Ives-Stilwell Time Dilation Li^+ ESR Darmstadt Experiment and Neo-Lorentz Relativity

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Progress in Physics 11, 14-17, 2014

Botermann, *et al.* in *Test of Time Dilation Using Stored Li^+ Ions as Clocks at Relativistic Speed*, *Physical Review Letters*, 2014, 113, 120405, reported results from an Ives-Stilwell-type time dilation experiment using Li^+ ions at speed 0.338c in the ESR storage ring at Darmstadt, and concluded that the data verifies the Special Relativity time dilation effect. However numerous other experiments have shown that it is only neo-Lorentz Relativity that accounts for all data, and all detect a 3-space speed $V \approx 470$km/s essentially from the south. Here we show that the ESR data confirms both Special Relativity and neo-Lorentz Relativity, but that a proposed different re-analysis of the ESR data should enable a test that could distinguish between these two theories.

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1 Introduction

Botermann *et al.* [1], reported results from an Ives-Stilwell [2, 3] time dilation experiment using Li^+ ions at speed $v = 0.338c$ in the ESR storage ring at Darmstadt, and concluded that the data verifies the Special Relativity time dilation effect, in (1). However numerous other experiments [4, 5] have shown that it is only neo-Lorentz Relativity that accounts for all of the data from various experiments, all detecting a 3-space speed $V \approx 470$km/s approximately from the south, see Fig.3. Here we show that the ESR data confirms neo-Lorentz Relativity, and that the ESR Darmstadt experimental data also gives $V \approx 470$km/s.

2 Special or Lorentz Relativity?

The key assumption defining Special Relativity (SR) is that the speed of light in vacuum is invariant, namely the same for all observers in uniform relative motion. This assumption was based upon the unexpectedly small fringe shifts observed in the Michelson-Morley experiment (MM) 1887 experiment, that was designed to detect any anisotropy in the speed of light, and for which Newtonian physics was used to calibrate the instrument. Using SR a Michelson interferometer should not reveal any fringe shifts on rotation. However using LR a Michelson interferometer [4], can detect such anisotropy when operated in gas-mode, i.e. with a gas in the light paths, as was the case with air present in the MM 1887 experiment. The LR calibration uses the length contraction, from (4), of the interferometer arms. This results in the device being some 2000 times less sensitive that assumed by MM who used Newtonian physics. Reanalysis of the MM data then led to a significant light speed anisotropy indicating the existence of a flowing 3-space with a speed of some 500km/s from the south. This result was confirmed by other experiments: Miller 1925/26 gas mode Michelson interferometer, DeWitte 1991 coaxial cable RF speeds, Cahill 2009 Satellite Earth-flyby Doppler shift NASA data [6], Cahill 2012 dual coaxial cable RF speed, [7], Cahill 2013-2014 [8, 9] Zener diode 3-space quantum detectors. These and other experiments are reviewed in [4, 10]. All these experiments also revealed significant space flow turbulence, identified as gravitational waves in the 3-space flow [10]. However there are numerous experiments which are essentially vacuum-mode Michelson interferometers in the form of vacuum resonant optical cavities, see [11], which yield null results because there is no gas in the light paths. These flawed experimental designs are quoted as evidence of light speed invariance. So the experimental data refutes the key assumption of SR, and in recent years a neo-Lorentz Relativity (LR) reformulation of the foundations of fundamental physics has been underway, with numerous confirmations from experiments, astronomical and cosmological observations [12–14].

However of relevance here are the key differences between SR and LR regarding time dilations and length contractions. In SR these are

$$\Delta t = \Delta t_0 / \sqrt{1 - v^2/c^2} \qquad (1)$$

$$\Delta L = \Delta L_0 \sqrt{1 - v^2/c^2} \qquad (2)$$

where v is the speed of a clock or rod with respect to the observer, c is the invariant speed of light, and subscript 0 denotes at rest time and space intervals . In SR these expressions apply to all time and space intervals. However in LR the corresponding expressions are

$$\Delta t = \Delta t_0 / \sqrt{1 - v_R^2/c^2} \qquad (3)$$

$$\Delta L = \Delta L_0 \sqrt{1 - v_R^2/c^2} \qquad (4)$$

where v_R is the speed of a clock or rod with respect to the dynamical 3-space, and where c is the speed of light with respect to the dynamical 3-space. In LR these expressions only apply to physical clocks and rods, and so the so-called time dilation in SR becomes a clock slowing effect in LR, caused by the motion of clocks with respect to the dynamical 3-space. Only by using (4) in place of (2) does the data from the Michelson-Morley and Miller gas-mode interferometers agree with the results from using other experimental techniques [5].

