How Can We Observe Waves Without Seeing The Ocean? Witte-Ulianov Time Interferometer: A Gravitational-Wave Detector Without Low Range Frequency Limitation

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In Memoriam:

Roland De Witte

The first modern physicist to see this new ocean

Abstract

This article presents a new kind of gravitational-wave detector, named by the author as the Witte-Ulianov Time Interferometer (WUTI) gravitational-wave detector. This new detector is based on the General Relativity (GR) concept that gravitational fields change "time flow".

In February 2016 the world received news that the Laser Interferometer Gravitational-Wave Observatory (LIGO) finally and successfully detected a gravitational-wave. Nevertheless, LIGO´s detectors have several technical limitations, mainly associated with low frequency noise sources, which result in a narrow measuring range, from 80 to 300Hz. It is very little if we consider that important events can generate gravitational-waves having periods of time ranging from a few seconds to several hours long. Using an analogy, we can say that LIGO shows us a universe that can be observed by gravitational-waves. Though, unfortunately, LIGO`s narrow measuring range has not really "opened the door" for this new universe, only allowed us to look at it through the "keyhole".

The Witte-Ulianov Time Interferometer can detect gravitational-waves, based on time distortion that, as provided by General Relativity, happens when this kind of wave passes through the detector.

To measure distortions of time, WUTI uses the Witte effect. This effect was first observed by R. D Witte in 1991 when he was measuring errors in atomic clocks. The Witte effect allows the observation of time distortions by measuring phase changes over precise time sources.

This author believes that the Witte effect enables us to measure changes in the "time flow" between two points in a space, using two very accurate clock sources (atomic clocks or high stable frequency laser sources). When these clocks are hit by a gravitational-wave, the "time flux" between these points changes. These changes can be easily observed using phase comparators.

As the WUTI detector of gravitational-waves monitors "Time flow", its operation is minimally affected by physical phenomenon, in contrast to the LIGO detectors that are affected by many noise sources (mainly in low frequencies).

Therefore, the WUTI detector is able to operate without low frequency limitation, making it possible to detect gravitational-waves that have time periods of seconds, minutes or even hours. <u>This allows the detection of very slow of gravitational fields</u>, enabling the observation of variations in the fields around Earth, caused by the planet´s displacement and rotation.

The WUTI is able to observe the moon and the sun´s gravitational fields, and also the Milky Way´s gravitational variations. This means this detector can "see" not only gravitational-waves, but also the Gravity Ocean in which the Earth sails.

Keywords

Gravitational waves, LIGO , Laser Interferometer Gravitational-Wave Observatory.

Academic Discipline and Sub-Disciplines

Relativity and Cosmology

Subject Classification

Physics Classification

Type (Method/Approach)

Theoretical analysis of LIGO detectors and analysis of the Witte effect in contexts of Especial Relativity and General Relativity.

INTRODUCTION

On September 13th in 2015, the Laser Interferometer Gravitational-Wave Observatory (LIGO), was reported [1] to have detected its first gravitational-wave, the GW150914 event.

However, some authors [10], [11] are claiming that this detection of gravitational waves by LIGO can be a false alarm!

The signals LIGO recorded from this event, presented in Figure 1, are related to gravitational-waves generated by black hole collisions.

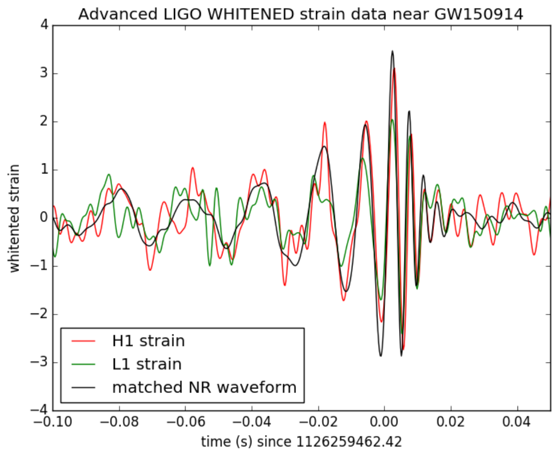


Fig 1: Processed signals from the GW150914 event

This discovery marked a triumph for hundreds of physicists that work at LIGO. Nevertheless, LIGO has several technical limitations associated with the way it detects gravitational waves, resulting in a very narrow frequency measuring range, from 80 to 300Hz. This range seems very restricted, mainly if we consider that important astronomical events can generate gravitational waves with periods of time ranging from a few seconds to several hours long.

In the GW150914 event, the recorded signals have less than 0.1 seconds of duration, as can be seen in Figure 1.
In Figure 2, we can see the "NF waveform" (in green) that is connected to the Numerical Relativity signal, a simulation of the black hole collision that lasts for a few seconds. Comparing the signals in Figure 2, is easy to observe that LIGO´s detectors lost the beginning of the gravitational-wave curves, due to their low frequency range limitation.

If LIGO had a wider frequency range, for example 10 to 300Hz, we could see both signals with the same shape in Figure 2, leaving no doubt about the occurrence of gravitational waves in this event.

So, just looking at the recorded signals we could see they were generated by a collision of two black holes!

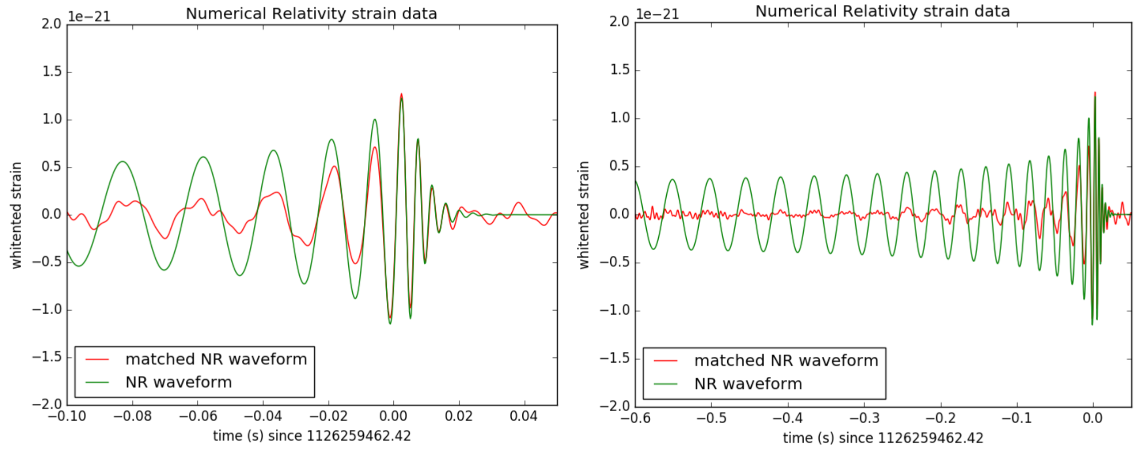


Fig 2: Signals from the black hole collision: NR waveform in green and matched NR waveform in red. The two graphs show the same curves in different time windows.

LIGO GRAVITATONAL WAVE DETECTION

According to Einstein´s General Relativity (GR) theory, gravitational waves generate space-time distortions. The LIGO detectors basically search for effects from space distortion over a modified Michelson interferometer, which record gravitational-wave signals by measuring the difference in length between the interferometer´s orthogonal arms.

In LIGO detectors, each interferometer arm has two mirrors, acting as test masses. A passing gravitational-wave effectively alters the arm lengths. This variation in length can be measured by laser beam interferences that are the basis of the Michelson interferometer´s operation.

