Special Relativity: The Ultimate Test

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1 Abstract

From the hypothesis of the validity of Newton's dynamics and space as a privileged reference frame, the null results of Michelson and Morley's type of experiments are experimentally reinterpreted and invalidated as a proof of the non existence of the Luminous Ether. Other recent experiments to test Special Relativity, such as Brillet-Hall's, Cedarholm-Townes', etc, are also epistemologically revisited and an alternative explanation of their null results is given. Finally, using two-beam interferometry techniques, two conclusive experiments to test the validity of the Special Theory of Relativity under this new perspective are proposed.

Keywords: Michelson Morley experiment, Ether drift experiments, Special relativity tests. Ether detection.

2 Introduction

The Michelson Morley Experiment (MME)[1], just like other experiments of the same nature as Kennedy-Thorndike's [2] and Hammar's [3], and more recent ones carried out with two masers like Cedarholm-Townes' [4][5] or with two lasers like Brillet-Hall's [6], or Torn-Kolen's[7], involving coaxial cables, or even some accomplished with Cryogenic Optical Resonators like H. Müller's et al. [8] and many others, are considered each time with even more force, as an irrefutable proof of the non-existence of a privileged reference frame (PRF), or Luminous Ether (LE), and also as the confirmation of the validity of the Special Theory of Relativity [9] (STR).

The present article demonstrates how from the hypothesis of the existence of an absolute space and time and using Newton's dynamics, the same 'negative' result is obtained in MME as well as in the other mentioned experiments, understanding by 'negative' the null detection of the absolute space, even if it effectively existed.

For the purpose of this article it is not necessary to introduce the Robetson-Mansoury-Sexl framework[10] for STR. On the contrary, a small mental effort of oversight these and other STR concepts is required in order to be able to follow the arguments developed here.

In that same sense it is also necessary to make a starting hypothesis: The assumptions of the validity of Newton's dynamics on space and time and their characteristics as a privileged reference frame where the speed of light $\boldsymbol{c}$ is fixed only with respect to it, as classical LE was considered.

These are not completely new assumptions. Many authors have already postulated as the best theory of physics of space and time the one based on absolute simultaneity and absolute space. Representative of them are F. Sellery [11] or V. Guerra and R. Abreu [12][13].

All these not new ideas and arguments have always needed of one definitive experiment to be corroborated, or definitively discarded, and that is why the present article also exposes two experimental set-ups to check the STR under this new perspective.

This article is meant as a proposal of one definitive experiment to test the validity of the postulates of STR and, in its case, to detect the movement of the earth with respect to the absolute space.

3 Some Previous Epistemological Considerations

3.1 On the Actual vs the Measured

There is not room for any doubt that in this precise instant there is at least one super-nova exploding somewhere in our universe. However that fact will not be registered by the humans until the light of that explosion gets to the earth.

As long as physics is concerned, facts happen only when they are measured because it is not possible to know in advance, like in the previous example, if a super-nova has really exploded, neither the place where it did.

In any case, the interest of this example is to point out that due to the transfer of information at finite velocity $\boldsymbol{c}$ there will always be a space-time gap between what is real, this being the very physical or ontological fact which takes place, and what is measured, this being the equivalent to what is observed, or what is perceived by the being that is registering that measurement. In this sense the very actual reality, the ontological truth, will always be impossible to measure.

With ‘real’ and ‘measured’ I do not intend to arise here an ancient dispute over whether ‘real’ is what you effectively measure or the very fact itself independently of the measurement. I only attempt to assign linguistic terms to different facts in physical space-time, so the aim of this section is double: On the one hand, to define the concepts that will be utilized in the rest of the present article and, on the other hand, to draw attention to that differential fact between both aspects of the same event in the physical world ruled by the speed of light.

3.2 Actual vs Measured Space and Time Intervals

That unbeatable fact of impossibility of registering the real world but only its observable characteristics is specially applied when any type of movement is involved. Time intervals and space intervals are measured as having different values depending on the state of movement of the observer, who makes the measurement and acts as a receiver, with respect to the object measured, which acts as an emitter.

Many texts have been written on this same topic and it is not necessary to review it in detail. The only important aspect to take into account here is that when analyzing the physical aspects of any object in a different state of movement it must be carefully studied whether any kind of space or time transformation to the relation 'observed'/'actual' must be applied.

The measured value of one particular variable may be different depending on the point chosen to measure that variable and this does not imply that the laws of physics are different in different reference frames, only that the objects to be measured are in a particular state of movement and our measurement rule $\boldsymbol{c}$ is fixed.

3.3 Galilean Transformations for a Common Static Medium

In the classical Galilean dynamics transformations between different reference frames there is an important aspect that has been neglected and must be carefully analysed in the case that an absolute static medium wanted to be considered.

Galileo himself on his treatise of 1632 [14] make his reference frame analysis form the point of view of a vessel's cabin where there were flying insects and also a drop of water falling into a basin. He argued that from an observer placed into that cabin point of view there were no difference if the vessel was continuously and strait moving or it was still because the flies always moved as if the vessel was still. But this example is not valid for the case that a common an absolute spatial medium is considered as LE.

In his analysis Galileo's cabin was considered isolated form the external air. This meant that the state of movement of the air inside and outside the cabin were different from an external observer point of view. In such condition from the flying insects' point of view the air inside the cabin was still although the ship was effectively moving. The media inside and outside the cabin were isolated from each other and with different relative speed. This is not the case of an experiment such as Michelson's that considered a common medium trespassing everything as LE.

If a comparison of two reference frames moving through a same medium wanted to be made, the Galilean insects would have to be placed over board, not into the cabin because the start hypothesis was precisely an absolute static medium that affects equally in all reference frames.

3.4 The Perceived Transverse Position

It is important to analyse now what is the perceived position of one particular emitter from a co-mobile receptor point of view placed in a position transverse to the movement considering the presence of a static absolute medium.

For the same reason that a particular star is not perceived in the night sky at the very same position than it is actually placed, the 'real' and the 'perceived' positions of any moving object do not generally coincide. This is due to the fact that light transmits through the medium at a finite speed.

The 'real' relative positions of a transmitter and a receiver with respect to each other or to any observer does not change, it is mathematically expressed by their position equations. But the 'measured' positions from any observed point of view effectively would change depending on the speed $\vec{v}$. This idea is represented in Figure 5 and treated in section 4.3.

4 The Doppler Effect

4.1 Classical Definition

In Christian Doppler's most notable work 'On the coloured light of the binary stars and some other stars of the heavens' [15] the formulas that relate the frequency transmitted to a medium with the status of movement of the emitter and the receiver throughout that medium are presented. These formulas in present-day notation can be expressed as:

$$\nu' = \nu \cdot \left(\frac{c \pm v_r}{c \mp v_s} \right) \quad (1)$$

Where:

ν = Frequency of the emitted wave.
ν' = Frequency of the observed wave.
c = Wave speed in the medium.
v_r = Relative speed of the receiver with respect to the medium. Positive if the receiver moves towards the source.
v_s = Relative speed of the source with respect to the medium. Positive if the source moves getting away from the receiver.

The vectorial notation has been omitted because the formula refers to the module of the velocities in any case.

It must be taken into account here that the transmitted frequency to a medium by a particular emitter that moves in relation to that medium are not isotropic with respect to the medium itself and will depend on the direction of the perception i.e. the place and the state of movement of the receiver with respect to the emitter. Figure 1 gives an idea of this frequency anisotropy received on the medium from a moving emitter.

