Standing Wave Interferometry

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Abstract

The effect of energy in standing waves upon the component wave velocities is discussed. The Silvertooth experiment, using a specially constructed photodetector that can scan along a standing optical wave with anomalous results, is shown to have a possible explanation which suggests that the energy can affect wave velocity. The technological implications of the Silvertooth experiment are of sufficient consequence to warrant further investigation.

Key words: ether detection, Silvertooth experiment, standing waves

1. INTRODUCTION

Historically the ether is regarded as a luminiferous medium in that it provides a frame of reference for the constant speed of light. Einstein's theory has led us, however, to accept the proposition that light speed is constant in a vacuum frame referenced on a nonaccelerated observer. Both of these propositions can be true if the ether has properties similar to those of a fluid crystal in that given the constraints of a local field presence, the space lattice that sets the local electromagnetic reference frame is nucleated on the structure sharing the observer's motion.

An experimental point then emerges. Can a machine sharing the virtually nonaccelerated motion of the Earth-bound observer, but having internal parts that are stongly accelerated, in some way upset that local space lattice to dissolve its connection with the observer? Alternatively, might there be an intermediate region of space in the accelerated zone that forms, between space lattices coextensive with local nuclear structure in matter, an in-fill lattice structure which is seated in an independent frame of reference? The latter is seen as that of an absolute or cosmic background frame of reference in regions devoid of matter. It gives us reason for probing the question of the true light speed reference frame in vacuous space.

A further experimental point emerges from the above hypothetical picture, bearing in mind that we sit on a rotating, and so accelerated, Earth. This is whether the degree of acceleration needed to dissolve the "fluid" space lattice form in such intermediate regions is a function of electromagnetic standing wave energy. If such energy has a sufficient presence and shares the translational motion through space of an enclosing apparatus, it may well be conducive to the formation of a bridging space lattice filling the interstices between atomic nuclei and locked into common motion with that substance. Perhaps standing wave conditions will then invalidate interferometry tests to measure motion through an absolute frame of reference.

These are speculative issues that would not warrant special attention but for certain experimental anomalies that need explanation. One of these anomalies is provided by the Silvertooth experiment, but another concerns the gravitational action, as interpreted in a manner unifying it with electromagnetic field effects. This paper concerns the Silvertooth topic and will not develop the latter theme except in the following brief way.

If the space lattice coupled with atomic nuclei is really the seat of the gravitational force and gravitons which mediate in this action act on the lattice in the close proximity of the relevant gravitating matter, it follows that any rupture of the lattice in the manner just outlined will mean that the gravitational force is partially exerted not directly on the accelerated matter but indirectly via the general background space lattice. Of crucial importance is whether this background space lattice is locked to and referenced on mother Earth for some distance above the Earth's surface, or whether it has some connection with the Sun, or whether it is set in some absolute or cosmic frame of reference. This is high speculation but speculation encouraged by the observed weight-loss properties of the force-precessed offset gyroscope as evidenced by the researches of several independent investigators.[1]

The distinction between a force-precessed offset gyroscope and a naturally precessed offset gyroscope is that the latter is precessed by an out-of-balance gravity action, whereas the former involves forces applied directly through the interatomic bonds of the gyroscope structure. The gravity effect acting via the space lattice adjacent atomic nuclei will not cause the lattice to dissolve, because the action is distributed over a region of lattice not coextensive with the atomic nuclei. Indeed, because of thermal vibrational motion with the flywheel, the atomic nuclei are displaced through much larger microscopic distances than the gravitons can move in their short lifetime. The gravitational action is then spread over a relatively substantial region of lattice. Since the lattice transfers the gravitational pull to the atomic structure, it can hardly be possible for the atomic nuclei to pull away from its enveloping lattice. There is then no dissolution of lattice in the dense body of the flywheel, and so it is not segregated into nuclear units separated by an in-fill lattice structure.

However, there could be such a dissolution even in dense matter if the action is not gravitational and is concentrated by physical force acting on the atomic electrons and via them on the atomic nuclei.

It will be some considerable time before research on the antigravitational properties of force-precessed gyroscopes clarifies this issue. The issue is confused, somewhat, because there is strong evidence suggesting that at least two new phenomena are involved. Apart from the weight loss there is a loss of centrifugal inertial effects for both the forced or natural mode of precession. This should not preclude us, in the meantime, from exploring the related research opportunity provided by Silvertooth's investigations.