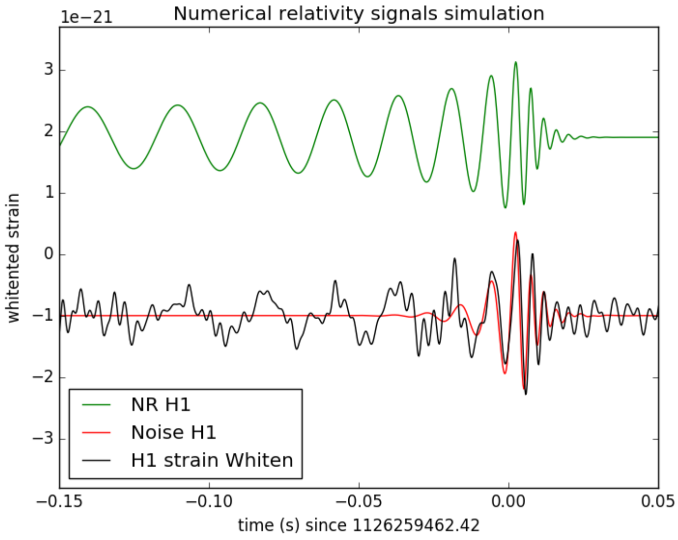


Fig 3: Signal from the black hole collision: NR waveform (in green), noise signal (in red), and record strain at Hanford (in black)

The problem with this type of “space distortion” detector is that many other factors can cause movement in the test mass. Therefore, the interferometer output has a very high superimposed noise over the measurement signal, which actually causes the LIGO measurement frequency range to be extremely limited, from 80 to 300 Hz.

This LIGO detector´s low range limitation causes a big problem; the record gravitational-wave can also be generated by a noise signal, as presented in Figure 3.

As presented in Figure 3, the H1 strain (the black signal) can be generated from a black hole collision (the green signal) or by a random noise (the red signal). This means that by only looking at the H1 strain curve, we cannot discern between a real event and a spurious noise event.

Thus, the LIGO system needs to use two detectors (Hanford and Livingston) to be able to differentiate the gravitational waves from the noise. In the GW150914 event, as presented in Figure 1, we can see the same kind of waves, which were recorded with 7.5ms of time shift between them. This time shift is inside of a 10ms time window (maximum time that light takes to get from one detector to the other), meaning that the signals detected in GW150914 event can be the same gravitational wave hitting both detectors in sequence.

However, this coincidence does not eliminate the fact that the signals recorded in the GW150914 event could just be two spurious noises randomly hitting the detector in the same time window. Hence, the LIGO team presented a statistical analysis concluding that this type of coincidence could occur once every 67 thousand years.

This author thinks that LIGO´s detector frequency range limitation turns this system from a “general gravitational-wave detector” into a “Black Hole Collision detector”, with several months or years before a new event can be detected.

In an analogy with real waves that occur in the ocean, it is as if LIGO were a Tsunami detector activated over a very long period of time that is unable to see the thousands of waves hitting the beach every day.

WITTE-ULIANOV TIME INTERFEROMETER

The White-Ulianov Time Interferometer basically observes gravitational waves using the effects of time distortion, which according to GR, appears when this kind of wave ‘hits’ the Earth.

This new kind of interferometer is based on the Witte effect, which was first observed by R. D Witte in 1991 while measuring errors in atomic clocks using phase comparison methods.

The Witte effect (which is presented in more detail later in this article) can be used to measure the Earth's speed in space, something that, until now, has not been fully accepted by modern physicists. Interestingly, this was the result expected by Michelson when he created his interferometer. Michelson´s experiment failed because, as shown in Special Relativity, the size of the interferometer´s arms change depending on the earth's displacement (and rotation). Thus, the speed of light measured by Michelson´s interferometer is always constant and he did not observe the addition (or subtraction) of the speed of light with Earth´s velocity.

This author believes the Witte effect can detect the Michelson´s interferometer arm size changes because this variation is a result of the space contraction phenomenon that is directly connected to the time dilatation phenomenon, which can be caused in two ways:

- According to Special Relativity, for observers moving in high velocity (near to the speed of light) time “flows” more slowly and objects shrink according to their movement direction;
- According to General Relativity, for observers inside of gravitational fields time also “flows” more slowly and the space shrinks.

Therefore, the same gravitational waves that effectively alter the LIGO interferometer arm lengths, will also change the time flow between two points at the end of the arms and at the junction point.

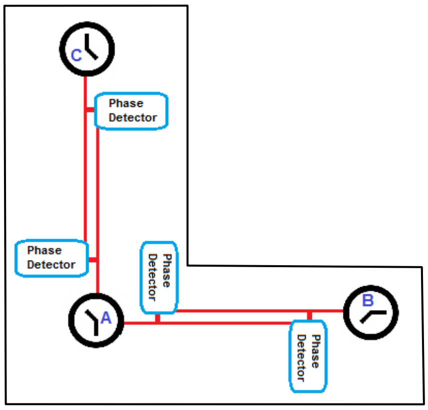


Fig 4: White-Ulianov Time Interferometer with two arms

Figure 4 presents a basic two-arm Witte-Ulianov Time Interferometer, which can easily be implemented over the current LIGO structure. Note that the clocks in this Figure can be atomic clocks, with output signals connected by coaxial cables or even by microwave conductors using electronic circuits to do the phase change detection. However, to gain more time accuracy we can also use stable laser sources that generate light beams, with the phase detection being made directly using photo detectors. The connections between the laser sources and phase detector can be made by means of optical fiber cables, but the best option is to use vacuum chambers that exist in LIGO detectors today.

It is important to note that the WUTI gravitational-wave detector can record two phase shift signals, each one being proportional to the gravitational-wave projection over the arm that generates the signal.

The WUTI gravitational-wave detector also can be mounted on a three arm configuration (with the third arm being mounted over a high tower or in a well dug in the ground).

THE WITTE EFFECT

The Witte effect was first observed by R. D. Witte [2] in 1991 by carrying out a 177 day experiment. In this experiment, Witte monitored the phase delays between atomic clocks connected by a 1.5 km length coaxial cable.

Figure 1 shows the delays observed by Witte over three consecutive days. In this figure we can observe a sinusoidal phase delay variation, which has a 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:

$$\Delta t = L\frac{v_E n^2}{c^2} \tag{1}$$

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

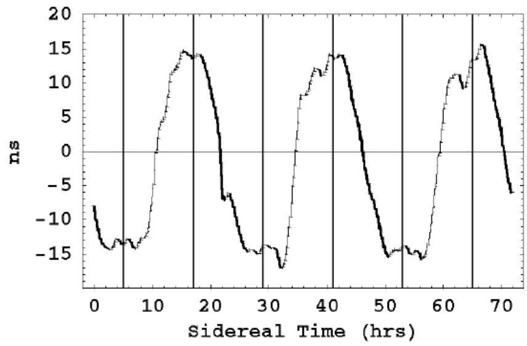


Fig 5: Phase drifts, as observed by Roland De Witte in 1991

Witte was unable to publish his experimental results, because they apparently contradicted Special Relativity. Hence, the Witte effect was recognized as being true only in 2006, when R. T. Cahill [2] proposed that the Witte effect can be explained without any contradiction of the principles of Einstein's relativity theories.

ROTATING EINSTEIN’S LIGHT CLOCK TO EXPLAIN THE WITTE EFFECT

The Witte Effect can be easily explained by rotating Einstein’s light clock [3]. Figure 6 presents the basic concept of Einstein’s light clock, which is the most popular example of relativistic time dilatation.

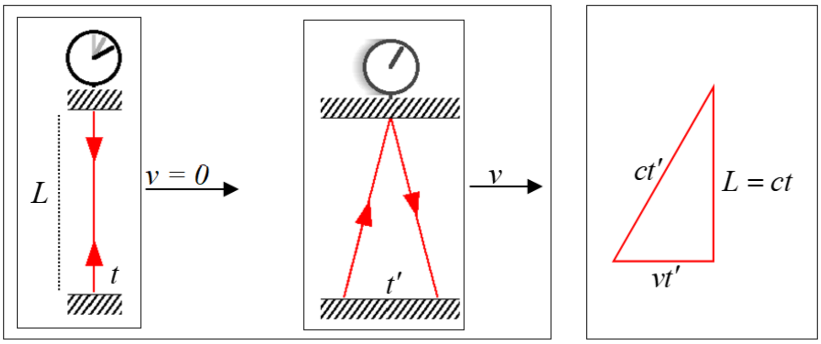


Fig 6: Einstein’s light clock

From the triangle shown in Figure 6, we can deduce the following equations:

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

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

$$t' = t\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \quad \rightarrow \quad t' = tY \tag{2}$$

$$Y = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{3}$$

Figure 7 presents Einstein's light clock, that was assembled in order to rotate as it moves. To better understand this light clock's operation, two standard atomic clocks are used, one at each end of the light clock. These atomic clocks are ideally accurate and can be synchronized by the "hits" of the light.