In the case that the emitter and the receiver were not located in line with the direction of $\vec{v}$ the previous velocities in Doppler's formula v_r and v_s must be substituted for the projections of them in the direction of the perception line emitter-receiver.

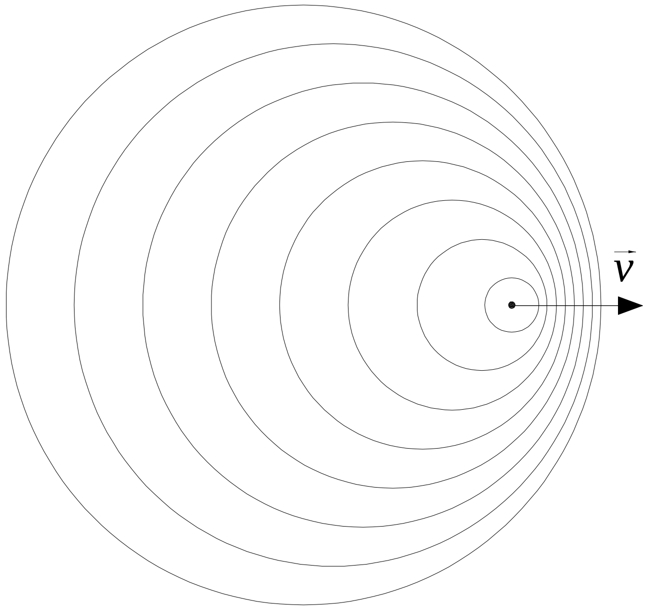

Figure 1: Classical representation of the wave fronts transmitted to a static medium by a moving emitter. For a static observer the transmitted frequency is anisotropic but not the wave speed.

One very important consequence of this aspect of the classical Doppler effect is that, from any receiver's point of view and due to the frequency anisotropy, there is a spatial direction-dependent observed frequency, i. e. a characteristic directional frequency which is directly related with Doppler's formula (1) and the relative position of the receiver relative to the emitter.

This frequency continuously changes for a observer in a different state of movement than the emitter, unless it is in the same direction of $\vec{v}$, but not for a observer co-mobile with the emitter as it is explained in next sections.

4.2 Doppler Effect for Co-mobile Emitter and Receiver

It is evident that the so defined classical Doppler effect is easily measurable by a receiver in different a status of movement than the emitter. However, what if the speed of the receiver is the same than the emitter's? i.e. emitter and receiver are themselves static in a system of reference **O'** in Uniform and Rectilinear Motion (URM) with respect to the medium?

In that case it is also possible to calculate the frequency on arrival to the detector, or measured frequency, by means of the Doppler effect formula but, because it is the medium which transmits the wave from A to B, it has to be applied twice: The first time when the moving emitter transfers its frequency to the medium, which acts as a static receptor. And the second time when the static medium, acting as an emitter, transfers its frequency to the moving receiver.

In the middle of those two processes there is an undetectable frequency, easily Doppler-effect calculable, that has been transmitted through the medium from A to B.

The Figure 2 represents an idea of this concept for a two co-mobile emitter and receiver placed in the same direction than velocity $\vec{v}$.

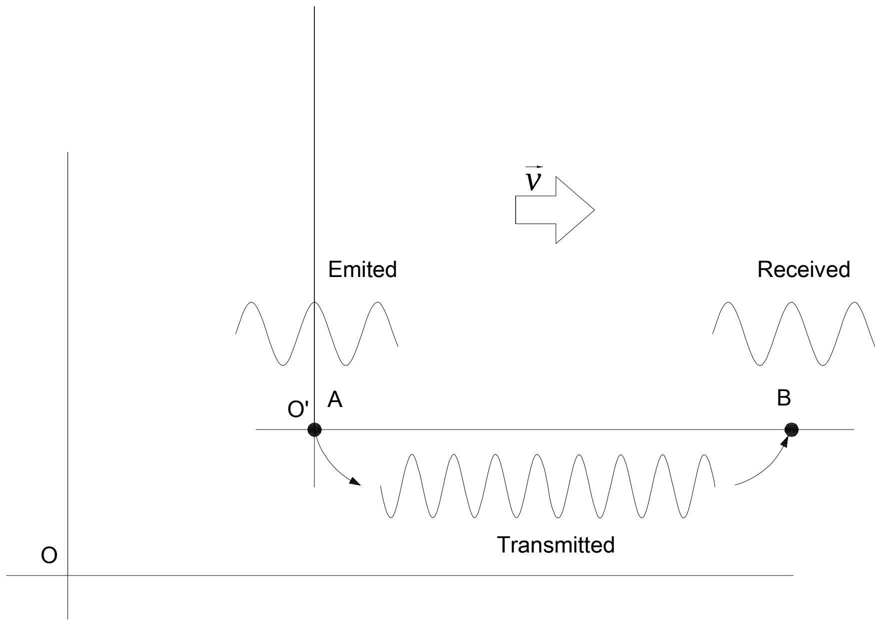

Figure 2: Representation of the idea of the medium as a wave transmitter between two material points of a moving reference frame.

To state it formally, let **O'** be a system of reference in URM at speed $\vec{v}$ with respect to a medium defined in a static PRF **O**, and let A and B be two material points, an emitter and a receiver, both placed at rest in **O'**.

The emission-reception process of a wave between the two material points A and B at rest in O' that uses the static medium defined in **O** as a transmitting element will pass through three phases:

Phase 1- Emission: The wave emitted from **A(O')** is received by the static medium **(O).**
The observer of the wave emitted in A is the motionless medium defined in **O**.

Any frequency ν_A emitted by a point A of **O'** will be observed by any point of the still medium **O** in the same forward direction of $\vec{v}$, as ν_o. This value of ν_o is given by the mentioned Doppler effect formula (1), which in this case would be:

$$\nu_o = \nu_A \cdot \left(\frac{c}{c - v} \right) \quad (2)$$

Phase 2- Transmission: The wave travels in the medium from A to B at speed ***c***
Now a wave of frequency ν_o, in the direction of is being transmitted at speed ***c*** over the static medium defined in **O**.

Phase 3. Reception: The wave emitted from the medium (**O**) is received by B (**O'**)
When the wave of frequency ν_o reaches the point B to be observed, the opposite phenomenon occurs. The static perturbed medium **O** transmits its frequency to the moving receiver B on **O'**.

The relation of these two frequencies, emitted from a static source and received to a moving point, is also given by (1)

$$\nu_B = \nu_o \cdot \left(\frac{c - \mathbf{v}}{c} \right) \quad (3)$$

Then, the relationship between the emitted frequency from a material point A ν_A, and a received to a material point in B ν_B will be, substituting (2) in (3):

$$\nu_B = \nu_o \cdot \left(\frac{c - \mathbf{v}}{c} \right) = \nu_A \cdot \left(\frac{c}{c - \mathbf{v}} \right) \cdot \left(\frac{c - \mathbf{v}}{c} \right) = \nu_A$$

That is to say, in an experiment of emission-reception between two material points A and B static with respect to each other and both defined on a moving reference frame **O'** at speed $\vec{v}$ with respect to the static medium that transmits the wave, the frequency measured on reception in the same direction of $\vec{v}$ will be always equal to the emission frequency, independently of the absolute value of the velocity of **O'** with respect to medium defined in **O**.

