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## RESEARCH ARTICLE

# A DIRECT ONE-WAY SPEED OF LIGHT TEST FOR AN ETHER IN SPACE

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## ABSTRACT

The concept of a luminiferous, meaning light bearing, ether has been a persistent idea throughout time. Einstein delivered an address in 1920 and revealed some relevant and prescient thoughts. The Special Theory of Relativity is based on two postulates. The second has come to be interpreted that the speed of light is always C in every inertial reference frame. This second postulate is one that was never been based on any empirical evidence. The general acceptance of this assumption has been perpetuated by the difficulty in measuring the one-way speed of light. Many experiments have been proposed to measure the constancy of the one-way speed of light but, so far, all have failed. What is significantly important is that there is now no experimental evidence to fully substantiate Einstein's second postulate by which the one-way speed of light is constant in all inertial reference frames. If there is an ether, the postulate may prove to be invalid. It might be assumed that the null result of the Michelson Morley Experiment has already determined the nonexistence of any ether, but that would be wrong. There is a need for an experiment to determine whether relative motion is always the key to known kinematic phenomena. The purpose of this paper is to suggest a new way to make one-way speed of light tests and to confirm or reject the assumed relativistic idea that all inertial reference frames are equal.

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## INTRODUCTION

The concept of a luminiferous, meaning light bearing, ether has been a persistent idea throughout time. It was postulated to explain the propagation of light waves through space after light was recognized to have a wave nature. Newton (Isaac Newton The Third Book of Opticks) suggested the existence of an either. In recent times, James Clerk Maxwell (James Clerk Maxwell, 1873) stated we have now to show the properties of the electromagnetic medium are identical with those of the luminiferous medium. Paul Dirac (Dirac, 1951) explored the idea of an ether of virtual particles and states that the ether is no longer ruled out by Relativity and that there are now good reasons to postulate an ether. Louis de Broglie[4]stated, "Any particle, ever isolated, has to be imagined as in continuous "energetic contact" with a hidden medium." As a 16-year-old youth, Einstein (Isaacson, 2007) was very interested in the idea of an aether. His initial proposal of a research thesis was to do an experiment to measure how fast the Earth was moving through the aether. Two of the fore fathers of Relativity, Lorentz and Poincare, persisted in the idea on an aether (Henri Poincaré, 1906; Olivier Darrigol, 2005). Most recently, Urban (Marcel Urban, 2013), et all have revisited the idea of a quantum flux of virtual particles as the origin of the speed of light. Einstein[9] delivered an address in 1920 and revealed some relevant and prescient thoughts. He stated that the Fizeau experiment and aberration favored the theory of an ether. Einstein states that for two reference frames that are physically equivalent in all respects and that have relative motion between them, there should not be an asymmetry between them when one frame is stationary in the Lorentzian ether. To accept the idea of an asymmetry is "intolerable," illogical and "unacceptable," but not a single bit of evidence or physical rationale is cited to justify this assumption. Other important statements are the following. "More careful reflection teaches us however, that the Special Theory of Relativity does not compel us to deny ether.""To deny the ether is ultimately to assume that empty space has no physical qualities whatever." Could these qualities be the quantum vacuum? "The ether of the General Theory of Relativity is a medium which is itself devoid of all mechanical and kinematical qualities, but helps to determine mechanical (and electromagnetic) events.""As to the part which the new ether is to play in the physics of the future, we are not yet clear." The Special Theory is based on two postulates. The first is that all of the laws of physics are the same in all inertial reference frames. The second has come to be interpreted that the speed of light is always C in every inertial reference frame. This second postulate is one that was never been based on any empirical evidence.Einstein's position was that evidence did exist for round-trip speeds as C as a universal constant. From that he apparently did no more than to assume that the one-way speed of light is always C. In other words, he accepted this assumption as a convention without any justification. The general acceptance of this assumption has been perpetuated by the difficulty in measuring the one-way speed of light.

