

Rotating the Einstein's light clock, to explain the Witte Effect. A basis to make the LIGO experiment work.

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Abstract

The Witte Effect, that was first observed by R. D. Witte [1] in 1991, and consist of a phase error between two synchronized atomic clocks, due to rotation of the earth, that can be connected to the earth "absolute" movement in the space.

The Witte Effect was explained in context of General Relativity, by R. T. Chaill[2], based on the Michelson-Morley Interferometer. Dr. Chaill demonstrates that, if the light speed in the medium (that forms the interferometer arms) is smaller than in vacuum (for example, using optical fibers) "absolute" velocities can be obtained. On this way, Chaill proposed that Witte experiments, in fact were measured "absolute" velocities of earth displacement in space, which maybe associated to the large gravitational fields references frames.

In this paper the author explains the Witte Effect, using only the Especial Relativity models, more specifically, rotating the Einstein's light clock and demonstrate that this Effect not is really connect to the Michelson-Morley Interferometer experiment. If this is true the Witte Effect can be used to update the gravitational wave detector, like the LIGO (Laser Interferometer Gravitational Wave Observatory) [5], and make it work.

1 – Introduction

The effect Witte [1] was first observed by R. D. Witte [2] in 1991 in performing a 177days experiment. In this experiment Witte monitored the phase delays between atomic clocks separated by a 1.5 km length coaxial cable. Figure 1 shows the delays observed by Witte in one direction, while in the opposite direction are observed the same phase delays, but with opposite sign. In this figure we can observe an sinusoidal phase delays variation, which has an period close to the sidereal day.

The value Δt represents the sinusoidal amplitude observed in the Witte effect, and can be calculated by the following equation:

$$\Delta t = L \frac{v_E n^2}{c^2} \quad (1)$$

Where L is the cable length, n is the cable refraction index, and the c vacuum light speed. The speed v_E is connected to the Earth travel speed the in space.

Witte was unable to publish their experimental results, because they apparently contradicted the SR. And so, the Witte effect was recognized as true only in 2006, when R. T. Cahill[2] showed that Witte effect can be explained without any contradiction with the principles of Einstein's relativity.

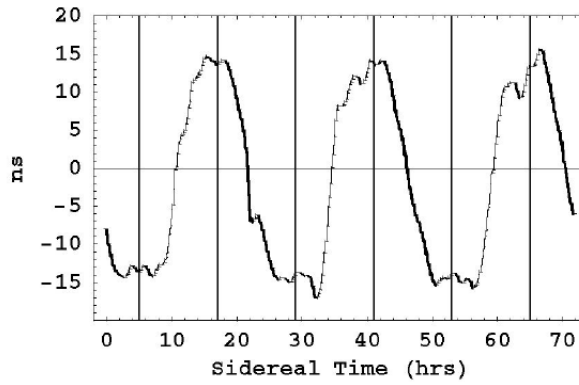


Figure 1 – Phase drifts, as observed by Roland De Witte in 1991

From the Witte experiment a 15ns phase delay was identified, like shown the graphic in Figure 1. By this value the equation (1) allows to calculate an Earth speed (v_E) of about 400km/s. According to Cahill [2] this Earth speed is fully compatible with a series of other experiments that have never been widely accepted by contemporary physics because they also apparently contradicted the SR.

2 – The Chaill explanation

In 2004 R. T. Chaill[3], explain the Witte Effect in context of Einstein’s Relativity Theories, considering a Michelson-Morley interferometer where the path of light propagation has it’s refractive index larger than 1.

Figure 2 present a schematic diagrams of the Michelson-Morley Interferometer, proposed by Chaill, with beam splitter/mirror at A and mirrors at B and C, on equal length arms when parallel, from A. D is a quantum detector (not drawn in(b)) that causes localization of the photon state by a collapse process. In (a) the interferometer is at rest in space. In (b) the interferometer is moving with speed v relative to space in the direction indicated. Interference fringes are observed at the quantum detector D. If the interferometer is rotated in the plane through 90° , the roles of arms AC and AB are interchanged, and during the rotation shifts of the fringes are seen in the case of absolute motion, but only if the apparatus operates in a gas. By counting fringe changes the speed v may be determined.