This same result and a very intelligent logical analysis on the MME in relation to the STR's postulates was obtained by C.I. Christov in [16] and revisited in [17] and also implicitly by Elmore W.C. [18] and Dichtburn R W [19] although the consequences of this result from the experimental point of view were not correctly weighed by anyone of those authors as explained in section 9.1.

It is immediate to deduce that this result can be generalized to any direction of the velocity simply by changing the velocity $\vec{v}$ for the projection of $\vec{v}$ in the direction of the line A-B.

According to this it is evident that, if one receiver would transmit its received frequency to a third arbitrary receiver, the result due to that same process will be that the frequency observed in this third receiver would be the same that the exit's from the first independently of the implicated drift velocities in the two sectors firs-second and second-third. This idea is represented in Figure 3 where, although the received frequency registered is always equal to that emitted, it is not equal to the transmitted frequency trough the medium, which depends on the velocity $\vec{v}$.

The result of this theoretical analysis is that any observer co-mobile with the emitter is not able, by means of any experiment involving single or multiple emission-reception, to know the state of movement with respect to an eventual static medium or to detect any frequency anisotropy. No experiment of this kind will ever result in the detection of the movement through a static medium, even though this meduim eventually existed.

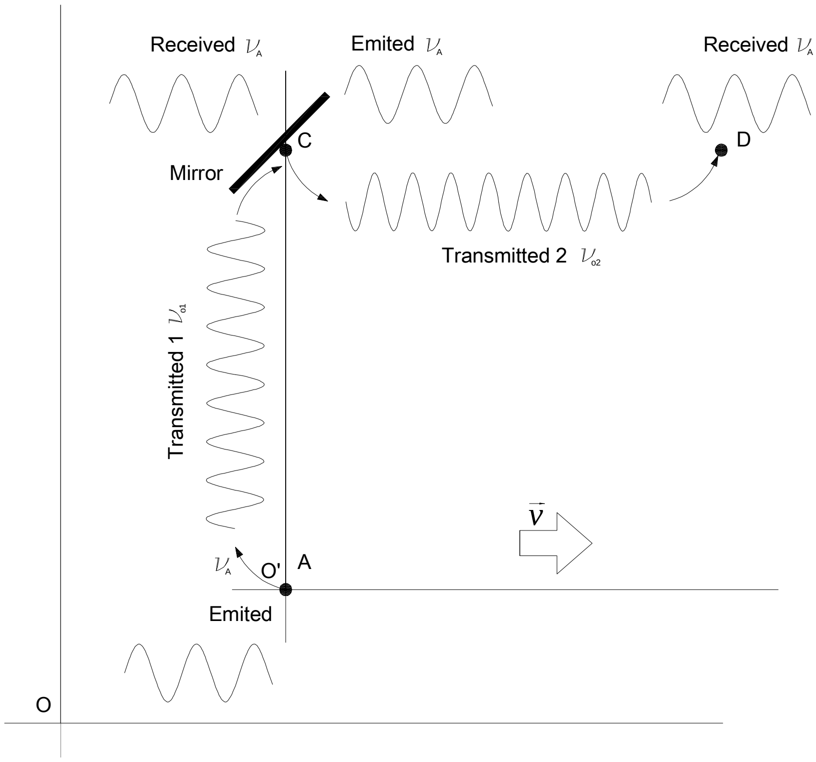

Figure 3: Representation of the "co-mobile detector effect" in a double emit-receive experiment and the unchanged registered frequency along its path

This remarkable result may be treated as an epistemological consequence or an experimental postulate that implies that a matter frequency detector in a moving system with the same motion state than the emitter can not detect the state of motion by emission-reception experiments, even if the detector is a single molecule. This result is also completely compatible with one STR consequence. From now on it will be referred as the "co-mobile detector effect".

4.3 Classical Transverse Doppler Effect Vs Perceived Transverse Doppler Effect for a Co-mobile Emitter- Receiver

The classical transverse Doppler effect for a co-mobile emitter-receiver is treated as represented in Figure 4. From the receiver's point of view in the point C of **O'** the velocity $\vec{c}$ is the composition of velocities $\vec{c}$ and $\vec{v}$, that is, $\vec{v}'$ in the figure.

The value of $|\vec{v}'|$ can be calculated form Pythagoras's Theorem as always:

$$|\vec{v}'| = \sqrt{|\vec{c}|^2 - |\vec{v}|^2}$$

This is the classic way to calculate a composite velocity transversal to a movement of speed $\vec{v}$ from a co-mobile receiver. It may be taken as the 'real' composite speed from any point of view. Mathematically, the emitter's position vector does not change with the state of movement of reference frame **O**'.

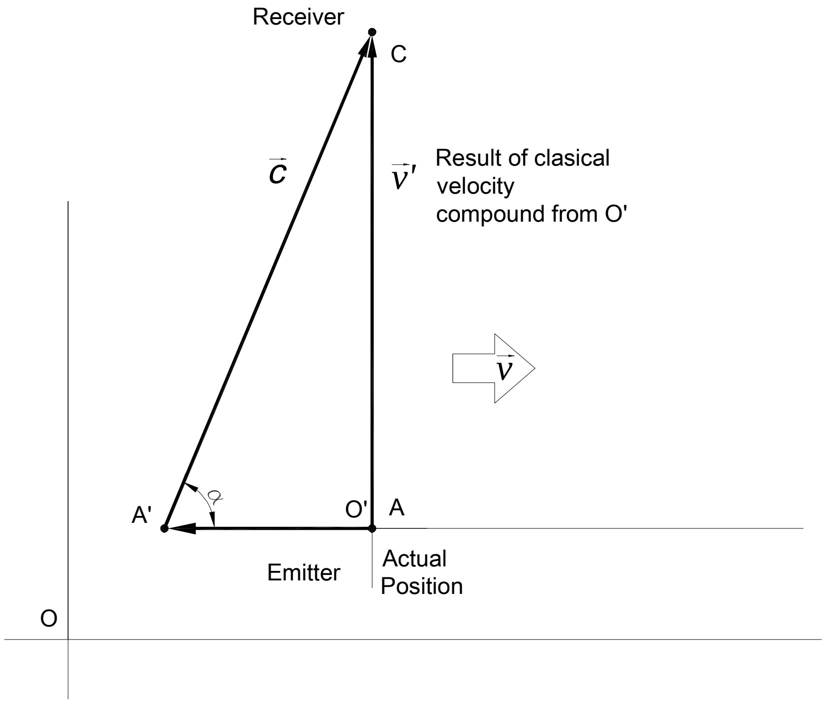

Figure 4: Representation of the classical transverse Doppler effect from the point of view of reference frame O not corresponding to a measured but a 'real' speed v*'.*

However this analysis does not correspond to an experimental fact where the medium is playing the role of the wave transmitter. This Galilean velocity composition $\vec{v}'$ is not taking into account the differential fact between 'real' and 'measured' objects explained in section 3.1 and, because it is assumed from the beginning the existence of a common and unique medium, the Galilean relativity is not suitable for this velocity analysis as explained in section 3.3.

It must not be forgotten that the medium that transmits the wave is supposed to exist and to be unique, and because of that, the object in A as seen from C is not measured in A but in A' position, although the object is effectively placed in A. The measured velocity from the C point of view would not be $\vec{v}'$.

The perceived position of A from the point of view of C is A' and the measured speed from C with respect to the wave emitted by A but perceived form A' is the wave velocity $\vec{c}$ minus the projection of $\vec{v}$ along the direction of perception A'C, i.e. $|\vec{c}| - |\vec{v}_p|$ as represented in Figure 5.

