Experiments to test special relativity

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All of the experiments supporting Einstein's Special Relativity Theory are also supportive of the Lorentz ether theory, or many other ether theories. However, a growing number of experiments show deviations from Einstein's Special Relativity Theory, but are supporting more extended theories. Some of these experiments are reviewed and analyzed. Unfortunately, many experiments are not of high quality, never repeated and mostly both. Results of repetition of several experiments (Silvertooth, Cahill) is reported and results of a new experiment based on the idea that the conductivity of a material depends in first order on the velocity of the material with respect to the ether will be presented. It is proposed that the most promising experiments should be repeated, under which the experiments performed by Demjanov in the 1960's.

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Introduction

Since the beginning of the 20th century is it generally believed that the kinematical interpretation of relativity theory is indistinguishable from the dynamical interpretation. It was Lorentz himself who stressed this in his book "The theory of electrons" paragraphs 189-194 although he remained a proponent of the concept of an ether as a dynamical interpretation [1].

Recently it has been argued by for instance Kohlmetskii [2,3,4] and de Haan [5] that this is not in general true. The Thomas-Wigner rotation due to the non-commutative property of the Lorentz transformations is a rotation that, in principle, is measurable as rotation of reference frame due to sequential boosts in non-collinear directions.

Further, occurrence of superluminal signal transport, as assumed to be possible in quantum mechanics due to its non-local character, as discussed for instance by Einstein [6] for the Einstein-Podolsky-Rosen thought experiment, would enable time synchronization and hence a reference frame in which the superluminal transport is instantaneous.

A pre-requisite for the kinematical interpretation of relativity theory is that *all* equations referring to moving axis have exactly the same form as those which apply for stationary systems [1]. This also should hold for the constitutive equations describing the interaction between matter and electromagnetic fields. These constitutive relations contain material properties such as permeability, permittivity and electrical conduction. The search for an ether reference frame can be regarded as a quest to verify or denounce the Lorentz covariant form of the constitutive relations by means of *experiments*.

Experimental categories

Simply one can divide the experiments to determine the absolute motion of the reference frame (or in other terms 'of the ether') into two categories: first order or second order experiments, where the observed effect should be proportional to the appropriate order of the ratio of the velocity of the laboratory frame relative to the speed of light.

Bradley aberration [7] and the cosmic microwave background signal [8] are the most famous ones of the first category, but these are already interpreted differently by mainstream physics. The observation of a dipole distribution in the cosmic microwave background radiation [7] is an important experiment. By special relativity it is interpreted as the remnants of the initiation of the universe. It can also be interpreted as a clear indication of a preferred reference frame and it has triggered renewed interest in the ether concept. If it is interpreted as the frame in which the ether is at rest, another conclusions must be drawn from the observation of the dipole: A first order effect is possible. This is in direct contrast to the popular believes of the 20th century.

The Michelson-Morley experiment [9] is the most famous one for the second category. Because of the large speed involved and the smallness of velocity of the laboratory, in the 19th and first half of the 20th century, measurements were restricted to interference techniques (polarization measurement can also be interpreted as an interference technique). The attention changed from first order experiments to second order experiments when at the end of the 19th century the Fizeau drag effect was used to explain why first order experiments were not able to detect the absolute speed of the earth. Nowadays, a further distinction into two other categories can be made: interference measurements and non-interference experiments.

In Table 1 the categories with some examples are shown. Some of these experiments have been performed, but never repeated. Others are proposals based on theoretical analysis. The listing is typical, but incomplete. Further details are discussed in [10].

	EXPERIMENT	PROPOSAL
Interference First order	Silvertooth (Standing waves) Galaev (Dynamic) De Haan (Gas-filled)	Wesley (Adapted Sagnac) Spaveri (Material-filled) Munera (Gas-filled)

	De Haan (Standing waves)	Christov (Correlator)
Interference Second order	Michelson-Morley Demjanov (Material-filled) Munera (Stationary) Cahill (Optical fiber) De Haan (Optical fiber)	Consoli (Gas-filled) Demjanov (Drag effect)
Non-Interference First order	Bradley aberration Cosmic Microwave background Marinov (Coupled shutters) De Witte (time difference)	Ahmed (Coupled shutters) Kozynchenko (time diff.) Kohlmetskii (Thomas Wigner rotation)
Non-Interference Second order		Sardin (time difference) Phipps, Jr. (aberration)

Table 1. Categories and possible experiments to test special relativity theory

Experimental results

Some of the experiments mentioned in table 1 have been repeated extensively. Miller [11] extended the work of Michelson and Morley and was convinced he measured a small but significant second order effect. Demjanov [12] repeated the experiments using material filled interference paths and reports both first and second order effects. However, the results obtained are all smaller than anticipated or without firm theoretical background. This triggered the author to repeat some of the mentioned experiments and perform some new ones based on the idea that the constitutive relations needs to be proven Lorentz covariant *by experiment*.