2. STANDING WAVE RESONANCE EFFECTS

It is the general belief that when two electromagnetic waves traverse the same region of space, each is completely unaffected by the presence of the other. Maxwell's equations are deemed to apply by linear superposition. The mathematics of the field equations take precedence over the physical consideration of how energy is deployed in the interfering wave system. Very simply, there are regions where the wave vectors have components in the same direction and regions where their components are in opposition. This means that the combined wave intensity, which is a measure of field energy density, is greater in some regions than in others. The energy has somehow deployed itself spatially as a function of the way in which the waves interfere. Now, if the two waves are traveling in the same direction, this is not really a problem, because the energy can move at the same speed. However, Maxwell's equations do not really tell us how that energy density adjusts without some speed adjustment when two converging waves come together. They give us formulas for use in calculating the energy distribution but do not spell out how energy can redeploy unless some can travel at a lower-than-light speed and some at a faster-than-light speed.

The author would rather believe that electromagnetic wave energy cannot travel at faster-than-light speed, virtually by definition, whereas what we refer to as waves can exhibit superluminal properties if the energy conditions make that physically expedient. In short, the author challenges the relativistic doctrine to the extent that it stands in the way of physical intepretation of new experimental data.

It is emphasized by those specialist in these matters that Maxwell's equations are rigorously valid and that energy cannot travel *in vacuo* at faster-than-light speed. However, there is something manifestly wrong with this combination of propositions. It is accentuated when we consider two similar plane polarized waves of identical frequency traveling through one another in opposite directions. We can choose an antinode position in the path at which the combined wave intensity has a maximum value. We can equally choose a different position at a node at which the combined wave intensity is always zero. The energy has become spatially segregated in a standing wave situation. It follows that if field energy density has any real physical presence, that energy cannot travel continuously with the waves at the constant speed of light.

Imagine a laser in which waves travel forward and backward along the same path to set up this standing situation. The energy trapped between the nodes has to be physically transported through space, carried along by the laser. Now, suppose instead that we have no laser but are at a position in space where two such waves seen to have the same frequency and coming from remote sources happen to be traveling at a constant speed relative to us as observers. The nodes and antinodes still exist, and field energy is trapped between the nodes, which are at rest in our observer rest frame.

In one case the laser certainly drags the antinode energy along with it in its motion through space. In the other case the energy is held in the reference frame of the observer. It is hardly dragged along by the observer. However, more important is the fact that in either case there is a valid argument of symmetry. If the motion, as opposed to the presence, of the energy field can affect the speed of the two waves, it must operate in an equal measure in increasing the speed of one wave and decreasing the speed of the other by the same amount. Put another way, the speeds of the oppositely directed waves must be compliant to assure that the antinodal energy disposition is not at all affected by the nonaccelerated speed at which the laser is transported. This further ensures that the speed of light as referenced on the body of the laser is the same along either axial direction.

Why should the energy field affect the speed of light? The answer is found by analogy with light traveling through a refractive medium. Energy density has to be a governing factor, the problem of the vacuum field being only that of justifying its nondispersive characteristics.

From this discussion it should be clear that the constancy of light speed as judged by an observer sitting in a standing wave field or as referenced on the moving laser is really an artifact of the standing wave condition. The light waves have adapted in speed over the interference path and to the extent that they do fully interfere, to allow the standing energy field to develop.

The direct way in which to test this proposition is to avoid measurement of light speed over a ray path that expressly sets up standing waves.

3. THE MICHELSON-MORLEY EXPERIMENT

The Michelson-Morley experiment was based on the assumption that the wave velocity of light traveling to and fro between a mirror and a beam splitter is absolutely independent of the energy set up by the standing wave condition. Michelson and Morley and a century of physicists teaching the physics involved have all made the assumption that light travels at a speed which in no way depends upon the energy field set up by reflected waves. Although it can be said that standing waves can be predicted from Maxwell's theory, the Michelson-Morley experiment was performed before Wiener's experimental detection of the standing wave phenomenon. Until that discovery was made it seems unlikely that researchers would have realized that standing waves form nodes and antinodes which inevitably share the translational motion of the mirror by which they are set up by a 180-deg reflection of the incident wave.

We know from Maxwell's theory that the motion of an electromagnetic wave traveling freely through empty space involves transport of the energy in the wave at the wave velocity. We know that when that wave is reflected through an angle close to 180 deg the standing waves halt that energy to cause it to relate to a lateral field oscillation with no forward motion relative to the reflecting surface. We also know that if the lateral field oscillations in the standing wave are in time phase along the length of the beam, the wave velocity c is the same in either direction for the incident and reflected waves as measured relative to the reflecting surface. As already noted, this is a physical requirement, justified essentially by a mathematical argument owing nothing to the logic of the theory of relativity, but it is not something that is easily verified experimentally.