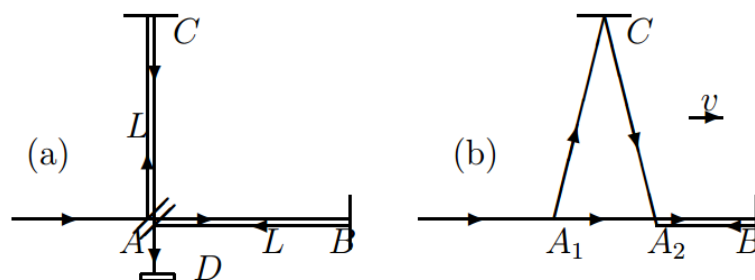


Figure 2 - Schematic diagrams of the Michelson-Morley Interferometer.

As detailed in [3], Chaill deduced the following equations:

$$v_p = \frac{v}{\sqrt{n^2 - 1}} \quad (2)$$

$$\Delta t = k^2 \frac{L|v_p|^2}{c^3} \cos(2(\theta - \psi)) \quad (3)$$

Where Δt is the time delay observed in the experiment, n is the refractive index of the gas through which the light passes, L is the length of each arm and c is the speed of light. The velocity v_p is the projection of the absolute velocity v of the interferometer through the plane of the interferometer. Here v_p has azimuth angle ψ relative to the local meridian, and θ is the angle of one arm from that meridian. The k^2 factor is $k^2 = n(n^2 - 1)$. Observe that equations (2) and (3) can be applied only for non-vacuum interferometers, where $n > 1$.

Although Chaill has demonstrated that interferometers, based materials with high refractive index, can used to absolute velocity measurements, the author believe that the Witte Effect not is really connected to the Michelson-Morley interferometer. On this way, the Witte Effect will appear even if the path that connected the two clocks on the Witte experiment has a unitary refractive index. In the following sections the Witte Effect is explained based on the Einstein's light clock rotation.

3 – Einstein's light clock

The Einstein's light clock [4], shown in Figure 3, is the most popular examples of relativistic time dilatation.

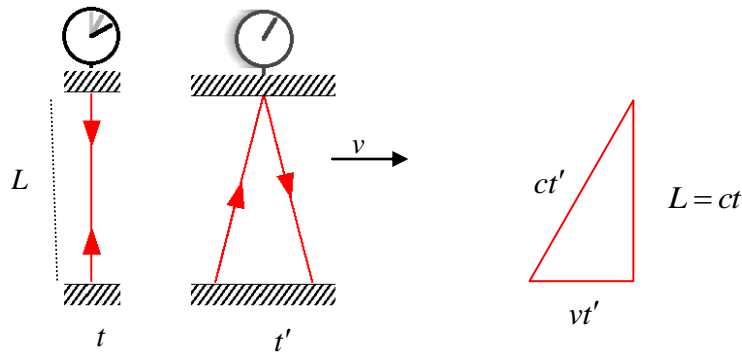


Figure 3 – Einstein's light clock

From the triangle shown in Figure 3 we can deduce the following equations:

$$(ct')^2 = (ct)^2 + (vt')^2$$

$$t'^2 \left(1 - \frac{v^2}{c^2} \right) = t^2$$

$$t' = Yt \quad ; \quad Y = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (4)$$

Figure 4 shows a variation of the Einstein's light clock experiment. This new experiment is based on a dual light clock, on with two light pulses traveling on perpendicular paths. There is vacuum inside the clock room, and so the light beams propagate in the clock at vacuum light speed c .

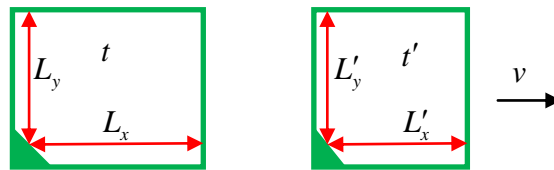


Figure 4 – Einstein's double light clock.

In Figure 5 the dual clock is presented in a time sequence for two situations: with the clock stopped and with the clock moving at a v speed.

If we consider that the watch is a perfect square, when it is stopped, we can observe the time sequence $(t_0, t_1, t_2, t_3, t_4)$ shown in Figure 5. In this sequence the two light pulses have basically the same movement, going out and returning at the same time.