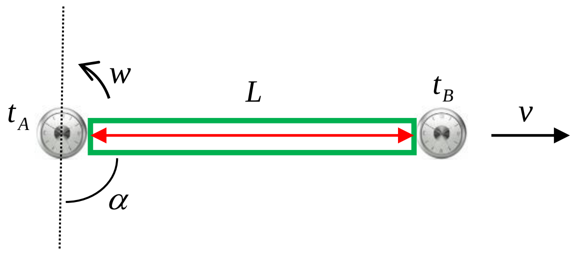


Fig 7: Rotating the Einstein's light clock.

To analyze Einstein's light clock rotation, we can first imagine two of Einstein's light clocks, in a room that are moving through space, as presented in Figure 8. There is a vacuum inside the clock room, where light beams propagate at the speed of light (*c*). If the room is stationary, it forms a square, but moving at speed v, the room shrinks according to its movement direction.

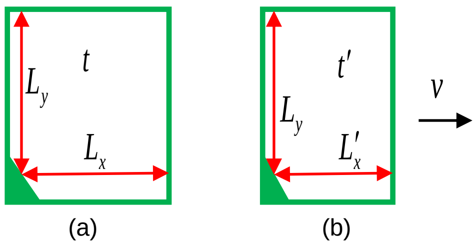


Fig 8: – Two of Einstein's light clocks: a) room stationary; b) room moving at speed *v*.

The dual clock presented in figure 8, can be observed in sequences of times, as presented in Figure 9, considering two situations: with the clock stationary, and with the clock moving at speed v. For the stationary case, we can see two light pulses traveling inside room in time frames $(t_0, t_1, t_2, t_3, t_4)$. These pulses have basically the same movement, going out and returning at the same time. For the room moving case, an external observer can see the light pulse in the horizontal path moving at the speed of light, but the room wall is also moving at *v* speed. Thus, the vertical light pulse hits the top of the room at time t'_2 before the horizontal pulse hits the right wall. On the other hand, when the horizontal light pulse returns, the relative speed (from the wall and the light pulse) is a little faster than the speed of light ($c+v$), with the two pulses arriving together.

One observer inside the room is always in the stationary case, not able to detect the room shrinking or see variations in the light pulses´ speeds .

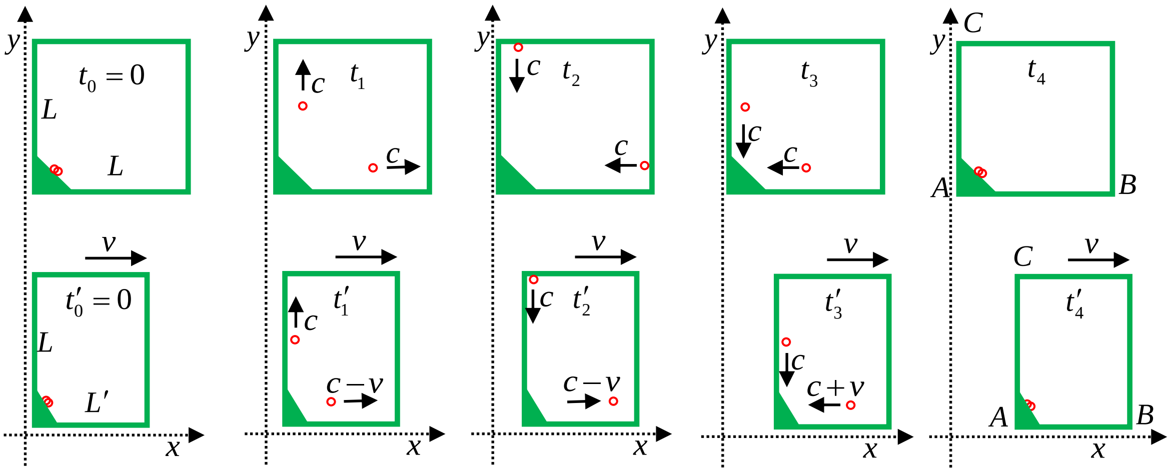


Fig 9: Time frames for the rooms presented in Figure 8.

Observing Figure 9, we can obtain the following relations:

$$t_2 = \frac{t_4}{2} = \frac{L}{c}$$
$$t_2 = \frac{t_{AB} + t_{BA}}{2}$$
$$t'_2 = \frac{t'_{AB} + t'_{BA}}{2} \quad (4)$$

Hence, from equations (3) and (4), we can define a phase delay (Δt), related to time differences with the vertical pulse hitting the top of the room and the horizontal pulse hitting the right wall. This delay can be calculated as follows:

$$t'_{AB} = \frac{L'}{c} + \Delta t'$$
$$t'_{BA} = \frac{L'}{c} - \Delta t'$$
$$2\Delta t' = t'_{BA} - t'_{AB} = \frac{L'}{c-v} - \frac{L'}{c+v} = L'\frac{2v}{c^2 - v^2}$$
$$\Delta t' = \frac{vL'}{c^2\left(1 - \frac{v^2}{c^2}\right)} = Y^2 \frac{vL'}{c^2} \quad (5)$$
$$\Delta t = \frac{vL}{c^2}$$

Returning to the rotating light clock presented in Figure 7, we can note that for null angle α the light clock has its maximum size (related with the vertical light clock in Figure 8). Therefore, when α is equal to 90°, the light clock shrinks to its minimum size (related with the horizontal light clock in Figure 8). And so, the length of the light clock changes according to angle α, and can be calculated by:

$$L'(\alpha) = \sqrt{L_x^2 + L_y^2}$$

$$L'(\alpha) = \sqrt{(\frac{L}{Y}\sin(\alpha))^2 + (L\cos(\alpha))^2}$$

$$L'(\alpha) = L\sqrt{(1-\frac{v^2}{c^2})\sin^2(\alpha) + \cos^2(\alpha)}$$

$$L'(\alpha) = L\sqrt{1-\frac{v^2}{c^2}\sin^2(\alpha)} \qquad (6)$$

In equation (6) the space contraction factor is "modulated" by angle α. From this equation it is easy to see that if α is equal to zero, the light clock length is not affected by the movement. Hence, if α is equal to 90° the length has a minimum value because it is shrunk by the movement.

As in Figure 7, clock "A" does not rotate, so the time measured by it (t'_A) is not affected by system´s rotation. Moreover, clock "B" rotates around clock "A", so clock "B" measures time t'_B that depends on angle α. This means that rotating Einstein´s light clock generates a time propagation delay ($t'_{AB} = t'_B - t'_A$), which varies according to angle α:

$$\begin{aligned} t'_B(\alpha) &= t'_A + t'_{AB}(\alpha) \\ t'_{AB}(\alpha) &= t'_B(\alpha) - t'_A \end{aligned} \qquad (7)$$

For the time frames presented in Figure 9, using equations (2) to (6), four values can be obtained for the t'_{AB} propagation delay:

$$\alpha = 0 \quad \Rightarrow \quad t'_B = t'_A + \frac{L'}{c} \quad \Rightarrow \quad t'_{AB}(0) = \frac{L'}{c}$$

$$\alpha = \frac{\pi}{2} \quad \Rightarrow \quad t'_B = t'_A + Y^2\frac{L'}{c} + Y^2\frac{vL'}{c^2} \quad \Rightarrow \quad t'_{AB}(\frac{\pi}{2}) = Y^2\frac{L'}{c}(1+\frac{v}{c})$$

$$\alpha = \pi \quad \Rightarrow \quad t'_B = t'_A + \frac{L'}{c} + \quad \Rightarrow \quad t'_{AB}(\pi) = -\frac{L'}{c}$$

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

Therefore, the time variation (as a function of angle α) can then be calculated, using the following equation:

$$t'_{AB}(\alpha) = \sqrt{\left(Y^2\frac{L'}{c}(1-\frac{v}{c})\right)^2 \sin^2(\alpha) + \left(\frac{L'}{c}\right)^2 \cos^2(\alpha)} \qquad (8)$$

It is important to note that in equation (8) time differences cannot simply be added, as it is necessary to use a square metric for calculating the “temporal distance”. This occurs because, in the context of Special Relativity, the time dimension behaves similarly to spatial dimensions, forming a four-dimensional continuum space-time.