The question then arises whether the Michelson-Morley experiment was conclusive in showing that the speed of light traveling freely in empty space is independent of the motion through space of the 180-deg reflecting mirror surfaces in the apparatus.

4. A MODIFIED MICHELSON-MORLEY EXPERIMENT

The uncertainty just outlined above is not expressed in the formal teachings, which rely on the premises on which Einstein's theory were founded, yet this can easily be tested. The obvious test configuration is one that creates a narrow coherent light beam and avoids the reflected rays from traversing the exact path and so overlapping the space taken up by the incident rays. The 180-deg reflections are replaced by 90-deg reflections in the mirror configuration shown in Fig. 1. It is believed that the form of apparatus depicted will be self-explanatory to readers familiar with the Michelson-Morley apparatus. Consideration will show that the apparatus can achieve the same test objectives but that its design eliminates the just-mentioned standing wave condition.

An interferometer using 90-deg mirror reflections was used by Michelson in a later experiment.[2] This was designed to detect the rotation of the Earth by reference to the nonrotating light reference frame. It gave the expected positive result and was not a null test in the sense of the original Michelson-Morley experiment.

It is submitted that the importance of the Michelson-Morley experiment is such that we cannot afford to tolerate the slightest doubt as to whether it is ill-founded owing to this standing wave uncertainty. The experimental setup shown in Fig. 1 therefore warrants our attention.

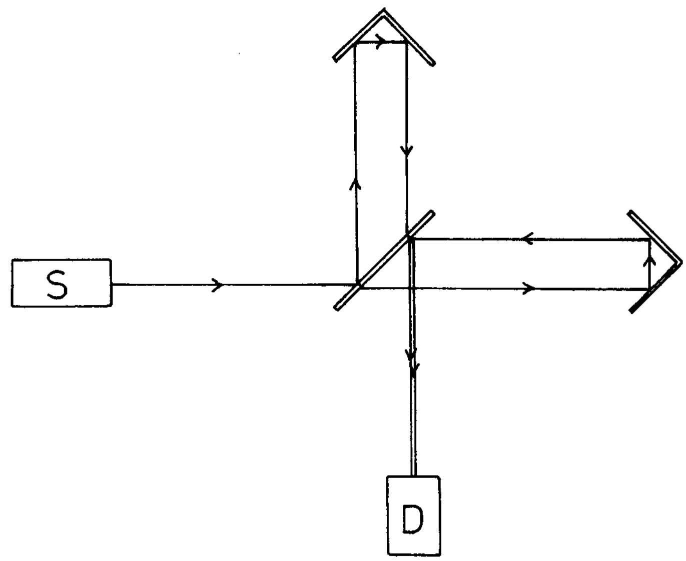

Figure 1. Michelson-Morley apparatus modified to avoid standing wave conditions.

5. THE EXPERIMENTAL OPTION

The apparatus of Fig. 1 could be used to repeat the Michelson-Morley experiment in a way that can eliminate doubts raised by the standing wave argument. Based on the same reasoning as that of Michelson and Morley, this configuration of beam splitter and mirrors should allow detection of light speed anisotropy, if it were really present. The theory is the same and so the objective is to sense a variation of the square of v/c, where v is the speed of the test apparatus through the imaginary preferred frame, and c is the speed of light assumed to be isotropic in that frame.

It has been suggested to the author that this distinguishing test is not worth doing, because in the mirror configurations actually used in certain Michelson-Morley tests, the separate light rays were subjected to multiple reflections before being brought back together to set up the interference observed. The argument is that these rays are reflected at spaced points along the mirror surface and so their incident and reflected components travel along different paths and so cannot set up standing waves.

The weakness of this criticism is that in these experiments there are in fact residual effects which do correspond to a non-null situation, albeit of insufficient magnitude to be a measure of the known motion of the earth through local space. More important, however, is the fact that the adjustments by which the light rays are reflected at spaced points are based upon seeing distinct spots when light is intercepted at the reflection surface. The experimenter is satisfied if the spots are sufficiently distinct to allow a count of the number of reflections involved and they are therefore as close as possible. It is inevitable, if a plane mirror construction is used, for the light rays to pass through one another in opposite directions over a significant range of the separation distance between the mirrors. The closer the light spots, and so the points of reflection, the greater this overlap of the oppositely moving rays. Indeed, the spots can be separated slightly, even though the rays overlap in some measure, over the whole distance between the mirrors, bearing in mind that when a reflected ray reaches the halfway position, it really becomes an incident ray entering the ray path of its own future reflection.

