Isotropic One-Way Times of Flight of Laser Pulses and Einstein's "compressible fluid" Space

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Abstract

We present measurements of one-way times of flight of 25 fsec laser pulses, along a given distance, in different directions in space. Using autocorrelation, a technique that dispels the need for clocks and their synchronization, we obtained full isotropy.

Einstein showed [1] that stars confine their local spaces and concluded that space is a "*compressible fluid*". Any static instrument on Earth is thus stationary relative to its local space and should yield isotropic results, as we have obtained.

Our results validate the second postulate of Special Relativity [2] and support Einstein's idea.

Key Words: Space; Inertial systems; Light velocity; Special Relativity, Compressible Fluid

1 Introduction

Einstein showed [1] that large enough masses, like stars, referred to in the literature as "Einstein clusters", confine their local spaces, which move with them. Hence, he considered space to be a "*compressible fluid*". Electromagnetic waves, whether they are space vibrations or the vibrations of their own "medium" that follow, as General Relativity requires, the topology of space, reside in Einstein's space [1].

Necessarily any static instrument on Earth, designed to measure light velocity, is stationary relative to the Earth's local space and should yield isotropic results, not only for two-way but also for one-way light velocity measurements. The isotropic result of two-way light velocity measurements, like that of the Michelson-Morley experiment, lead to the following alternative:

Option one – Lorentz and Larmor theory of real length contraction and time dilation.

Option two – Einstein's postulate [2] on the constancy of light velocity (the assumption that the times of flight forward and backwards are always equal); "verified" by experiments, but without any explanation despite being in the consensus.

An explanation is needed since electromagnetic waves are waves of a certain medium, and motion of the measurement equipment relative to this medium should affect the one-way results. Length contraction and time dilation are not relevant in this case, since the results of one-way time of flight experiments are (v/c) dependent and not $(v/c)^2$ dependent, as for a two-way experiment.

Previously one-way light velocity measurements were problematic, since synchronization of clocks is required. To dispel the need for clocks and their synchronization, we used an autocorrelation technique. The isotropic results reported here support Einstein's idea [1] and provide a possible turning of his Special Relativity (SR) [2] second postulate into a physical fact.

In one-way times of flight experiments there are two possible results:

Anisotropy could be the result of the Earth, stars, and material bodies in general, sliding through space. The entire global space can serve as a special frame that coincides with the Cosmological Microwave Background (CMB) frame. A velocity relative to this frame yields a CMB Doppler shift.

Isotropy could be the result of space (and hence the electromagnetic wave's "medium") being carried by the Earth and by other stars, inside and near them, but not necessarily by "small" bodies. In this case instruments for measuring times of flight on the Earth must be at rest relative to the Earth's local space. This carrying of space, while maintaining space continuity, is possible only if space is an elastic fluid – Einstein's [1] *compressible fluid.* These confined zones of space are individual special frames for "small" bodies moving inside or close to them.

Note that: In the case of anisotropy, we have one special frame, whereas in the case of isotropy there are many special frames. The consideration of space as a fluid is proposed in [3] and [4]. The Frame Dragging phenomenon, see [5], also supports Einstein's idea.

2 The Experiment

The aim of our experiment was to measure a variation in one-way times of flight of 25 fsec counter-propagating laser pulses, along a given distance: (A) in the same line in space as that of the Earth's velocity in the CMB frame, and (B) in various directions in the celestial sphere. A variation in the time of flight of the counter-propagating light pulses is supposed to enable us to derive the velocity of the experimental system with respect to surrounding space.

We wanted to check if this derived velocity coincidences with the Earth's velocity in the CMB frame. This velocity, derived from the Doppler shift in the CMB spectrum, expresses the velocity of Earth in the global space. However, the zero result of our measurement, as we now know, indicate that we had measured the velocity relative to the local space and not to the global space. Our results for different directions in the global sphere also yielded full isotropy.