Equation (8) is valid for both rotation directions (clockwise and anti-clockwise), and we need to consider two possible signs defined in the square root function, for example:

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

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

Using some basic trigonometric relations equation (8) can be simplified to:

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

$$t'_{AB}(\alpha) = \pm(Y^2 \frac{L'}{c} - \frac{L'v}{c^2}\sin(\alpha)) \qquad (9)$$

For an observer inside the room, equation (9) becomes:

$$t_{AB}(\alpha) = \frac{t'_{AB}(\alpha)}{Y} \quad ; \quad L = YL'$$

$$t_{AB}(\alpha) = \frac{L}{c} - \frac{vL}{c^2}\sin(\alpha) \qquad (10)$$

And so, we can define a variation over the time propagation delay (t_{AB}):

$$t_{AB}(\alpha) = \frac{L}{c} - \Delta t_{AB}(\alpha)$$

$$\Delta t_{AB}(\alpha) = L\frac{v}{c^2}\sin(\alpha) \qquad (11)$$

Equation (11) means that if we rotate Einstein’s light clock, as presented in Figure 7, a phase delay variation (Δt_{AB}) between the two clocks can be observed.

It is important to note that if angle α is equal to 90º, equation (11) calculates a time propagation delay that is equivalent to the Witte effect´s delay, calculated by equation (1). Otherwise, the refraction index that appears in equation (1) is not used in equation (11), because Einstein’s light clock operates in a vacuum.

If the experiment presented in Figure 7, was mounted on the Earth´s surface, angle α varies according to the sidereal time, and a sinusoidal wave form given by equation (11) can be easily measured. This is the basis of R. D. Witte´s experiment, using two atomic clocks positioned a few kilometers from each other. Witte generated two synchronized sine waves (over a coaxial cable) that were compared using a phase shift meter. This experiment generated a sine wave delay with amplitude of 15ns and a sidereal time period, as presented in Figure 1. As this wave amplitude is a function of the clocks´ distance and speed, R. D. Witte was able to use this value to calculate the velocity where Earth is moving in space.

This phenomenon become known as the Witte effect, and as shown in this section, by rotating the Einstein's light clock we can calculate phase delays, using equation (1), without any contradiction with Special Relativity.

If we consider the Earth´s motion in relation to the Cosmic Microwave Background (CMB), its speed is at around 369 km/s. Thus, using a Witte-Ulianov Time Interferometer, with an *L* value equal to 4km, we will detect a time delay that, from equation (11), is equal to 16,2ns.

WITTE EFFECT OVER GRAVITATIONAL FIELDS

When the GR field equations are applied to the basic case, where there is a single spherical body of mass M is placed in an empty space, it generate a solution called the Schwarzschild metric [4]. This metric can be defined in spherical coordinates by the Schwarzschild equation:

$$ds^2 = c^2(1-\frac{2GM}{c^2r})dt^2 - \frac{dr^2}{1-\frac{2GM}{c^2r}} - r^2 d\Omega^2 \quad 12)$$

Whit $d\Omega^2$ defined by:

$$d\Omega^2 = d\theta^2 + \sin^2(\theta)\, d\phi^2 \quad 13)$$

Where (r, θ, ϕ) indicates the considered point from a spherical coordinate system, whose center is positioned at the gravity center of the considered spherical body.

For an observer far away from the mass, from equation (12) we can define the displacement ds^2 as:

$$ds^2 = c^2 dt^2 - dr^2 - r^2 d\Omega^2 \quad 14)$$

For an observer near to the mass, positioned in a specific *r* distance, we can use the same notation presented in equation (2) and define a displacement ds'^2 as:

$$ds'^2 = c^2(1-\frac{2GM}{c^2r})dt'^2 - \frac{dr'^2}{1-\frac{2GM}{c^2r}} - r^2 d\Omega'^2 \quad 15)$$

Comparing equations (14) and (15), the time dilatation effect given by Schwarzschild equation, can be calculated as:

$$c^2 dt^2 = c^2 (1 - \frac{2GM}{c^2 r}) dt'^2$$

$$t' = t \frac{1}{\sqrt{1 - \frac{2GM}{c^2 r}}} \qquad (16)$$

Comparing equations (2) and (16) we can observe a time dilatation equivalence:

$$t' = t \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad ; \quad t' = t \frac{1}{\sqrt{1 - \frac{2GM}{c^2 r}}}$$

$$v^2 = \frac{2GM}{r}$$

$$v = \sqrt{\frac{2GM}{r}} \qquad (17)$$

Note that equation (17) connected the time dilatation predicted by Special Relativity (defined as function of the velocity *v*), to time dilatation predicted by General Relativity, defined as function of the mass (*M*) and distance (*r*).

This equivalency allow us to repeat the experiment of rotating Einstein's light clock presented in Figure 7, considering now that the system velocity is null and that the two clocks are at the distance *r* to an body of mass *M*, as presented in Figure 10.

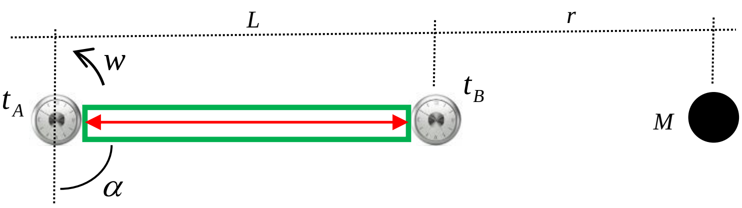


Fig 10: Rotating the Einstein's light clock near to a spherical *M* mass.

Considering that the experiments presents at Figure 7 and Figure 12 has an equivalent time dilatation effect, from equations (11) and (17) we can obtain, the Witte effect applied to gravitational time distortions, when we rotating clocks over a gravitational field, considering the angle α defined in Figure 10:

$$\Delta t_{AB}(\alpha) = \frac{L}{c^2} \sqrt{\frac{2GM}{r}} \sin(\alpha) \qquad (18)$$

Observing the Figure 12 experiment, we can assume that the time distortion in the clock A is constant.

And so, when the clock B revolves around clock A, the time distortion over clock B will change in function of angle α , as given by equation (18).

If we consider the moon mass (7,6x10^{22} kg) and its distance from Earth (3,8x10^{8} m) to an L value equal to 4km, equation (18) give us the maximum time variation around 7,1 picoseconds.

If we consider the sun mass (1,99x10^{30} kg) and its distance from Earth (1,49x10^{11} m) to an L value equal to 4km, equation (18) give us the maximum time variation around 1,8 ns.

This means, that if we have two timer clocks, with time resolution in order of 0.1 picoseconds (10 GHz clock frequency) and the possibility of comparing, the time differences between then, with a precision of these order of magnitude, it would be possible to detect not only gravitational waves, but also to detect the Witte Effect, generated by the earth's rotation, in the presence of the moon gravitational field and so the clock time, affected by the sun gravitational field.

WUTI IMPLEMENTATION USING ATOMIC CLOKS

Figure 11 presented a basic Witte-Ulianov Time Interferometer (with only one arm), using two atomic clocks as time source references.

Each clock synchronizes a sine wave generator (SG) which operates at a fixed frequency (for example 10Mhz or 100Mhz). The output signal of each generator is connected to two phase comparators (PC) using coaxial cables.

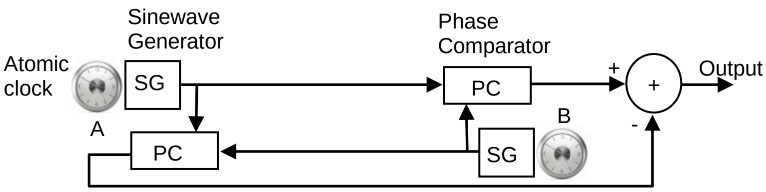


Fig 11: WUIT implementation using atomic clocks.

As presented in Figure 11, each phase comparator (PC) receives two sine wave signals, one local e another remote. In an ideal situation both clocks register the same time and the phase comparators have a null output. In a real operation the clocks operations will be affected for some problems, as for example temperature variations, that can be model as an error signal, that are added to a ideal time ($t_{ClockX} = t + e_X$).

