An Experiment to Test the Galilean Principle of Relativity

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It is proposed that a simple experiment utilizing a telescope mounted instrument of an original design, when it is aligned with the assumed Apex of the absolute motion of the Earth, may be able to confirm whether the Galilean Principle of Relativity is also valid in all cases where radiant energy is involved. The result of this test may finally resolve the continuing conflict between those who believe that all previous experiments have already upheld this principle, and those that still believe that some previous results have cast doubt upon this assumption. The effect that the absolute spatial motion of the observer's frame of reference has upon his measurement of the magnitude of the phenomenon of Time Dilation is also discussed.

Keywords: Doppler Effect. MM Experiments. Apex of Absolute Motion. CMBR. Miller Velocity Diagram. SR, LR, and LET, relativity theories.

1. Introduction

It was Galileo Galilei who was the first to formulate the dynamical principle of relativity in order to silence the critics of his support for the Copernican Heliocentric System. He stated that no physical experiment conducted entirely within a frame of reference could differentiate between a frame that is moving at a constant velocity and one that is stationary, as the laws of physics are identical in both inertial systems. This principle, which is closely associated with the law of inertia involving material particles, was incorporated later into Newtonian mechanics.

In the late 19th.Century it was believed that since electromagnetic radiation had a motion that was independent of that of its source it would be excluded from the principle of relativity. However, all the experiments to detect the spatial velocity of the Earth by the effect that this motion was expected to have upon the velocity of electromagnetic waves ended inconclusively.

In the 20th.Century, Einstein's Special Theory of Relativity proposed that these experimental results demonstrated that the velocity of radiant energy was invariant in all inertial frames of reference and that therefore the principle of relativity was upheld, but only at the expense of Newtonian concepts of physical space and time.

2. The basis for the proposed experiment

In recent years there have been a number of improved tests of the isotropy of space, such as those undertaken by Brillet and Hall [1]. These have increased the order of accuracy by more than 4,000 times of that of previous Michelson Morley [2] type experiments. Complimentary experiments by Hils and Hall [3] have also increased the order of accuracy of Kennedy-Thorndike (KT) type experiments by some 300 times. The magnitude of these improvements was achieved by the use of laser technology.

For those already convinced of the unassailability of Special Relativity (SR) the above experiments would no doubt have been regarded as the definitive last word with little point in pursuing this line of research any further.

In 1975 this Author [4] also suggested a new experiment utilizing laser technology to re-examine the small but positive result of an Ether Drift experiment that had been conducted by Dayton C. Miller [5], because his result had been at variance with those that had been obtained by other researchers.

After publication of this paper, confidence in the use of interferometers as the appropriate way forward for this type of test was reduced by reading a 1905 paper by Morley and Miller [6]. In response to criticisms that had been levelled at the previous MM experiments by W.M.Hicks [7], they undertook an exhaustive analysis of the behaviour of light waves passing through a Michelson interferometer.

It was clear from this reappraisal that the behaviour of light waves reflected from mirrors that were themselves in motion was not as straightforward as had been assumed. One extraordinary conclusion was that even if the spatial velocity of the Earth was half of that of light in vacuum, when the two split beams within the interferometer are recombined, the wavelength of each beam, in the direction in which alone they are measured perpendicular to the axis of the viewing aperture, are assumed to be identical! The explanation for this will follow later.

Morley and Miller also pointed out that although the two recombined beams, as viewed in the detector, always appeared to have the same wavelength when the mirror arms were aligned at a specific azimuth, this did not mean that these apparent wavelengths would always have the same magnitude during a full rotation of the instrument. As the instrument was rotated relative to the direction of the spatial motion of the Earth the monochromatic light from a source moving with the apparatus had its wavelength modified by this motion. Due to the Doppler Effect, the light would undergo a blue shift when the source was facing towards the direction of the spatial motion of the Earth, and it would then undergo a red shift when the light source was turned 180 degrees to the spatial motion. At two other opposing points the source would be moving transverse to the spatial motion and the Doppler shift would be at a minimum. Since the emitted beam was split into two and sent down paths at a right angle to each other, the success of the experiment depended upon measuring the difference of less than 0.002mm between the two recombined and coherent trains of light waves, as the beam that had travelled to and fro in the assumed direction of the spatial motion of the Earth took longer to arrive at the viewing detector by that amount. This difference could only be measured by the shift of interference fringes set up by the two trains of light waves. It was therefore important that the variation in wavelength from the light source due to the above Doppler shifts was not sufficient to prevent a measured movement in the interference fringes when the instrument was turned through 90-degrees and the two paths exchanged their roles. Morley and Miller calculated the amount of this Doppler effect and concluded that for a spatial velocity of the Earth of less than 1/100*c*, or 3000km/s, the difference in scalar values between the recombined wavelengths would be insufficient to affect the sought for fringe shift in MM type experiments.

In fact, in the year of 1905 when this analysis was published, very little was known about the structure and cosmic motion of our own galaxy or of the universe as a whole, the only spatial velocity of the Earth that was known with any certainty was the orbital velocity vector in the plane of the solar ecliptic of some 30km/s.

It is interesting to note that in our own era, with the Hubble expansion of the universe having been generally established, some of the more distant galaxies have been measured to possess red shifts of more than 3/5ths.of the velocity of light, although these latter velocities are generally attributed to the actual expansion of space and not to the Doppler shifts caused by motion through space.