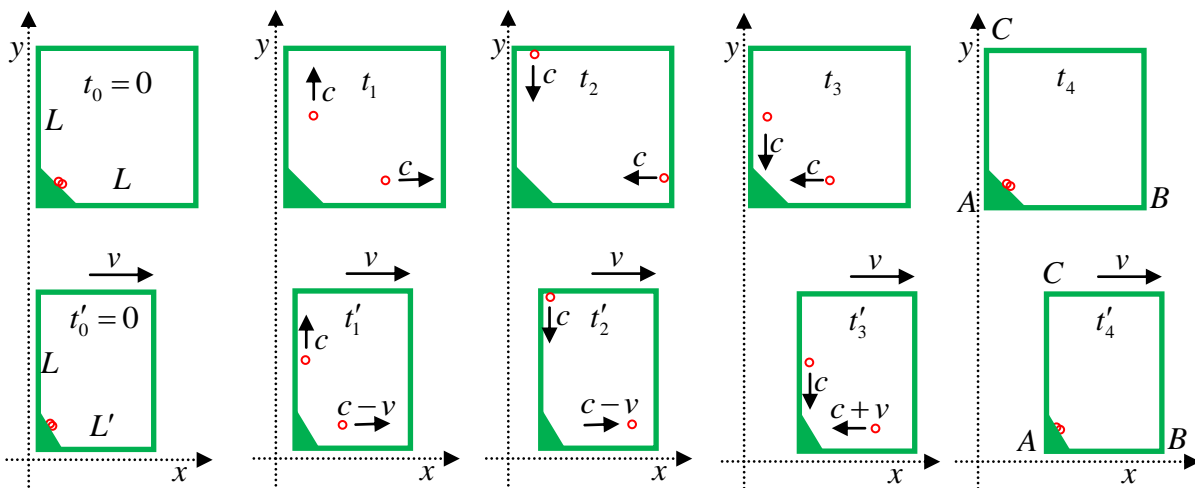


Figure 5 – Moving the Einstein's double light clock.

Observing the moving clock, we can see that the light pulse in AC path, up to the top of the box in time t'_2 , hit the mirror and begins to return. At this time the light pulse in AB path not arrived in the mirror because the point B is "running away" from these pulse, generating a relative velocity slightly less than the light speed $(c - v)$. On the other hand when the light pulse in the direction BA returns, the relative speed is a little above the light speed $(c + v)$ and so the two pulses arrive together.

Note that one observer inside the moving clock will see the same condition of one stopped clock, with all light pulses moving at the vacuum light speed.

Based on equation (4) and observing Figure 4, we can obtain the following relations:

$$\begin{aligned}
 t_2 &= \frac{t_A}{2} = \frac{L}{c} \\
 t_2 &= \frac{t_{AB} + t_{BA}}{2} \\
 t'_2 &= \frac{t'_{AB} + t'_{BA}}{2}
 \end{aligned}
 \tag{5}$$

On this way, from Equation 5, a phase delay Δt can be calculated as follows:

$$\begin{aligned}
 t'_{AB} &= \frac{L'}{c} + \Delta t' \\
 t'_{BA} &= \frac{L'}{c} - \Delta t' \\
 2\Delta t' &= t'_{BA} - t'_{AB} = \frac{L'}{c-v} - \frac{L'}{c+v} = L' \frac{2v}{c^2 - v^2} \\
 \Delta t' &= \frac{vL'}{c^2 \left(1 - \frac{v^2}{c^2}\right)} = \gamma^2 \frac{vL'}{c^2} \\
 \Delta t &= \frac{vL}{c^2}
 \end{aligned}
 \tag{6}$$

It may be noted that the delay shown in equation (6) is equivalent to the delay indicated for Witte effect in equation (1), except that the refraction index was not used in equation (6), because the Einstein's light clock operates on vacuum.

4 – Rotating the Einstein's light clock

Figure 6 shown an Einstein's light clock, that was assembled in order to rotate as it moves. In this case two atomic clocks are used, one at each end of the light clock. These atomic clocks are synchronized by the "hits" of the light clock.

Also in Figure 5, the rotating angle α was defined on the way that for a null angle, the light clock has a its maximum size.