Thus, if the SGs operate at angular frequencies, w_A and w_B, its outputs can be model by the equations:

$$S_A(t) = V_A \sin(w_A(t + e_A) + \phi_A) \tag{19}$$

$$S_B(t) = V_B \sin(w_B(t + e_B) + \phi_B) \tag{20}$$

Each PC receive the signals defined by equations (19) and (20), also considering the delay in the coaxial cables. Considering that Δt_{XY} is the cable delay to the signal travel from point *X* to point *Y*, we can calculate:

$$P_A(t) = PhaseCompare[S_A(t), S_B(t+\Delta t_{BA})]$$
$$P_A(t) = w_A\, t + w_A\, e_A + \phi_A - w_B t - w_B \Delta t_{BA} - w_B\, e_B - \phi_B \tag{21}$$

$$P_B(t) = PhaseCompare[S_A(t+\Delta t_{AB}), S_B(t)]$$
$$P_B(t) = w_A\, t + w_A \Delta t_{BA} + w_A\, e_A + \phi_A - w_B t - w_B\, e_B - \phi_B \tag{22}$$

Where the *PhaseCompare*[S_1,S_2] function calculate the phase shift (in radians) from two sine signals S_1 and S_2 .

Subtracting the PCs outputs, from equations (21) and (22), give us:

$$\Delta P(t) = P_B(t) - P_A(t)$$
$$\Delta P(t) = w_{\mathrm{A}} \Delta t_{BA} + w_{\mathrm{B}} \Delta t_{AB} \tag{23}$$

Considering that:

$$w_A = w_B = w$$
$$\Delta t_{BA} = \Delta t_{AB} = \Delta t$$

Equation (23) becomes:

$$\Delta P(t) = 2w\Delta t \tag{24}$$

Equation (24) means that subtracting the PC output angle is equal to two times the coaxial cable delay. As the phase comparators receives basically the same signals, the subtractions of its outputs remove the clock errors.

If the WUIT presented at Figure 11 is placed at one spaceship moving at velocity *v* and rotating in an angle α , as defined in Figure 7, from equations (11) and (24) we can calculate:

$$\frac{\Delta P(\alpha)}{w} = \frac{2L}{c^2} v \sin(\alpha) \tag{25}$$

If the WUIT presented at Figure 11 is placed at one spaceship orbiting the mass *M* at distance *r*, and rotating in an angle α , as defined in Figure 10, from equations (18) and (24) we can calculate:

$$\frac{\Delta P(\alpha)}{w} = \frac{2L}{c^2} \sqrt{\frac{2GM}{r}} \sin(\alpha) \tag{26}$$

Equations (25) and (26) means that the Witte-Ulianov Time Interferometer presented at Figure 11, can detect “time flow” variations between the points where the atomic clocks are placed. Thus equation (24) allow the WUIT to measure time dilatation effects predicted by Special Relativity and equation (26) allow the WUIT to measure time dilatation effects predicted by General Relativity.

WUTI IMPLEMENTATION USING TWO LASER SOUCERS

Paul Dirac in his book "The Principles of Quantum Mechanics" [5] has claimed quite famously that the interference of two independent light beams can never occur. He stated that "the wave function gives information about the probability of one photon being in a particular place, and not the probable number of photons in that place."

Nevertheless several published papers [6] [7], have shown that interference between two laser sources, seize presenting some technical complexities, can be performed.

So, to achieve higher resolution the WUIT can use two laser sources as time references, replacing the atomic clocks and sine wave generators, meaning that the two signals to be "phase compared" becomes two laser beans,

The laser, phase comparing can be easy achieved using a bean splitter to merge the two laser beans, and the combined beam impinges on a photodetector as presented in Figure 12.

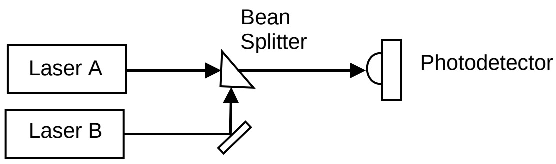


Fig 12: Two laser sources interference.

At the photodetector the light intensity I can be calculated from the laser beans equations:

$$E_A(r,t) = E_{0A}e^{i(k_A r - w_A t - \phi_A)}$$
$$E_B(r,t) = E_{0B}e^{i(k_B r - w_B t - \phi_B)}$$
$$I = (E_A + E_B)^2$$
$$I(r,t) = E_{0A}{}^2 + E_{0B}{}^2 - 2E_{0A}E_{0B}\cos((k_B - k_A)r - (w_B - w_A)t - (\phi_B - \phi_A))$$
$$I(0,t) = I_0 - I_1\cos(\phi_A - \phi_B + tw_B - tw_A) \qquad (26)$$

Equation (26), means that at the photodetector we can detect an wave with frequency proportional to the differences between the laser frequencies. So if we use laser sources with wave length very stable (or using light filters tuned to specific wavelengths, e. q. Farby-Perrot resonator) with few Hz difference between the operating frequencies, the photodetector output can be easy read to achieve the differences between the laser frequencies.

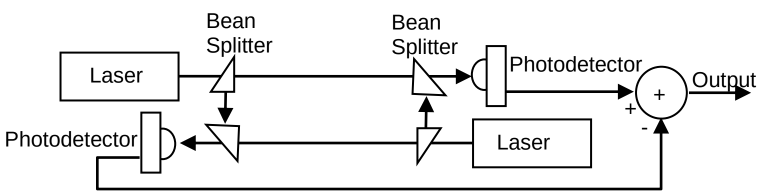


Fig 13: WUIT implementation using two Laser sources.

The Witte-Ulianov Time interferometer can be mounted using the Figure 12 optical configuration in two positions, as presented at Figure 13. For these configurations the intensity at each photodetector (I_A and I_B) can be calculated from equation (26), and the output signal (*S*), can be easy obtained subtracting these intensities:

$$
\begin{aligned}
&I_A(t) = I_{0A} - I_{1A}\cos(\phi_A - \phi_B + (t+\Delta t_{AB})w_B - tw_A) \\
&I_A(t) = I_{0A} - I_{1A}\cos(\varphi + \Delta t_{AB} w_B) \qquad \Rightarrow \quad \varphi = \phi_A - \phi_B + tw_B - tw_A \\
&I_B(t) = I_{0B} - I_{1B}\cos(\phi_A - \phi_B + tw_B - (t+\Delta t_{BA})w_A) \\
&I_B(t) = I_{0B} - I_{1B}\cos(\varphi - \Delta t_{BA} w_A) \\
&S(t) = I_B(t) - I_A(t) \\
&S(t) = I_{0B} - I_{0A} + I_{1A}\cos(\varphi + \Delta t_{AB} w_B) - I_{1B}\cos(\varphi - \Delta t_{BA} w_A)
\end{aligned}
\tag{27}
$$

Considering that:

$$
\begin{aligned}
&I_{0A} = I_{0B} = I_0 \\
&I_{1A} = I_{1B} = I_1 \\
&w_A = w_B = w \\
&\Delta t_{BA} = \Delta t_{AB} = \Delta t
\end{aligned}
$$

Equation (27) becomes:

$$
\begin{aligned}
&S(t) = I_1(\cos(\varphi + w\Delta t) - \cos(\varphi - w\Delta t)) \\
&S(t) = -2I_{1A}\sin(\varphi)\sin(w\Delta t) \\
&S(t) = -2I_{1A}\sin(\phi_A - \phi_B + tw - tw)\sin(w\Delta t) \\
&S(t) = -2I_{1A}\sin(\phi_A - \phi_B)\sin(w\Delta t)
\end{aligned}
\tag{28}
$$

Using some optical adjust the system can be adjusted to obtain the maximum output value ($\phi_A - \phi_B = \pi/2$) and so equation (28) becomes:

$$S(t) = -2I_{1A}\sin(w\Delta t) \tag{29}$$

From equation (29) we can consider that the phase variation in $S(t)$ is given by:

$$\Delta P = w\Delta t \tag{30}$$

As the two photodetectors, in Figure 13 receives basically the same signals, equations (29) and (30) given us an value that is constant if the delay Δt is also constant.

If we consider that the system presented at Figure 13 is placed in a spaceship moving at speed *v*, over a rotating table that can be associated with an α angle as presented at Figure 7, the value of Δt changes in function of the α angle as defined in equation (11), and so equation (30), can be written as:

$$\Delta P(\alpha) = w\Delta t(\alpha)$$

$$\Delta P(\alpha) = wL\frac{v}{c^2}\sin(\alpha) \tag{31}$$

Note that equation (31) is basically the same equation (25), meaning that we can also use laser beans to measure variation on the time flow.

