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The Relative Motion of the Earth and the Ether Detected

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"I have reviewed the experiment of Sagnac, having in mind the claim that the ether can not be detected experimentally. I have asserted that, in the light of the experimentally found variation of clock rate with motion, this experiment does detect the ether."

Herbert E. Ives, Science 91, 79, 1940

"If future experiments were to reveal a non-zero aether drift, then Einstein's relativity would crumble."

Diana Buchwald and Kip S. Thorne
Preface, The Born-Einstein Letters, 2005

Abstract — This paper explores first-order methods of detecting the ether or preferred reference frame of a semi-classical absolute space theory, which has been shown by many researchers to produce results that are in close agreement with special relativity. It is demonstrated that the first-order experiments of Roemer and Doppler detect the relative motion of the Earth and the ether in the Earth's approximately uniform motion around the Sun, precisely the motion that the famous Michelson-Morley experiment failed to detect. Our results therefore confirm the existence of a detectable ether that is inconsistent with special relativity.

Keywords: special relativity – ether — preferred reference frame — Roemer — Doppler — cosmic microwave background radiation

1. Introduction

One of the most famous experiments in the history of science is the Michelson-Morley experiment[1]. In this experiment conducted in 1887, two scientists, Albert Michelson and Edward Morley, searched for evidence of movement through the luminiferous ether, a continuous medium believed by 19th century scientists to fill all of space and to be the bearer of light waves. This belief arose on the basis of overwhelming theoretical and experimental evidence that accumulated over many years[2]. Based on an interferometric method, the experiment was designed to determine the speed of the Earth's movement through the ether as it revolved around the Sun, using the expected change in light speed resulting from movement with or against the associated ether wind.

The experiment was of second-order in that the effect being searched for was proportional to the second power of the ratio between the velocity of the movement v and the velocity of light c. As is well known, the Michelson-Morley experiment was unsuccessful and this represented a serious blow to the ether hypothesis. In 1925 Miller did appear to achieve some level of detection[3] but his results were later claimed by others to have arisen from diurnal and seasonal variations in equipment temperature[4]. Several repetitions of the same basic experiment, one as recently as 2003, have all yielded negative results[5–8] and as a result today, the scientific community generally believes that no experiment has detected or can detect movement through the ether[9–15]. However, it is well established, based on the theoretical and experimental work of Ives[16–19] and earlier theoretical work by Lorentz[20], Fitzgerald and Larmour[2], that because of the compensating effect of length contraction and frequency reduction, the Michelson-Morley and other second-order experiments will always yield approximately null results. This class of experiments is therefore generally unsuitable for detecting ether drift and hence the question of the detection of the ether remains open.

It is important to note that Lorentz, acknowledged as the pre-eminent theoretical physicist at the beginning of the 20th century, defended the concept of the ether right up to his death in 1928. In 1904 he wrote, "The problem of determining the influence exerted on electric and optical phenomena by a translation, such as all systems have in virtue of the Earth's annual motion, admits of a comparatively simple solution, so long as only those terms need be taken into account, which are proportional to the first power of the ratio between the velocity of the translation v and the velocity of light *c*"[20(p11)]. Lorentz was here indicating that first-order rather than second-order methods can easily detect the Earth's approximately uniform motion around the Sun. At the speeds involved, such experiments are essentially immune to the second-order effects of length contraction and frequency reduction. Many years before in 1879, Maxwell also suggested a first-order method to detect ether drift arising from the Earth's galactic movement[15,21] but the unavailability of sufficiently sensitive equipment prevented the execution of this experiment. In 1913 Sagnac[22] claimed ether drift using a first-order method for rotational but not uniform motion. First-order experiments have been re-visited recently using maser and Mossbauer technology[23,24] but null results were obtained. In the case of the Mossbauer experiment[z4], Ruderfer, who had proposed the experiment[z5], concluded in a published erratum[26] that a null result was actually the expected result.