It cannot therefore be said, with any justification, that the test based on the Fig. 1 mirror configuration is superfluous. It really is essential if we are to hold faith with the accepted interpretation of the Michelson-Morley experiment.

However, there is a special argument that we can now use. If our doubts were sustained and the Fig. 1 test were to give evidence of anisotropy of light speed, that evidence would be based on detection of an effect having second-order dependence upon v/c. It would be a very small effect and difficult to detect unless the apparatus and experimental conditions are special. Happily, however, on the same physical basis and with the benefits provided by the modern laser, there is now the possibility of designing an experiment that affords a direct first-order sensing of v/c. This is now explained.

If the standing wave condition "forces" local light speed to be isotropic relative to the frame of the apparatus, and free waves travel at a speed that is isotropic in the so-called "preferred" frame, then this first-order measure in v/c simply has to be a possibility.

Such an experiment, based upon the above argument was suggested by Aspden[3] and arose from collaboration with Silvertooth, who was then involved in the preparatory design work for a conclusive experimental test which was first briefly reported in 1986.[4]

Silvertooth was not thinking in terms of energy interactions affecting wave velocity components in standing waves. His motivation arose from a concern that the well-known Sagnac effect, as used in ring laser gyros, had empirical implications when examined in the light of the null result of the Michelson-Morley experiment. His objective was to build a nonrotating Sagnac configuration with a linear path section and actually scan a detector through that linear path to sense for evidence of any v/c effect that might have eluded Michelson and Morley. The principles involved in the Sagnac effect are, of course, the same as those involved in the Michelson-Gale experiments detecting Earth rotation.

The point about this approach is that the Sagnac interferometer does sense rotation of the apparatus relative to an inertial frame of reference. This conforms with the predictions of those who advocate an ether, but the accepted viewpoint of the few modern physicists who have sought to defend the relativistic viewpoint on this issue tends to follow the interpretation suggested by Langevin.[5] This renders the Sagnac experiment consistent with the behavior of the Foucault pendulum or the gyroscope and assumes that it is explicable within the framework of general relativity. Nevertheless, since there are standing waves in the Sagnac interferometer that are not locked to the mirror surfaces, owing to the avoidance of 180-deg reflections, the question remains open for clarification by experiment.

Silvertooth commissioned the construction of a special type of standing wave sensor. It was fabricated from standard parts of image orthicons by General Electric in the United States. This sensor was able to measure the intensity of a standing wave beam passing through a 500 Å thickness of a photocathode formed by a photosensitive coating on a transparent aperture. This coating thickness was much smaller than the laser wavelength used with the detector, and it made it an effective device for scanning a standing wave beam and measuring its amplitude variations. The wave sensor is reported by Silvertooth and Jacobs.[6]

Silvertooth then embarked on an experiment that is quite remarkable in its conception.

In its most recent form, as recently disclosed by Silvertooth,[7] it uses a single laser which performs two functions. Firstly, the laser supplies a ray that is divided to pass clockwise and counterclockwise around a loop which includes the linear section scanned by the specially constructed photodetector. This sets up a standing wave along the axis of the detector. Secondly, the laser supplies a ray that is fed into a conventional Michelson-Morley mirror configuration to set up a separately sensed interference pattern that can measure displacement through successive half-wavelengths at the laser frequency with a reliable dependence upon an isotropic value of c.

This displacement measuring device is used to determine when the standing wave sensor, the specially constructed photodetector, has moved through an integral number N of the wavelengths λ in its linear scan, where λ is c/f, and f is the laser frequency. The following theoretical analysis will then reveal how the experiment works.

6. ANALYSIS OF TEST METHOD

This analysis depends upon how one understands the detector to operate and also upon whether the standing wave system is a free system, as in a Sagnac configuration, or is a "forced" system, as in a Michelson-Morley configuration.

As to the detector, the thin photocathode will intercept light waves fed from either direction. This means that in the apparatus used by Silvertooth the detector responds to the superimposed action of the two oppositely traveling wave components. However, we have spoken of a "forcing" action which arises only to the extent that a wave traveling one way has to contend with its equal traveling the other way.

