A Laboratory Experiment for Testing Space-Time Isotropy

S. Sarg Sargoytchev[1] and B. M. Quine[2]
[1]Department of Computer Science and Engineering, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3
[2]Department of Physics and Astronomy, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3
E-mails: stoyans@cse.yorku.ca, bquine@yorku.ca

We describe a simple experiment to validate the principle of light isotropy. The method is based on measurement of the ratio between refractive indices of two different optical media by using a collimated beam. The method exploits the speed-of-light dependence of light propagating at an angle across optical interfaces. The experiment provides a means to test for light anisotropy with respect to a preferred reference frame, for example, determined from measurements of the Cosmic Microwave Background anisotropy. Presently, the operational management of the GPS system applies corrections indicating the existence of a universal clock. Other researchers have identified evidence of altitude dependence for the speed-of-light and other speed variation effects. These phenomena do not fully comply with the definition of the inertial frame according to Special Relativity. Previous tests of the speed of light may be categorized into one-way or two-way dependency tests. Two-way tests, such as Michelson and Morley's original experiment average a round trip velocity and, consequently, can only provide limited bounds for some anisotropic effects. One-way tests, such as the experiment described here, measuring the speed of light in a single direction may be designed with significantly increased sensitivity to time-dependent variations in light propagation. They may also be designed to be resilient to clock and wavelength variation errors. Our preliminary results indicate a time-dependent variation of the speed of light that is not correlated with CMB anisotropy but is consistent with anisotropy reported by other investigators. The identification of an absolute or preferred reference frame would provide new experimental evidence that may constrain theories that seek to unify gravity with the other fundamental forces or improve the standard model.

Keywords: CMB anisotropy, isotropy of light

1. Introduction.

This paper presents a new experiment and preliminary experimental results for an inexpensive means to measure light anisotropy in a laboratory environment. The paper first reviews previous experimental attempts to provide a bound on light isotropy. Cosmic Background Radiation (CMB) anisotropy, the most likely candidate for a preferred or absolute reference frame, is introduced. Methodological problems associated with clock errors in results reported by previous investigators are described that may provide some explanation for experimental inconsistencies. The methodology for our one-way experiment that exploits the time dependence of the refractive index of light is presented and discussed. Preliminary data from the experiment is reported along with a comparison with previously reported results. Further experimentation and refinement is required to provide sufficient experimental confidence, however preliminary results appear are consistent with other researchers who find small temporal variations in one way light speed that appear uncorrelated with the CMB.

2. Background

2.1. Experiments to Detect Anisotropy

Attempts to detect a possible light speed anisotropy have a century long history. In 1887 Michelson and Morley reported the results from their famous experiment [8]. The expected drag effect from a Luminiferous Ether was not confirmed, but a small non-null effect was observed. One of the most prominent researchers of the non-null effect was David Miller. He first observed the dependence of this effect on altitude [9]. In 1929 Michelson repeated his experiment in the basement of the Wilson Mount observatory and obtained the same result with the unexplainable non-null effect [10]. In 1927 E. Esclangon, director of the Paris Observatory, published results from his year-long experiment conducted in the Observatory of Strasburg at an altitude of 142 m [11]. He also detected a non-null effect at the same right ascension as Miller. After Miller, a few experiments have been done in the past century with different results [12]. The experiments of R. J. Kennedy [13] and K. K. Illingworth [14] are often cited in refutations of the Miller result, but a careful analysis of their experiments based on the Kennedy method reveals one problem. They used a monochromatic light from a 546.1 Hg arc lamp collimated by a lens along an axis lying in the horizontal plane. In such an arrangement, the emitted light at the source has a spatial orientation and it is subject to a small wavelength change depending on direction. This may cancel the detection of the non-null effect, because according to the Lorentz theorem (1899) the frequency of the oscillating electrons generating the light waves is lower in systems in motion than in those at rest by:

$$\gamma T = T \Big/ \sqrt{1 - V^2 / c^2} \qquad (1)$$

Miller, like Michelson, used white light. Miller mentioned explicitly that a light from a small acetylene lamp in a stationary arrangement was "brought to the interferometer in the axis of rotation" (p. 220) [9]. In such an arrangement, the emission is not dependent on the direction of instrument rotation. Esclangon also used white light. Nobody after Michelson, Miller and Esclangon used a white light source.

After 1980 a number of other ether-drift experiments were able to measure a non-null effect [15,16,17,19,20,21,22,23,24,25,26]. In a recently published article C. E. Navia et al. [20] reviewed and analyzed the results from the light speed anisotropy experiments and the CMB anisotropy. They suggested that the problem might be in the theoretical treatment of Lorentz-Poincare and Einstein's Special theory of Relativity, because they do not involve gravitation. Navidia et al. used a new method for investigating light speed anisotropy proposed by C. M G. Lattes based on diffraction, but the derived direction differed from the direction reported by other researchers. In this respect, it is worth mentioning the recent experiments of Red Cahill [21,22,23]. He provided three different light anisotropy experiments based on a time measurement in two counter-propagated signals – one in optical fiber and another in coaxial cable [21], a countepropagated EM waves in coaxial cables with different dialectical constant [22] and an optical fiber interferometers with arms at 90 degrees [23]. While he could not offer a physical explanation why these methods are able to detect anisotropy, he concluded in [21] that only the signal in coaxial cable is affected. A better explanation of enigma and discussion of his results will be provided hereafter.