Optical fiber

The experiment with optical fibers claimed by Cahill to be able to detect the ether [13] have been repeated. The results are described in [14,15]. Although a first and second order signal was observed, the sidereal dependence is absent. The same set-up was used to measure the effect with a helium gas-filled tube [16], to find a difference in drag from a gas filled path with respect to an optical fiber path. Again a first and second order signal was observed, but again the sidereal dependence was absent.

Standing waves

Other interesting candidates to reproduce are the experiments by Silvertooth [17,18] where a special standing wave detector was used measuring a first order effect. The standing wave detector used by Silvertooth was a thin layer of light sensitive material in front of a photo-multiplier tube. This detector could measure the intensity of a light beam in a standing wave. This detector could not be reproduced, so a program was carried out to construct a standing wave detector based on amorphous silicon layer on a glass substrate [19,20]. It was shown that a successful standing wave detector could be constructed. The detector was used in a set-up where the phase difference between two arms of a Mach-Zehnder interferometer was compared with the phase of the standing wave. The set-up was rotated and data treatment was similar as described in [14,15]. Upon rotation of the set-up the phase difference revealed a first order effect, the amplitude and azimuth of which are shown in figure 1. However, the first order effect is very small compared to expectations and the sidereal dependence is even smaller[1].

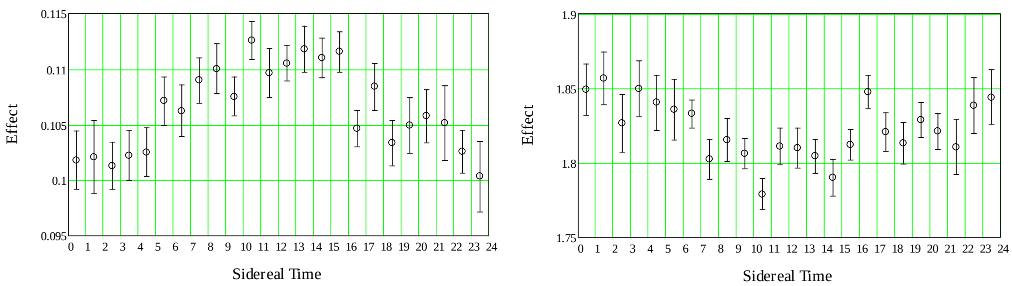

Fig. 1. Amplitude (left) in radians and azimuth (right) of first-order phase difference effect as function of sidereal time for measurements of the difference between the phase of a standing wave and the phase difference of two arms of a Mach-Zehnder interferometer. The measurements were performed form April 7 to April 16, 2012 at Puttershoek in The Netherlands (latitude 51.8^o; longitude -4.6^o).

[1] A peculiar effect was noticed though in these experiments. It seemed that the standing wave shifted its position with respect to the interferometer when the detector was moved along the standing wave, compared with the situation when the detector was fixed with respect to the interferometer creating the standing wave. This shift seemed to be independent of the velocity of the detector and occurs for detector speeds down to 3 micrometer per second (I was not able to move any slower, except for full stop). This strange behavior was very reproducible, but I am not able to explain it….

To possibly enhance the effect the standing waves were constructed by means of a Fabry-Pérot cavity [21] as shown in figure 2. The cavities were constructed by means of two semi-transparent thin silver layers on glass substrates. In such a way the phase difference due the conducting silver layers is enhanced by the multiple reflections in the cavity. During the measurements the transmission of the cavities was kept minimal by means of adaptation of the cavity length by piezo-crystals. The set-up was rotated and data treatment was similar as described in [14,15]. Upon rotation of the set-up the phase difference revealed a first order effect, the amplitude and azimuth of which are shown in figure 3. The measurements were performed form April 8, 2013 to September 10, 2014 at Puttershoek in The Netherlands (latitude 51.8^o; longitude -4.6^o). Again a first and second order signal was observed, but the sidereal dependence was much smaller than expected. Although the sidereal dependence is much smaller than expected, it is clearly visible in the data and confirmed by the Fourier transform of the data as shown in figure 4.