This introduces an unfamiliar notion. The electric field at a single position in a standing wave can comprise three different components, and if the detector takes an average over several such positions, there can, in fact, be four component waves to consider.

Imagine first that light waves having the same frequency and polarization travel through one another in opposite directions and suffer no absorption by a photocathode. If one wave has a greater amplitude than the other, then that wave really has two separate components: one that is an equal match in strength for the wave coming in the opposite direction and one that we can say is the residual wave component. The "forcing" action only influences how the matching waves affect one another.

On the basis of the foregoing discussion it is suggested that the latter effect is to render both wave velocities equal in the frame in which the countermoving waves are seen to have the same frequency. This means that we have really three waves to consider: two moving in opposite directions at speed c and one residual wave moving conceivably at a speed set by a free-space condition.

When the photocathode is present, then what would otherwise be a farily uniform wave system becomes more complicated, because a wave approaching the photocathode from one direction can be the stronger wave on the entry and the weaker on passing through, as judged against the oppositely moving wave. The same argument holds for the wave coming from the other direction. The photocathode is therefore really affected by four identifiable wave components: two that together behave as a normal standing wave condition and two that are really of separate character and have speeds $c + v$ and $c - v$, where v is a measure of translational motion of the detector through free space along the beam axis.

The most important point to then consider is that these latter wave components never penetrate fully through the photocathode. They are wave components that see no interference from the oppositely moving waves. All they see are the atoms in the obstructing photocathode. However, the extent to which they are affected in being attenuated by these atoms is a function of the electric field amplitude of the underlying standing wave presence. They combine to define a local wave intensity to give a measure of what is detected as a signal output.

It can, therefore, be envisaged that in general terms, using a suitably polarized coherent light source with appropriate optical equipment, the photocathode will "see" four wave components. We suppose that in its initial position the photocathode is positioned to respond to a maximum intensity combination of these wave components. We write them as

$$\alpha \sin(2\pi ft) + \alpha \sin(2\pi ft) + \beta \sin(2\pi ft) + \gamma \sin(2\pi ft), \quad (1)$$

where t is time.

Now consider these waves at a point along the axis displaced by the distance Δ. They become:

$$\alpha \sin(2\pi ft + 2\pi\Delta/\lambda) + \alpha \sin(2\pi ft - 2\pi\Delta/\lambda) + \beta \sin(2\pi ft + 2\pi\Delta/\lambda_1) + \gamma \sin(2\pi ft - 2\pi\Delta/\lambda_2), \quad (2)$$

where $\lambda_1 = (c + v)/f$, the inverse of which, to first order in v/c, is $(1/\lambda)(1 - v/c)$. Also, $\lambda_2 = (c - v)/f$, the inverse of which is $(1/\lambda)(1 + v/c)$. Note that all consideration of relativistic effects such as the Lorentz contraction are avoided, because they give rise to second order effects in v/c. Such effects are important so far as the outcome of the experiment outlined in Fig. 1 is concerned. Silvertooth, from his empirical interpretation of the Michelson-Morley experiment and the Sagnac experiment, believes that that experiment will give a null result as consistent with relativity theory. However, the issue is open and his experiment aims at a first-order effect in v/c measurement, which allows us to ignore second-order effects.

Now suppose that the photocathode senses the intensity in terms of the square of the sum of these four wave components. However, by using the N count to ensure that the detector is stepped through a known integer multiple of steps λ, suppose it moves through the distance Δ before the total intensity is again a maximum and the standing wave α components are in the same phase. The four wave components in this new position will then be independent of the terms in $2\pi\Delta/\lambda$ because this involves no change of phase. This allows us to write the sum of the four wave components at the new maximum intensity position as

$$2\alpha \sin (2\pi ft) + (\beta + \gamma) \sin (2\pi ft - 2\pi Nv/c), \tag{3}$$

as may be verified by eliminating the wavelength terms from Eq. (2).

The result is that this new equation, when resolved into quadrature components, comprises a term in $\sin (2\pi ft)$ of amplitude

$$2\alpha + (\beta + \gamma) \cos (2\pi Nv/c) \tag{4}$$

and a term in $\cos (2\pi ft)$ of amplitude

$$(\beta + \gamma) \sin (2\pi Nv/c). \tag{5}$$

By squaring these expressions and adding, it is found that the intensity of the signal measured becomes a function of $4\alpha (\beta + \gamma) \cos (2\pi Nv/c)$. It passes through its maxima when N has specific values related in linear measure to v. Knowledge of N determines v/c as applicable in the direction of the photodetector axis. On such a basis v/c can be measured in the enclosed laboratory, notwithstanding the null result of the Michelson-Morley experiment.