David Miller devoted more than 30 years to investigating the speed of light anisotropy before delivering the final results. These have since been confirmed by a number of modern experiments. In 1933 Miller published his experimental work in an extensive paper published in the Review of Modern Physics [9]. In the International Congress of Physics in Paris 1900, Lord Kelvin strongly urged the repetition of the Michelson-Morley experiment in order to test the Lorentz-Fitzgerald hypothesis. Morley and Miller then constructed a new interferometer with longer arms. From 1902 it was tested initially with a wooden frame. In 1904, with funding from the American Academy of Art and Sciences, a new instrument with a steel cross frame was built. In order to increase the optical path for higher sensitivity, each of the two 90 degree arms had 8 mirrors (4 mirrors at each end). In such an arrangement, the effective length of the arm was 3203 cm and the total path of the going and returning beam was 6406 cm. The instrument weighed about 1200 kg and floated on 275 kg of mercury. In 1921 the steel cross frame was replaced with a base of concrete. The instrument was tested with monochromatic and white light sources but all the measurements were made with a white (broad band) light source. The fringes were observed with a small telescope while the instrument was in slow continuous rotation. In 1905 the instrument was temporarily mounted at Cleveland Heights at an altitude of about 285 m where some measurements were made. In 1921 the instrument was mounted at the Mount Wilson Observatory at an altitude of about 1750 m where extensive observational data were accumulated for a few years.

One unexplainable effect mentioned by Miller and also previously observed by Michelson - Morley is a systematic small non-null result he called “a reduced velocity”, because it matches the direction of the Earth motion but not the real velocity. Miller found that this non-null effect is greater at higher altitudes. In Cleveland, which is at 265 m above sea level, Miller observed a reduced velocity of about 3 km/s, while at Mount Wilson (1750 m above sea level) it was about 10 km/s. Also, it varied from 9.3 km/s in February to 11.2 km/s in August. To verify the altitude dependence of this effect, Miller returned the heavy instrument to the laboratory at Cleveland in 1922 and 1923 where he did many trials for identifying possible side effects, and then reestablished it back at Wilson Height in 1925 – 1926. The fringe shift caused by a possible speed-of-light anisotropy will have 3 components: from the sidereal Earth rotation, from the orbital rotation and from the solar system motion. The fringe shift from the sidereal rotation of the Earth should not be expected to be symmetrical because the cosine between the beam axis and the vector of the solar system velocity varies around some constant angle. Then the combination of all these effects may cause a diurnal distortion of the 24 hrs fringe shift cycle. Some additional fluctuations of the 24 hr cycle were observed not only by Dayton Miller but also in many other experiments. Their possible cause will be discussed later in the discussion section of this article. Despite all these distortions, the final analysis of all refined data that Miller collected from 1924 to 1926 revealed that the Earth with the solar system is moving with a velocity of about 208 km/s towards the apex having a right ascension of 4 hrs and 54 minutes and declination of -70 Deg 33’ (for the epoch of 1924). He found that the orbital component of the Earth motion was difficult to detect in a short period because it is almost perpendicular to the velocity vector of the solar system motion. In 1929 A. A. Michelson, F. G. Pease and F. Pearson repeated the experiment in the basement of Mount Wilson Laboratory. The non-null effect is stated in their article published in Nature, where they say: “The results gave no displacement as great as one-fifteenth of that to be expected on the supposition of an effect due to a motion of the solar system of three hundred kilometers per second” [10].

While only Miller investigated the dependence of the non-null effect on altitude during the past century, some recent experiments at different heights were performed in Russia and the Ukraine. In 2001 and 2002 Yu. M Galaev published articles describing experiments sponsored by the Institute of Radiophysics and Electronics of NSA, Ukraine [14,15]. The Galaev experiments are based on original two-way interferometers, one in the optical band and another in the millimeter radiowave band. The measurements in the optical band were performed at heights of 1.6 m and 4.75 m above sea level from August 2001 to January 2002. With the radiowave interferometer, the measurements were at an altitude of 1414 m above sea level from September 1998 to January 1999. Galaev compared the results from these two experiments with Miller’s results and they matched closely. The log-log plot of the observed non-null effect at different heights from the three experiments appears linear. It is shown in Fig. 1.

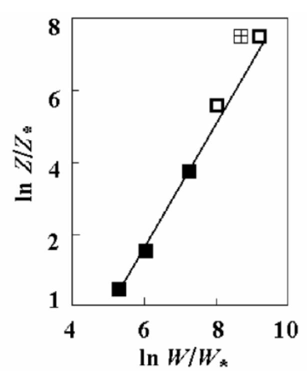

Fig. 1 Dependence of the ether-drift velocity (non-null effect) on altitude at five different heights above sea level (1.6 m, 4.45 m, 42 m, 265 m and 1830 m). The black squares are from Galaev’s experiments [17,18], the white squares are from Michelson’s [8,10] and Dayton Miller’s [9] experiments. Courtesy of Galaev [18].

The non-null effect and its dependence on altitude is an interesting phenomenon from the point of view of Special Relativity (SR). On one hand, its small value confirms the validity of SR in the strong Earth gravitational field with some degree of accuracy, but on the other hand, it indicates that some correction might be needed at higher altitudes. This conclusion is supported by the fact that the operational management of the GPS system requires clock corrections that do not fully comply with SR. This is discussed in a number of articles published by Ronald Hatch, a pioneer in the GPS system [24,25]. The GPS satellites are at an altitude of about 20,000 km from the ground and the correction is quite above the statistical error. This indicates the existence of universal time, something that does not comply with the SR definition of inertial frame. This problem is discussed also in the article of Wang and Hatch [26] and the concluding comments of Cynthia Whitney's article [27]. Hatch also believes that the clock depends on the gravitational potential and suggests that a Mossbauer experiment be performed in free fall conditions [28]. The clock rate behavior of Soviet satellites and missions is discussed by V. H. Hoteev in one of his monographs [38]. S. K. Whitney provides a good methodological classification of different types of ether drift experiments. It shows also that the light velocity anisotropy may provide different signatures in first and second order experiments (in respect to V/c ratio) [27].