As a result of this obstacle, the controversy has still to be resolved. Einstein even claimed that measuring the one-way speed of light might be impossible because two different reference frames and two different clocks would be necessary. Without an impossible, instantaneous signaling technique to synchronize the two clocks, one-way measurements of the speed of light may be unattainable, but this assumes that the source and the receiver are separated by a significant distance. From his days in the patent office, he suggested a way to synchronize two distant clocks, but this technique would then have the two clocks set in such a way that the one-way speed of light between the two would equal the average speed in a two-way measurement. Philosophers such as Reichenbach[10] have also suggested the content of the Special Theory of Relativity may preclude any experiment from ever measuring the constancy of the one-way speed of light. Many experiments have been proposed to measure the constancy of the one-way speed of light but, so far, all have failed[11]. It is still a mystery what explains this continuous series of unsuccessful attempts, except perhaps that it has been consistently assumed that the light source and the detector must necessarily be separated by a significant distance with separate clocks. Upon close examinations, these proposals have been flawed in numerous ways. An experiment that will resolve this controversy will be one that determines the one-way speed of light in a single reference frame that is moving in two different directions at two different times, as will be outlined.

What is significantly important is that there is now no experimental evidence to fully substantiate Einstein's second postulate by which the one-way speed of light is constant in all inertial reference frames. And if this is accepted, then it is time to revise the Special Theory of Relativity. The principle of relativity and the Lorentz transformations, in particular, are based on the idea that all inertial reference frames are equal. But if an asymmetry is observed in the speed of light, then the best explanation is that a preferred frame of reference is possible. An inertial frame moving towards and away from a source with respect to the preferred frame will give different values of the speed of light if there is an ether such as the quantum flux. It might be assumed that the null result of the Michelson Morley Experiment has already determined the nonexistence of any ether, but that would be wrong. In the two arms of the Michelson interferometer, only the effect of two-way speeds was detectable. Also, the original experiment was done in the medium of air and subsequent versions were done in Helium. As Feynman (Feynman explains the origin of the index of refraction in chapter) showed, a medium has its one permissible speed given by C/n, where n in the prior experiments is the index of refraction of air or Helium. Therefore, observing the speed of light in air or Helium, one should expect no other speed than the characteristic speed in air or Helium. It seems that this experiment has been much misinterpreted. There is a need for an experiment to determine whether relative motion is always the key to all known kinematic phenomena. The case of stellar aberration does not seem to comport with the concept of relative motion. If we take binary Mizar A, for example, the two stars are known to have orbital velocities of approximately 50 Km/s with an orbital period of 104 days. The earth has an orbital speed of approximately 30 Km/s and a period of approximately 365 days. This means that the relative motion between the earth and these stars will fluctuate between +/- 80Km/sec with a period of approximately 630 days. This would then mean that the apparent aberration of Mizar A would fluctuate similarly, but we know that it does not. The periodicity of its apparent aberration is tied closely to the orbital period of the earth. Relative motion does not govern stellar aberration; it is the motion of the receiver of the transmitted light that appears to be more important. This is best explained by assuming an existent ether and an asymmetrical one-way speed of light as observed by a moving receiver. A further discussion is to be found in a paper by Hayden[13] who states, ‘that stellar aberration does not support special relativity theory, it contradicts relativity theory.” The purpose of this paper is to suggest a new experiment to make one-way speed of light tests and to confirm or reject the assumed relativistic idea that all inertial reference frames are equal. The hypothesis to be tested is that the one-way speed of light is always C.

**Proposed Experiment:** The proposed experiment will take place in earth orbit. Onboard the satellite, a light velocimeter will measure the one-way speed of light produced by the sun. Measurements will be made in two places in the earth orbit. These will be near the two places where the speed of the satellite is moving toward and away from the sun with maximum speeds. If an asymmetry of speeds does exist, then the measured one-way speed when moving towards the sun will be

$$v_{measured}=C+v_0, \quad (1)$$

where C is the accepted value of the speed of light in a vacuum (299,792,458 m/s), and $v_0$ is the orbital speed of the satellite. When moving away form the sun, the measured speed will then be