Despite these difficulties, interest in a preferred or absolute frame continues. For example, in a paper published in Physical ***Review A*** in 1988, Gagnon et al.[27] studied a semi-classical ether-type absolute space theory in which light propagates isotropically at a fixed speed in a preferred reference frame. These authors referred to this absolute space model as the generalized Galilean Transformation (GGT) since it involved the classical Galilean transformations adjusted to take into account the real effects of the Fitzgerald-Larmour-Lorentz

(FLL) contractions first experimentally confirmed by Ives[16–19] according to which a rod of length l_o in a preferred frame, when moving with speed v relative to that preferred frame, is shortened to a length l given by

$$l = l_o(1 - v^2/c^2)^{1/2} \tag{1.1}$$

and a system of frequency f_o when stationary in the preferred frame, has a reduced frequency **f** given by

$$f = f_o(1 - v^2/c^2)^{1/2} \tag{1.2}$$

resulting in

$$x = \gamma(x_o - vt_o), \quad y = yo, \ z = z_o, \ t = \gamma^{-1}t_o \tag{1.3}$$

Here the zero-subscript coordinates are the coordinates of space and time in the preferred reference frame, the unsubscripted coordinates are coordinates in a reference frame moving at speed v relative to the preferred frame, c is the speed of light in the preferred reference frame and v is the FLL contraction factor given by

$$\gamma = (1 - v^2/c^2)^{-1/2} \tag{1.4}$$

Thus for measurements made by an observer at rest in the preferred frame, the (real) speed u_r' relative to the moving frame is given by

$$u_r' = u - v \tag{1.5}$$

where u is the speed relative to the preferred frame. This is the Galilean law of velocity composition. If the measurements are carried out by an observer moving relative to the preferred frame, Levy[28(pp42–43)] has shown that because of FLL contractions i.e. contracted meter sticks and retarded clocks, the (apparent) speed u_a' relative to the moving frame is given by

$$u_a' = (u - v)/(1 - v^2/c^2) \tag{1.6}$$

Equation (1.6) can be written as

$$u_a' \ (1 - v^2/c^2) = u - v \tag{1.7}$$

which is the Galilean law of velocity composition obtained when contracted meter sticks and retarded clocks are used to measure speed relative to the moving frame. From (1.5) and (1.7), the real speed u_r' and the apparent speed u_a' are related by

$$u_a' \ (1 - v^2/c^2) = u_r' \tag{1.8}$$

The Galilean law of velocity composition (1.6) is different from the special relativity law of velocity composition, which is[21]

$$u' = (u - v)/(1 - uv/c^2) \tag{1.9}$$

where u' is the speed relative to the moving frame. If $u = c$ in (1.9), then i.e. $u' = c$ the measured speed is c and this is consistent with the light speed invariance postulate of special relativity. If $u = c$ in (1.6) of the GGT, then

$$u'_a = (c - v)/(1 - v^2/c^2) \approx c - v, \quad v \ll c \qquad (1.10)$$

i.e. for sufficiently low speeds the measured velocity is c – v and not c. This light speed variation is what distinguishes the ether theory from special relativity. The GGT semi-classical theory is considered viable by several other authors including Maciel and Tiomno[27], Mansouri and Sexl[30], Selleri[31] and Levy[28], all of who have noted importantly that such a theory is in close agreement with special relativity for nearly all predicted effects. Selleri[31] actually considers GGT, which he refers to as inertial transformation, to be the better performer and Levy[28] has published a monograph discussing the theory and its application.

In view of this, we are encouraged to re-explore the possible detection of an ether drift resulting from movement through a preferred frame using first-order methods as advocated by Lorentz and Maxwell, instead of the difficult second-order methods repeatedly used by others. We have found that unlike the unsuccessful second-order ether-drift experiments, first-order ether-drift experiments, which yield non-null results, actually exist! Two of these experiments, namely the Roemer experiment and the Doppler experiment, are discussed below. They both detect the Earth's ether drift in its approximately uniform motion around the sun, precisely the motion that the famous Michelson-Morley second-order experiment attempted unsuccessfully to detect. Though these first-order experiments are well known, their results are not interpreted as detecting ether drift; Poincaire believed the ether was undetectable, Einstein[32(p38)] considered the ether "superfluous" and Born declared, "the ether wind does not exist"[15(p218)]

The main contribution of this paper, therefore, is a demonstration that the effects produced in these two experiments, namely the Roemer Effect and the Doppler Effect, both result from ether drift and are indicators of that drift. We accomplish this by demonstrating light speed variation in these experiments, a definitive phenomenon that distinguishes an absolute space theory from special relativity in which light speed is postulated to be constant.