The linear plot of the non-null effect shown in Fig. 1 deserves careful analysis. It is known that the air refractive index is slightly dependent on altitude but this dependence is not linear. As well, the gravitational potential is inversely dependent on altitude. One might expect that SR may need some correction due to the altitude dependence of gravity or the refractive index of air.

Some recent experiments also detected a light propagation anisotropy. Amongst them are the experiments based on rotated active cryogenic optical resonators [19], the diffraction experiment of Navia et al. [20] and the experiments of R. T. Cahill [21,22,23]. Amongst the different experiments, only the Miller, Galaev and Cahill experiments provide a close match between derived spatial directions. An important issue in these experiments is that sidereal rather than diurnal time was used in data processing. It is an indication that the light-speed anisotropy is not related to Earth-orbital motion but to the solar system motion in some absolute frame of reference. According to Cahill "absolute motion is motion presumably relative to some substructure to space, whereas Lorentz transformation Lorentz symmetry parameterizes dynamical effects caused by the motion of systems through that substructure" [21]. In 2002 S. Sarg suggested a model of a superfine sub-structure that provides space-time properties and physical explanations of Special and General relativistic effects in absolute space [29,30].

2.2 A Preferred Reference Frame

Since the discovery of the Cosmic Microwave Background (CMB) with its anisotropic variation indicating the presence of a universal center, a co-ordinate frame referenced to this core has become the leading contender for any preferred or absolute reference frame. After CMB radiation was initially predicted by G. Gamow, R. Alpher and R. Herman and later by R. Dicke (1960), it was experimentally discovered by Arno Penzias and Robert Wilson in 1965. In 1978, Penzias and Wilson were awarded the Nobel Prize for Physics. In 1966 T. F. Howel and J. R. Shakeshaft were able to distinguish the CMB blackbody radiation from a non-blackbody radiation coming from our galaxy while analyzing the data from a broader microwave spectral range [1]. In 1967 D. T Wilkinson and R. B. Partridge published an article about the anisotropy observed in the spatial distribution of quasi-stellar objects [2]. In 1967, J. M. Stewart and D. W. Sciama predicted anisotropy in microwave radiation and described a method for detection of solar system motion in respect to distant matter [3]. In 1969, E. K. Conklin published an article "Velocity of the Earth with Respect to the Cosmic Background Radiation" [4]. Using the method described in [3] and data from 23 observations with a radiometer operated at 8 GHz and bandwidth of 1.2 GHz, he obtained a velocity vector with magnitudes of 160 km/s towards RA 13 hrs and declination of 32^0. The detected motion he claimed is a result of two combined motions: the solar system rotation in the Milky Way and the solar motion in respect to the local supercluster of galaxies. After the launch of the Cosmic Background Explorer (COBE) in 1989, the CMB anisotropy was accurately determined by George Smoot [5]. In 2006, he was awarded a Nobel Prize for his work. From a later WMAP experiment, C.L. Bennett et al. confirmed the results of CMB anisotropy with improved accuracy: a spatial dipole anisotropy of 0.123% towards $l = 263.85^0$ $b = 48.25^0$ in a galactic coordinate system [6.] B. Nodland and J. P. Raltson, while investigating the polarized radiation emitted by distant radiogalaxies, also found a signature of anisotropy in electromagnetic propagation over cosmological distances [7].

The existence of CMB anisotropy raises the following questions: (1) Is this a spatial anisotropy or anisotropy of the speed of light; (2) Is the anisotropy detectable within the Earth gravitational field? The answers to these questions have direct relevance to tests of Einstein's theory of Special Relativity and on other cosmological models of the Universe. Further experimental evidence may also explained effects known as "non-null" results from the old and new "ether-drift" (light-speed anisotropy) experiments.

2.3 Methodological clock problems with previous results

The space-time property of the physical vacuum is one of the important consequences of Einstein's theory of relativity. From the equation $c = \lambda\nu$ we see that wavelength is directly defined by frequency when the speed of light $c = const$. However, if assuming anisotropy of the speed of light, the data interpretation suffers from ambiguity - we cannot determine which of the three parameters is actually affected. This is valid for all experiments using interferometric principles and confuses the data interpretation. This might be the reason for the wide spread of directions of light propagation anisotropy detected by different experiments.

The one and two-way optical experiments described in the literature are usually based on the interferometric principle. The two-way interferometric experiments are either with two channels at 90 deg such as in the Michelson-Morley experiment or with two opposite channels. These cannot not eliminate ambiguity from the relativistic clock rate change and the wavelength change caused by the Earth motion. Navia *et al*. provided an experiment based on the use of a diffraction grating, as proposed by C. M G. Lattes, but it also is not free from ambiguity [20]. In the method description of their experiment, they made the assumption that the frequency in the relation $\lambda = c/\nu$ is constant, but this assumption is invalidated in the case of a clock rate change. The one-way experiments based on the Mossbauer effect are accurate, but they also could not eliminate the above-mentioned ambiguity.