Before referring to actual experimental data, let us now consider an alternative way in which the photocathode responds to the wave components. This is by absorbing energy from the β and γ components before the waves merge.

The β component is absorbed to input energy to the photocathode according to the square of

$$2\alpha \sin (2\pi ft) + \beta \sin (2\pi ft - 2\pi Nv/c) \tag{6}$$

and so contributes $4\alpha\beta \cos (2\pi Nv/c)$ to the measured signal. Similarly, the γ term makes its contribution and the net signal detected, so far as any axially variable component is concerned, is the same as before. This assumes that the small phase differences due to the thickness of the thin photocathode has negligible effect on this analysis. In Silvertooth's apparatus this thickness is less than one percent of a wavelength.

It is clear, therefore, that without the α term of the "forced" standing wave underlying the two free wave components, there would, on the above interpretation, be no possibility of sensing v/c. The value of α has to be finite.

7. THE SILVERTOOTH EXPERIMENT

Until May 1989 Silvertooth had only made a limited public disclosure of the findings in his experiments. Details of his latest implementation by using a single laser have now been published,[7] and the findings confirm the earlier-reported observations.[8] The earlier experiment used separate but matched lasers for the linear Sagnac circuit and the Michelson-type displacement measurement. Even so, this discloses the result by which a relationship between the measured Δ and the v-dependent orientation of the photodetector in space was observed.

Silvertooth's measurement technique involves piezoelectric vibration of a mirror in each optical path under common phase control. This allows the relative phase of the detected signals to be compared on an oscilloscope. He then adjusts the scan of the detector to vary Δ until, in Eq. (3) or (6), the terms in β and λ are 180 deg out of phase with the α terms. For this condition

$$2\pi\ (\Delta/\lambda)\ (v/c) = \pi, \tag{7}$$

because N is Δ/λ. It suffices to measure Δ by a micrometer because the nominal value of λ of the laser used is known to be 0.63 μm. However, a precision test based on the use of a single laser for the two optical systems would involve a determination of N by a count of the half-wavelength steps indicated by the detector in the Michelson part of the apparatus.

Silvertooth found that depending upon spatial orientation of the axis of his detector on a horizontal optical platform in his laboratory in Washington State, U.S.A., Δ varied with time of day but had a minimum value of 0.025 cm. At right angles to this optimum direction any displacement of the wave sensor relative to the light source in his various experiments consistently gave no discernible phase shift. This means that Δ is then too large to yield any definitive measure of v, meaning, from Eq. (7), that v is virtually zero. This is seen as evidence of light speed anisotropy of the kind sought by Michelson and Morley.

The Δ value of 0.025 cm with λ as 0.63 μm gives, from Eq. (7), a value of v/c of 0.001 26 and corresponds to a measured velocity v of 378 km/s. The direction of this motion whenever the experiment is performed is always found to be along a line drawn between Earth and the constellation Leo. This result is consistent with the anisotropy effect detected by reference to cosmic background radiation.[9]

8. CONCLUSIONS

This paper has suggested that the standard Michelson-Morley type of experiment may have failed in its objective owing to the standing wave activity that is inevitably established by 180-deg mirror reflection. The standing wave system entrains standing wave energy that does not move with the wave velocity and could well force the wave components to adopt speeds affected by that energy. Light waves travel at velocities different from the free wave velocity when in transit through energy fields, whether in dielectrics or in strong gravitational fields *in vacuo*. The Silvertooth experiment, therefore, may have replicated in a linear scanning device the same physical conditions which, in a ring laser gyro as used in navigational applications, allows absolute rotary motion to be measured.

Theoretical discussion of the Michelson-Morley experiment which does recognize that it depends upon standing wave theory (see, for example, Ref. 10) has, it seems, been too committed to the impossibility of detecting any linear cosmic motion. Thus such analysis seems to have missed the line of experimental research that has now opened up. Elbaz[10] interprets the Michelson-Morley experiment as the verification of a kinematic property of standing waves by showing that the Lorentz transformation is specific to standing waves. Yet, this argument is not advanced to cover the case in optical configurations where the Lorentz transformation may have no relevance. This is the realm of the Sagnac experiment, the Michelson-Gale experiment, the ring laser gyro, and the Silvertooth experiment.