2. First-Order Detection Methods

In the framework of the GGT light propagates isotropically at a speed c in a preferred or absolute reference frame. In such an absolute frame, consistent with classical velocity composition, the one-way speed of light relative to an observer changes according to the observer's motion relative to the preferred reference frame. Thus as observed by Hawking, "It was expected that light would travel at a fixed speed through the ether but if you were travelling through the ether in the same direction as the light, its speed would appear lower, and if you were travelling in the opposite direction of the light, its speed would appear

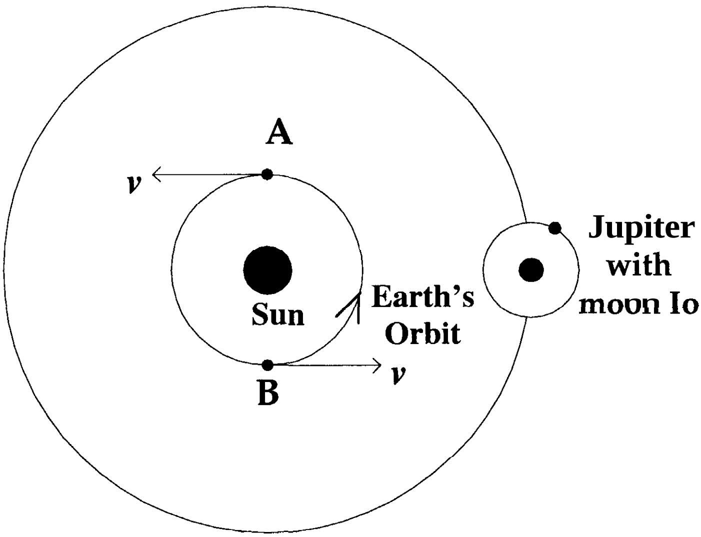

Fig. 1. **Orbits** of Earth, Jupiter and moon Io.

higher"[9(p6)]. This anticipated light speed change in the GGT characterizes ether drift and is the basis of the Michelson-Morley, Kennedy-Thorndike and many other ether-drift detection experiments. This is completely different from special relativity in which the light speed invariance postulate requires that no such light speed changes be detectable by a moving observer. In addition, FLL contractions (1.1) and (1.2) occur as a result of movement relative to the preferred frame and true measurements are those made in frames fixed relative to the preferred frame. These contractions alter the normal Galilean transformations that relate the coordinates of the preferred reference frame to coordinates in any other inertial frame, which now become (1.3). Our objective is to investigate the possibility of detecting movement relative to this preferred frame i.e. ether drift, from a moving platform.

2.1. The Roemer Experiment

Ole Roemer, a Danish astronomer observed that Io, the innermost satellite of Jupiter, undergoes a regular variation in its period of revolution T_o as the Earth revolves around the Sun at speed v as shown in Figure 1 (Roemer Effect). He used this observation to determine the speed of light[2,10]. Maxwell later described a method utilizing this occulting satellite to determine the speed of the solar system relative to the ether[15,21]. We use it here to determine the speed of revolution of the Earth relative to the ether and thereby demonstrate ether drift. We do so by analyzing the phenomenon in the framework of the semi-classical absolute space theory in a manner that is different from previous approaches.