This analysis illustrated that the principle limitations of utilizing interferometers to detect the spatial motion of the Earth was that the result depended upon an assumed difference in path length between the two recombined beams of only $(v/c)^2$. It was assumed that the alignment of the optical plane with that of the orbital velocity in the solar ecliptic should have produced a fringe shift indicating a mean motion of 30km/s. The best results measured were always less than a quarter of this amount. Therefore, since the device could only achieve a second order result, and given the extreme difficulties encountered in conducting such experiments, this disappointingly low fringe shift was largely assumed to have been caused by unavoidable errors.

The above explanation for the so-called 'Null' result has always satisfied those already convinced of the veracity of (SR), but it has never pacified those who still adhere to some variant of the pre (SR) Lorentz Ether Theory (LET). Their main argument being that the small but persistent positive results could be caused by a partial entrainment of the Aether by the terrestrial frame of reference under certain circumstances. Even the later evolution of Lorentzian Relativity (LR), whilst accepting a 'Null' result, requires a physical Fitzgerald-Lorentz contraction of an interferometer arm in order to reject both (SR) and (LET).

This Morley-Miller paper, and the continuing controversy mentioned above, would appear to make a case for trying an entirely different method of testing the Galilean Principle by attempting to detect the spatial motion of the Earth. In order to be justified such an experiment must deliver certain original characteristics.

a. It should give a first order result to provide an unambiguous verdict.
b. It should not utilize interferometers to achieve this result.
c. It must not rely on hoped for variations in the speed of light caused by spatial motion.
d. The instrument should be capable of being mounted on a telescope.
e. The experimental result should not be affected by a possible Fitzgerald-Lorentz contraction of the instrument.

Only if the above unique parameters are achievable can it be hoped that the result of the experiment will finally settled the matter between the adherents of the various relativistic theories mentioned above once and for all.

Morley and Miller have pointed the way to such a device by drawing attention to the effect that a moving source should have upon the frequency of light, according to the classical non-relativistic theory.

Unfortunately, the direction and magnitude of the spatial velocity of our own galaxy through space is still the subject of debate. But the significance of this analysis is that even if the Earth has a resultant spatial velocity of only one kilometre per second, the spectrometers that are now available are sensitive enough to easily measure the change in wavelength of the light emitted by a source that this may cause. It should thereby be possible to provide a genuine test of the Galilean Principle, since according to it; even such a small motion should not be capable of being detected by an experiment conducted entirely within an inertial frame of reference.

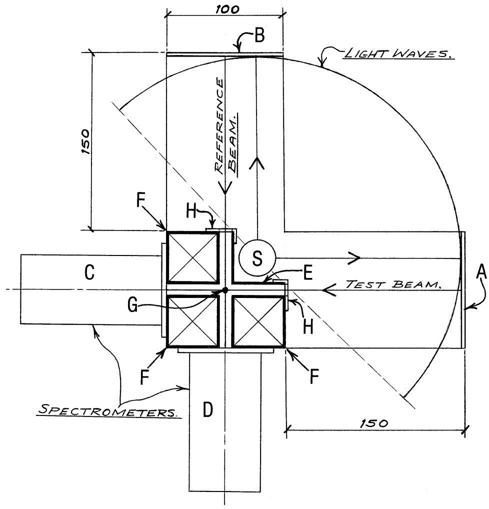

Figure 1: Plan of the Instrument.

3. Description of the instrument

In order to conduct an experiment to detect a possible change in the non-relativistic wavelength caused by the Doppler effect of a moving source, it would be necessary to utilize a specially constructed instrument as shown in plan on Figure 1, where the main section is an ‘L’ shaped structure forming two arms 150mm long by 100mm wide. At each end of these arms are mounted plane mirrors at A and B, about 100mm square. It is important that light is reflected only off the front face of these mirrors. Two identical Spectrometers at C and D are fixed to the structure in such a manner that their optical axes are positioned exactly central with the two mirrors. A monochromatic light source S is mounted as close to the optical axes of the spectrometers as possible and at an equal distance to the two plane mirrors. It is recommended that this source is a conventional Sodium, or Mercury lamp, and not a laser. A light absorbing screen at E is fixed behind the light source, which also forms part of the aperture slit for the two spectrometers. This screen is required to eliminate secondary reflections from the mirrors. At F, are three box sectioned light screens that form the other sides of the aperture slits. They should be substantial enough to increase the rigidity of the structure. The whole instrument should be designed for a motorised rotation through a vertical axis at point G. It may also be necessary to provide balance weights to stabilise the structure during rotation. Although the two beams that enter the aperture slits cross each other before entering the spectrometers this should not affect the result of the experiment. But if it is felt to be necessary, electronically controlled shutters at H could be installed to open and close in sequence so that only one light beam enters its respective spectrometer at a time during the tests.

For reasons to be discussed later, this instrument must be designed for mounting upon an equatorial telescope. Therefore, the whole mechanical configuration should be made as small and rigid as possible to minimize gravitational distortion of its shape when the plane of the apparatus is aligned at an acute angle to the horizontal. To avoid centrifugal stretching, rotation of the instrument should be avoided if possible whilst spectrometer readings are taken at a particular point on the celestial sphere. If this is not possible, then rotation must be kept to a minimum to reduce Doppler variations of the light due to the axial motion alone.

Ideally, the light paths should be exposed to the air, but if it is found to be necessary to enclose them to minimize distortions due to vertical temperature gradients, then the thermally isolated enclosures should be as thin walled as possible. Since C.H. Thompson [8], has pointed out that in the classical wave theory of light, a thick walled structure could restrict the passage of a wave-transmitting medium.