Consider, the classical Michelson-Morley type of experiment with two arms at 90 deg. The path difference between both arms is adjusted to be close to zero. The interferometer is slowly rotated and measurements are taken at different angular positions of the arms in respect to the North-South direction. Let us consider that the maximum fringe shift (or number of fringes) corresponding to the non-null effect is between two angular positions distinguished by 90 degrees. If the path difference is adjusted to zero in one of these positions, the fringe shift at the other 90 deg position must be contributed by a small change of the path difference between the two arms. Presently, interferometers with non-zero path difference are successfully used for measurement of wind velocity [31,32] and their theory is well established. The change of wind velocity ∂V corresponds to a fringe shift $\delta\phi$ according to the expression.

$$\delta\phi = 2\pi \frac{\Delta}{\lambda}\frac{\partial V}{c} \qquad (2)$$

where: $\Delta = Ln$ is the path difference, n is the refractive index of the involved optical media, L is the path length, λ is the wavelength for monochromatic source (or effective wavelength for white source, 570 nm, light in Miller's experiments) contributed to the fringes, c is the speed of light.

According to the Einstein definition of inertial frame, the Earth motion should not affect the local speed of light, so the air refractive index should not be affected. Then the refractive index of glass will only participate in equation (2), for which we have $n = c/c_G$, where c is the speed of light in air and c_G is the speed of light in the glass. Substituting this in (1) and rearranging we obtain

$$\delta\phi = 2\pi \frac{L}{\lambda} \frac{\partial V}{c_G} \qquad (3)$$

Let us analyze (3) to find out what parameter change may contribute to the small fringe shift corresponding to the non-null effect. L and λ are of the same dimensions (length), but λ could be affected by the clock rate change or by a Fitzgerald contraction, while L only by a Fitzgerald effect, in other words, by some space-time effect. However, the ratio L/λ is dimensionless, so it could not be affected by such a space-time effect. Assuming the validity of the Einstein postulate, one could not expect a change in ∂V . Then the only parameter to be affected is the speed of light in glass c_G that may change a small amount. A small fringe shift (non-null effect) could be caused by some small change in the ratio between the refractive indices of glass and air. If this effect can be measured by a non-interferometric method then ambiguity from possible clock rate changes, Doppler shift and Fitzerald contractions is eliminated.

The wavelength λ in Equation (3) is for the propagated light, not for the source. Only Michelson and Miller used a white light that was isotropically emitted from the source. All later interferometric experiments used a monochromatic source including lasers, which are usually anisotropically emitted and may cancel the non-null effect. This may be one reason that some later experiments did not detect a non-null effect.

Our initial choice for a non-interferometric experiment was an attempt to replicate the coupled shutters experiment of S. Marinov reported after his death by one of his collaborators [31]. The experiment is based on signal intensity measurements in two counter-propagated beams with high-speed kinematics. This experiment was carefully tested at York University, Toronto, but the conclusion was that a number of technical problems related to experimental stability made this experiment limited in accuracy [34]. However, the extensive testing of different modifications led to the idea of a new method that is discussed here.

3. Methodology

The ambiguity from the relativistic clock rate and wavelength change can potentially be eliminated if the method is based on measuring the ratio between the refractive indices of two optical media with different refractive indices. The effect of wavelength change could be strongly suppressed by using a broadband optical source and detectors. To detect only the refractive index change two dissimilar arms are utilized. In one of the arms, an array of consecutive parallel glass windows with air gaps between them are used. They must be tilted at an angle with respect to the collimated beam that is determined below. Due to the multiple reflections from the entrance and exit glass surfaces, the output beam will be attenuated and slightly displaced. Let us assume that the refractive index ratio slightly depends on the angle between the optical beam axis and the light propagation anisotropy. Then with a change of this angle, the rays of the passing beam will undergo a slight parallel shift. If the beam is focused by a lens possessing a spherical aberration, the parallel ray shift will cause a slight image change. This change could be detected if a proper slit is put in front of the detector.

The Fresnel reflectance and transmittance from a flat optical surface for near normal incidence are given by the expressions (4). They are valid for the entrance and exit surfaces of a flat window without a coating.

$$R=\left(\frac{n_2-n_1}{n_2+n_1}\right)^2; \qquad T=1-R \tag{4}$$

where: R is the reflectance, T the transmittance, n_1 and n_2 refractive indices of the glass and air

For a tilted surface with a beam incidence angle θ_1 the refracted angle θ_2 is given by

$$\cos\theta_2=\left[1-\left(\frac{n_1}{n_2}\right)^2\sin^2\theta_1\right]^{1/2} \tag{5}$$

If the tilting approaches the Brewster angle given by Eq. (6) a partial polarization occurs.

$$\theta_B=\arctan\left(\frac{n_2}{n_1}\right) \tag{6}$$

For a flat window in air, $n_1=1.000226$. For BK7 glass in a spectral range between 404 nm and 852 nm the mean refractive index is 1.516, so the Brewster angle is 56.6^0. For incidence angle smaller than the Brewster angle, Equations (3) and (4) are valid. When considering multiple reflections and transmissions in an array of a finite number of parallel windows, the total integral transmission will approach 50% for a proper incidence angle below the Brewster angle. This can be achieved by an array of 12 windows if using uncoated windows of BK7 glass and tilting angle of about 40^0. From Equations (4), (5) and (6) one may see that the passing beam will exhibit a change only if the ratio (n_2/n_1) changes. Detection of such a change due to the diurnal and orbital motion of the Earth will indicate a light velocity (or space-time) anisotropy. The possible gravitational influence could also be detected.

The optical layout of the proposed experiment is shown in Figure 2.