Since Io, as seen from Earth, is periodically eclipsed by Jupiter, this occulting source emits what may be described as "pulses of darkness" to Earth as Io revolves around Jupiter. The distance between successive pulses is fixed at a value λ_o where

$$T_o = \frac{\lambda_o}{c} \tag{2.1}$$

Based on ether-drift theory utilizing classical velocity composition, when the Earth is at position A moving away from Jupiter, the speed of the light relative to the Earth is c – v and because of this reduced speed the time T_A between pulses recorded at A is greater than T_o and is given by

$$T_A = \left(\frac{\lambda_o}{c - v}\right) \tag{2.2}$$

Let be the period actually measured by the moving observer. Then as a result of the FLL contraction, the true period T_A is given by

$$T_A = \frac{\bar{T}_A}{(1 - v^2/c^2)^{1/2}} \tag{2.3}$$

From (2.2) and (2.3),

$$\frac{\bar{T}_A}{(1 - v^2/c^2)^{1/2}} = \frac{\lambda_o}{c - v} \tag{2.4}$$

giving

$$\bar{T}_A = \frac{\lambda_o}{c - v}(1 - v^2/c^2)^{1/2} \tag{2.5}$$

Similarly when the Earth is at position B moving towards Jupiter, the light speed relative to Earth is $c +$ v and because of the increased speed, the time T_B between pulses recorded by the observer at B is less than T_o and is given by

$$T_B = \left(\frac{\lambda_o}{c + v}\right) \tag{2.6}$$

For the measured period $\bar{T}_B$, the FLL contraction lowers the period such that the true period at B is given by

$$T_B = \frac{\bar{T}_B}{(1 - v^2/c^2)^{1/2}} \tag{2.7}$$

From (2.6) and (2.7),

$$\frac{\bar{T}_B}{(1 - v^2/c^2)^{1/2}} = \frac{\lambda_o}{c + v} \tag{2.8}$$

giving

$$\bar{T}_B = \frac{\lambda_o}{c + v}(1 - v^2/c^2)^{1/2} \tag{2.9}$$

The total measured change in the period, $\Delta\bar{T} \equiv \bar{T}_A - \bar{T}_B$ of Io is given by

$$\Delta\bar{T} = \lambda_o\left(\frac{1}{c-v} - \frac{1}{c+v}\right)(1 - v^2/c^2)^{1/2}$$
$$= cT_o\frac{2v}{c^2 - v^2}(1 - v^2/c^2)^{1/2} \tag{2.10}$$

This gives

$$\Delta\bar{T} = 2T_o\frac{v}{c}(1 - v^2/c^2)^{-1/2} \tag{2.11}$$

Since $v \ll c$, (2.11) reduces to

$$\Delta\bar{T} = 2T_o\frac{v}{c} \tag{2.12}$$

(The orbital movement of Jupiter around the Sun will in general superimpose a change in period on that resulting from the Earth's movement. The two effects can be easily separated. This is also the case for the effect resulting from the movement of the Sun.) For the satellite Io, *AT* is calculated using (2.12) to be exactly the value observed. The result (2.12) has been confirmed with great precision and is now usually stated in the form of a law involving the fractional change: The fractional change of the orbital period of a satellite is simply the ratio of the speed of the Earth's motion to the speed of light[33(p191)]. Additionally, the same data that confirm (2.12) also confirm equations (2.2) and (2.6) which demonstrate light speed variations. Ether drift has therefore been detected. The traditional interpretation of the Roemer experiment is that light travels with finite speed with no reference to ether drift. The additional interpretation given here that the period change $\Delta\bar{T}$ is an indicator of ether drift i.e. movement through the ether is new and unexpected. It is however valid since in this experiment, as the Earth moves away from Jupiter (position A) in the same direction as the light, its speed appears lower c – v and as the Earth approaches Jupiter (position B) in the opposite direction to the light, its speed appears higher c + v, precisely as expected in the ether-drift theory as discussed by Hawking[9(p6)] earlier and used in the Michelson-Morley experiment. It is the ether drift that gives rise to the change in the speed of light relative to the moving observer on Earth, at A and at B, which results in the variation of the period of Io.