However, the empirical arguments on which the Silvertooth experiment was based were not cast in terms of standing wave anomalies in the Michelson-Morley experiment. Nor were the "ether"-based beliefs on which the Sagnac and Michelson-Gale experiments were founded. However, unless one does admit that a different physical activity arises in these experiments when contrasted with the Michelson-Morley experiment, the logic inevitably leads to distorted formulations of light speed in the preferred space frame as a function relative to an observer. That then causes us to hold to the relativistic principles and means that we must now face up to explaining Silvertooth's observations in a way that is consistent with relativity. This author has preferred the causal standing wave argument but is aware of efforts to build a relativistic account, albeit one that implies that the photon may have mass.

An earlier experiment of record is that of Cialdea,[11] which is a one-way test to measure light-speed anisotropy and which does involve 90-deg mirror reflections and no standing waves in the test path. The experiment gave a null result and was hailed in the popular scientific press as new proof supporting Einstein's theory. However, Cialdea had used two lasers operating at the same frequency for the period during which he reorientated them to test for dependence upon v. He failed to take account of the fact that that small relative movement of these wave resonant lasers itself developed a phase shift. This phase shift exactly cancels the effect that should have arisen from anisotropy. This was the basis on which Tyapkin[12] discredited experiments of this kind. The null result of the Cialdea experiment is consistent with the free motion of light referenced on a preferred frame, if we admit that lasers (and atomic clocks) suffer frequency effects that accord with the time dilation formula with v referenced on that preferred frame. In a sense, this is the fascinating aspect of the theory of relativity; even if the preferred frame can be detected optically, relativity will still contribute its "time dilation" feature. However, the Tyapkin criticism cannot be raised against Silvertooth's single laser experiment, because in that test Silvertooth moves the photodetector, and the standing wave light system is unaffected by that motion.

In the classical experiments of prelaser days there were presumably spurious effects that could cause some flutter in the standing wave resonance. A slight fluctuation of frequency of the light source would inevitably preclude momentarily the inphase standing wave oscillation which overrides the sensitivity to the v/c response. This means that some partial anisotropy effect in the measurement could have crept in, but in a spurious, rather than systematic, way. We should therefore take note that in the protracted experiments such as those performed by Kennedy and Thorndike,[13] there was a daily variation as the Earth rotated to change the orientation of the apparatus. The effects observed were commensurate with a motion through space of 24 km/s, albeit almost all swamped by uncertainty. At that time this was seen by Kennedy and Thorndike as of no consequence when set alongside the "thousands of km/s known to exist among the nebulae."

It is therefore significant that what were reported by many such observers to be small but yet significant, though inconsistent, indications of anisotropy were no longer sensed once the frequency stability of the laser was harnessed. In theory, for a Michelson-Morley experiment with equal optical path lengths, the small frequency fluctuations of the light source in the early experiments should have little effect on the fringe patterns detected. It is surprising, therefore, that the onset of standing wave resonances during transient periods of frequency stability were not seen as a causal physical factor detracting from the physical state that was assumed as a basis for the experiments.

It may be difficult for some readers to concede that a light wave can have separate components of the same frequency which travel in the same direction and yet at slightly different speeds: one referenced on the local energy field and one on an independent frame. This is really what the author has advocated on the basis that one component is part of the standing wave system that accounts for the energy field, and the other is the free wave component that sees no interference. The more obvious distortion might seem to be one for which the composite wave is partially affected and adopts a speed that is an intermediate compromise between one referenced on the energy field of the apparatus and one referenced on the independent frame. The latter would, however, be inconsistent with Maxwell's equations as used in a refractive medium, which require that wave components add in a linear sense, even though they may have different speeds as a function of their frequency. The author sees no real difficulty in substituting the concept that speed of separate wave components depends upon how the obstructing energy or matter field responds to frequency, for one which says that the speed of the components depends upon how they match up to the energy field set up by interference with a wave moving in the opposite direction. The concept may seem difficult because it is unfamiliar. It is, however, one that may well have to be accepted once the Silvertooth experiment is fully confirmed by independent research.

What has been described above is not a ballistic interpretation of light, as has been suggested by one critic. It is an argument based wholly on wave theory and wave interaction, but one which regards the wave velocity as being subject to what lies in the wave path. What is suggested cannot be contrary to Maxwell's equations, provided those equations are used in the form in which they apply to actions in an energetic medium or the real matter equivalent, and the waves are seen as contributing to that medium as well as being affected by it.

