed experiment at values where  $v < 730,000$  m/s. Extensive

analysis and prediction results may be found in “Fresnel Drag vs. Einstein Velocity - a Case for Further Investigation” [4].

When calculations are made for the clockwise and counter-clockwise round-trip time durations, based on the group speed of light as given by Eq. (4), for the experiment depicted in Figure 1 and an assumed experiment and observer common speed of 365,000 m/s with the direction of motion parallel to the length of the experiment, then the time between the arriving pulses, shown in Figure 3, is 0.239 ns. Potentially favorable parallel alignments are as follows:

1. Our direction through the Cosmic Microwave Background Radiation reference frame (right ascension = 168 deg, declination = -7 deg)
2. Our direction through Dayton C. Miller’s Ether reference frame (right ascension = 73.5 deg, declination = -70.55 deg).

If the direction of motion is perpendicular to the length of the experiment, our prediction for the time between arriving pulses is, of course, zero based on symmetry. Please note that when the value of  $c$  in Eq. (4) is negative, for light moving from right to left, the value of  $G$  must also be negative (making it positive in the equation). The absolute magnitude then gives the positive speed used to calculate time duration. Perhaps a simpler way to get the correct positive speed for right to left light travel is to change the sign of  $v/n^2$  and leave the other two terms as they are. Note also in applying equation (4) that for a vacuum,  $G$  equals zero and  $n$  equals one.

In commenting on the Fizeau experiment Einstein says, “In accordance with the principle of relativity we shall certainly have to take for granted that the propagation of light always takes place with the same velocity  $w$  with respect to the liquid, whether the latter is in motion with reference to other bodies or not” [5]. Thus for our proposed experiment and conditions, he must predict identical clockwise and counterclockwise time durations, based on the group speed of light, and the time between the arriving pulses shown in Figure 3 should be 0.0 ns.

Our proposed experiment is a variation of an experiment performed by the Dutch astronomer M. Hoek in 1868 and shown in Figure 4. [6]

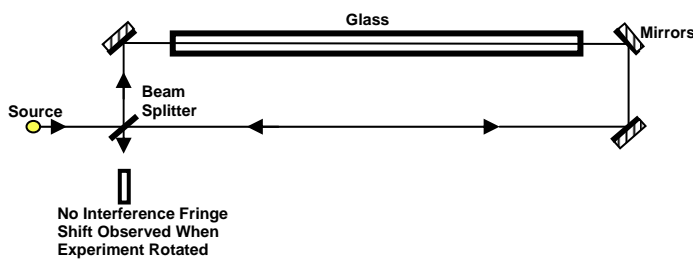


Fig. 4. M. Hoek Experiment

Hoek attempted to measure an interference fringe shift following a rotation of the experiment. Our variation is that we will measure the actual arrival time difference of the light energy and require no rotation. Hoek attempted to measure a change in the difference between clockwise and counterclockwise times based on phase speed. We are attempting to measure the absolute difference in light pulse arrival times based on group speed. The Hoek experiment and similar later experiments using phase speed support both Fresnel and Einstein to the accuracy available

because the predictions for phase speed differ by an extremely tiny amount. But the predictions for group speed differ by substantially more, allowing us to make a direct measurement (See advantages below).

Our proposed experiment **distinguishes** between a Lorentz-Poincare viewpoint and Einstein’s viewpoint on simultaneity.

## 5. Advantages over Related Experiments

The proposed group light speed experiment has the following advantages over related experiments which have been performed to date.

1. For a speed of 365,000 m/s, the Fresnel optical path time difference per length of medium is about;  $6.38 \times 10^{-18}$  s/m for phase speed and  $2.39 \times 10^{-13}$  s/m for group speed!
2. Our group light speed experiment has the sensitivity to distinguish between Fresnel and Einstein predictions (it appears that similar phase light speed experiments by Hoek [6], Trimmer [7], Byl [8], and Aspden [8] did not).
3. The measurement technique is different than the one always used in similar experiments. The actual difference in laser pulse arrival times is measured on an oscilloscope instead of by an interference fringe shift. This technique has been demonstrated as capable of measuring group light speed [9].
4. Since optical fibers guide the light, the experiment should be relatively easy to build, perform, and transport (no difficult mirror alignments).
5. The experiment is not sensitive to a Fitzgerald-Lorentz contraction and environmental changes (e.g. humidity, temperature, pressure, and noise) as are Michelson-Morley type experiments which require time to rotate.