The primary use of this instrument would be to try and measure the magnitude of a Doppler change in wavelength, and how this would vary as the light source's orientation changes relative to the assumed apex of the absolute spatial velocity of the Earth on the celestial sphere. The non-relativistic Doppler effects to be expected should have the greatest magnitudes when the light source is either moving directly with, or directly away, from the Earth's own motion.

The configuration of the apparatus as shown in fig.1 is therefore necessary for this task because if the light source S is facing towards the apex of the spatial velocity of the Earth, then its emitted wavelength should be shortened by the Doppler effect of its own motion. But if mirror A has also been aligned on the apex at this point of an experiment, then its own identical motion away from the oncoming train of light waves would exactly compensate for this Doppler Effect. The result would be that the light reflected off mirror A and back towards spectrometer C would have an identical wavelength to that of a stationary source and not of a moving one. However, since spectrometer C is also moving in the same direction and with the same velocity of that of the light source S, then its own forward motion would again shorten the wavelength of the light reflected back from mirror A and passing into its own optical system.

For if a non-relativistic Doppler effect is at all possible, then whether a source is in motion and a spectrometer registering the wavelength of its emitted light is stationary, or the source and the spectrometer exchange these roles, a Doppler variation in the emitted wavelength would still be measured in either case. Mirror A represents the equivalent of a stationary source in the above case.

If the instrument were now rotated 180 degrees, the light source S would now be facing away from the apex of the terrestrial motion and the wavelength of its emitted light would be lengthened by the Doppler Effect. In this latter case, mirror A would now be advancing towards the oncoming train of light waves and therefore its own motion would again exactly compensate for this Doppler Effect, so that the reflected wavelength from mirror A back to spectrometer C would be identical to the wavelength of a stationary source again. But with this alignment of the instrument the spectrometer C would now be moving away from the reflected light coming from mirror A, and so the wavelength registered by it would again be lengthened by the Doppler Effect.

In both the above orientations of the instrument the other arm upon which is fixed mirror B would be moving 90 degrees, or transverse, to the apex of the spatial motion and therefore the wavelength of the light emitted from the source S, and also reflected from mirror B, would not be Doppler affected by this spatial motion. So that Spectrometer D should not detect any change in wavelength due to motion of the source.

Since the light passing into the optical systems of both spectrometers has been emitted by the same source it would be possible to make a comparison of the readings obtained by the two instruments, because a significant difference between the wavelengths obtained by them at the same instant of time would indicate that the principle of relativity can *not* be extended to the realm of radiant energy.

Although the light source in this arrangement is offset from both optical axes of the spectrometers, this misalignment should be too small to affect the result sought for, as the light apertures of these optical axes should be as narrow as possible.

It may be objected that although the two spectrometers are of an identical type they may still give different wavelength measurements due to inherent optical variations between them. But any difference in optical calibration should be entirely neutralised by rotation of the instrument. Every quarter turn would result in the optical path that was previously aligned with the assumed apex of the spatial velocity of the Earth being repositioned transverse to this motion. Therefore, the two arms of the apparatus would interchange their roles every 90 degrees. So that with a full 360 degree rotation of the instrument any discrepancy in the readings obtained by the two spectrometers due to lack of calibration should be consistent in nature over time. This could be allowed for in the final analysis of the sought for variations in wavelength caused by the Doppler Effect alone.

This is the opportune point to define the spectrometric requirements for the above instrument. Fortunately, thanks to the latest technologies, there are a growing range of small and lightweight radial velocity spectrometers becoming readily available on the open market. For example, the Santa Barbara Instrument Group [9] can provide a Model SGS Dual CCD Self-Guiding Spectrograph. This is designed to be used with a range of 'In-house' cameras, such as the ST-7XE CCD imaging camera. This whole package, including its mounting screw, has a maximum weight of 3kg.

This system is capable of measuring the spectral Doppler Shift across the full visible light range, with several high-resolution gratings available. It also has data acquisition and spectral analysis PC software included for Microsoft Windows. These programs can provide full light wave scans in real-time displayed on the PC screen, if required.

A website perusal of the full performance capability of Model SGS will confirm that it is an ideal system for fitting to the instrument in this proposed experiment.

4. The apex of the spatial velocity

Previous to 1925 a considerable number of so-called Ether Drift experiments of the Michelson-Morley type had been conducted.

These were applied to test this question only with the specific assumed spatial motions of the Earth that were known with any certainty in this era. Namely, the axial rotation of the planet and the orbital motion of some 30 km. per second in the plane of the solar ecliptic, combined with an apparent constant motion of the solar system relative to the fixed stars directed towards the constellation Hercules at 19 km. per second. The result of these experiments showed that although a small consistent effect appeared to have been registered, it was such a small fraction of even the orbital motion that all these tests of the Ether Drift Hypothesis were considered to have given a null verdict.

During the period 1924-26 D.C. Miller, see [5], conducted a series of new interferometer experiments of the MM type at Mount Wilson. The primary object of these were to ascertain if an absolute motion of the Earth in space, acting in a direction out of the plane of the solar ecliptic, could account for the small result obtained by previous experimenters, including Miller, who had ignored this possibility. Miller realized that none of the earlier tests had been conducted for a sufficient enough time, nor repeated again at evenly spaced epochs throughout a full year, to have ensured that the optical plane of their of instruments would have registered this absolute motion for certain. Unfortunately, in this time period very little was known about the possible magnitude and direction in space of such an absolute motion, and so Miller was forced to employ the indirect methods described in his paper. His eventual conclusion was that a definite Ether Drift effect had been verified, and he gave the calculated value of the absolute velocity that his data implied. Since MM experiments have been generally considered an important test of the Special Theory of Relativity, these results have always attracted considerable interest.