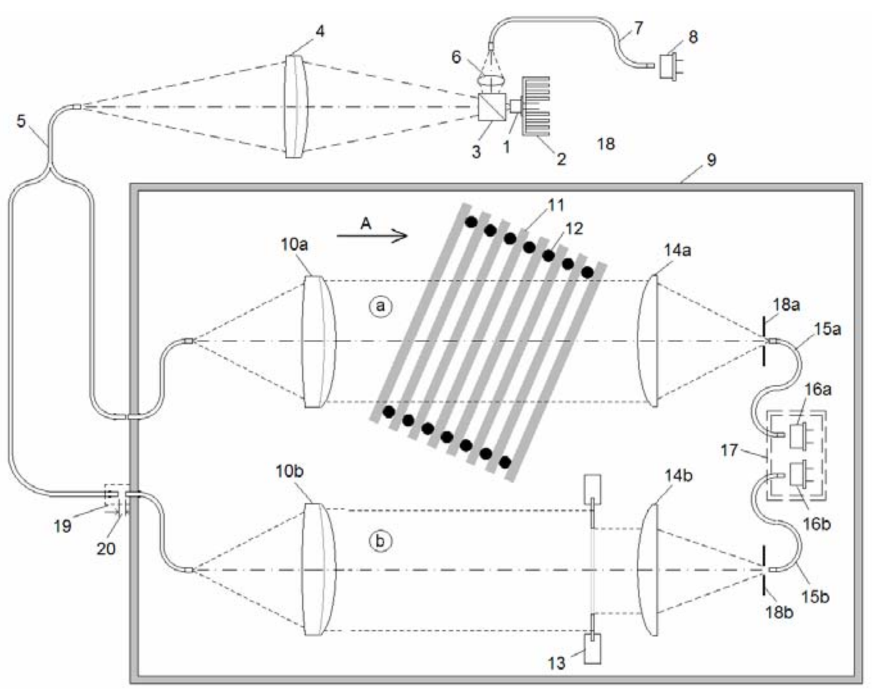

Fig. 2. Optical layout of the experiment.

The broadband light source (1) is a white InGaN LED with a Ce:YAG phosphor. It has an intensity of 35 candelas and a spectral range from 450 to 750 nm with a maximum peak at 465 nm and a broad secondary maximum at 550 nm. The LED source emits within an angle of +/-10^0. The light passing through a beam splitter (3) is focused by the lens (4) to the fiber optics guide (5) splitting into two ends – one for the measurement channel (a) and another one for the reference channel (b). The beams for each channel are collimated by achromatic lenses (10a) and (10b) with EFL of 10 cm. The collimated beam for channel (a) passes through a set of 13 uncoated flat windows with thickness of 2 mm and gaps of 2 mm. The windows are tilted at an angle of 36^0 in respect to the beam axis. The reference channel (b) has an adjustable iris diaphragm (13) for adjusting the intensity of the reference beam to be similar to the measuring one. The plano-convex lenses (14a) and (14b) focus the beams into fiberoptics guides (15a) and (15b) in front of which are mounted circular diaphragms (18a) and (18b) with a diameter of 1 mm. The lenses (14a) and (14b) are intentionally selected to be non-achromatic and non-aplanatic. Light guides (15a) and (15b) guide the lights transfer both channels to the silicon photodiodes (16a) and (16b) mounted on a common plate. The photodiodes are ODD-12W with a circular sensitive area of 4mm diameter. In order to prevent any influence from ambient change of pressure and humidity, both optical channels with the photodiodes must be enclosed in a housing (9) at normal air pressure. For facilitating the optical adjustment, an additional fine adjustment of the beam intensity of the reference channel is possible by tuning the gap (20) between the two fiberoptics ends. The air in the gap is sealed with O-rings. The current through the white LED source is stabilized at 25 mA. Additionally, the source may be optically stabilized. An additional optical channel is used comprised of a beam splitter (3), a lens (4), a fiber optics guide (5) and a photodiode (8). The photodiode must be of the same type as (16a) and (16b). The optical elements and photodetectors of the measuring and reference channels are mounted on a small optical table with dimensions approximately 70 cm x 35 cm.

During the measurement acquisition, the LED source is periodically turned ON and OFF for a time much longer than the time constant of the amplifiers. This is for monitoring a possible drift due to the photodiode dark current or amplifiers gain. Alternatively a shutter can perform the ON/OFF switching. The optical channels' axes are oriented in the North-South direction. In this orientation, the sidereal rotation of the Earth causes a change of the angle between the beam axis and the larger velocity component of the Earth motion. If anisotropy in light propagation exists, the effect will be a slight parallel shift of the beam rays in channel (a) after passing through the parallel windows (11). This effect is based on the assumption that the anisotropy will cause a slight change of the ratio between the refractive index of the air and the BK7 glass. The plano-convex lens 14a has a larger aberration for non-central rays, so in contrast to the achromatic lens, it focuses a parallel light not into a sharp spot but into a comma image. The axial beam displacement will cause a comma increase that could affect the light passing through the diaphragm (18a). With a properly selected tilt angle of the parallel windows and the position of the diaphragm (18a) coupled to the fiber optics guide (15a), the necessary sensitivity could be achieved.