## 6. Feasibility

Recently (2001) Kyle Cochrane and others conducted measurements of optical-fiber transit times to determine the transit time dependence on wavelength [9]. The predicted transit times for group velocity are based on Rayleigh’s formula [3], and demonstrated to be correct. The method is based on measuring the difference in light pulse arrival times between a short and longer optical-fiber of the same material. The device used for this measurement was a Tektronix Model 640A oscilloscope. It appears that they were able to measure differences in transit times to an accuracy of .01 ns. Therefore, our measurement concept, based on group light speed, is feasible.

Air-Core fiber is expensive and is not easy to align and connect with Silica fiber. Analysis shows, however, that the experiment still works if Air-Core fiber is replaced by a solid fiber with refractive index significantly higher than Synthetic Fused Silica fiber since a higher refractive index results in higher Fresnel drag and thereby still provides us with two different dragged reference frames where the speed of light is isotropic at different values. With a difference in core refractive index of 12 %, we would require fiber lengths of 2,500 m, instead of 1000 m, to get the same sensitivity. Another interesting possibility for a fiber with an air core is “Hollow core perfect mirror fiber” recently (1998) developed by MIT’s Yoel Fink [10], but it has been difficult to obtain information on this fiber!

The total length of the experiment can be cut down to any reasonable size to allow it to fit in a given test area. This size reduction can be accomplished by increasing the number of continuous loops with, say, Silica fiber always followed by Air-Core fiber for each loop. Increasing the number of loops, however, also increases the signal attenuation due to more connectors. This may result in too weak an output signal given the candidate oscilloscope sensitivity, pulsed laser power, and performance of the amplified light wave converter. This presents a design challenge to balance component performance and cost against desired sensitivity and assembly difficulty.

Any university with a good optics lab probably already has all major components described for our proposed experiment, except for the fibers, splitters, and connectors. The main tasks to complete the experiment are as follows:

1. Find a university with a good optics lab and people who are interested in the experiment and believe it is worth performing.
2. Obtain funding.
3. Identify and purchase the appropriate optical fibers, splitters, and connectors and assemble the multiple loop portion of the experiment.
4. Test the university equipment, with a known time delay, to assure that it is able to measure the expected time difference.
5. Assemble, test, and perform the experiment.

## 7. Conclusion

As mentioned earlier, in commenting on the Fizeau experiment Einstein says,

"In accordance with the principle of relativity we shall certainly have to take for granted that the propagation of light always takes place with the same velocity  $w$  with respect to the liquid, whether the latter is in motion with reference to other bodies or not" [5].

Therefore, from Einstein's point of view, the velocity of light moving from left-to-right in the synthetic fused silica fiber leg of our proposed experiment must be exactly the same as the velocity of light moving from right-to-left in the same leg. The same holds true for the air-core leg of our experiment.

In our proposed experiment, the silica and air-core transparent mediums take the place of the "liquid" referred to by Einstein, but unlike in the Fizeau experiment we are now moving with the "liquid" relative to an unknown preferred reference frame.

Based on the above, the principle of relativity must predict identical clockwise and counterclockwise round-trip times, and no difference in the arrival times of the related pulses. Therefore, a round-trip time difference between the clockwise and counterclockwise light paths for the experiment shown in Figure 1

would disprove SRT and allow us to restore the concepts of absolute time and separate space. Simultaneous events in one inertial system could once again be considered simultaneous in all inertial systems. Going back to our original concept of space and time does not imply that there is any way to measure one's speed relative to space itself, as in early ether theories, but only relative to other moving fields or bodies. A null result from this experiment would support SRT or mean that, for our actual speed relative to the PRF, the length of the fiber loops and the accuracy of the time difference measuring device are not great enough to produce a measurable result which favors Fresnel drag theory.

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