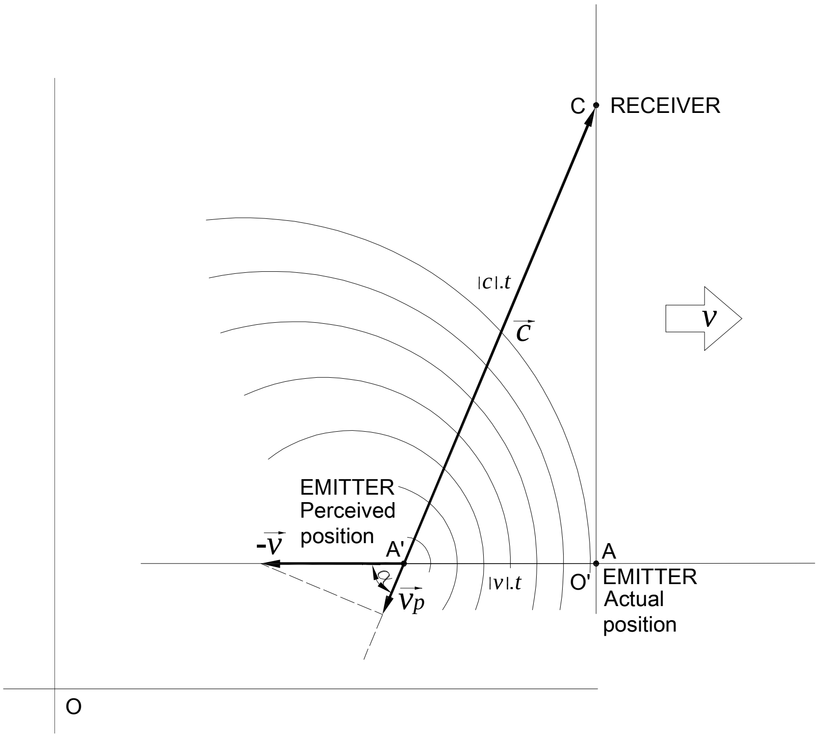

Figure 5: Representation of the perceived speed from a receiver point of view C over the moving O' reference frame, and the projected speed Vp.

This is the main point of the epistemological foundation of this article and it has to be analysed carefully. It is of the biggest importance to distinguish between the actual fact and the measured one as explained in section 3.1. Any given experiment does not actually measure any 'real' quantity, but an 'observed' one.

The 'measured' transverse Doppler effect for a co-mobile emitter-receiver is in this way correctly interpreted as represented in Figure 5. The emitter is in point A and the receiver in C.

The result of this effect is a projection of the velocity $\vec{v}$ in the direction of perception A'C that affects the speed perceived by C in the direction of A'C. This means that so is affected the obtained equation of the Doppler effect perceived by C substituting $|\vec{v}|$ by $|\vec{v}_p|$ in (2).

According to Figure 5, from trigonometry we obtain:

$$\cos\alpha = \frac{|\vec{v}|\cdot t}{c\cdot t} = \frac{|\boldsymbol{v_p}|}{\boldsymbol{v}}$$

Hence, the Observed/Actual modulus of speed $\vec{v}$ projected onto the line of perception A'-C in this setup will be:

$$|\vec{v}_p| = \frac{|\vec{v}|^2}{\boldsymbol{c}} \quad (4)$$

If we now take under consideration the results of section 4.2 this phenomenon, for the analysis of an emitted-received frequency in arbitrary direction of $\vec{v}$ with respect to the straight line A-C, is exactly the same than stated in 4.2 but substituting $|\vec{v}|$ for the projection of that speed in the direction of perception that C have of A, $|\vec{v}_p|$ just as shown in Figure 5.

The result of Phase 1 in 4.2 will correspond to a transmitted frequency to **O** in the direction of C smaller than the corresponding one for velocity $\vec{v}$, i.e., from (2) and (4):

$$\nu_o = \nu_A \cdot \left(\frac{c}{c - \frac{\boldsymbol{v^2}}{c}} \right) = \nu_A \cdot \frac{c^2}{c^2 - v^2} \quad (5)$$

5 Wave fronts in a Moving Reference Frame

Because the electromagnetic wave in a setup as in MME is defined between two reflecting surfaces, emitter's A and receiver's B where the electric field is E=0, a fixed number of wave fronts will appear between these two surfaces A and B for a given speed of the system **O'** and a given frequency emitted. In other words, the frequency of the wave from the point of view of the static medium defined in system **O**, and therefore its wave number, will depend on the state of movement of the system containing A and B, **O'** with respect to **O**. This trivial idea is already shown in Figure 1.

From the point of view of reference frame **O** it can be considered that the distance travelled by the wave from A to B varies with the state of movement of **O'**, but from **O'**, the wave travels exactly the distance L. The state of movement of the system **O'** with respect to **O** determines the frequency of the wave ν_o in **O** along the direction A-B and therefore its wave number $\tilde{\nu}_o$ registered from **O'**. The same phenomenon will occur in any direction in which the wave is transmitted to a co-mobile receptor.

6 Analysis of the STR Tests

There are literally hundreds of experiments that have tested the STR. Those described below are possibly the most highlighted ones and a part of a list by no means aimed to be complete.

Although Fizzeau's experiment [20], aimed to determine the possible changes in the speed of light travelling through transparent bodies, has interesting outcomes about STR and the relativistic addition of speeds, it is intentionally excluded here because it is not considered a direct test on STR.

6.1 Epistemology of One Way and Two Way Experiments

The experiments that, after clock synchronization, try to measure the speed of light in one direction (or the time that the light takes to travel a given distance) are defined as 'one way' experiments. It is supposed that they must produce results to first order in ***v/c***.

'Two way' experiments are those that use a round path, go and return, to measure the mean value of these travels. It is supposed that they must produce results to second order in ***v/c***.

But in a detailed analysis of one way direct comparison experiment it is concluded that whatever mean to directly compare the speed in one direction will need feedback information about the arrival, or travel time, which converts the experiment into a two way one.

But as shown in next section 6.2, these two way experiments are epistemologically impossible to detect any space, time, or speed anisotropy nullifying also any one way direct experiment.

6.2 Interference Experiments: Michelson-Morley's

Michelson-Morley experiments [1] use a light interferometer, which is a device that measures for comparison the difference between two optical paths over the instrument's two arms along light's journey outward and backwards in two different directions.

In Michelson's the light waves already have completed round trip over the distance L of both arms. The interferometer as it is conceived does not measure directly any time difference but a spatial difference. This is achieved comparing the difference in the total number of wave-fronts along the light path of both arms.

The number and width of interference fringes observed is related to the difference between the lengths of the arms, the wavelength, and a multiple of an integer m. That one and other relationships such as the intensity of the observed fringes are perfectly well known and it is not considered necessary to go into any detail for the purpose of this article.

The classical analysis of the experiment and its results is based on the comparison of the light time's travel the in its journey along both arms of the interferometer and therefore the distance travelled over the two arms. That classical analysis is made from a motionless of point of view of the ether and the result of that is a Galilean compound speed $\vec{v}'$ explained in section 4.3.

Since the experiment and the results of it are all accomplished and analysed from the very reference frame moving through the supposed luminous ether, as it is the case of an experiment placed at a laboratory over the earth, the Michelson's analysis must be carried out from a moving reference frame point of view, not form the still ether point of view.