In 1955 a new analysis of Miller's experiments was undertaken by R.S. Shankland, *et al.* [10]. Their conclusions were that Miller's positive result was probably caused by unavoidable experimental errors. This latter verdict is still the cause of some controversy to this day.

The problem that Miller had in establishing the Apex of the absolute spatial motion of the Earth can be illustrated by considering the galactic data which was unavailable to him. For it is now known that the sun itself has an orbital motion around the centre of mass of our own galaxy. If we assume for the purpose of discussion that the centre of the galaxy is an absolute frame of reference, then the direction of the apex of the terrestrial velocity on the celestial sphere could be presumed to be the resultant of two major component motions only, the terrestrial orbital motion relative to the sun, which at all times acts in the plane of the solar ecliptic, and also the solar orbital motion relative to the galactic centre. The magnitude of this galactic velocity is 250 km/s approximately, and its direction is towards a point not far from the star Deneb in the constellation Cygnus, at RA 20hr 40min, dec +45 degrees. Also this solar velocity is directed at all times out of the ecliptic plane at an angle of 68.5 degrees to it.

Adopting Miller's own method of obtaining the apex of the terrestrial motion, if we take that $\mathbf{V}_1$ of 30km/s is the mean orbital velocity of the Earth acting parallel to the ecliptic plane, and also that $\mathbf{V}_2$ of 250 km/s is the solar galactic velocity, with the previously stated apex, then the direction of the resultant spatial velocity $\mathbf{V}$ of the Earth at any chosen epoch may be obtained by application of the parallelogram law. An important point to consider first is that the direction of the apex of velocity $\mathbf{V}_2$ remains constant during the whole of a terrestrial year, but the direction of velocity $\mathbf{V}_1$ in the ecliptic plane varies continuously throughout the same period. Therefore, the direction of the actual apex of the resultant velocity $\mathbf{V}$ must vary between certain limits, due to the differing directions of its components $\mathbf{V}_1$ and $\mathbf{V}_2$ at particular points in the terrestrial orbit as shown in Figure 2, below.

Where in the Miller Diagram shown in Fig.2b, velocity **V** is at the correct angle and all vectors to scale, j is the angle of 68.5° between the vectors $\mathbf{V}_1$ and $\mathbf{V}_2$ calculated for the 1st. epoch E1, y is the angle of 62.4° between the vectors **V** and $\mathbf{V}_1$, and m is (j minus y) = 6.1°, the important angle between the vectors $\mathbf{V}_2$ and **V** at E1. It should be noted that for this simple velocity diagram, all the above angles and vectors shown in Fig.2b have been calculated in the laminar where they all act.

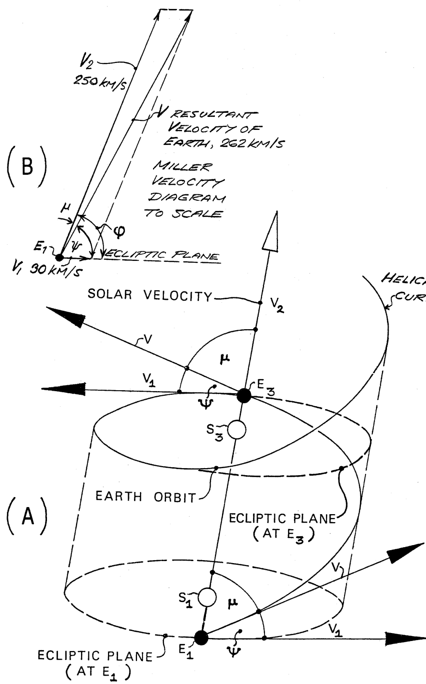

Figure 2: Helical orbit of the Earth due to the solar motion.

If velocity diagrams are calculated for every orbital point of a terrestrial year, and then if all the velocity vectors **V** are taken from a common origin O, they will form a narrow 'cone of aberration' about the apex of the solar velocity $\mathbf{V}_2$ on the celestial sphere, since μ is always less than 7° in magnitude. This surprising narrowness is caused by the latter galactic velocity $\mathbf{V}_2$ being the order of 8.333 times greater than the terrestrial velocity $\mathbf{V}_1$ acting in the ecliptic plan. Because the spatial motion of the sun is ignored in the Heliocentric System the apparent direction of the terrestrial velocity relative to the sun always describes a closed two-dimensional elliptical orbit. But when the observer's frame of reference is transferred to the galactic centre and the solar motion is allowed for, the resultant locus of the Earth's orbit will be found to describe an open three-dimensional helix in space with elliptical co-ordinates, with the sun's velocity acting as the vertex generator. The main parameters are shown in fig.2a, where the direction of the resultant velocity **V** of the Earth is at all times along the tangent to this helical orbital curve and not parallel to the ecliptic plane: angle μ is not shown at the correct angle in 2a.

However, it is now known that the centre of our galaxy also possesses a spatial motion of its own. Therefore, the apex of the solar galactic velocity alone would not provide a sufficient datum to derive the absolute spatial motion of the Earth. But the above example does illustrate the difficulty faced by an experimenter that attempts it.