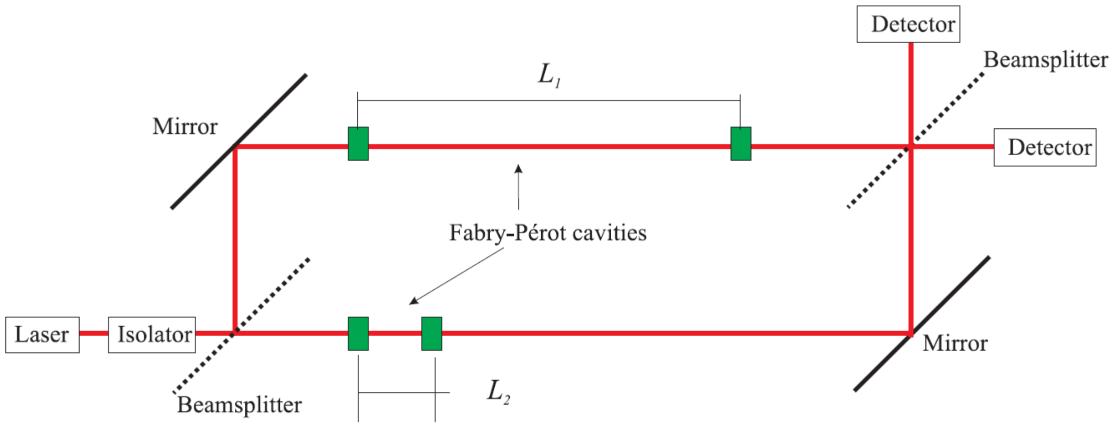

Fig. 2. Mach-Zehnder geometry for double Fabry-Pérot cavity

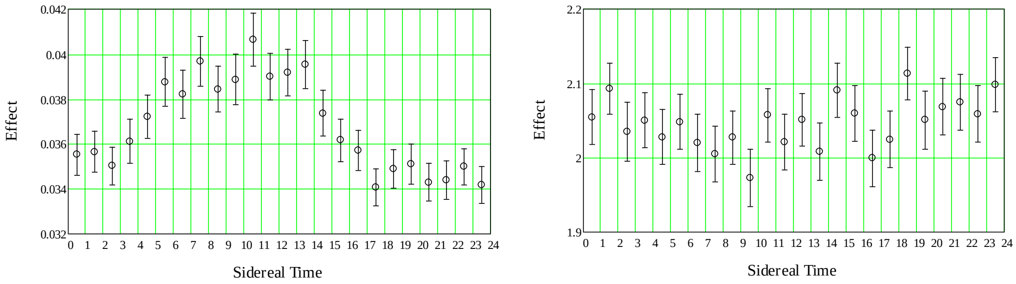

Fig. 3. Amplitude (left) in fringes and azimuth (right) of first-order phase difference effect as function of sidereal time for the phase difference of two arms of a Mach-Zehnder interferometer

with absorbing Fabry-Pérot cavities. The measurements were performed form April 8, 2013 to September 10, 2014.

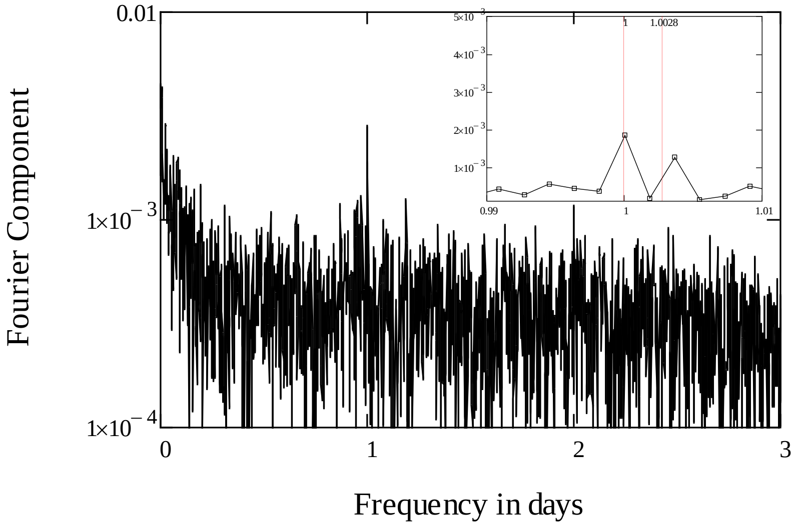

Fig. 4. Fourier components of the data presented in figure 3. The inset is a zoom of the region around a period of 1 day.