In any case, and if the laws of physics are equal in any reference frame, the results of Michelson's analysis from a moving reference frame point of view will have to be perfectly valid.

Let us analyse Michelson's interferometer from the point of view of a reference frame placed in a moving laboratory taking into account the precedent sections 4.2 and 4.3.

From the conclusions given in these sections it is evidently possible to obtain, via time and space analysis, the same result than it is going to be showed below using wave fronts idea.

Let us define a classical Michelson interferometer in a reference frame **O'** moving at velocity $\vec{v}$ with respect to a static medium defined over a PRF **O**. The monochromatic light source will emit a frequency ν_A to the beamsplitter which separates the beam in two different directions over the arm 1 and the arm 2. The setup is a standard Michelson interferometer represented in

Figure 6.

Let us call arm 1 to the interferometer's arm that moves longitudinally to speed $\vec{v}$, and arm 2 the one that moves transversally to $\vec{v}$.

ARM 1: Number of wave fronts over the go path (***nwg₁***).
When frequency ν_A is transmitted from the beamsplitter in the direction of the arm 1 it will be observed, from any point of the static medium **O** in the $\vec{v}$ direction, as ν_{og}. According to the Doppler effect formula for a moving emitter approaching the receiver as explained in section 4.2 that will be:

$$\nu_{og} = \nu_A \cdot \frac{c}{c - \mathbf{v}}$$

Being its wave number in that direction:

$$\tilde{\nu}_{og} = \frac{\nu_A}{c - \mathbf{v}}$$

And the total number of wave fronts over the one way trip of arm 1 will be the wave number times the length of that travel. Due to from the **O'** reference frame point of view the length of the travel is exactly L, the number of wave fronts observed from **O'** will be:

$$nwg_1 = \frac{L \cdot \nu_A}{c - \mathbf{v}}$$

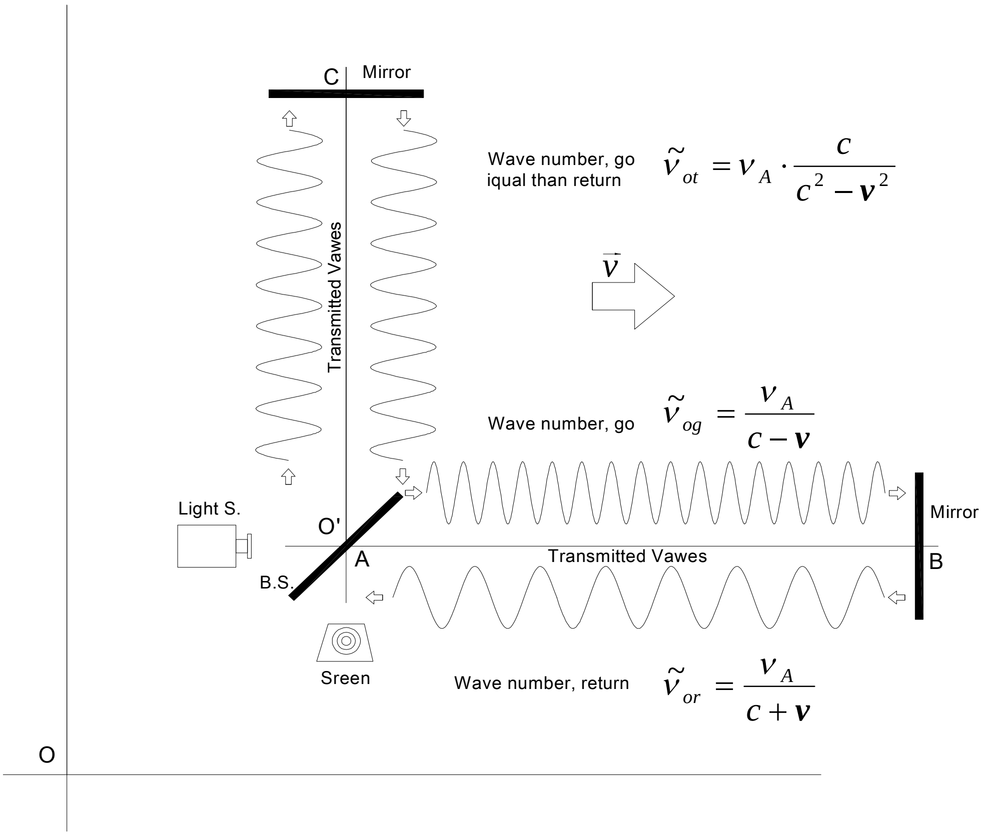

Figure 6: Michelson-Morley experiment setup and representation of transmitted wave number in each two way light path.

ARM 1: Number of wave fronts over the return path (nwr_1).

When the light beam reaches the mirror of the end of arm 1, the frequency ν_{og} is observed and reflected as ν_A, but now according to the Doppler effect formula for a moving emitter A getting away from the receiver **O** will be:

$$\nu_{or} = \nu_A \cdot \frac{c}{c + \mathbf{v}}$$

Being its wave number in that direction:

$$\tilde{\nu}_{or} = \frac{\nu_A}{c + \mathbf{v}}$$

And the total number of wave fronts observed form **O'** over the return travel of arm 1 as stated previously will be:

$$\boldsymbol{nwr_1} = \frac{L \cdot \nu_A}{c + \mathbf{v}}$$

Total number of waves fronts over arm 1($\boldsymbol{tnw_1}$).

The total number of wave fronts as seen from the beam splitter (**O'**) will be the total number of wave front over the two way path, plus the total number of wave front in the return path. Thus, the total number of wave fronts in arm 1 is:

$$\boldsymbol{tnw_1} = \boldsymbol{nwg_1} + \boldsymbol{nwr_1} = \frac{L \cdot \nu_A}{c - \mathbf{v}} + \frac{L \cdot \nu_A}{c + \mathbf{v}} \Rightarrow \boldsymbol{tnw_1} = \frac{2L \cdot \nu_A \cdot c}{c^2 - \mathbf{v}^2}$$

ARM 2: Number of wave fronts over the go path ($\boldsymbol{nwg_2}$).

When frequency ν_A is transmitted from the beamsplitter to the static medium **O** it will be observed as a different frequency depending on the direction of the observer. In the case of arm 2 the observer is the mirror C at the end of the arm, the transmitted frequency to the medium **O** in the direction of perception A'C will be the ν_{ot} as explained in section 4.3:

$$\nu_{ot} = \nu_A \cdot \left(\frac{c}{c - \mathbf{v_P}} \right)$$

And:

$$\mathbf{v_P} = \frac{\mathbf{v}^2}{\mathbf{c}}$$

Then that frequency will be:

$$\nu_{ot} = \nu_A \cdot \frac{c^2}{c^2 - \mathbf{v}^2}$$

And its wave number:

$$\widetilde{\nu}_{ot} = \nu_A \cdot \frac{c}{c^2 - v^2}$$

And the total number of wave fronts over the outward journey of arm 2 will be, as before, the wave number times the length of that travel. Due to, from the point of view of **O'** reference frame, the length of the travel is exactly L, the number of wave fronts observed from **O'** will be:

$$nwg_2 = \frac{L \cdot \nu_A \cdot c}{c^2 - v^2}$$

<u>**ARM 2:** Number of wave fronts over the return path (***nwr₂***).</u>

The process in this case is symmetric to the previous one and, therefore, exactly the same but acting now as emitter the mirror C at the end of arm 2. The number of wave fronts over this return path will be:

$$nwr_2 = \frac{L \cdot \nu_A \cdot c}{c^2 - v^2}$$

<u>**Total number of waves fronts over arm 2 (*tnw₂*).**</u>

The total number of waves in the arm 2 is the sum of both previous quantities

$$tnw_2 = nwg_2 + nwr_2 \Rightarrow tnw_2 = \frac{2L \cdot \nu_A \cdot c}{c^2 - v^2}$$

<u>**That is the same as obtained for arm 1.**</u>

That means that there is no difference of optical path between both arms of a Michelson's interferometer and, thus, no movement detection through ether at all.