5. Conducting the experiment

Given the limited technology and astronomical data that was available in 1924 to 26, Dayton Miller was forced to attempt to detect the apex of the absolute terrestrial velocity with an instrument that was so large and heavy that it was impossible to take advantage of a telescope mounting. It involved taking more than 200,000 visual readings of the positions of interference fringes while the observer slowly rotated the instrument in a horizontal plane and walked in a small circle, a distance of some 250 km, over the full period of the experiment. In order to ensure that that the optical paths swept through the unknown apex of the terrestrial motion, the instrument required continuous rotation for nearly 24 hours, and the whole process had to be repeated at four evenly spaced epochs in a terrestrial year.

That is why the problems involved in obtaining the Apex of the motion of the Earth have been previously elaborated. It should now be clear why it is essential that this new experiment should have an instrument that is small and light enough for mounting on an equatorial telescope, to ensure that it can be conducted at a time and on celestial co-ordinates of the observer's own choosing.

With the above assumptions in mind the ideal procedure may well be not to prejudge the position of the terrestrial motion, as this is still in some doubt even today, but that the observer should select an arbitrary preferred point on the celestial sphere as the initial datum. It is of course assumed that the instrument will be capable of a remote controlled operation. Whilst the spectrometer readings obtained will also be automatically registered and recorded for analysis after an experimental session is completed.

If the experiment is commenced with mirror arm A aligned with the hoped for apex of the spatial motion on the celestial sphere, and a non-relativistic Doppler Effect is at all possible, then spectrometer C should register a maximum blue shift at this point. Whilst the data from the other arm B and spectrometer D being transverse to the spatial motion should register an unshifted wavelength.

By now rotating the instrument through 90 degrees in a clockwise sense, the two arms would interchange their roles, and arm B would now be pointing at the apex. Another quarter turn would result in arm A being aligned with the anti-apex of the spatial velocity. This should therefore result in spectrometer C registering a maximum red shift, whilst arm B being once again transverse to this motion, spectrometer D should indicate an unshifted wavelength again.

So every full turn of the instrument should create a series of maximum and minimum shifts in wavelengths between the data recorded by the two spectrometers. This data could no doubt be printed out graphically in wave form, where the peaks and troughs would indicate the magnitude of the blue and red shifts, if indeed any occurred.

It was previously pointed out that ideally the arms should be fixed on a chosen point on the celestial sphere whilst measurements are obtained. The rotation of the instrument during the period of measurement should be avoided if possible to avoid the secondary Doppler Effects that may occur, caused by a rotation of the instrument alone.

The non-relativistic Doppler shift to be expected is given by the formula,

$$l' \approx \frac{u\,l}{c} + l \tag{1}$$

where l is the rest wavelength of light, l' is the shifted wavelength of light, c is the velocity of light, and u is the velocity of the source (or mirror), where the convention is that when a source (or mirror) is moving towards the observer u is minus. So that the spatial velocity u would be obtained by,

$$u \approx \frac{c\left(l' - l\right)}{l} \tag{2}$$

However, the instrument is designed to rotate through a vertical axis and the initial alignment of one of the arms with the apex of the spatial motion cannot be guaranteed. Also the motion of the mirrors influences the magnitude of the hoped for Doppler Effect, so that the formulas derived by W.M. Hicks’ own analysis would appear to be more appropriate. These follow below without their formal proofs.

The modification produced on the light at any point by motion of the source: owing to this motion the light reaching a point P will not come from the instantaneous position of the source but from a position occupied by it at some time previously. Consequently if S denote the source, P this position, and n the velocity of S perpendicular to SP, the light at P makes an angle q with SP where, $c \sin q \approx v$. P in the above case is a fixed point on the instrument, such as a mirror, or a Spectrometer. Also, if l' denote the wavelength at P (or c / l' the frequency), and if l denote the rest wavelength of the source, and u denote the velocity of the source with respect to P,

$$l' \approx \frac{(c \cos q - u)}{c} \times (l \cos q) \tag{3}$$

where according to Hicks, u is to be regarded as positive when the source is moving towards P and negative when it is moving away from P. Also c is of course the velocity of light, and angle q is as above.

Although it was stated that the light waves measured by the spectrometer from the arm that was moving transverse to the spatial motion would remain unshifted this is not entirely correct. The motion of the mirror causes an aberration in the direction that the wave fronts make with the optical axis of the spectrometer, so that the wavelengths registered by it are not the true wavelengths but only apparent ones. If we follow Morley and Miller’s response to W.M. Hicks’ criticisms, and take their own extreme example that the spatial velocity of the earth is one half of that of light. Given that the velocity ratio would then be that the velocity of light c is 2 and the velocity u of the earth is 1, the general condition is shown in Figure 3.

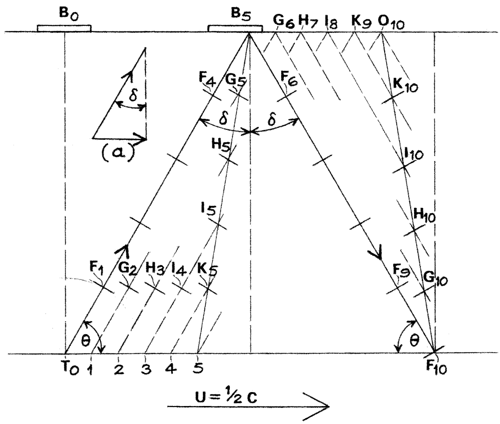

Figure 3: Displacement of successive wave fronts caused by the lateral spatial velocity of the source and mirror.