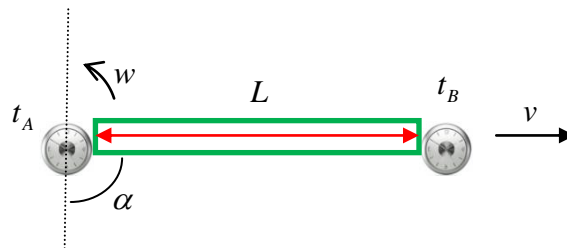


Figure 6 – Rotating the Einstein's light clock.

In the Figure 5 experiment, the length of the light clock can be calculated according to the α angle, through the equations:

$$\begin{aligned}
L_n(\alpha) &= \sqrt{L_x^2 + L_y^2} \\
L_n(\alpha) &= \sqrt{\left(\frac{L}{Y} \sin(\alpha)\right)^2 + (L \cos(\alpha))^2} \\
L_n(\alpha) &= L \sqrt{\left(1 - \frac{v^2}{c^2}\right) \sin^2(\alpha) + \cos^2(\alpha)} \\
L_n(\alpha) &= L \sqrt{1 - \frac{v^2}{c^2} \sin^2(\alpha)} \tag{7}
\end{aligned}$$

In equation (7) the space contraction factor is "modulated" by the α angle. Thus for a null angle the light clock length is not affected and so for a 90° angle to the length reaches a minimum value.

In Figure 5, clock "A" does not rotate and so the t'_A time is not affected by system rotation. The "B" clock, in turn, will present a t'_B time and a t'_{AB} propagation delay, which varies according to the α rotation angle:

$$\begin{aligned}
t'_B(\alpha) &= t'_A + t'_{AB}(\alpha) \\
t'_{AB}(\alpha) &= t'_B(\alpha) - t'_A \tag{8}
\end{aligned}$$

Based on the Figure 4 experiment of, and using equations (2) to (6), four values can be obtained for the t'_{AB} propagation delay:

$$\begin{aligned}
\alpha = 0 &\quad \Rightarrow \quad t'_B = t'_A + \frac{L'}{c} &\quad \Rightarrow \quad t'_{AB}(0) = \frac{L'}{c} \\
\alpha = \frac{\pi}{2} &\quad \Rightarrow \quad t'_B = t'_A + Y^2 \frac{L'}{c} + Y^2 \frac{vL'}{c^2} &\quad \Rightarrow \quad t'_{AB}\left(\frac{\pi}{2}\right) = Y^2 \frac{L'}{c} \left(1 + \frac{v}{c}\right) \\
\alpha = \pi &\quad \Rightarrow \quad t'_B = t'_A + \frac{L'}{c} &\quad \Rightarrow \quad t'_{AB}(\pi) = -\frac{L'}{c} \\
\alpha = \frac{3\pi}{2} &\quad \Rightarrow \quad t'_B = t'_A - Y^2 \frac{L'}{c} - Y^2 \frac{vL'}{c^2} &\quad \Rightarrow \quad t'_{AB}\left(\frac{3\pi}{2}\right) = -Y^2 \frac{L'}{c} \left(1 + \frac{v}{c}\right)
\end{aligned}$$

On this way the time variation (as a function of α angle) can then be calculated similarly to equation (7), using the following equation:

$$t'_{AB}(\alpha) = \sqrt{\left(Y^2 \frac{L'}{c} \left(1 - \frac{v}{c}\right)\right)^2 \sin^2(\alpha) + \left(\frac{L'}{c}\right)^2 \cos^2(\alpha)} \tag{9}$$

It is important note that in equation (9) times cannot simply be added, being necessary to use a quadratic metric for calculating the “temporal distance”. This occurs because, in the context of the SR, the time dimension behaves similarly to special dimensions, forming a four-dimensional continuum space-time. Equation (9) is valid both for rotation directions (clockwise and counter-clockwise), and thus should be considered the two possible signs defined in the square root function, as for example:

$$t'_{AB}(0) = \sqrt{\left(\frac{L'}{c}\right)^2} = \pm \frac{L'}{c}$$

$$t'_{AB}\left(\frac{\pi}{2}\right) = \sqrt{\left(Y^2 \frac{L'}{c} \left(1 - \frac{v}{c}\right)\right)^2}$$

$$t'_{AB}\left(\frac{\pi}{2}\right) = \pm Y^2 \frac{L'}{c} \left(1 - \frac{v}{c}\right)$$