The interpretation of (1 and (3), relevant to the experiment discussed herein, is that if a time interval Δt_0 corresponds to 1 cycle of an oscillatory system at rest with respect to to an observer in SR, or at rest with respect to to space in LR, then $\nu_0 = 1/\Delta t_0$ is the frequency of the emitted photon. When the system is moving, with speed v with respect to to an observer, or with speed v_R with respect to to space, then the time internal Δt_0 is increased, and the emitted photon frequency is decreased to $\nu = 1/\Delta t$.

Here the LR effects are applied to the frequencies of photons emitted by the moving Li^+ ions, to the Doppler shifts of these photons, and to the clock slowing of the two detectors that measure the detected photon frequencies.

Fig.1 shows the direction of the 3-space flow as determined from NASA satellite Earth-flyby Doppler shifts [6], revealing that the flow direction is close to being South to North, which is relevant to the ESR Darmstadt experiment in which the Li^+ ions travel also from South to North.

Fig.2 shows the simple circuit for the quantum detection of the 3-space velocity, The measured 3-space speeds are shown in Fig.3, and follow from measuring the time delay between two such detectors, separated by 25cm and orientated such that the maximum time delay is observed for the 3-space induced quantum tunnelling current fluctuations.

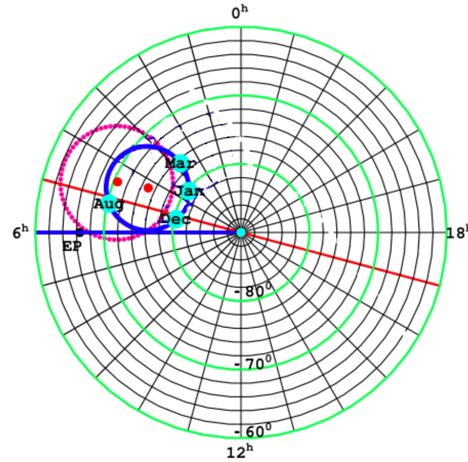

Figure 1: South celestial pole region. The dot (red) at RA=4.3^h, Dec=75°S, and with speed 486km/s, is the direction of motion of the solar system through space determined from NASA spacecraft Earth-flyby Doppler shifts [6], as revealed by the EM radiation speed anisotropy. The thick (blue) circle centred on this direction is the observed velocity direction for different months of the year, caused by Earth orbital motion and sun 3-space inflow. The corresponding results from the 1925/26 Miller gas-mode interferometer are shown by 2nd dot (red) and its aberration circle (red dots). For December 8, 1992, the speed is 491km/s from direction RA=5.2^h, Dec=80°S, see Table 2 of [6]. EP is the pole direction of the plane of the ecliptic, and so the space flow is close to being perpendicular to the plane of the ecliptic.

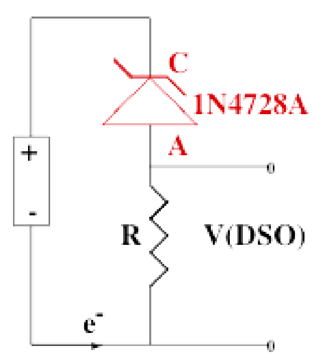

Figure 2: Circuit of Zener Diode 3-Space Quantum Detector, showing 1.5V AA battery, 1N4728A Zener diode operating in reverse bias mode, and having a Zener voltage of 3.3V, and resistor R= 10KΩ. Voltage V across resistor is measured and used to determine the space driven fluctuating tunnelling current through the Zener diode. Current fluctuations from two collocated detectors are shown to be the same, but when spatially separated there is a time delay effect, so the current fluctuations are caused by space speed fluctuations [8,9]. Using more diodes in parallel increases S/N. as the measurement electronics has 1/f noise induced by the fluctuating space flow.