A ray of light would trace out a path T0 to B5, and on reflection from the moving mirror B would complete an equilateral triangle, with velocity u moving at $1/2c$ from left to right in the figure. The incident and reflection angles d would be equal. Fig.3a shows the resulting velocity diagram: where $\cos d \approx \sqrt{(c^2 - u^2)} \div c$, therefore angle d is 30°, or $d = ½q$. In the time T0, T1,….Tn, each successive wave front G6, H7, I8, K9, etc., would be reflected off the moving mirror at different spatial points as shown, where the angle d is the aberration caused by the moving mirror. Figure 4 shows the position of the wave fronts relative to the optical axis of the moving spectrometer D at time T15. At this time the optical axis is on line T15, Q. The successive wave fronts F15, G15, H15, I15, K15, are on line O,P, at the same time interval. The actual wavelengths are given by l, but the *apparent* wavelengths measured by the spectrometer are as L, where from figure 4, $L \approx l \div \cos d$. For example, with the above extreme velocity u the rest wavelength of yellow light would be increased by some 15.5% as measured by the spectrometer's optical axis along L.

Since the actual absolute spatial velocity of the Earth is very likely only a small fraction of the velocity of that of light, the difference between the apparent wavelength L and the rest wavelength l would be proportionally reduced, but it should still be allowed for.

In the case of the arm A which is moving directly with the spatial motion in this example, the light reflected off the mirror A is perpendicular to its motion and so the phenomenon of aberration does not occur.

It should be noted that with the Michelson interferometers used in the so-called Ether Drift experiments, the apparent wavelengths from *both* mirrors should be identical due to the motion of the central beam splitter plate causing aberration to both of the recombined beams as

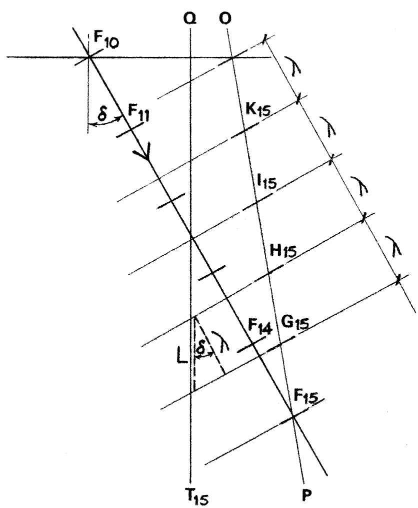

Figure 4: Position of displaced wave fronts at time T15.

viewed in the telescope, at least in theory.

If the result of the experiment is inconclusive with the instrument aligned with the initial selected apex, then the search could be gradually expanded to cover the whole celestial sphere. If it were to be objected that this would incur an unnecessary time and expense then the search could be limited to a few of the most likely coordinates only.

For example, the discovery of an apparent dipole anisotropy of the cosmic microwave background radiation (CMBR) by G.F. Smoot, *et al.* [11] has become increasingly regarded as evidence that the solar system has a spatial velocity of some 370 km/s with an apex on the celestial sphere at RA 11.2 Hrs., and declination - 7º.

Another apex to be selected should surely be D.C. Miller's, since he was the only experimenter to actively seek one, and his results could therefore be finally checked by a direct experiment. His final conclusion was that this apex was at RA 4.9 Hrs., and dec. - 70.55º. This location is in the constellation Dorado in the southern hemisphere. The anti-apex in the northern hemisphere would be diametrically opposite this. Its RA would be the RA of the apex +12 hours. Its declination would have the same numerical value as per the apex but with a plus sign.

Another worthwhile search may be the catalogue of the peculiar velocities measuring the spatial motion of the solar system relative to the nearby galaxies, research which has been undertaken for years by V.G.Rubin, N.Visvanathan, *et al.*

6. Time dilation and spatial motion

For almost a century a great number and variety of physical and astronomical experiments have been devised and conducted to verify the prediction of the phenomenon of time dilation in accordance with the equations of (SR) and (GR) Relativity. With the modern techniques of atomic clocks and other high frequency measuring devices of extreme precision being increasingly available, time dilation in accordance to the theory have invariably been claimed to have been proven within a margin of experimental error of less than one percent.

In all such tests, whether conducted within a terrestrial laboratory, or of an astronomical nature, the spatial motion of the Earth during the time interval of the experiment has not been considered. Or if it has, it has been assumed that the velocity vectors obtained within the Heliocentric System have been sufficient to obtain the above level of accuracy. This assumption has been held in spite of the fact that all radiant energy, regardless of its frequency, once it has been emitted from its source, travels independently through all three dimensions of space in spherical waveform. We have already seen that in the heliocentric model of the solar system the planets describe closed elliptical paths in two dimensions of space only, whereas, when the sun's own spatial motion is considered, the planets move through space in open helical orbits in three dimensions. For everyday matters, or for measuring the behaviour of material particles in physical experiments, the heliocentric model provides a sufficient level of accuracy. But since time dilation involves utilizing radiant energy in some form as the measuring system to detect the phenomenon, it does not appear to be justified to assume that a heliocentric reference frame provides a sufficient level of accuracy during the time interval of conducting such tests.

As an example we could examine what is one of the most impressive astronomical experiments that demonstrate one aspect of the phenomenon of time dilation. This is the so-called Shapiro Effect. This was named after Irwin.I.Shapiro [12], who in the 1960's proposed a fourth test of General Relativity (GR). Namely, that according to this theory the speed of a light wave depends upon the strength of the gravitational potential along its path. He suggested that with the powerful radars that were now available this could be verified by observing the time delay of radar signals returned to Earth from the surface of the planets Venus and Mercury. The estimate was that the effect of the sun's gravitational field on the radar beam would cause a delay of as much as 200 microseconds in the round trip travel time of these radar signals when the beams passed in their closest approach to the solar disc.