Thus, the WUIT that use atomic clocks (Figure 11) and the WUIT that use Laser sources as time reference sources have the same behavior. Otherwise, the laser sources operating at frequencies from 10^4 to 10^5 times greater than a sine wave generator frequency and allowing better accuracy to measured the phase delays.

For example, using a 10Mhz SG and considering that the phase comparator use 16bits Analogical Digital Conversers (ADC), given at least 10.000 levels to the phase detection processing, the WUTI time resolution is in order to 10^{-14}s.

If we use a He-Ne laser source (632nm wavelength), and considering that the photodetector output can be digitalized by an 16bits ADC, the time resolution of this WUTI is in order of $2x10^{-19}$s.

EXERIMENTS USING TWO LASER SOUCERS

The author found, some experiments that confirm the possibility of measure the Witte effect using two laser sources. The first experiment [8] performed in 1963 used two He-Ne laser placed in a rotting table as presented in Figure 14. The laser frequency difference was found to be constant to within 30Hz over times as short as about one second.

Figure 15 presents the frequency variation between lasers when the table is in rotation, resulting in 275 KHz sine wave, that this author believe appear in function of the Witte effect over the two laser sources.

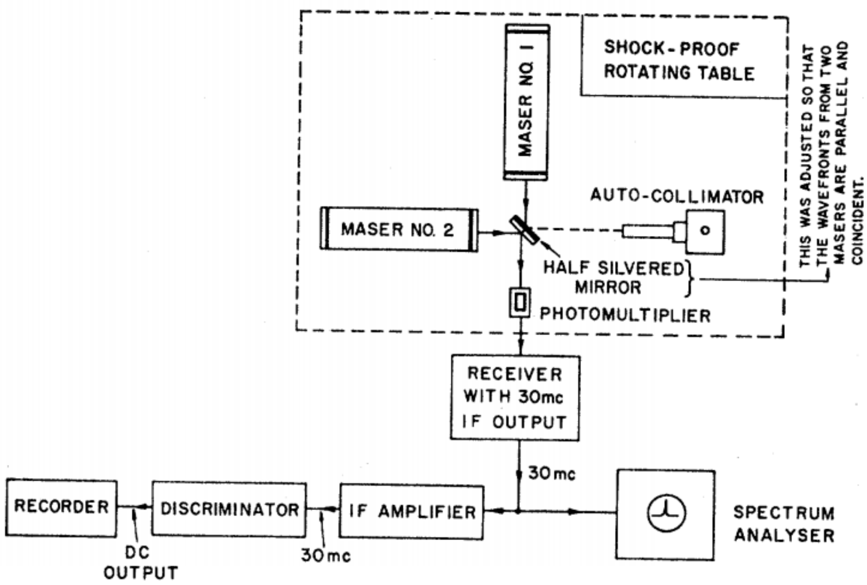


Fig 14: Schematic diagram for recording the variations in beat frequency between two optical maser oscillators when rotated through 90^o in space. Apparatus on the shock-proof rotating table is acoustically isolated from the remaining electronic and recording equipment.

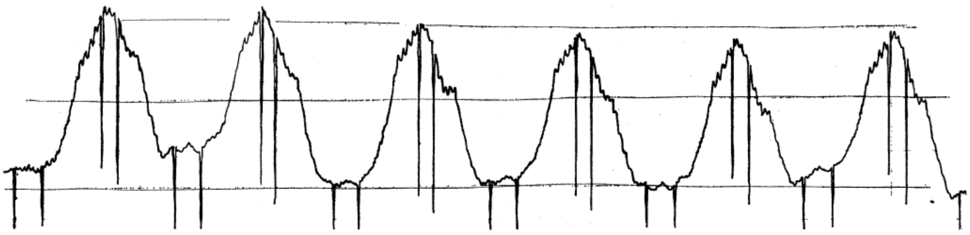


Fig 15: A plot of frequency variation between lasers due to 90° rotation of the table. Vertical scale is such that maximum variation is about 275 kHz. Markers indicate rotational angular positions zero and 90°. Double markers appear because the total rotation slightly overshot the zero and 90' positions on each swing.

In the article [8] we can see the flowing explanation for the 275 kHz signal, presented in Figure 15:

> *"The magnitude of this frequency change is about 275 kHz, or somewhat less than that attributable to the earth's orbital velocity on the simple ether theory. The change is mostly associated, as indicated above, with local effects such as the Earth's magnetic field, and must be measured throughout some appreciable part of the day to allow detection of any more fundamental spatial anisotropy."*

The above explanation supposing that the *"Earth's magnetic field"* can change the laser frequencies was used, to not admit that some unknown effect is acting over the system. This author believes that the Witte effect can explain this frequency change, and so calculate its value from some parameter of this experiment.

The equation (29) developed to the laser configuration presented at Figures 12 and 13, cannot be applied to the system presented in Figure 14, because the lasers sources not are placed in the same line. Thus we need develop new equations to represent the Figure 14 system:

$$
\begin{aligned}
&E_A(t) = E_{0A} e^{i(\phi_A - w_A t)} \\
&E_B(t) = E_{0B} e^{i(\phi_B - w_B t)} \\
&I = (E_A + E_B)^2 \\
&I(t) = E_{0A}{}^2 + E_{0B}{}^2 - 2E_{0A}E_{0B}\cos((\phi_B - \phi_A) - (w_B - w_A)t) \\
&I(t) = I_0 - I_1 \cos(\phi_0 + t(w_A - w_B)) \\
&I(t) = I_0 - I_1 \cos(\phi_0 + \Delta w\, t)
\end{aligned}
\tag{32}
$$

Knowing that w_A and w_B values depends on the laser wave length (λ_A and λ_B), considering the Earth speed (v) these lengths vary in function of the table rotation angle:

$$\lambda_A = \frac{w}{c}\sqrt{\cos(\alpha)^2 + (1 - \frac{v^2}{c^2})\sin(\alpha)^2} \tag{33}$$

$$\lambda_B = \frac{w}{c}\sqrt{\sin(\alpha)^2 + (1 - \frac{v^2}{c^2})\cos(\alpha)^2} \tag{34}$$

Thus for α equal to zero equations (33) and (34) given:

$$\lambda_A = \frac{w}{c} \;\; ; \; \lambda_B = \frac{w}{c}\sqrt{(1-\frac{v^2}{c^2})}$$
$$w_A = c\lambda_A = w$$
$$w_B = c\lambda_B = \frac{w}{\sqrt{(1-\frac{v^2}{c^2})}}$$
$$\Delta w = w_A - w_B = w(1-\frac{1}{\sqrt{(1-\frac{v^2}{c^2})}}) \tag{36}$$

For α angle changing in 90^o steps the frequency variations between the two lasers will have a maximum value that is like the same presented at equation (36).

Thus, the equation (32) basically generates a sine wave whit maximum frequency that can be calculated by equation (36).

Otherwise, to obtain the signal generated from the laser interference, we need also consider the Witte effect acting over a distance *L* that is presented in Figure 16 as a red line contenting the centers of the laser sources.

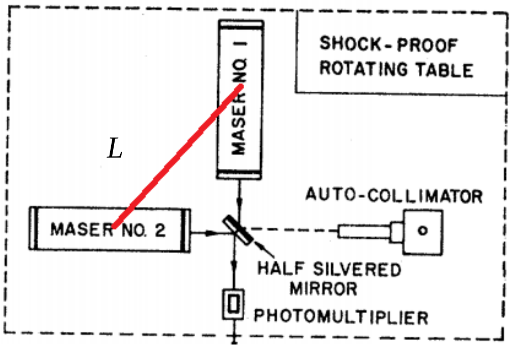


Fig 16: Distance *L* between the lasers sources, used to calculate the Witte effect.