2.2. The Doppler Experiment

The Doppler Effect[34] is the shift in frequency of a wave emitted by a source resulting from relative movement of the observer and source. Consider light waves travelling through the preferred frame as shown in Figure 2. A stationary light source S emits waves at frequency f_E which travel through the preferred frame at speed c relative to the medium and an observer O moves at speed v

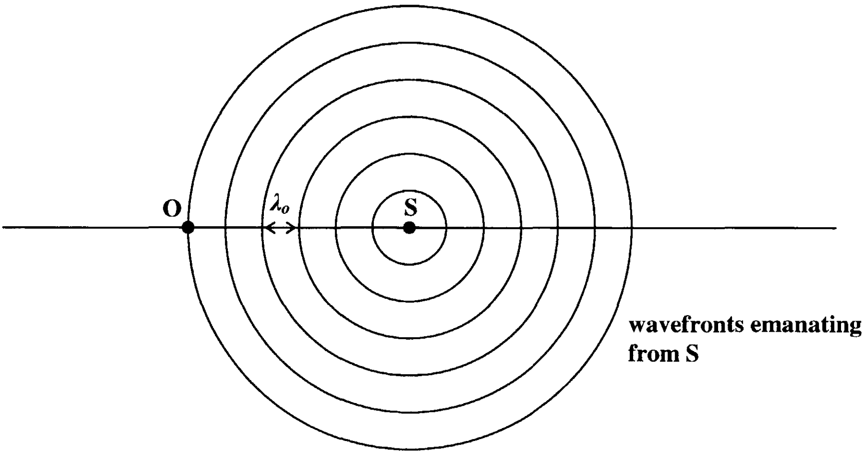

Fig. 2. Doppler Effect due to motion of the observer.

relative to the medium. The circles represent wavefronts separated by a fixed wavelength λ_o given by

$$\lambda_o = \frac{c}{f_E} \tag{2.13}$$

If the observer is at rest in the medium, the light wave speed relative to the observer would be c and he would intercept wavefronts at a rate f_E. For the observer moving at speed v towards the source S as in Figure 2, based on classical velocity composition, the speed of the light wave relative to the observer is higher at c + v and therefore the observer intercepts wavefronts at a rate f_H which is greater than f_E. Using elementary classical analysis, the relationship between the emitted light frequency f_E and the observed frequency f_H is given by

$$f_H = \frac{c+v}{\lambda_o} \tag{2.14}$$

Let $\bar{f}_H$ be the frequency actually measured by the moving observer. Then, because of the FLL contraction, the true frequency f_H is given by

$$f_H = \frac{\bar{f}_H}{(1 - v^2/c^2)^{1/2}} \tag{2.15}$$

From (2.14) and (2.15),

$$\frac{\bar{f}_H}{(1 - v^2/c^2)^{1/2}} = \frac{c+v}{\lambda_o} \tag{2.16}$$

giving,

$$\bar{f}_H = \frac{c+v}{\lambda_o}(1 - v^2/c^2)^{1/2} \tag{2.17}$$

If the observer is moving away from S at speed v, then the relative light wave speed is lower at $c - v$. As a result the observer intercepts wavefronts at a reduced rate and therefore the received frequency f_L is given by

$$f_L = \frac{c - v}{\lambda_o} \tag{2.18}$$

For the measured frequency, $\bar{f}_L$ the FLL contraction lowers the frequency such that the true frequency f_L is given by

$$f_L = \frac{\bar{f}_L}{(1 - v^2/c^2)^{1/2}} \tag{2.19}$$

From (2.18) and (2.19),

$$\frac{\bar{f}_L}{(1 - v^2/c^2)^{1/2}} = \frac{c - v}{\lambda_o} \tag{2.20}$$

giving

$$\bar{f}_L = \frac{c - v}{\lambda_o}(1 - v^2/c^2)^{1/2} \tag{2.21}$$

The measured change $\Delta\bar{f}_E \equiv \bar{f}_H - \bar{f}_L$ in the frequency is, using (2.17) and (2.21), given by

$$\Delta\bar{f}_E = 2f_E\frac{v}{c}(1 - v^2/c^2)^{1/2} \tag{2.22}$$

Consider the case of light from a stationary star on the ecliptic observed from the revolving Earth. For such a star, the maximum frequency shift occurs when the Earth is directly approaching and directly receding from the star consistent with Figure 2. In such a case the frequency change is given by (2.22) and since $f_L \ll$ c, the maximum frequency change resulting from movement of the Earth through the preferred frame is given by