More recently, as a result of NASA's Viking project, an unmanned landing craft placed transponders on the surface of the planet Mars. These devices were able to return the radio and radar signals from the Earth instantaneously. Such a controlled response from fixed Martian positions eliminated the random nature of reflected signals from an irregular planetary surface.

The ideal period for the experiment occur when the line of sight between Earth and Mars draw at their closest at superior conjunction, see Figure 5.

As the beams pass closer and closer to the Sun, a delay in transit time is measured which at the closest approach, the gravitational time delay noted is 200 microseconds.

These experiments have been repeated many times and they are considered to verify the equations of GR to within a margin of error of less than one percent.

However, the essential assumption underlying this experiment is that the astronomical distance between the two planets, and their spatial positions relative to each other at any given time, are known to a high order of accuracy. This assumption is correct within the heliocentric model as long as it refers to the motions of material bodies only. But since radio and radar beams travel in spherical waveform through three dimensional space, once emitted from their

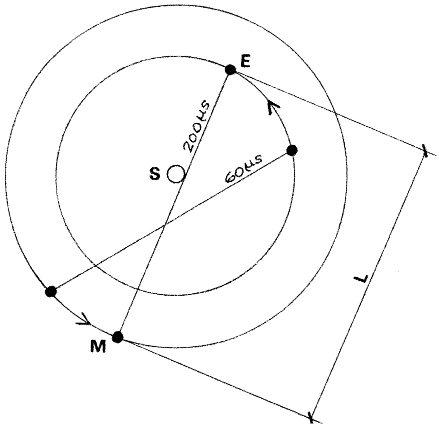

Figure 5: Increased time dilation as the orbits of Earth and Mars approach Superior Conjunction.

source, it would appear to be essential that the absolute spatial motions of the two planets and the sun must also be considered during the total time interval of such experiments.

The position of these three bodies shown in figure 5 at superior conjunction is, in effect, a typical plan view as derived in the two-dimensional heliocentric system.

The astronomical distance L between Earth and Mars is a maximum of about 400 million kms, in this model. If we ignore any drag effect upon the speed of the radiation caused by the solar gravity, then the total time of travel T of a beam of radiation from Earth to Mars and back again would be given by,

$$T \approx \frac{2L}{c} \tag{4}$$

where c is the accepted velocity of light.

In the previous section on conducting an experiment it was suggested that two of the apexes for the absolute spatial velocity of the Earth may be Miller's own position in the constellation Dorado, and also the dipole anisotropy of the CMBR. The first apex is almost perpendicular to the solar ecliptic in a southern sense, whilst the latter one is only some 16½ degrees from that of the ecliptic. If for discussion, we take the two possible extreme directions for the apex of the spatial motion as being firstly, directly perpendicular to the plane of the solar ecliptic in a southerly sense, and secondly, exactly parallel to this plane, it can be established what influence this spatial motion may have on the measurement of the Shapiro Effect.

It is also fortunate that the mean orbital velocity of Mars is less than 6 km/sec. from that of the Earth's own, while the Martian orbital inclination is also less than 2 degrees from that of our own planet's ecliptic plane in the heliocentric system, so that the direction and speed of the two planets resultant spatial velocity caused by the sun's own spatial motion would be almost identical in the short term.

The general condition of Miller's derived apex is shown diagrammatically in Figure 6, below. The distance L of 400 million kms connecting E1, S1, M1, are those of the three celestial bodies derived in the heliocentric system. But if the perpendicular apex is now considered, then due to the solar motion, a beam of radiation travelling through three dimensional space from Earth at E1, would arrive at Mars when it was in position M2. It would then be relayed by the transponders on its surface at M2 and return to Earth when it was in position E3. So that if we ignore the effect of the solar gravity, then from the geometry of the diagram, the time of travel would be,

$$\text{E1 to M2} \approx \frac{L}{\sqrt{c^2 - v^2}}$$

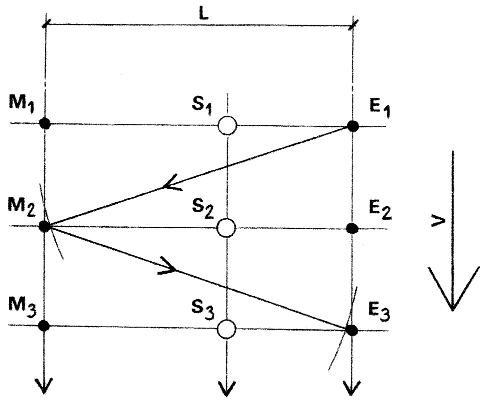

Figure 6: Three dimensional displacement of Earth and Mars during a Time Dilation experiment.

and the time of travel for the return journey,

$$\text{M2 to E3} \approx \frac{L}{\sqrt{c^2 - v^2}}$$

where v is the absolute spatial velocity of the three bodies, and L and c are as before. So that the total time T from E1 to E3 would be,

$$T \approx \frac{2L}{\sqrt{c^2 - v^2}}$$

$$\approx \frac{2L}{c\sqrt{1 - v^2/c^2}}$$

This is approximately,

$$T \approx \frac{2L}{c} \times \left(1 + v^2/2c^2\right) \tag{5}$$

In the case of the parallel apex we could assume that the direction of the spatial motion is directly from Earth to Mars, or vice versa. Since we chose to make this velocity vector parallel to the solar ecliptic the beam of radiation would travel through two dimensions of space only in this case, but the time of travel would be increased if we ignored the solar gravity again. The total time of travel *T* from Earth to Mars and back to Earth would be,

$$
\begin{aligned}
T &\approx \frac{L}{(c-v)} + \frac{L}{(c+v)} \\
&\approx \frac{2Lc}{(c^2 - v^2)} \\
&\approx \frac{2L}{c(1 - v^2/c^2)}
\end{aligned}
$$

or the total time is approximately,

$$
T \approx \frac{2L}{c} \times (1 + v^2/c^2) \qquad (6)
$$

where v, L, and c, are as before.