For measurement of the difference between channels (a) and (b) a high gain amplifier electronics is used. The photodiodes (16a) and (16b) are operated in a photovoltaic mode. They are connected through resistors of 1 MΩ to the inverted inputs of two operational amplifiers. This configuration provides a possibility for fine adjustment of the offset caused by the small bias voltage difference between the photodiodes due to the slight difference in their internal shunt resistors. For this purpose a precision voltage reference V_{ref1} is used with isolated ground. The fine bias adjustment is provided by the multi-turn precision potentiometer P_3. The precision multiturn potentiometer P_1 and P_2 at the outputs of the amplifiers serve for fine adjustment in the signal difference from both channels. A differential amplifier and the final amplifier amplifies the signal difference until reaching the necessary level for data recording. The gain of this amplifier is adjusted by an external resistor. For suppressing the fluctuations from the photon shot noise and the dark

current fluctuations, low pass filtering is used. In order to monitor the signal change in the separate channels (a) and (b), two additional amplifier stages are also built based on operational amplifiers. They provide output signals that are not referenced to ground but to a reference voltage about -2.5 V. The reference voltage provided by the precision voltage regulator depends on the signal value, so is adjustable by potentiometer P4. The two amplifier stages are supplied by separate supply voltages +12 V and -12 V galvanically isolated from the ground of the differential channel. For achieving the necessary accuracy, the gain of all amplifiers must be very stable. Resistor network packages with a low resistance temperature coefficient are used. Separate resistors from the resistor network packages are used with dividers defining the gain of the differential and other two channels so temperature drifts can be compensated.
The fine tuning of the signals from channels (a) and (b) is provided by the precision potentiometers P1 and P2 when the LED source is ON. These adjustments must be made consecutively, with the bias adjusted by the potentiometer P3 when the LED source is off. A millivoltmeter with the needle at the middle scale is helpful for the fine adjustment. The output terminals are connected to a Data Acquisition system (DAQ) that contains 4 differential analog channels with adjustable gains from 1 to 8 and 12 bit A/D conversion.

Fig. 4 shows the experimental setup without a hermetical housing and the front panel of the amplifier unit. The optical channels with the photodetectors are mounted on a small optical table 70 cm x 35 cm, while the white LED source is mounted on the top.

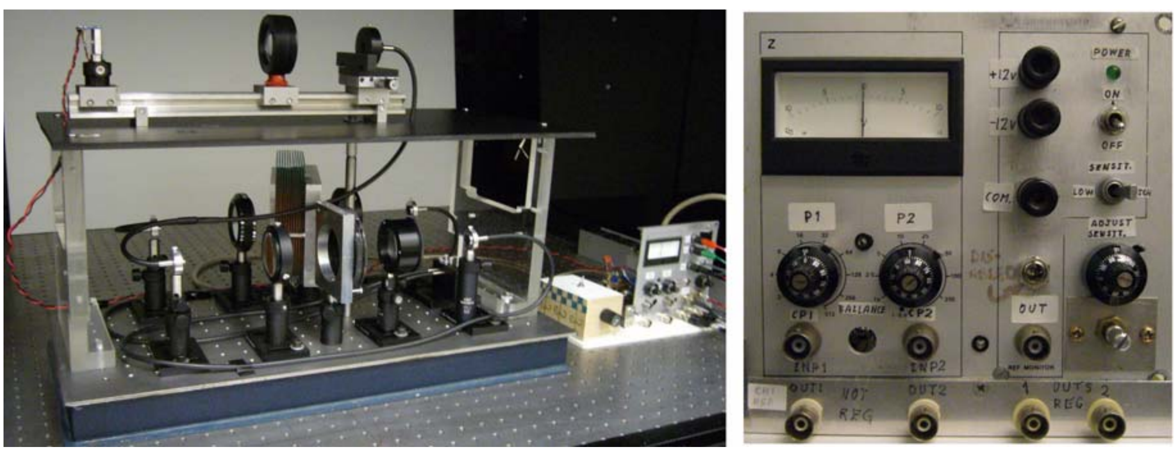

Fig. 4 Optical setup (left) and amplifier unit (right)

The use of a DC shifted reference voltage permits the amplification for the two single channels to be set to the same level as the differential channel, but the signals “out a” and “out b” appear in the range of the DAQ only when the light source LED is ON. The simultaneous measurement of the differential output and the outputs from the two separate channels was useful for observing that the change in the differential output was caused by the change in the measurement channel (a). The signal from the differential output was adjusted to be in the DAQ range for the ON and OFF states of the light source. This allowed monitoring of the DC drift from the amplifiers. At a proper light level, this drift is significantly suppressed. At the same time, the light intensity is selected to not exceed some level because the photoelectric mode of the photodiode has an upper range non-linearity.

4. Preliminary Results

The described experiment was setup in April 2010 in one a basement laboratory at York University, Toronto, at geographical coordinates of 43^0 43`N and $79^0$20`W and 133 m above sea level. In the initial setup the experiment was not in a sealed enclosure but the humidity, the barometric pressure and ambient temperature were permanently monitored and recorded. Initially the optical channel orientation A (see Fig. 2) was S-N. More systematic measurements were made in June. The light source LED was stabilized by current at 25 mA and it was periodically turned on/off with ON and OFF duration of 30 min. The data collecting covered periods of about 24 hours but the measurements. Fig. 5 shows measurement results from June 10 to June 13.