$$v_{measured}= C-v_0 \quad (2)$$

The velocimeter to be described will be capable of measuring these speeds very rapidly by sending pulses of light through a known internal distance. It will then be possible to test these speeds very many times by producing large numbers of pulses that transit through the instrument. A digital sampler will then start and stop as a pulse makes its way through the velocimeter. As a result, each pulse will be sampled many times. According to equations (1) and (2), fewer or more samples will be obtained compared to the number that would occur if there is no asymmetry. The ratio of $\frac{v_0}{C}$ will be very small, and if an asymmetry is detected, very few excess or deficient samples will occur for each test pulse of the velocimeter. Therefore, a large number N of pulses will be sent while in the two sides of the orbit, and the number of time samples in the away direction will be subtracted from the number of samples in toward direction. It follows that if the digital sampling rate of the transit times is $f_s$ and the optical path length provided internally to the instrument is L, the differential number of samples will be approximately

$$N_{differential} \cong f_s \frac{2Lv_0}{C^2} N, \quad (3)$$

where the differential numbers are the sum of the excess and deficit numbers. As N increases, the probability of detecting a possible asymmetry increases. As will be shown, the measured speeds are done entirely in the compact instrument in the same inertial frame, obviating the problem with clock synchronization. Since the time between the event of light entering the instrument and the exiting event is done on one clock in one inertial reference frame, the time interval and the path length will be considered proper.

**Sensor Operation:** The proposed velocimeter is shown in Fig 1. It is made up of a solar afocal collection telescope, followed by another afocal telescope, a parabolic mirror and a reflection chamber where sunlight is reflected back and forth between parallel flat mirrors.

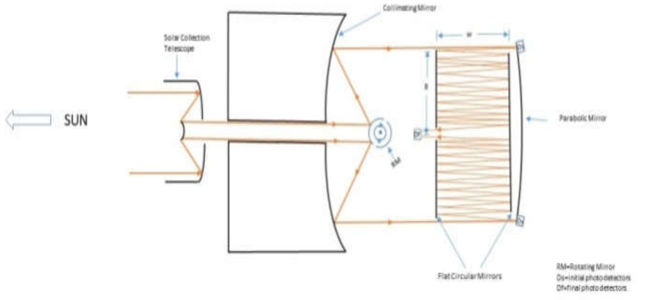


Figure 1. Self-Contained Light Velocimeter

Light having an incidence irradiance of $I_0$ is collected by the leftmost telescope. It produces a collimated beam of sunlight that then encounters a convex, segmented and rotating secondary mirror that intermittently reflects light to the primary mirror in this second afocal Cassegrain telescope. It is the purpose of the rotating mirror to generate light pulses to be propagated through the instrument.The power collected and transmitted through the system is

$$P_0 = \frac{\pi D_s^2 I_0}{4}, \tag{4}$$

where $D_s$ is the diameter of the primary mirror in the solar collection telescope. Once the light leaves this second primary mirror, it moves as a collimated beam toward the parabolic mirror having a radius of R which is slightly larger than the diameter of the two flat mirrors preceding it. The two flat mirrors act as a stop preventing most of the collected light from reaching the parabolic mirror; only a ring of light having an approximate width of S encounters the parabolic mirror. With a separation distance between the two flat mirrors of w, the ring width is given by

$$S = \frac{Rw}{f} \tag{5}$$

where f is the focal length of the parabolic mirror. The area of the ring then is given approximately by

$$A_r \cong 2\pi RS. \tag{6}$$

The power in the ring of light delivered to the parabolic mirror is then

$$P_d = A_r P_0 = \frac{\pi I_0 S D_s^2}{2R} \tag{7}$$

The parabolic mirror is the element that will provide the desired optical path length as light travels from its first encounter with the parabolic mirror until it makes it way by repeated reflections between the flat mirror and to the final photo detector. The first detectors are located around the parabolic mirror's periphery. In this way, the leading edge of the pulse of light generated by the rotating mirror will be detected by the detectors $D_s$, and the arrival of this leading edge will be detected by the final photo detector $D_f$. The parabolic mirror is nearly flat having a focal length of many meters. Light's first incidence with the parabolic mirror will cause the ring of light to converge toward its focal point, many meters away through the passage of the parallel flat mirrors. These mirrors must be of very high quality having a high reflectivity and a substantial scratch-dig specification. In exiting the set of flat mirrors, the input power $P_d$ will be attenuated signicantly. If the reflectivity of the two mirrors is r, the attenuation will be