Of course, these two times given in eq. (5) and eq. (6) are extreme, since the direction of the apex of the spatial velocity is most likely somewhere in between. However it is clear that if time dilation is a real phenomenon, then there are *two* elements that need to be considered in measuring its magnitude. The first part is derived from the equations of Einstein Relativity (or any other relativity theory), but the second part is the physical translation of the Earth through space during the time interval of an experiment when radiation is used to measure its magnitude.

The total time of travel derived with heliocentric parameters would be via eq. (4), $T \approx 2L/c$, with any delay attributed to time dilation. But the true total time would very likely be as per eq. (5), that is: $T \approx 2L/c \times (1 + n^2/2c^2)$. This would need to be allowed for in assessing time dilation. Although of course this allowance depends upon the magnitude of the speed v and upon its direction.

Therefore if the above comments are correct, the claim that time dilation has been verified in accordance with (GR), (or any other relativity theory), *alone* and within a margin of error of less than one percent would appear to be subject to legitimate query. Since in every experiment where radiant energy has been used to measure this phenomenon a certain percentage of the time delay must be due to the absolute spatial motion of the Earth during the time interval that it has been conducted.

7. Conclusions

The assumption that the Galilean Principle of Relativity has been amply confirmed is of course soundly based when confined to the measurement of the behaviour of material particles in motion within inertial frames of reference. But the supporters of (LET) appear to have a reasonable case when they argue that when the validity of this principle has required that the behaviour of radiant energy is unaffected by the spatial velocity of the Earth, then the results have always been more ambiguous in nature. Because the objective view is that the belief that the so-called Ether Drift experiments which attempted to detect this spatial motion have always produced a negative result is *not* entirely correct. In fact most such experiments, including the famous M-M original, have always registered a small but positive result. All these experiments have been considered a failure only because the magnitudes of the registered effects were a small fraction of the earth's own orbital motion. It was recounted that the velocity vectors derived from the plane of the solar ecliptic were considered to be sufficient for the alignment of the interferometers utilized in most such tests.

We have recounted that Dayton Miller later investigated whether these unexpected experimental results were caused by the Apex of the absolute spatial velocity of the Earth not being in the plane of the solar ecliptic.

Miller's response to challenges of his more positive results in his investigation was to state that in none of the other experiments had observations been of such an extent and of such continuity as to determine the exact nature of the diurnal and seasonal variations that this absolute motion would cause.

An attempt has been made to demonstrate that by utilizing modern astronomical data, the implications of Miller's research is that the path of a planet around a moving sun is an open helical orbit in three dimensions of space. Therefore, the spatial velocity vectors derived in the normal two dimensional Heliocentric System only provide a sufficient accuracy for measuring the behaviour of material particles in terrestrial experiments. But this does not appear to be true in experiments that utilize radiant energy as the system of measurement of a phenomenon such as time dilation.

For example, in the Shapiro Effect it was indicated that since radiant energy travels through three dimensional space in spherical waveform, time dilation appears to be composed of two separate factors. The first part of time delay may be derived from the equations of (GR), (or any other relativity theory), but there is always a second part of the time delay caused by the physical motion of translation of the observer's frame of reference through three dimensional space during the time interval of such experiments. This additional physical factor must be independent of any theory that attempts to explain the phenomenon, and it applies to *all* experiments investigating time dilation and not merely to the Shapiro Effect alone.

Although interferometers have always been the principle instruments used in attempts to detect the magnitude of the spatial velocity of the Earth, scepticism has been expressed that their inherent design may be detrimental in achieving this aim. Their success depends on measuring the amount of shift in the position of interference fringes when the instruments are rotated through the assumed plane of the earth's motion. This limitation means that any positive result registered is only second order in nature. This fact, coupled with the extreme difficulty in conducting such experiments, has meant that any such data has always been easily dismissed by those who adhere to (SR) or (LR) theories.

For this reason it has been recommended that an entirely different method of measuring the magnitude of the spatial velocity should be employed. Instead of trying to seek a variation in the speed of light to achieve this object it would be better to try to detect a change in its frequency. For if a non-relativistic Doppler Effect is at all possible it would more likely be derived by the instrument previously described, for in this latter case a hoped for variation in the wavelength from the moving source, caused by the earth's motion, can be measured directly without the intervention of a complex system of mirrors and beam splitting devices. Also, since it is a first order device, the result of the experiment would be unambiguous-regardless of its verdict. Of special merit is the fact that the operation of the instrument would be unaffected by any so-called Fitzgerald-Lorentz contraction that is required by (LR), to confuse the issue.

Therefore, this novel way of testing the Galilean Principle of Relativity would appear to be justified, because if the result of such an experiment still produces a null result it would confirm the validity of the Galilean principle extended to the behaviour of radiant energy, and favour the established paradigm of Einstein Special Relativity.

However, should the result register even a fraction of the Absolute Spatial Velocity of the Earth it is difficult to see any other explanation than that provided by a variant of (LET) theory. Finally of course, it would also be able to confirm or reject the still controversial results obtained by Dayton C. Miller by a direct experiment.

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