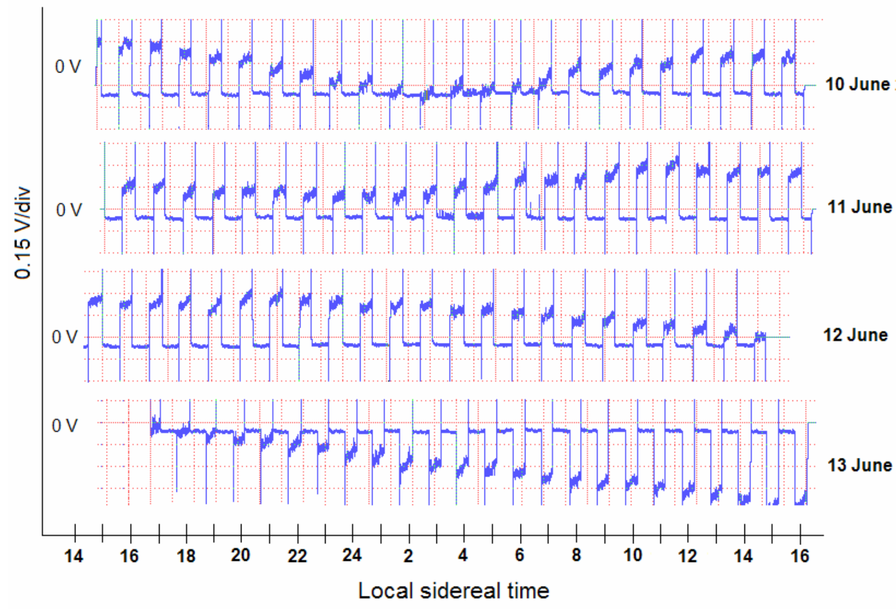

Fig. 5 Measurement results from June 10 to June 13 2010. The LED source was 30 min ON and 30 min OFF.

Preliminary results indicate that the 24 hr (diurnal) signal is superimposed on another effect probably dependent on the position of the laboratory with respect to the Earth-Moon barycentric center of gravity. There was a new Moon on June 12. We may speculate that the large change of the signal on June 12 and 13 could be from the gravitational influence of the Moon or some gravity wave effect. The orientation of our optical channels is opposite to the orientation of the Miller and other MM experiments, therefore the minimum of the diurnal cycle in Miller's experiment would correspond to the maximum of our experiment. Since the solar system velocity is larger than the Earth orbital velocity, the extremum position in the diurnal cycle does not change much when plotted against the LST (Local Sidereal Time). In Miller's data (Fig. 26 of his paper) [9], the minimum for April is at 14.5 hr LST and for August at 16 hrs LST. Interpolating for June it will be at 15.25 LST. In our observations on June 10 and 11, this corresponds to a maximum (we have a reverse direction) that is close to this value. This is in agreement also with the Esclangon experiment, Gallaev experiments and R. Cahill experiments. In his experiment described in [21] Cahill used fiber optics for a reference channel and claimed that the light velocity in the fiber optics is not affected by the Earth motion, while in the coaxial channel is affected. Later he abandoned this assumption but the effect was left unexplained. The multiple internal reflections of the light in the fiber optics depends on the refractive index ratio of the glass and the clad. Our conclusion is that the effect is explainable if assuming that the dielectric constants of the optical or EM medium of channels are affected but not proportionally. Then the methods used by Cahill becomes similar to our method. Therefore, these kinds of experiments will be suitable for detection of direction of light speed anisotropy but not for estimation of the actual speed of the Earth motion.

Additionally short and long time fluctuations were observed that are not caused by the instrument or surrounding environments. Such fluctuations are apparent in other experiments. According to Cahill they are from gravitational waves causing the day to day variations that are not contributed by the velocity components [35]. One possible explanation of this result is based on the different cosmological concept discussed by S. Sarg in [29,30]. If further validated, short-term gravitationally dependent anomalies may be explained, for example, by processes in the Sun. If such gravitational fluctuations exist, a time fluctuation will also exist. Such a conclusion would also explain recent observations of time fluctuation estimated by variations in radioactive decay [36]. Another signature of time fluctuation may be the unexplainable period fluctuation observed in millisecond pulsars known as pulsar timing noise or pulse frequency change [35]. According to Kosmogorov, it is of cosmological origin but it may also have a local component.

In order to eliminate convincingly changes induced by environmental effects from our results including temperature, pressure and humidity effects, the experiment will be enclosed in a sealed housing. The acquisition of longer data sequences will provide light-speed isotropy bounds with improved confidence levels. Previously effects identified by Cahill will also be addressed.

Our preliminary results appear to correlate with those of Miller, Esclangon, Galaev, Cahill and R. de Witte [35] where the direction of the velocity vector of the non-null effect is not shown to coincide with the direction of the CMB anisotropy.

5. Summary and conclusions

Presently, there is insufficient experimental confidence for light speed isotropy, an important postulate of the current standard model in Physics. A growing number of researchers have sought to identify a preferred reference frame with anisotropy observed in CMB radiation. However, these studies have provided ambiguous results or results were perceived anisotropy is correlated primarily with orientation with respect to the Earth-moon Barycenter. In this work we have presented a laboratory experiment to measure one-way speed of light anisotropy that is portable and inexpensive. Reliable and correlated data can now be accumulated. The experiment may be operated at different geographical locations and can also be used in the Pulsar observatories to look for possible correlations with pulsar timing noise.

We express our special thanks to Brian Solheim from CRESS, York University for the help with a lab space and optical components, William Treurniette for useful discussions and Nikolaos Balaskas from York University for the encouragement. This work was funded in part by Discovery Channel Canada, Thoth Technology Inc. and York University.

References

1. T. F. Howell and J. R. Shakeshaft, Measurement of the Minimum Cosmic Background Radiation at 20.7 cm Wave-length, Nature, v. 210, 1318-1319, (1966)
2. D. T. Wilkinson and R. B. Partridge, Large Scale Density Inhomogeneities in the Universe, Nature, v. 215, 719, (1967).
3. J. M. Stewart and D. W. Sciama, Peculiar Velocity of the Sun and its Relation to the Cosmic Microwave Background, Nature, v. 216, 748-753, (1967).
4. E. K. Conklin, Velocity of the Earth with Respect to the Cosmic Background Radiation, Nature, v. 222, 971-972, (1969).
5. G. F. Smoot et al, Detection of Anisotropy in the Cosmic Blackbody Radiation, Physical Review Letters, v. 39, No. 14, 898-901, (1977)
6. C. L. Bennett et al., First-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Results, The Astronomical Journal, Supplement Series, 148:1-27, (2003).
7. B. Nodland and J. P. Ralson, Indication of Anisotropy in Electromagnetic Propagation over Cosmological Distances, Physical Review Letters, v. 78, No. 16, 3043-3046, (1997).