It is conceded that there is good sense in the views expressed by another critic, to the effect that what is an unorthodox experiment having no endorsement from checks by independent authoritative sources should be viewed with suspicion if it needs an unorthodox distortion of accepted electromagnetic wave theory to give it theoretical foundation. Unquestionably, the experiment should be viewed with suspicion until its findings are undeniably confirmed. However, the reader should bear in mind that if the existing theory were to be consistent with such an experiment, the experiment would have occurred to someone and been performed a long time ago. The strong acceptance of established theory is a reason why such an experiment would not have been undertaken. It is not a valid reason for denying the results of the experiment, once performed. Only a repetition of the experiment can sway general opinion, but even to undertake such an experiment a would-be researcher needs to have some theoretical notion to guide the effort. It is particularly saddening to hear that Silvertooth has been urged to rework his experiment so that its data output is automated and so less likely to be tainted by the human desire to see what one hopes to see. Michelson and Morley did not automate their experiment before their findings were given a hearing, and the fact that Einstein's theory was unorthodox as an interpretation has not precluded its intrusion into our scientific philosophy.

To conclude, it can be said that in finding a way in which to use a laser which avoids standing wave node locking to mirrors in a linear implementation of a Sagnac-type apparatus, Silvertooth has revealed new possibilities in optical experimentation. His findings warrant our attention, particularly in the light of the theoretical case presented in this paper. It is unreasonable to build future centuries of scientific thought on the truths of the Michelson-Morley experiment if there is the slightest doubt as to its meaning that can be reconciled by alternative experiment. It is the doubt raised by the related Trouton-Noble experiment that has motivated this author to challenge aspects of electrodynamic law.[14] Hence there is an ongoing parallel struggle to break through to new levels of scientific truth in this field, and Silvertooth's discovery is not something that stands in isolation.

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what the author presented at a recent meeting at the University of Bologna in Italy, convened by Professor Roberto Monti especially to examine the implications of Silvertooth's experiment and hear Silvertooth present the latest details. It is also appropriate to mention that up to the time of this meeting there has been considerable controversy concerning the underlying principles of the experiment. In this regard, the author also acknowledges the active interest and helpful comments supplied both by Dr. J.P. Wesley, Dr. T.E. Phipps, Jr. and particularly the constructive analysis provided by B.A. Manning. Papers by Phipps[15] (not supportive of the Silvertooth findings) and by Manning[16] (supportive of the Silvertooth findings) have recently appeared in issues of *Physics Essays.*

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Résumé

L'on discute l'effet de l'énergie dans les ondes stationnaires sur la vitesses des ondes composantes. L'on montre que l'expérience de Silvertooth utilisant un photo-détecteur spécialment conçu pour balayer le long d'une onde optique stationnaire et qui a donné des résultats anormaux a une possible explication suggèrant que l'énergie peut influencer la vitesse des ondes. Les implications technologiques de l'expérience de Silvertooth sont d'une envergure telle à mériter une étude plus approfondie.

References

1. H. Aspden, Electron. Wireless World **96**, 29 (1989).
2. A.A. Michelson and H.G. Gale, Astrophys. J. **61**, 140, (1925).
3. H. Aspden, Lett. Nuovo Cimento **38**, 568 (1983).
4. E.W. Silvertooth, Nature **322**, 590 (1986).
5. P. Langevin, C. R. Acad. Sci. **173**, 831 (1921).
6. E.W. Silvertooth and S.F. Jacobs, Appl. Opt. **22**, 1274 (1983).
7. E.W. Silvertooth, Electron. Wireless World **96**, 437 (1989).
8. *Idem,* Spec. Sci. Tech. **10**, 3 (1987).
9. G.F. Smoot, M.V. Gorenstein, and R.A. Muller, Phys. Rev. Lett. **39**, 898 (1977).
10. C. Elbaz, C. R. Acad. Sci. **298**, 543 (1984).
11. R. Cialdea, Lett. Nuovo Cimento **4**, 821 (1972).
12. A.A. Tyapkin, Lett. Nuovo Cimento **7**, 760 (1973).
13. R.J. Kennedy and E.M. Thorndike, Phys. Rev. **42**, 400 (1932).
14. H. Aspden, Spec. Sci. Tech. **10**, 9 (1987).
15. T.E. Phipps, Jr., Phys. Essays **1**, 150 (1988).
16. B.A. Manning, Phys. Essays **1**, 272 (1988).

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