$$\Delta\bar{f}_E = 2f_E\frac{v}{c} \tag{2.23}$$

where v is the speed of revolution of the Earth and c is light speed. (As in the case of the Roemer experiment, any spatial motion of the star with respect to the Sun will superimpose a Doppler shift on that caused by the Earth's revolution. The two effects are easily separated[34[p44]].) Relation (2.23) has been confirmed to a high degree of accuracy and is therefore routinely used to determine the speed of revolution of the Earth[34(p44)]. It is sometimes stated as a rule involving the fractional $(\Delta\bar{f}_E/2)/f_E = (vc)$ change (which to first-order is equal to the fractional change in wavelength): The fractional change of the frequency of a spectrum line of a star lying on the ecliptic plane is the ratio of the Earth's orbital speed to the speed of light[33(p244)]. Moreover, the same data that confirm (2.23) also confirm equations (2.14) and (2.18) both of which demonstrate light speed variations. Movement through the ether or ether drift has therefore again been detected. This interpretation that the Doppler Effect $\Delta\bar{f}_E$ is an indicator of ether drift appears not to have been presented before and is again surprising. As in the Roemer experiment, however, it is valid since as the Earth moves towards the source, the light speed appears higher $c + v$ and as the Earth moves away from the source, the light speed appears lower $c - v$, exactly as expected in the ether-drift theory[9(p6)]. It is the ether drift that produces the change in speed of the light relative to the moving observer on Earth, $c + v$ towards the star and $c - v$ away from the star, which results in the change in frequency.

3. Discussion

The Roemer and Doppler experiments, because of the demonstrated light speed variation, detect the Earth's movement through the ether—the preferred reference frame of the GGT—in its approximately uniform motion around the Sun. This is precisely the motion that the Michelson-Morley experiment failed to detect. The Michelson-Morley experiment is of second-order and was simply unsuitable for this detection as has been experimentally shown by Ives[16–19] some 50 years later. The Roemer and Doppler experiments are first-order and both yield positive results. This is consistent with the fact that Maxwell's equations are not covariant under a Galilean transformation. It should be noted that the light speed variation associated with this ether-drift detection is not contradicted by any experiment since one-way light speed isotropy has not been confirmed because of the inability to achieve the clock synchronization necessary for such a test[35].

Mansouri and Sexl[36] also considered first-order methods and showed that the transformations (1.3) can be converted to the Lorentz transformations of special relativity by an appropriate change of convention about clock synchronization. They concluded, therefore, that "first-order tests cannot be used to distinguish between special relativity and ether theories"?. This conclusion is incorrect. While special relativity also predicts the Roemer Effect and the Doppler Effect, the light speed variation demonstrated in these two first-order tests contradicts the light speed invariance postulate and thereby invalidates special relativity! This is the crucial point that appears to have been missed by Mansouri and Sexl and most other researchers. Sagnac[22] claimed ether-drift detection for a rotational motion in his famous successful first-order experiment of 1913. This experiment involved sending two light beams in opposite directions around a rotating disc and examining the returning beams in an interferometer. The basic experiment was later repeated on a progressively larger scale involving the rotating Earth by Michelson and Gale[37] and Allan et al.[38], again with positive results. We now for the first time claim ether-drift detection for uniform motion involving the Earth's revolution around the Sun.

As already mentioned, Maxwell had rejected second-order methods as being unsuitable for detecting ether drift and suggested a first-order experiment to detect the Sun's movement through the ether using Jupiter's eclipsing satellite Io. This involved the classical first-order relation[15,21]

$$\Delta t = 2t_o \frac{v}{c} \tag{3.1}$$

where v is the Sun's velocity through the ether, t_o is the time for light to travel a distance corresponding to the diameter of the Earth's orbit around the Sun and Δt is the change in the delay of Io's eclipse. While Maxwell's ether-drift detection experiment could not be performed at the time because of the unavailability of sufficiently sensitive instrumentation, it is an interesting observation that Maxwell's relation (3.1) is identical in form to Roemer's relation (2.12). Thus, Maxwell seemed unaware that an essentially equivalent experiment, the Roemer experiment, involving relation (2.12) and also using Jupiter's occulting satellite Io, actually detects ether drift, specifically the movement of the Earth in its approximately uniform motion around the Sun. With the availability of more sophisticated equipment, Maxwell's first-order ether-drift experiment may now be viable as was suggested by Born[15].