It must be noticed here that these quantities are exactly equal which means that no orientation dependence phase shift is observed between two arms.

Conclusion; A Michelson-Morley interferometer, by its own conception, is NOT able to detect the PRF or any static medium as luminous ether, even if this exists. It is not suitable to test the STR and its results do not give any information about the PRF.

6.3 Michelson-Morley's Experiment with Pulsed Light

These experiments try to avoid the fact that Michelson's interferometer does not measure directly any speed or time difference between the two arms. The idea of this type of experiment is to effectively measure the time intervals in the journeys of both arms by sending a light pulse, dividing it, and then checking the arrival time via both arms of the interferometer.

The availability of ultra-short pulse lasers makes possible the emission of a very short laser pulse about the size of one wavelength. The idea of the experiment is to send one light pulse trough both paths and check if the arrival has any phase shift.

This type of experiment is proposed by G Sardin [21] on the basis of Vigo's [22] and Ligo [23] experiments.

Also an apparent(ly) similar experiment trying to exploit this same idea was the one carried out by Stefan Marinov in his "coupled shutter experiment" [24] where, the presumable results obtained are in reality caused by the setup of his experiment, being a Sagnac [25][26] type of interferometer.

As demonstrated in section 6.2 for a Michelson interferometer the number of wave fronts does not change along both arms of the interferometer. This has the consequence that one split pulse is going to behave similarly than a single wave front, point to point, in each arm and consequently, because the number of wave fronts does not change, both pulses will arrive at the exactly the same instant to the beamsplitter with no phase shift at all.

Conclusion; A pulsed light Michelson interferometer is NOT able to detect any anisotropy nor a static medium, even if it were to exist. It is not suitable to test the STR.

6.4 Interference Experiments: The Kennedy-Thorndike's

The Kennedy-Thorndike [2] experiment is a variation of the MME with two arms of different lengths, *L1* and *L2*. The difference between the number of wave fronts in both arms will give as a result the order of the fringes that appear in the interference pattern but, even if the length of the arms of the interferometer are different, the difference in the number of wave fronts of both trajectories when they turn in relation to the motionless system O does not chage.

Using the same relationships that those exposed in section 6.2 the total of wave fronts, in the two way trip, over the arm of length *L1* of the interferometer is:

$$tnw_1 = \frac{2L_1 \cdot v_A \cdot c}{c^2 - v^2}$$

And the total number of wave fronts, over the two way trip of arm of length L2, similarly:

$$tnw_2 = \frac{2L_2 \cdot v_A \cdot c}{c^2 - v^2}$$

The difference between the total number of wave fronts between both arms measured by the interferometer will be:

$$Dtnw_1 = \frac{2v_A \cdot c}{c^2 - v^2} \cdot (|L_1 - L_2|)$$

Evidently the absolute value of the formula represents the difference in distance of *L1* and *L2*.

If we now turn the interferometer 90º that difference of wave fronts will be:

$$Dtnw_2 = \frac{2v_A \cdot c}{c^2 - v^2} \cdot (|L_2 - L_1|)$$

That is the same as the previous one.

Conclusion; The Kennedy-Thorndyke experiment is NOT able to detect any static medium, even if it exists. It is not suitable to test the STR.

6.5 Interference Experiments: The Sagnac's

The Sagnac experiment [25][26], first suggested by Oliver Lodge [27], is based on a circular light interferometer that was aimed to prove the existence of the luminous ether by detecting self rotation. The setup is drafted in Figure 7. The formal relativistic explanation was given by Max von Laue [28] from the Oliver Lodge idea even before the experiment was carried out by Sagnac.

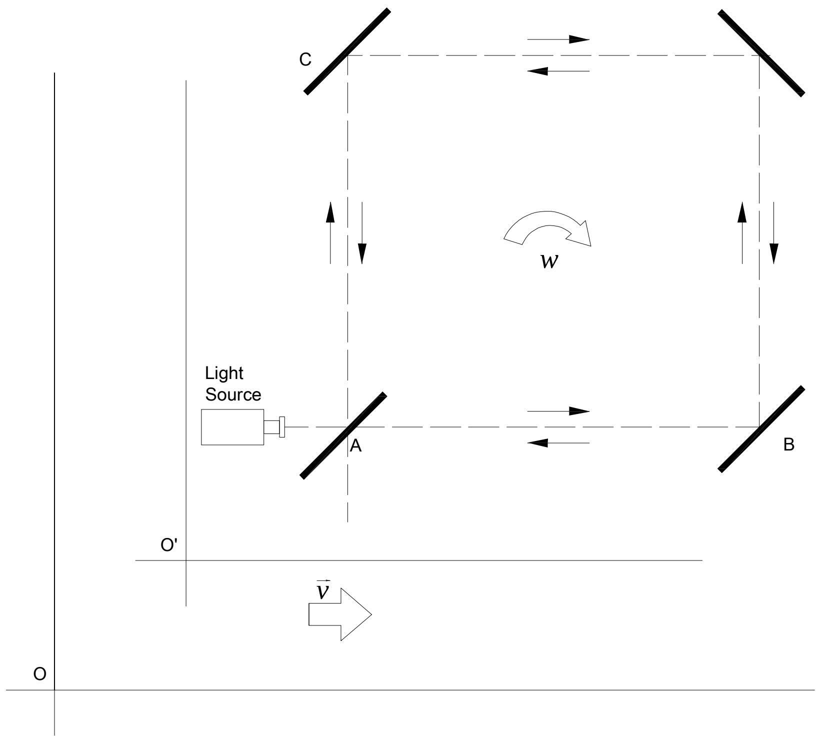

Figure 7: Schematic of the Sagnac experiment aimed to detect the ether by rotating opposite paths from the same light source.

It is not the aim of this article to deeply analyse this experiment but it is easily demonstrable through a classical analysis of it, as seen in previous sections, that the rotation of the Sagnac interferometer causes the light path of the circle in one direction of the beam to increase, depending of the angular velocity, and decrease in the other direction. This gives an actual difference of wave fronts between both directions and, consequently, detection of rotation.

Conclusion; The result obtained in the Sagnac experiment is also explained via classical analysis considering the existence of a PRF.

6.6 Frequency Drift Experiments: Measurement of the Anisotropy of c Using Detectors

Most of the experiments carried out, either of the one- or two-way type are assumed to register the velocity of the earth with respect to a supposed static medium by using one or various detectors to register any minute change in the frequency of one or various directions along the space. These experiments are accomplished with different emitted electromagnetic frequencies, some with microwave range frequencies, and others with light range, but all of them use detectors or optocouplers and eventually frequency analyzers to register that frequency shift.

The number of this type of experiments is huge and only the most representative are going to be reviewed here.