If we consider the Earth moving in the space ate speed *v*, equation (31) allow calculate the Witte effect phase delay, given in radians. Otherwise, for the Figure 14 system, to convert the maximum phase delay (given in radians by equation (31)) in the maximum frequency variation (f , given in Hz), we need consider the sine wave signal defined in equation (32), which has an angular frequency Δw, using the flowing relation:

$$f = \frac{\Delta w}{\Delta P} \tag{37}$$

Appling equation (36) to equation (37) give us:

$$f = \frac{\Delta w}{wL \frac{v}{c^2}} \tag{38}$$

Knowing the laser frequency (w=1.88x10^{15} *rad/s*) and considering the Earth motion in relation the CMB (v=369 km/s), from equation (36) we can calculate:

$$\Delta w = 1.42\text{x}10^{9}\, rad/s$$

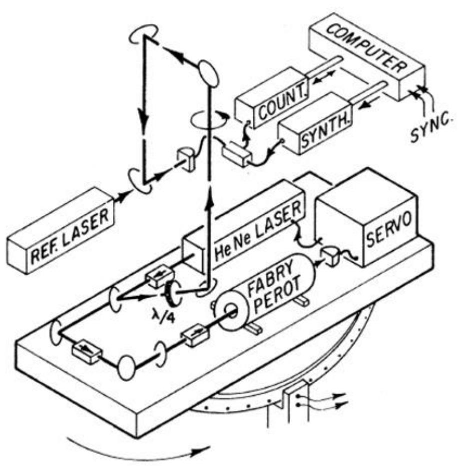
Unfortunately, the article [8] does not have the physical dimensions of the experiment and is not possible to determine exactly the value of the distance *L* as presented in Figure 16.

Beside this we can suppose that *L* value can be found in a reasonable range, for example from 0.25m to 1.0m, and so obtained a range of values of frequency using equation (38):

$$L = 0.25m \;\Rightarrow\; f = 738kHz$$
$$L = 0.50m \;\Rightarrow\; f = 369kHz$$
$$L = 0.67m \;\Rightarrow\; f = 275kHz$$
$$L = 0.75m \;\Rightarrow\; f = 246kHz$$
$$L = 1.00m \;\Rightarrow\; f = 184kHz$$

Thus, if the distance between the laser centers in Figure 14, is in order to 67cm and considering the Erath speed in relation the CMB equal to 369km/h, applying the Witte effect to this system (equation (38)) give us an frequency variation in order of 275 kHz, that is the same measured at the experiment, as presented at Figure 15.

Other experiment [9] was carried out in 1973, using two laser sources, as presented in Figure 17. This experiment use a He-Ne laser source placed at a rotating table and a CH4 stabilized laser in a fixed position acting as a reference source.



Schematic of isotropy-of-space experiment. A He-Ne laser (3.39 μm) is servostabilized to a transmission fringe of an isolated and highly stable Fabry-Perot resonator, with provision being made to rotate this whole system. A small portion of the laser beam is diverted up along the table rotation axis to read out the cavity length via optical heterodyne with an "isolation laser" which is stabilized relative to a CH_4-stabilized reference laser. The beat frequency is shited and counted under minicomputer control, these frequency measurements being synchronized and stored relative to the table's angular position. After 30 minutes of signal averaging the data are Fourier transformed and printed out, and the experiment is reinitialized.

Fig 17: Experiment using a rotation laser and a fixes laser.

Figure 18 presented the result of this experiment, where a small frequency variation can be observed. Like the table in Figure 17, allow measure the angular position the experiments results express the frequency variation considering a sidereal frame, and so in data plotted is possible note that the angular variation is related to the sidereal time. This author believes that article [9] results, presented at Figure 18, are also related to Witte effect, otherwise in this system the reference laser is mounted in a fixed position over the rotating table, and so to analyze their operation is necessary one mathematical equation different from what has been presented above, which is beyond the scope of this article.

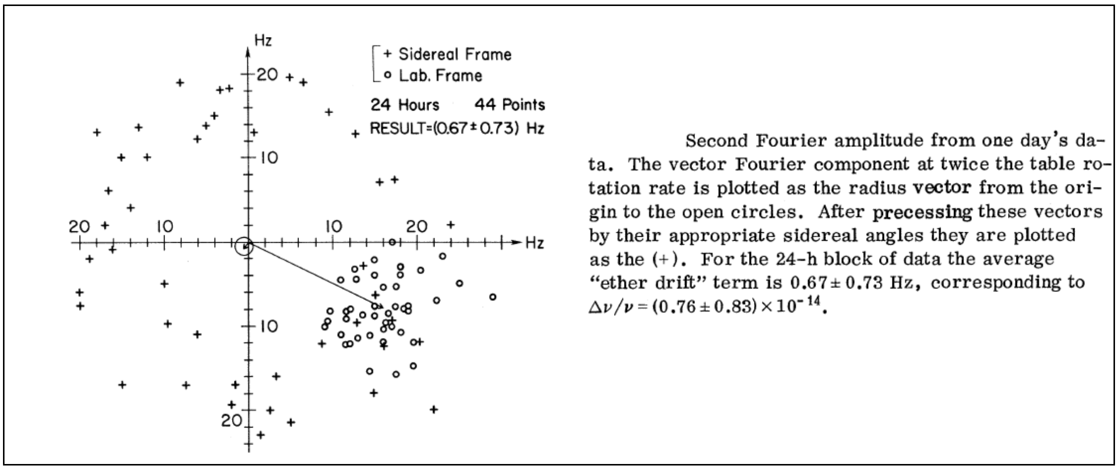


Fig 18: Result from Figure 17 experiment.

It should be noted that the use of two laser sources generating interference patterns that can be easily observed and thus the Witte effect can be monitored by means of atomic clocks can also be measured using light sources having stable frequency.

WUTI GRAVITACIONAL WAVES OBSERVER

The Witte-Ulianov Time interferometer can observe "time flow" variation predicted in Special Relativity for bodies moving in high speed and so "time flow" variation predicted in General Relativity for bodies inside strong gravitational fields.

This author believe that the WUTI can also detect gravitational waves.

Observing the WUTI "one arm" structure presented in Figure 11 that use two atomic clocks. Supposing that a gravitational-wave pulse "hit" the Clock A, it will affected by one time dilatation effect that initially not is observed over Clock B. As the gravitational-wave pulse travel at light speed, some microseconds after it "hit" clock B that will also be affected by the time dilatation. Thus the time delay between the two clocks varying with the gravitational wave and so the phase compares present complementary variations that can be observed at the WUIT output.

From equation (26) we can deduce that the WUIT output has a signal that is proportional to the gravitational-wave amplitude:

$$\Delta P(t) = \frac{2wL}{c^2} GW(t) \tag{39}$$

Equation (39) meaning that the WUTI sensibility is related to the interferometer length (*L*) and to the angular frequency (*w*). Thus one good option is applied "all in fiber" optics components, as presented in Figure 19, and use optical fiber cables to connected the laser sources.

This kind of WUIT can use fiber optics cable whit many kilometer of length, and so the photodetector output signal need be recorded by an data acquisition system whit a global time synchronization, for example by the GPS time.

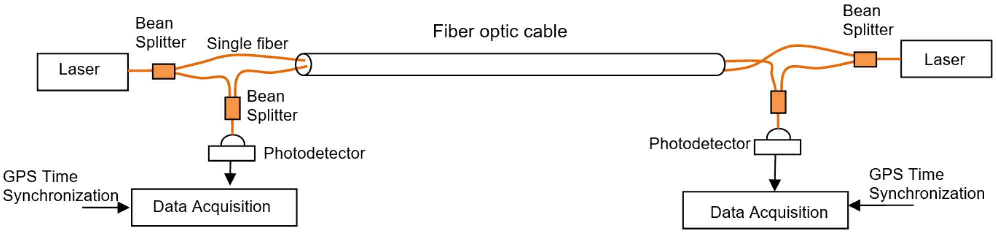


Fig 19: WUIT implementation using “all in fiber”.

Figure 20 present, a “five arms” Witte-Ulianov Time interferometer, using the actual LIGO detector structure to implement the WUIT presented in Figure 13 and using the WUIT presented in Figure 19, to connect both installation, using a very long fiber optic cable (3.000 Km extension).

This kind of detector has the potential to observe gravitational waves, without low range frequency limitation and whit a large accuracy provides by the “all in fiber” WUIT that has the potential to be 1000 times more precise, because it is 1000 times longer.