This physical radiation-bearing ether extending throughout space is consistent with the cosmic microwave background radiation (CMBR) discovered by Penzias and Wilson[39]. This radiation displays large-scale isotropy on large angular scales indicative of a non-local origin[4'] and has an almost perfect blackbody spectrum at 2.7k, characteristic of radiation that originates from a state of perfect equilibrium between matter and radiation. We therefore make the plausible suggestion that the CMBR is the blackbody radiation that is in thermal equilibrium with the ether and therefore that the CMBR gives the temperature of this underlying extragalactic medium. Similar to the ether, the CMBR provides a preferred reference frame or absolute standard of rest since its isotropic nature enables the determination of the absolute movement of the Earth by anisotropic measurements based on Doppler shift in a manner first demonstrated by Conklin[41] and Henry[42]. Thus, motion relative to the CMBR results in frequencies of CMBR being higher in the direction of motion and lower in the opposite direction. Recent measurements indicate a velocity of 390 $\pm$ 30 kms^{-1} in the direction of the constellation Virgo.

Weisskopf[43] had this to say about the anisotropic measurement of the Earth's absolute motion relative to the CMBR: "It is remarkable that we now are justified in talking about an absolute motion, and that one can measure it. The great dream of Michelson and Morley is realized. They wanted to measure the absolute motion of the earth by measuring the velocity of light in different direction. According to Einstein, however, this velocity is always the same. But the [2.7k] radiation represents a fixed system of coordinates. It makes sense to say that an observer is at rest in the absolute sense when the [2.7k] radiation appears to have the same frequencies in all directions. Nature has provided an absolute frame of reference". Marinov[44] succeeded in measuring the absolute motion of the Earth relative to the ether by using an ingenious modification of the Sagnac experiment. He obtained a value of 303 ± 20 kms^{-1}, which is comparable to the value measured relative to the CMBR. This is further evidence that the CMBK may be associated with the ether.

4. Conclusion

Ether drift is detectable and has been detected. In his book *Relativity* The *Special* and the General Theory, Einstein[45(p53)] declared on the basis of his theory of relativity, "there can be no aether-drift, nor any experiment with which to demonstrate it". Einstein was wrong! In this paper we have reported positive results in a renewed search for ether drift associated with movement through the preferred frame of a semi-classical absolute space theory. This was achieved through the agency of light speed variation in the Roemer and Doppler experiments. These first-order experiments detect ether drift, specifically the Earth's approximately uniform motion around the Sun, exactly the motion that Michelson and Morley attempted unsuccessfully to detect in their celebrated experiment of 1887.

It is instructive to summarize the cumulative evidence relating to the ether and its possible existence:

(1) The vast body of theoretical, experimental and observational evidence supporting light wave transmission through an all-pervasive medium, especially the spectacular prediction of electromagnetic waves with speed set by the characteristics of the ether medium, that had accumulated up to the end of the 19th century and beyond[2].

(2) Explanation of the null results of second-order ether-drift detection experiments via experimentally confirmed length contraction and frequency reduction that result from movement through the ether[16–19].

(3) The discovery of what may be the ether's blackbody radiation—the isotropic CMBR—that provides an observable absolute frame of reference for determining **absolute** speeds[39–43] as does the ether[44].

(4) Positive detection of ether drift first for **rotational** motion[22,37] and now for **uniform** motion, the latter by two first-order experiments as described for the first time in this paper.

In the spirit of the historic search for ether drift by Michelson and Morley, we believe that this evidence, particularly the ether-drift detection for uniform motion, confirms the existence of the ether as a light-bearing medium and absolute reference frame. In the process, the experimentally verified light speed variation occurring in the two first-order tests falsifies special relativity. This falsification justifies the relaxation of the Lorentz covariance requirement that led to a new gauge theory of gravity[46] in which a massless spin 0 graviton mediates the gravitational interaction and extends Newtonian gravity into the quantum domain (no more action-at-a-distance).

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