Discussion and Conclusions

Several experiments have been performed to observe possible deviations from the predictions of Einstein's special relativity theory. These experiments are both repetitions of experiments reported in literature and novel ones. Interestingly, although much smaller than expected, the observed sidereal dependence of two different experiments seem to exhibit some similarities. The ratio of the projection of the Earth velocity (with respect to a preferred frame) on the interferometer plane and the speed of light, for an assumed speed of the Sun with respect to the preferred frame given by Miller [11], at Puttershoek in the Netherlands is (latitude 51.8^o; longitude -4.6^o) is shown in figure 5. It is tentative to conclude that there exists a correlation between the experiments performed by Miller and the ones presented here, although the correlation between the phases is less obvious. More and similar correlations have been exposed by for instance Allais [22], Múnera [23], Cahill [24] and Consoli [25].

As noted by Múnera [23], the direction of the Cosmic Microwave background dipole is almost perpendicular to the direction given by Miller. This difference might be explained by the assumption that the interference measurements are not sensitive to the projection of the velocity on the plane of the interferometer, but to its rotation in that plane.

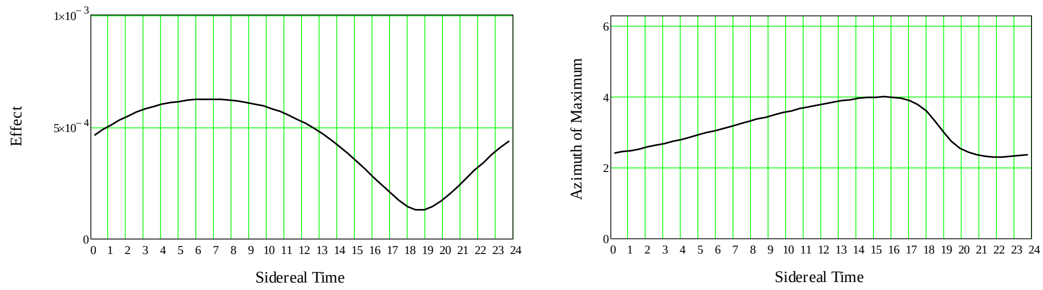

Fig. 5. Amplitude (left) in radians and azimuth (right) of the ration between the projection of the Earth velocity on the interferometer plane and the speed of light, for an assumed speed of the Sun with respect to the preferred frame given by Miller at Puttershoek (latitude 51.8^o; longitude -4.6^o) [11].

Although the experiments reveals some sidereal deviations, the magnitudes of the measured deviations are too small to reach any final conclusion. The question arises why the magnitude is smaller than expected. One can think of several reasons, the most important one is that the measured effect is just an instrumental artifact and that the observed similarity between the experiments is just a coincidence. However, it is also possible that the measured effect is due to a combination of instrumental artifact (for instance variable stresses in the set-up upon rotation) and a real first-order effect, with a smaller than expected value. In such a case the sidereal dependence remains, but is much smaller than expected. Finally it is also possible that the sidereal dependence of the effect is less due to a physical explanation as for instance referred to by Miller as 'entrainment' [11]. In such a case the ether is dragged along by the translation of the Earth around the Sun, but not by its rotation along its axis. Otherwise it would be impossible to measure the rotation of the Earth by means of Sagnac interferometers. It should be noted that the areas of the interferometers used in the experiments are of the order of few squared decimeter. The Sagnac effect can not be used to explain the observed phase differences, without additional assumptions on the influence of Earth rotation upon the constitutive relations yielding the phase differences. Millers experiments were performed at higher altitudes than the one described here (performed at an altitude of -10 m), hence it could be beneficial to repeat the experiments at a higher altitude.

It is proposed that the reported experiments are repeated and extended to include longer periods in time at several heights above the Earth surface. Further, except for the first-order measurements described here, experiments of Demjanov [12] can easily be repeated against moderate costs [26]. Except for experiments involving light interference, experiments exploiting the Thomas-Wigner rotation, as proposed recently by Kohlmetskii [4], are also possible and quite inexpensive.

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