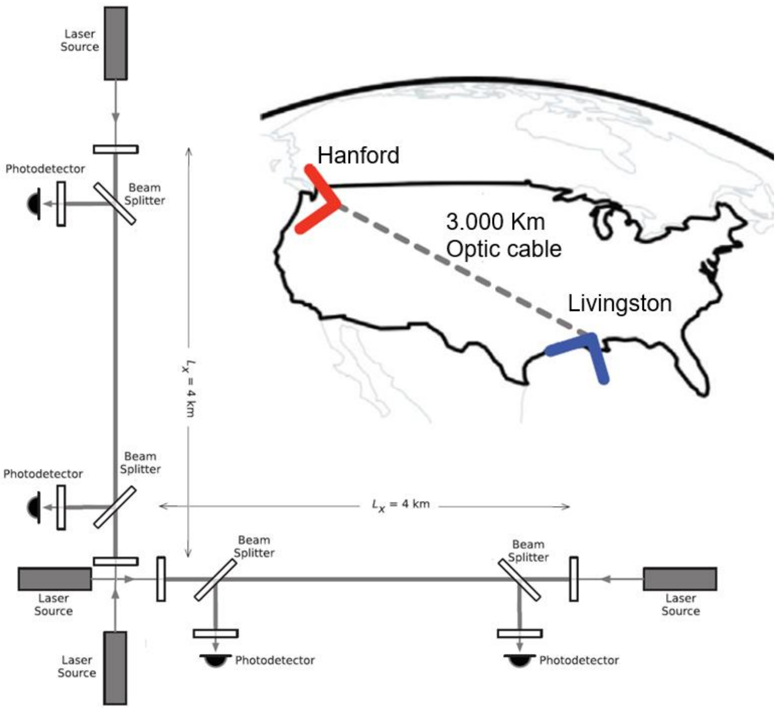


Fig 20: WUIT “five arms” implementation over the LIGO detectors.

CONCLUSION

As the LIGO detector can operate only in a narrow band of frequencies (from 80hz to 300hz) the LIGO, system becomes more an black hole collision detector than a generic gravitational-waves detector.

It should be remembered that, although those responsible for LIGO, won the Nobel Prize in 2017, the number of scientists who today question the results of the LIGO, gravitational wave detections, grows every day. I believe that the scientists, will soon realize that LIGO is a FAKE [26] [27] and that this detector, in the past an currently, only detecting noise [14] [15] [16] [17] [18] [19] [20] [21], or else electromagnetic [24], terrestrial or sidereal phenomena, that are affecting the United States Power Grid, and generating simultaneous effects (limited by the speed of light) on the both LIGO detectors, as we can see in [25]:

"*The analyze of the data for the gravitational wave (GW) events observed in LIGO detectors, from the viewpoint of signal estimation, detection and interference mitigation, shown that the GW events, are buried in detector noise and that the GW channel in the LIGO detector does in fact pick up strong 60*n Hz electromagnetic interference (EMI) from power lines…. and external magnetic field, from astrophysical objects, can enter the GW channel through electrical power points and wires, in which case we may not see any correlated peaks in the magnetometer channel and may mistake this interference, as a GW signal.... In conclusion, the magnetic coupling function between the received signal with the template in both the GW channel and the magnetometer channel is unknown for high frequencies. Hence it is suggested that the detected LIGO GW signals be further studied independently, given that magnetic field cannot be ruled out as a candidate for the GW events. ...*"

It is interesting to observe that the LIGO teams themselves, report the presence of correlated noises in the two detectors [22] and Noise Bursts (Blips) that appear continuously in the interval of a few minutes, in each day of operation, and that can be easily confused with gravitational waves, if by chance they happen at close intervals of time in the two LIGO detectors [23]:

"Blip glitches are short noise transients present in data from groundbased gravitational-wave observatories. These glitches resemble the gravitationalwave signature of massive binary black hole mergers. Hence, the sensitivity of transient gravitational-wave searches to such high-mass systems and other potential short duration sources is degraded by the presence of blip glitches. The origin and rate of occurrence of this type of glitch have been largely unknown. In this paper we explore the population of blip glitches in Advanced LIGO during its first and second observing runs. On average, we find that Advanced LIGO data contains approximately two blip glitches per hour of data. We identify four subsets of blip glitches correlated with detector auxiliary or environmental sensor channels, however the physical causes of the majority of blips remain unclear."

Oh yes! these bursts of noise happen thousands of times a year, in the two detectors, and they don't know, where it comes from or what they are…

What would actually be, the probability that two of these noise surges, happened at the same time in both detectors, without having any correlation over them in a time window of several years?

Would it be, something really impossible, for this "Blips", to occur simultaneously, and generate a false GW detection alarm in the LIGO detector?

But then, how come they won a Nobel Prize, basically for th e first GW event that they detected?

From what is stated in the [22] and [23] articles, the LIGO team ,itself knew that there was a Great chance of some GW detected at LIGO, was the result of "Blips" and noise Bursts.

Even so, the LIGO, leaders preferred to ignore these facts, and present to the whole World, the first detection of LIGO (the GW150914 event) as proof that not only the LIGO detector works well but as a unnecessary proof the Einstein's General Relativity Theory, also works well!

Aside the fact, that they was sure to win the Nobel prize, the LIGO leaders, spending millions of Dolars producing media and paying advertising costs at magazines, newspapers, on television and on Internet pages, around world, with amazing news of one GW detection, that had a high chances of being a false alarm.

Obviously, at this first detection moment, they needed to justify the work of ten thousands scientists, who have been projecting, constructing and operating the LIGO detectors for over 20 years, without any presentable result, and also they need to justify the billions of dollars that have already been spent on the LIGO project, and in this critical, situation even the Nobel prize, ends up being a small bonus, for the LIGO leaders, and not the main concern of them…

On other hand, the Witte-Ulianov Time Interferometer here presented, can detecting gravitational-waves in very low frequency, and as stated in the title of this article, this detector can first see the ocean (the gravitational fields sea of the Moon, the Sun and Galaxy), and then it can see and record, the gravitational waves

The first step to obtain this new kind of detector, is confirm the existence of the Witte effect, that can be achieved in simple experiment, with very low coast, using two atomic clocks, two phase compare detectors and some kilometers of coaxial cables, as presented on this article.

Can be noted, the that historical experiments using two laser sources [8] [9] are not conclusive and have not explained effects, that this author believes, are related to the Witte effect, something that until now has not been recognized widely in scientific means. This occur because, in 1991, when R. D. Witte accidentally discovery, the Witte effect, the experimental results was interpreted by Witte, as proofs that the Einstein´s Especial Relativity was wrong.

The Witte, radical positioning turned the Witte effect in a kind of "bad" science.

Then always in 2006, when R. T. Cahill [2] showed that Witte effect, can be explained using Einstein's relativity, the Witte effect, was accepted at this first time, but still something obscure because, it use the Earth travel speed through, space as a velocity parameter, pointing to some sort of Ether, that can generate an absolute speed reference.

On the other hand, if we look at the Witte effect considering the orbit of the earth around the sun (average speed of 30km/s), or considering the gravitational field caused by the sun (for a distance given by the average radius of the orbit) the WUIT output has the same value. This means that the large gravitational fields, generated from Milk Way, and near galaxies can define a reference frame, to the Earth velocity, used in equation (1) that define the Witte effect.

This author believes that experiments using independents time sources, whether two atomic clocks or two laser sources, have until, now been poorly understood, and in a sense the physical scientists "fled" of these problems, avoiding points that apparently generated conflict with the Einstein's Relativity Theories.

Otherwise as the Witte, experiment with atomic clocks is very easy and cheap to be repeated, it is important to establish, more fully, the fact that the Witte effect exists, and can detect the "flow time" variations between two space time points.

If the Witte effect exist, it can be used as base to construct the Witte-Ulianov Time Interferometer, that is based in flow time variations detection.

For this author, time distortions, as predicted by Einstein's, Especial and General Relativity, is the key to construct gravitational-wave detectors that can operate in very low frequency, that can observe gravitational waves whit period of seconds, minutes or even hours.

On this way the Witte-Ulianov Time Interferometer besides allowing to observe low frequency gravitational-waves also makes it possible to observe the ocean of gravitational fields that surrounding the Earth. It can also be used, to a low coast, improving of the current LIGO detector (using tree lasers instead of one) and create a New LIGO, that in the future, can by capable of detecting Real gravitational waves, instead of Fake GW, like this is doing now

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