Earth Velocity in the CMB Frame

The solar system's velocity relative to space is: V= 371.0 ±0.5 km sec^{-1} [6]. This velocity **V** is towards a point with equatorial coordinate (α, δ) = ($11.20^h \pm 0.01^h$, $-7.22^0 \pm 0.08^0$), [6].

This direction points from the cluster of galaxies, Aquarius, towards the cluster Leo -Virgo.

Earth's velocity **v** varies around **V** due to the rotation of Earth around the sun. We have calculated these variations in the Right Ascension (RA), Declination (DEC), and |**v**| as a function of the day in the year and use these results in our calculations. These results are summarized in the following un-attached graphs:

1. Velocity of the Earth v in the CMB frame (Km/s) versus Days since spring equinox.

2. RA of the Earth velocity **v** versus Days since spring equinox.

3. DEC of Earth velocity **v** versus Days since spring equinox

The Velocity as it Appears in the Laboratory

To identify the velocity **v** in our laboratory, located at coordinates N 31^0 46' 22", E 35^0 11'56", we translate its Equatorial Coordinates to the latitude and longitude in our laboratory. To simplify our experiment, we restrict ourselves to the case in which the velocity **v** is contained in the goniometer plane of our system, only. We have derived and calculated the times for each day in 2018, when the vector **v** is contained in this plane, together with its angular orientation. These results are summarized in the following un-attached graphs:

4. ALT Degrees and relevant calendar Days versus Time in minutes relative to 11:00 GMT

5. AZ Degrees and relevant calendar Days versus Time in minutes relative to 11:00 GMT

3 The Goniometer

The goniometer, see Fig. (1), is a circular plate 100 cm in diameter mounted on a tripod. The plate is balanced horizontally and the optical bench, mounted on top of it, can rotate around its center and point at different directions in space. The 0^0 and the 180^0 degrees marks on the circumference of the goniometer point from south to north, with an accuracy of 0.2^0. This alignment was achieved by casting the shadow of a thin rod, oriented vertically at the center of the plate, when the Sun was on the meridian at our laboratory. The accuracy is obtained by an exact calculation of the time the Sun is in the meridian at our laboratory's coordinates on the specific date of the alignment.

Directions in Space

Directions in space are represented by their Declination (Dec) and Right Ascension (RA) in the Equatorial Coordinate System of the Celestial Sphere. For simplicity, we have restricted our measurements to only one plane in the Celestial Sphere that contains the velocity vector **v** of Earth in the CMB frame, and coincide with the goniometer plane.

This coincidence happens only once a day (or twice if we also consider the anti-parallel direction) and at a different moment, according to the day in the year. By allowing a tolerance of $+/-2^0$ of angular accuracy around the velocity vector **v**, we can "stretch the moment" to about 45 minutes - enough time to conduct the measurements.

The Altitude and Azimuth were calculated [7] at http://jukaukor.mbnet.fi/star_altitude.html. The calculations are for about 25 minutes around the time when the altitude is zero.

These results are summarized in the following un-attached graphs:

6. The time at which ALT=0 for the days between May 9 and May 24, 2018. Minutes relative to 11:00 versus the Day in May 2018.