$$A_r = r^{N_r} \tag{8}$$

where $N_r$ is the number of reflections in the passage through the reflection chamber.

This number of reflections is given by

$$N_r=f/w \tag{9}$$

The expected power arriving at the final detector $D_s$ is then

$$P_d = A_r P_0 = \frac{\pi I_0 S D_s^2}{2R} r^{\frac{f}{w}} \tag{10}$$

The transit time for the light's passage through the path length traveling at a speed of C will be

$$\Delta T_c = \frac{f}{C} \tag{11}$$

The transit time for the light's passage through the path length traveling at a speed of C +$v_0$ will be

$$\Delta T_+ = \frac{f}{C+v_0} \tag{12}$$

The transit time for the light's passage through the path length traveling at a speed of C -$v_0$ will be

$$\Delta T_- = \frac{f}{C-v_0} \tag{13}$$

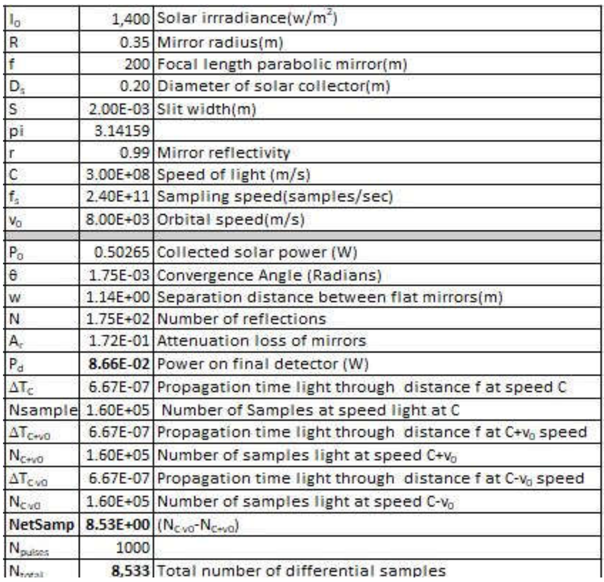
**The total number of differential samples to be expected then is**

N_differential=⟦Nf⟧_s (ΔT_--ΔT_+) (14)

Numerical Example

Table 1 shows the practical application of the velocimeter described here. It indicates that it is possible to measure the one-way speed of light in a self-contained instrument. It shows that very substantial amounts of optical power will be available for detection, and more is easily obtained by increasing the size of the solar collection telescope. The analysis shown here does not include diffraction loses, which will be minimal, that can easily be compensated for by increasing $D_s$. It might be argued that the reflected light between the flat mirrors will become scrambled by scattering and diffraction. The primary light will make its way along the reflective path that is the least-time path. Other secondary light will largely travel on slower paths. This implies that the leading edge of the light pulses should be used in timing the pulse transit. It is also noted the no where in the instrument does light ever make a passage through any dielectrics with its speed ever limited in any way anywhere along its way.