One interesting one-way experiment was performed by A. Brillet and J.L. Hall [6], involving a stabilized He-Ne laser was 90º interfered with a reference NH4 laser. The idea was correct, including a plausible cosmic affection of the laser cavity. They used thermal isolation, and vacuum cavity but also a material detector to analyse the resultant frequency shift. It must be taken into account that a vibrating co-mobile molecule is also affected by the co-mobile detector effect, not being able to detect any anisotropy.

Another example of this one-way type is the Lee-Hall experiment [29] where the frequency of a two-photon transition in a fast atomic beam is compared to the frequency of a stationary observer while the direction of the fast beam is rotated relative to the fixed stars. The hidden failure here is the use of the acousto-optic frequency shifter locked by the fast-beam two-photon absorption line (material) to analyse the frequency shift.

Also have the same problem the one performed by Ch. Eisele et al. [30] using 3 laser beams and a monolithic ULE glass structure containing two orthogonal, crossing Fabry-Perot cavities and a cavity frequency read-out with detectors.

All these experiments, and most of others not mentioned here, use detectors for registering frequency changes and due to the co-mobile detector effect described in section 4.2 all of them are immediately nullified in the sense that they can not measure any frequency drift even if a static medium **O** existed.

Conclusion: all experiments using frequency detector/s or analyzer/s to compute the frequency shift in different directions are not suitable to detect any speed of light anisotropy due to the co-mobile detector effect. None of these types of experiments enable us to detect any static medium, and are not suitable to test the STR.

7 Classical Derivation of Lorentz Factor from MME

Analyzing the results obtained in sections 3.1, 4.3 and 6.2 it possible to calculate the relationship between the 'actual' and the 'observed' speed from point C of a Michelson interferometer.

Being the 'actual' speed v' calculated from the velocity composition, and the 'observed' speed $c-v_p$ measured from the receiver point of view in point C, the relationship between them will be:

$$\frac{v'}{c-v_p} = \frac{\sqrt{c^2-v^2}}{\frac{c^2-v^2}{c}} = \sqrt{\frac{1}{1-\frac{v^2}{c^2}}}$$

This is the Lorentz factor γ .

γ expresses the relationship between the ontological world and the observed world between two material points for the case of a transverse Doppler effect.

8 Conclusions

As it is proven in this article and because there is classical mechanical explanation to the null results of MME and many other experiments to test the STR, two new TBI based experiments are proposed to ultimately check the validity of the Special Theory of Relativity.

The Lorentz factor γ expresses the relationship between the ontological world and the observed world between two material points for the case of a transverse Doppler effect.

9 Proposal of 2 Experimental Set-Up to Test the Anisotropy of Speed of Light.

9.1 Interference of Independent Photons Beams

The interference of independent photon beams has already been theoretically studied by L Mandel [31] and by T.F. Jordan and F. Ghielmetti [32] where is concluded the possibility of temporally interference. These results were corroborated by G. Magyar and L. Mandel [33] in 1963 and also by Pfleegor and Mandel's experiment [34] in 1967.

There are few known proposals of Two Beam Interferometry (TBI) for detecting absolute motion purposes. Two of them are proposed by C.I. Christov in [16] and revisited in [17] and with a comprehensive exposition of mathematics in [35] which the co-mobile detector effect is also concluded.

Ruyong Wang et al [36] also propose a TBI for detecting anisotropy but using a detector to analyse the frequency shift.

In those texts different experimental setup using this TBI idea are suggested but both have the same epistemological defect: To use a detector in order to analyze the beat frequency. So, even if the beat frequency is present, that frequency shift could not be measured by installing a co-mobile detector.

9.2 Two Beam Interferometry.

The idea of the TBI, as seen in section 9.1, is not new. The theoretical studies and experiments carried out by [31][32][33][34] and other more recent ones like reviewed in H. Paul's abstract [37] or specific experimental setups where such an interference was obtained as in L. Bazano-P. Ottonello [38], I. Verovnik-A. Likar [39], or in L. Bazano et al. [40] show that it is possible to obtain interferometric results at least temporally.

The experiment proposed here does not have any of the flaws observed in the experiments revisited in section 6 in the sense that it does not make use of any detector to analyse frequency shift or frequency beat. Neither it has a Michelson's type of setup. The main idea of the proposed experiment is to make a TBI with two lasers travelling in opposite direction and observe the difference in the interference fringes. Because the direct observation of these fringes may result unclear as explained in the cited references, maybe a camera or an opto-copupler is needed but not treated as a frequency detector.

9.3 SET-UP 1: Linear Interferometric Setup.

The proposed experimental setup is as shown in Figure 8. It comprises two continuous wave lasers in parallel disposition in order that any possible cosmic affection inside of its cavities be the same. At least one of them must be able to turn in order to search (for?) the polarization coherence.

The rays are then deviated to point in opposite directions in order to produce different light paths.

To guarantee the coherence it may be necessary that one of the lasers be wavelength adjustable to match the other's wavelength to achieve the interference pattern and also a possibility to turn. In that same sense an optical phase shifter is needed to guarantee the beam's coherence.

Also two frequency analysers may be needed to check the steadiness of the output frequency of both lasers.

The opto-coupler may be necessary in case the interference pattern is not directly visible as in experiment [38].

From the previous position and turning all the set 180º notable changes in the interference figure would have to appear evidencing the existence of a PRF.

Also the setup may be used to calculate the translation speed as the earth moves on its orbit by analysing the interference fringes. For this purpose the setup is placed in a fixed mount and a periodic check for changes in the fringe patterns for an interval of 24 hours must be done.

The interferometry will compare the number of wave fronts along the two optical paths O1-A-B-B' on one side and O2-C-B' on the other.