8. A.A. Michelson and E.W. Morley, On the Relative Motion of the Earth and the Luminiferous Ether, Am. J. Sci. 34, 333-345 (1887)
9. D. Miller, The Ether-Drift Experiment and the Determination of the Absolute Motion of the Earth, Review of Modern Physics, v. 3, 203-241, (1933).
10. A. A. Michelson, F. G.Peas and F. Pearson, Repetition of Michelson-Morley Experiment, Nature, v. 123, 88, (1929).
11. E. Esclangon, Comptes Rendus, v. 185, 1593, (1927). http://www.conspiracyoflight.com/Esclangon/Aberration_and_Esclangon.html
12. http://en.wikipedia.org/wiki/Michelson-Morley_experiment (Table of experiments)
13. R. J. Kennedy, A refinement of the Michelson-Morley Experiment, Nt. Acad. Sci. Proc, v.12, 621-629, (1926)
14. K. K. Illingworth, A repetition of the Michelson-Morley Experiment using Kennedy's Refinement, Physical Review, v. 30, 692-696, (1927).
15. S. Marinov, Measurement of Laboratory's Absolute velocity, General Relativity and Gravitation, v. 12, No. 1, 57-65, (1980).
16. E. W. Silvertooth, Experimental detection of the ether, Speculations in Science and Technology, v. 10, No 1, 3-7, (1986).
17. Yu .M. Galaev, Etheral wind in experience of millimetric radiowaves propagation, Spacetime & Substances, V. 2, No 5, 211-225, (2001)
18. Yu .M. Galaev, The measuring of Ether-drift velocity and kinematic Ether viscosity within optical waves band, Spacetime & Substances, v. 3, No 5, 207-224, (2002).
19. M. Consoli and E. Constanzo, Motion toward the Great Atractor from an ether-drift experiment, arXiv:astro-ph/0601420 v. 2, (2006) (analysis of 3 Modern laboratory experiments, two in Germany and one in Australia, based on active and cryogenic optical resonators).
20. C. E. Navia et al, Search for Anisotropic Propagation as a Function of Laser beam Alignment Relative to the Earth's velocity Vector, v.1, Progress in Physics, 53-60, (2007).
21. R. T. Cahill, A New Light-Speed Anisotropy Experiment: Absolute Motion and Gravitational Waves Detected, Progress in Physics, v. 4, 73-92, (2006).
22. R. T. Cahill, D. Brotherton, Experimental Investigation of the Fresnel Drag Efect in RF Coaxial Cables, http://arXiv:1009.5772v1 [physics.gen-ph] 29 Sep 2010
23. R. T. Cahill and F. Stokesy Correlated Detection of sub-mHz GravitationalWaves by Two Optical-Fiber Interferometers, Progress in Physics, v.2, 103-110, (2008).
24. R. Hatch, Clocks and Equivalence principle, Foundation of Physics, v. 34, No11, 1725-1739, 2004.
25. Those scandalous clocks, GPS Solutions, 8:67-73, Springerlink.com, (2004)
26. R. Wang and R. H. Hatch, Conducting a Crucial Experiment of the Constancy of the Speed of Light Using GPS, Infinite Energy, 11, 64, 11-19, (2005).
27. C. K. Whitney, Is Optical Detection of linear velocity possible?, Infinite Energy, issue 69, 24-33, (2006)
28. R. R. Hatch, Contesting and testing infinitesimal Lorentz transformations and the associated equivalence principle, Physics Essays, 23, 1, 137-143, (2010)
29. S. Sarg, A Physical Model of the Electron according to the Basic Structures of Matter Hypothesis, Physics Essays, vol. 16 No. 2, 180-195, (2003)
30. S. Sarg, *Basic Structures of Matter –Supergravitation Unified Theory*, Trafford Publishing, 2006, ISBN 1412083877
31. G. Thuillier and M. Herse, Thermally stable field compensated Michelson interferometer for measurement of temperature and wind of the planetary atmosphere, Applied optics, v.30, No 10, 1210-1220, (1991).
32. G. Shepherd et al., The Wind Imaging Interferometer,
33. S. Marinov, Progress in Physics, v.1, 31-37, (2007)
34. F. Ahmet, B. M. Quine, S. Sargoytchev, A. D. Stauffer, A review of one-way and two-way experiments for test of isotropy of the speed of light, http://arxiv.org/ftp/arxiv/papers/1011/1011.1318.pd
35. R. Cahill, The Roland De Witte 1991 Experiment (to the Memory of Roland De Witte), Progress in Physics, v.3, 61-65, (2006).
36. J. H. Jenkins and E. Fischbach, Perturbation of Nuclear Decay Rates During the Solar Flare of 13 December 200, http://arxiv.org/abs/0808.3156v1
37. D. A. Hemberger and D. R. Stinnebring, Scintillation & Pulsar Timing: Low-Level Timing Noise from the Kolmogorov Halo, Chin. J. Astron. Astrophys. V. Suppl. 2, 1-4, (2006).
38. V. H. Hoteev, Discussions about Universe (In Russian), St. Petersburg, (2004)