Using some basic trigonometric relations the equation (9) can be simplified to:

$$t'_{AB}(\alpha) = \frac{L'}{c} \left(Y^2 - \frac{v}{c} \sin(\alpha) \right)$$

$$t'_{AB}(\alpha) = Y^2 \frac{L'}{c} - \frac{L'v}{c^2} \sin(\alpha)$$

$$t_{AB}(\alpha) = \frac{L}{c} - \Delta t \sin(\alpha) \tag{10}$$

Where Δt is given by equation (6).

Similarly we can calculate:

$$t_{BA}(\alpha) = \frac{L}{c} + \Delta t \sin(\alpha) \tag{11}$$

Figure 7 shows an experiment similar to Figure 6 experiment, also held in a vacuum, but now with two atomic clocks generating periodic laser pulses at the same frequency.

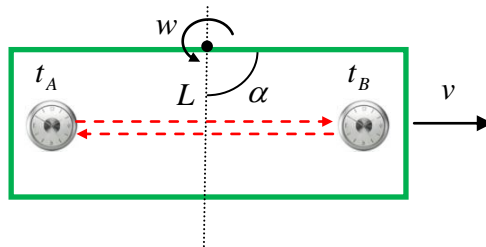


Figure 7 - Rotating two atomic clocks connected by two pulsed laser beams

In this condition the equations (10) and (11) point to the fact that the pulses will have its phase changed during the clock rotation. On this way a measurable phase delay will be generated, as shown by the red dot lines in Figure 8.

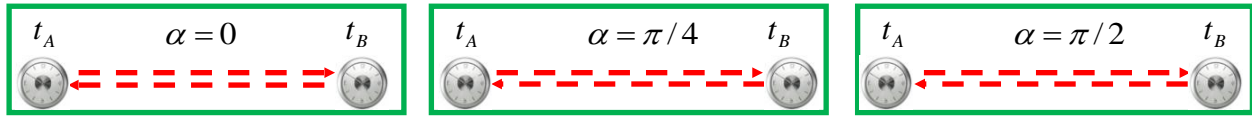


Figure 8 – Witte effect observed when comparing the light pulses phase shifts.

If this experiment is mounted on the Earth surface, the phase delays will vary according to the sidereal time, with a sinusoidal wave form given by equation (10). The wave amplitude will be function of the transmission channel characteristic and so function of the Earth speed like predict by the Witte effect. Thus, as shown in this section, rotating the Einstein’s light clock we can calculate the Witte effect, without any contradiction with the SR mathematical formulation.

5 – Conclusion

In references [2,3] R. T. Cahill has demonstrated that the Witte Effect can be considered valid, based on the fact that an absolute earth movement can be detected with Michelson-Morley interferometer that use for example, optics fiber in its arms.

Nevertheless the author believes that a simple rotation, in Einstein’s light clock, shows a relative phase delay, between two atomic clocks placed at both sides of the light clock, like presented in Figure 6.

In this kind of experiment, we cannot precisely synchronize the atomic clocks, but if its atomic oscillators have a frequency close to one another, the relative phase delay between these clocks tends to be constant, except if we rotate the clocks like shown in Figure 7. In this case the clocks will present phase delay that can be easy measured and depends on the rotation angle, the distance between the clocks, and is connected to the clocks “absolute” velocity.

Is important observe that equations (6), (10) and (11) can exactly model the effect observed in the Witte experiment, except that the refraction index presented in equation (1), that isn’t used in equation (6), because the Einstein’s light clock operates on vacuum.

These results suggest that one spacecraft could use the scheme presented in Figure 7 in order to determine its speed of displacement in space.

But it generates one doubt: Which is the reference for this "absolute" speed.

For Cahill this reference frame comes from the galactic (or even universal) gravitational field, for the author its reference frame point to some kind of Ether.

The author also believes that Witte Effect can be used to detect gravitational waves. On this way experiments like the LIGO [5] that until now, completely fail in the processes of gravitational waves detection, can be easy modified, based on the Witte Effect, turning to obtain the expected results.

References

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