**Table 1. Numerical example of the velocimeter performance**



| | | |
|---|---|---|
| $I_0$ | 1,400 | Solar irrradiance(w/m$^2$) |
| R | 0.35 | Mirror radius(m) |
| f | 200 | Focal length parabolic mirror(m) |
| $D_s$ | 0.20 | Diameter of solar collector(m) |
| S | 2.00E-03 | Slit width(m) |
| pi | 3.14159 | |
| r | 0.99 | Mirror reflectivity |
| C | 3.00E+08 | Speed of light (m/s) |
| $f_s$ | 2.40E+11 | Sampling speed(samples/sec) |
| $v_0$ | 8.00E+03 | Orbital speed(m/s) |
| | | |
| $P_0$ | 0.50265 | Collected solar power (W) |
| θ | 1.75E-03 | Convergence Angle (Radians) |
| w | 1.14E+00 | Separation distance between flat mirrors(m) |
| N | 1.75E+02 | Number of reflections |
| $A_r$ | 1.72E-01 | Attenuation loss of mirrors |
| $P_d$ | **8.66E-02** | Power on final detector (W) |
| $\Delta T_C$ | 6.67E-07 | Propagation time light through distance f at speed C |
| Nsample | 1.60E+05 | Number of Samples at speed light at C |
| $\Delta T_{C+v0}$ | 6.67E-07 | Propagation time light through distance f at C+$v_0$ speed |
| $N_{C+v0}$ | 1.60E+05 | Number of samples light at speed C+$v_0$ |
| $\Delta T_{C-v0}$ | 6.67E-07 | Propagation time light through distance f at C-$v_0$ speed |
| $N_{C-v0}$ | 1.60E+05 | Number of samples light at speed C-$v_0$ |
| **NetSamp** | **8.53E+00** | ($N_{C-v0}$-$N_{C+v0}$) |
| $N_{pulses}$ | 1000 | |
| $N_{total}$ | **8,533** | Total number of differential samples |

## Conclusion

A question whether the suggested earth-orbiting satellite is a proper inertial frame to perform the suggested experiment might arise. The satellite is in free fall in its orbit and experiences no net forces for most locations above the earth. It is accelerating because of the change in the direction of its velocity vector, however. If the amount of space travelled and the amount of time taken are small during a measurement, the satellite reference frame is a good inertial approximation. Spacetime is locally Minkowski. For the example given, light pulses travel a distance of 200 meters in the instrument. At the speed of light, the transit time through the velocimeter is about 667 ns or 0.667 µs. In the given example, the satellite has an orbital speed of 8.0 Km/s, and the average earth orbital speed is 30 Km/s. The satellite will have moved approximately ½ mm in its orbit, and the earth will have moved approximately 2.0 cm when a measurement is being made. These quantities are very small and will make the satellite a very good approximate inertial frame. If no asymmetry is detected in the one-way speed of light going toward or away from the sun source, much of the controversy about the validity of the second postulate of Special Relativity should abate. In this event, no changes to the theory would be obligatory. A credible detected asymmetry, on the other hand, will require some serious changes to the theory. The entire theory will not need to be entirely eliminated. It will be necessary to preserve those parts that produce validated observations, such as time dilation and speed-dependent mass. A possible move to an ε-Lorentz form may be necessary. Fortunately, many14,15 have already explored these avenues of change. With a validated asymmetry, there will be major changes in how the universe is viewed. One, it will be finally established that a form of ether does exist, possibly the quantum virtual particles. This will stand as a refutation of all prior experiments that have asserted the nonexistence of an ether, and it will affirm many longstanding assertions that the ether is real. Two, it will be possible to define an absolute reference frame. Absolute speeds in the ether will be determined by measuring the deviation of the speed of light from C by examining the sources of light embedded in the ether. Whether the source is moving or not is unimportant, as the speed of light has been confirmed to be unaffected by the motion of the source. Motion of the observer, however, may prove to be different. The basic idea that all inertial reference frames are equal would have to be abandoned, and this would strike at the principle of relativity. More advanced and more accurate and more compact instruments like the one given here will be possible when coupled with an onboard atomic clock. The discussion here is based on a moderate clock capable of resolving approximately 2 parts in $10^{11}$. Another experiment intended to fly on the space station was the PARCS (Primary Atomic Reference Clock in Space) experiment but was cancelled. The clock design was based on an advanced laser-cooled Cesium beam clock for operation in microgravity. Its time resolution was expected to be 1 part in $10^{16}$. A very small self-contained reflection chamber would result with such a device to measure the speed of solar light in the two orbital directions with great improvements should a PARCS-like clock be used.

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