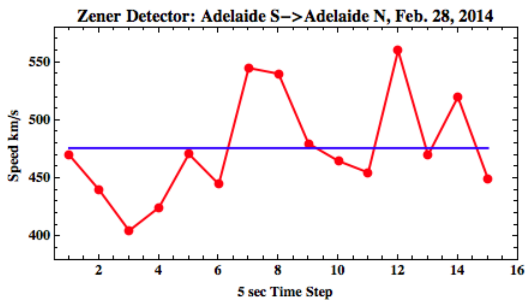

Figure 3: Average speed, and speed every 5 sec, on February 28, 2014 at 12:20 hrs UTC, giving average speed = 476 ± 44 (RMS) km/s, from approximately S → N, using two Zener Diode detectors [9]. The speeds are effective projected speeds, and so do not distinguish between actual speed and direction effect changes. The projected speed = $V cos[\theta]$, where θ is the angle between the space velocity V and the direction defined by the two detectors. V cannot be immediately determined with only two detectors. However by varying direction of detectors axis, and searching for maximum time delay, the average direction (RA and Dec) may be determined. As in previous experiments there are considerable fluctuations at all time scales, indicating a dynamical fractal structure to space.

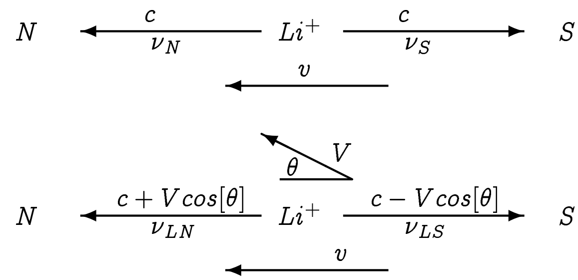

Figure 4: **Top:** Special Relativity speed diagram with Li^+ ions travelling at speed v towards the North, emitting photons with speed c and frequency ν_N to the North, and speed c to the South with frequency ν_S, with all speeds relative to the detectors N and S frame of reference. The invariant speed of light is c. The photons are emitted with frequency ν_0 with respect to the rest frame of the ions.
Bottom: Neo-Lorentz Relativity speed diagram with space flow speed V at angle θ and Li^+ ions travelling at speed v towards the North, emitting photons with speed $c+V cos[\theta]$ to the North and frequency ν_{LN}, and speed $c-V cos[\theta]$ to the South and frequency ν_{LS}. $V cos[\theta]$ is the projected space flow speed towards the North, with speeds relative to the detectors N and S frame of reference. The speed of light is c relative to the 3-space. The photons are emitted with frequency ν_0 with respect to the rest frame of the ions.

3 Special Relativity and Li$^+$ ESR Darmstadt Experiment

The Li^+ ESR Darmstadt experiment measured the photon frequencies ν_N and ν_S at the two detectors, emitted by the ions moving North at speed $v = 0.338c$, see Fig.4 Top. In SR there are two effects: time dilation of the emitting source, giving emitted photons with frequency $\nu_0\sqrt{1-v^2/c^2}$, from (1), where ν_0 is the frequency when the ions are at rest with respect to the two detectors. The 2nd effect is the Doppler shift factors $1/(1 \pm v/c)$, giving the detected frequencies

$$\nu_N = \nu_0\sqrt{1-v^2/c^2}/(1-v/c) \tag{5}$$

$$\nu_S = \nu_0\sqrt{1-v^2/c^2}/(1+v/c) \tag{6}$$

Then

$$\nu_N\nu_S/\nu_0^2 = 1 \tag{7}$$

and this result was the key experimental test reported in [1], with the data giving

$$\sqrt{\nu_N\nu_S/\nu_0^2} - 1 = (1.5 \pm 2.3) \times 10^{-9} \tag{8}$$

On the basis of this result it was claimed that the Special Relativity time dilation expression (1) was confirmed by the experiment.