7. The Azimuth for these dates when ALT=0. Degrees versus Day in May 2018.

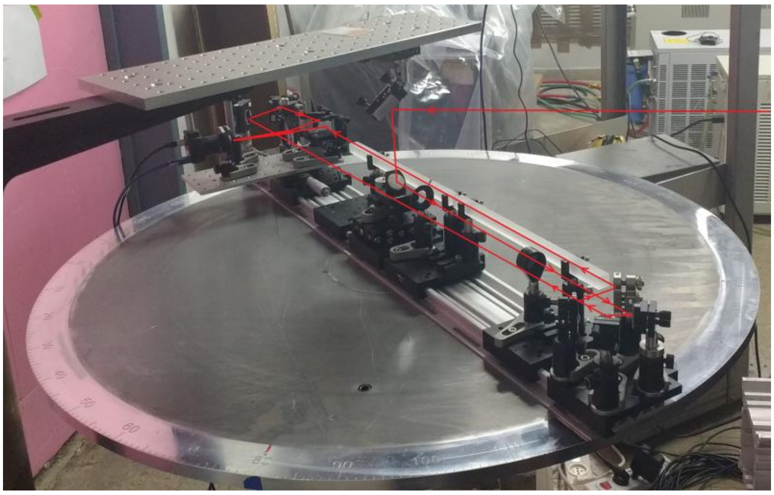

Fig. (1) The Goniometer & Optical Bench. The red line represents the trajectory of the laser pulse with arrows indicating the direction of propagation of the pulse.

4 The Optical Bench and its Components

Laser pulses from a 25 fsec laser are delivered to the optical bench. We use a 25 fsec Ti: Sapphire laser. It consists of a 20 fsec Spectra Physics Tsunami oscillator, followed by a regenerative amplifier. The pulse energy at a wavelength of 798 nm is 3 mJ, and the repetition rate is of 10 Hz. The laser beam diameter is approximately 0.8 cm. In our system, we superimpose two laser beams on a Barium Borate (beta-BaB_2O_4, BBO) crystal that serves as our autocorrelator. The 600 mm optical rod, constructed of two rods of 300 mm length each, serves as an optical delay line that ensures the simultaneous arrival of the two pulses to point C, see Fig. (2), on the first arm and at point G on the second arm. The rods are made of Schott BK7 glass, cross-section 12 mm, Index of refraction n = 1.51 (For λ = 798 nm) We ignore the variation in the refractive index of the glass n, due to Lorentz contraction, since this is a $(v/c)^2$ dependent effect. The time interval $\Delta t(\text{rod})$ of a pulse moving along the rod, being a moving medium in space, is: $\Delta t\ (\text{rod}) = L\ /(c\ /n + v)$, where we use +v for a pulse moving in the direction of the system from A to B, or –v for a pulse moving in the opposite direction.

Fig. (2) shows the scheme of the optical bench.

The laser beam pulses are delivered to the optical bench vertically and enter the bench at point O on a mirror mounted on the rotation axis of the bench. From this mirror the pulses are delivered to point P. At point A, a 50:50 beam splitter delivers one half of the beam to point C and the other half via point I and through a glass rod to G. The distance AB (AB=AC) was chosen so that the optical path ABC=AIG. The two beams pass through equal optical lengths and in the same direction, hence the times of flight along these paths are equal – points C and G are reached simultaneously regardless of the bench's direction in space.

The micrometer-controlled stage (dashed square) that carries the autocorrelator is located in approximately the middle of CG. Autocorrelation is achieved when the time of flight along paths ACE and AGE, taking in account the effect of velocity, are equal.

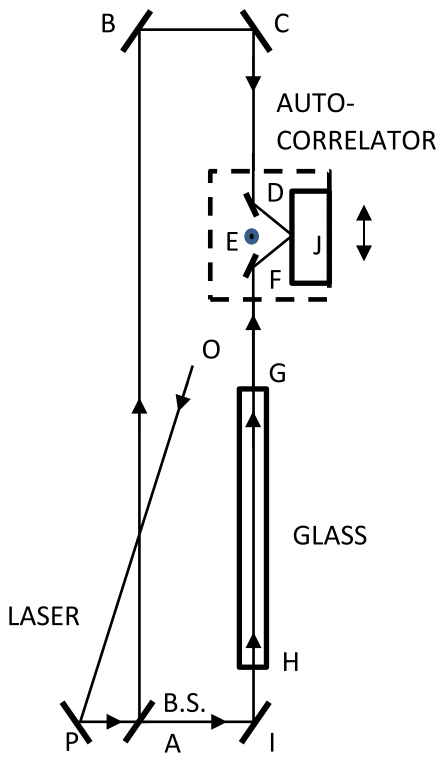

Fig. (2) The Optical Bench

5 The Experimental Results

The experiments have been conducted as follows:

24 May 2018 at 13:30 local time, where v = 340km/sec and the azimuth was 80^0

28 May 2018 at 13:05 local time, where v = 340km/sec and the azimuth was 80^0

31 May 2018 at 12:55 local time, where v = 340km/sec and the azimuth was 80^0

06 Jun 2018 at 12:35 local time, where v = 339km/sec and the azimuth was 80^0

On all these occasions we oriented the optical bench at the appropriate time and at the azimuth of 80^0. Immediately after autocorrelation we rotated the optical bench a full 360^0, checking the autocorrelation every few degrees on the goniometer. The autocorrelations were fully retained.

Autocorrelation is obtained within +/- 20µm of the stage movement. The optical path is:

CE= 15cm = $1.5 \cdot 10^5$µm. Hence the accuracy is: $20\mu m/1.5 \cdot 10^5 \mu m \sim 1 \cdot 10^{-4}$

To further investigate the isotropy in the one-way times of flight of the laser pulses, we conducted a series of measurements in which the optical bench was left untouched for 12 hours. During this time, individual auto-correlation measurements with a given repetition rate were taken. The Earth's rotation around its axis modified the direction in which the bidirectional optical bench was oriented during the time of the experiment. Thus, during the period of 12 hours, the earth's rotation rotated the optical bench by 180deg with respect to the Earth's axis of rotation. In each experiment, the initial orientation of the optical bench was changed. Table (1) below summarizes the experiments and their parameters.

Date of experiment	Initial orientation (degrees)	Starting time	Repetition rate	Total duration
28/8/2018	305deg	18:00	0.002Hz	13hours
8/10/2018	260deg	17:48	0.01Hz	12hours
23/10/2018	215deg.	17:20	0.01Hz	12hours
24/10/2018	170deg.	17:25	0.01Hz	12hours.

Table (1)

The outcome was a full isotropy in the times of flight of the pulses. The accuracy of the measurement is estimated as shown above.

6 Discussion

To explain our results, we assume that the velocity, **v**, of our laboratory, is Earth's velocity in the CMB frame. For $v << c$ the time of flight of a laser pulse in direction **v** of the laboratory. frame is:

$$\Delta t_1 = L/(c - v) \sim (L/c)\cdot(1 + v/c) \quad (1)$$

We ignore the Lorentz contraction of L, since it is $(v/c)^2$ dependent, whereas the measurement of Δt depends on (v/c), see equation (1). For the direction opposite to **v** the time of flight is:

$$\Delta t_2 = L/(c + v) \sim (L/c)\cdot(1 - v/c) \quad (2)$$

A measurement of the variation in the one-way time of flight of two counter propagating pulses in the direction of v, along a given distance, is thus v/c dependent. We thus conclude that our null result: $\Delta t_1 - \Delta t_2 = 0$ means that our laboratory velocity relative to space is zero. This could be a result of the Earth confing its local space [1].

Einstein's assumption, [2], that the time for one-way light propagation along a given path is always equal to the time of propagation back, ($\Delta t_1 = \Delta t_2$), led him to the "light velocity constancy" postulate [2]. Experiments to verify this postulate have measured the time for two-way, back and forth, propagation, but did not relate to Einstein's assumption. There has not been any convincing proof that Einstein's original assumption is valid. However, our measurements of one-way propagation times validate Einstein's assumption and hence validate his second postulate. Our results could be a consequence of space being a "compressible fluid", as shown, 1939, by Einstein.

A full isotropy in a one-way light velocity measurement, which utilized a different technique, was reported by Ahmed, et al, [8], and also by Gurzadyan and Margaryan [9].

7 Summary

The isotropy revealed in our one-way times of flight of 25 fsec laser pulses, in various directions in the celestial sphere, turn Einstein's Special Relativity, [2], second postulate (assumption) into a physical fact. This result is explained by our system being stationary relative to the confined local space of Earth, as Einstein, [1], suggests. All this supports Einstein's idea, [1], that space is an elastic fluid.

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