4 Lorentz Relativity and Li$^+$ ESR Darmstadt Experiment

In LR expressions (5) and (6) are different, being

$$\nu_{LN} = \frac{\nu_0\sqrt{1-(v-V cos[\theta])^2/c^2 - V^2 sin[\theta]^2/c^2}}{(1-v/(c+V cos[\theta]))\sqrt{1-V^2/c^2}} \tag{9}$$

$$\nu_{LS} = \frac{\nu_0\sqrt{1-(v-V cos[\theta])^2/c^2 - V^2 sin[\theta]^2/c^2}}{(1+v/(c-V cos[\theta]))\sqrt{1-V^2/c^2}} \tag{10}$$

where $\nu_0\sqrt{1-(v-V cos[\theta])^2/c^2 - V^2 sin[\theta]^2/c^2}$, from (3), is the expression for the lower emitted photon frequency with the ions moving at velocity

$$v_R = (v - V cos[\theta], -V sin[\theta]) \tag{11}$$

with respect to the 3-space ; with $1/(1-v/(c+V cos[\theta]))$ and $1/(1+v/(c-V cos[\theta]))$ being the Doppler shift factors as the photons have speed $c \pm V cos[\theta]$ with respect to the detectors frame of reference; and $1/(1-V^2/c^2)$ being the time dilation effect for the clocks in the frequency measuring devices, as the slowing of these clocks, from (3), makes the detected frequency appear higher, as they have speed V with respect to the 3-space; see Fig.4 Bottom. From (9) and (10) we obtain

$$\nu_{LN}\nu_{LS}/\nu_0^2 = 1 - \frac{v^2 sin[\theta]^2}{c^2(c^2-v^2)}V^2 + O[V^4] \tag{12}$$

which is identical to (7) to 1st order in V. We obtain

$$\sqrt{\nu_{LN}\nu_{LS}/\nu_0^2} - 1 = -\frac{v^2 sin[\theta]^2}{2c^2(c^2-v^2)}V^2 \tag{13}$$

and, for example, $V = 400$km/s at an angle $\theta = 5^\circ$, with $v = 0.338c$, gives

$$\sqrt{\nu_{LN}\nu_{LS}/\nu_0^2} - 1 = -0.9 \times 10^{-9} \tag{14}$$

which is nearly consistent with the result from [1] in (8). It is not clear from [1] whether the result in (8) is from the smallest values or whether it is from averaging data over several days, as the LR prediction varies with changing θ, as would be caused by the rotation of the earth. Here we have used $\theta = 5^\circ$ which suggest the former interpretation of the data.

A more useful result follows when we examine the ratio ν_{LN}/ν_{LS} because we obtain a 1st order expression for V

$$Vcos[\theta] = \frac{c(c-v)^2}{2v^2}\left(\frac{c+v}{c-v} - \frac{\nu_{LN}}{\nu_{LS}}\right) \tag{15}$$

which will enable a more sensitive measurement of the projected $Vcos[\theta]$ value to be determined from the Li^+ ESR Darmstadt data. This result uses only the neo-Lorentz Doppler shift factors, and these have been confirmed by analysis of the Earth-flyby Doppler shift data [6]. $Vcos[\theta]$ will show space flow turbulence fluctuations and earth rotation effects, and over months a sidereal time dependence. The values are predicted to be like those in Fig.3 from the 3-space quantum detectors. Indeed such a simple detection technique should be run at the same time as the Li^+ data collection. The data is predicted to give $Vcos[\theta] \approx 470$km/s, as expected from Fig.3. Then the Li^+ experiment will agree with results from other experiments [4–10].

Note, that SR gives, from (5) and (6),

$$\left(\frac{c+v}{c-v} - \frac{\nu_N}{\nu_S}\right) = 0 \tag{16}$$

in contrast to (15).

5 Conclusions

The non-null experimental data, from 1887 to the present, all reveal the existence of a dynamical 3-space, with a speed $\approx$ 500km/s with respect to to the earth. Originally Lorentz proposed an aether moving through a static geometrical space. However the data and theory imply a different neo-Lorentz Relativity, with there being a dynamical fractal flowing 3-space, which posses an approximate geometrical measure of distances and angles, which permits the geometrical description of relative locations of systems [5]. As well the dynamical theory for this 3-space has explained numerous gravitational effects, with gravity being an emergent quantum and EM wave refraction effect, so unifying gravity and the quantum [4, 10, 13–16]. An important aspect of Lorentz Relativity, which causes ongoing confusion, is that the so-called Lorentz transformation is an aspect of Special Relativity, but not Lorentz Relativity. The major result here is that the Li^+ ESR Darmstadt experimental data confirms the validity of both Special Relativity and neo-Lorentz Relativity, but only when the 3-space flow is nearly parallel to the NS orientation of the Li^+ beam. Then to distinguish between these two relativity theories one could use (15). This report is from the Flinders University Gravitational Wave Project.

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