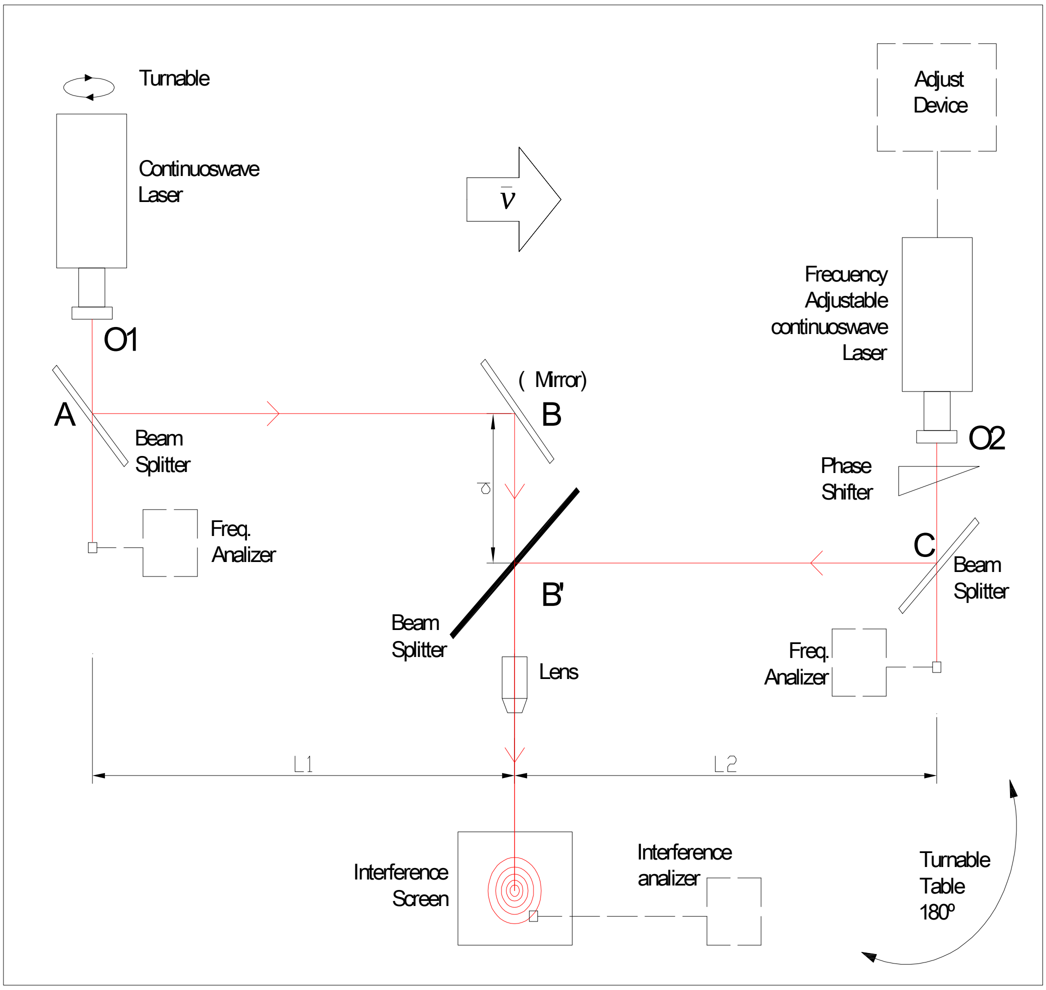

*Figure 8: Schematic of proposed experimental set-up for checking the anisotropy of **c** with linear beam compare.*

Supposing the lasers have the same output frequency ν. The frequency transmitted to the hypothetic static medium and the corresponding wave number in those paths as seen in section 4.2, will be, for path A-B:

$$\nu_{ab} = \nu \cdot \frac{c}{c + \mathbf{v}}$$

And its wave number:

$$\tilde{\nu}_{ab} = \frac{\nu}{c + \mathbf{v}}$$

The total wave fronts in the path A-B

$$nw_{AB} = \frac{L1 \cdot \nu}{c + \mathbf{v}}$$

The path B-B' also adds a number of wave fronts depending on the distance *d,* including the internal path of the beam splitter, being a quadratic factor due to the transversal velocity $\vec{v}$ as seen in sections 4.3 and 6.2, the total number of wave fronts of the path results:

$$nw_{BB'} = \frac{d \cdot v \cdot c}{c^2 - v^2}$$

The same occurs in the path O1-A including the inner cavity of laser 1. Assuming a total distance of O1-A as *d1*, the total number of wave fronts, including the cavity, would be:

$$nw_{O1A} = \frac{d_1 \cdot v \cdot c}{c^2 - v^2}$$

This means that the total number of wave fronts in path 1: O1-B' is the sum of these:

$$tnw_{01\text{-}B'} = nw_{AB} + nw_{BB'} + nw_{O1A} = \frac{L1 \cdot v}{c + v} + \frac{d \cdot c \cdot v}{c^2 - v^2} + \frac{d_1 \cdot c \cdot v}{c^2 - v^2}$$

Now, using the same method over the path 2: O2-B'. The total number of wave fronts in the path C-B':

$$nw_{CB'} = \frac{L2 \cdot v}{c - v}$$

The total number of wave fronts in the path O2-C':

$$nw_{O2C} = \frac{d_2 \cdot v \cdot c}{c^2 - v^2}$$

The total number of wave fronts in path 1 is the sum of these:

$$tnw_{02\text{-}B'} = nw_{CB'} + nw_{O2C} = \frac{L2 \cdot v}{c - v} + \frac{d_2 \cdot c \cdot v}{c^2 - v^2}$$

The interferometry in this position of the experimental setup is related to the difference between those two optical paths i.e. its difference in wave fronts:

$$Dtnw_{A\text{-}C} = tnw_{O1\text{-}B'} - tnw_{O2\text{-}B'} = \frac{L1 \cdot v}{c + v} + \frac{d \cdot c \cdot v}{c^2 - v^2} + \frac{d_1 \cdot c \cdot v}{c^2 - v^2} - \left(\frac{L2 \cdot v}{c - v} + \frac{d_2 \cdot c \cdot v}{c^2 - v^2} \right)$$

Now the experimental setup is turned 180º.

The new values of wave fronts in the two directions will be, as done before and because the transversal terms do not change since they are equally affected in both directions of $\vec{v}$:

$$\boldsymbol{tnw}_{O1\text{-}B'} = \boldsymbol{nw}_{AB} + \boldsymbol{nw}_{BB'} + \boldsymbol{nw}_{O1A} = \frac{L1\cdot v}{c-v} + \frac{d\cdot c\cdot v}{c^2-v^2} + \frac{d_1\cdot c\cdot v}{c^2-v^2}$$

and

$$\boldsymbol{tnw}_{02\text{-}B'} = \boldsymbol{nw}_{CB'} + \boldsymbol{nw}_{O2C} = \frac{L2\cdot v}{c+v} + \frac{d_2\cdot c\cdot v}{c^2-v^2}$$

The new interferometry now will show the difference of these two:

$$\boldsymbol{Dtnw}_{C\text{-}A} = \boldsymbol{tnw}_{O1\text{-}B'} - \boldsymbol{tnw}_{O2\text{-}B'} = \frac{L1\cdot v}{c-v} + \frac{d\cdot c\cdot v}{c^2-v^2} + \frac{d_1\cdot c\cdot v}{c^2-v^2} - \left(\frac{L2\cdot v}{c+v} + \frac{d_2\cdot c\cdot v}{c^2-v^2}\right)$$

The difference of those two quantities, $\boldsymbol{Dtnw}_{C\text{-}A}$ and $\boldsymbol{Dtnw}_{A\text{-}C}$ represents the difference between the wave front numbers in both paths changing the orientation of the experiment. It may be easily calculated:

$$\boldsymbol{Dtnw}_{C\text{-}A} - \boldsymbol{Dtnw}_{A\text{-}C} = \frac{-2v\cdot v\cdot(L1+L2)}{c^2-v^2}$$

In the case of *L1=L2* this difference is an absolute value and can be translated to a net space gap difference by multiplying it by the wavelength:

$$\Delta s = \lambda\cdot\left|\boldsymbol{Dtnw}_{C\text{-}A} - \boldsymbol{Dtnw}_{A\text{-}C}\right| = \frac{4L\cdot c\cdot v}{c^2-v^2}$$

In an experimental setup with one meter long arms, the light speed $\boldsymbol{c}=3\text{x}10^8\text{ms}^{-1}$ and neglecting the Local Standard of Rest speed, the orbital velocity of the earth $\boldsymbol{v}=3\text{x}10^4\text{ms}^{-1}$ that net spatial gap would be:

$$\Delta s = \frac{4\cdot1\cdot3\cdot10^8\cdot3\cdot10^4}{9\cdot10^{16}-9\cdot10^8} = 4{,}04\cdot10^{-4}\,m$$

And this would be easily observable in the interference pattern changes as the instrument rotates 180º.

9.4 SET-UP 2: Perpendicular Interferometric setup.

The second proposed setup is similar to a Michelson interferometer but makes use of two lasers, both pointing to the same direction. The diagram is shown in

Figure 9

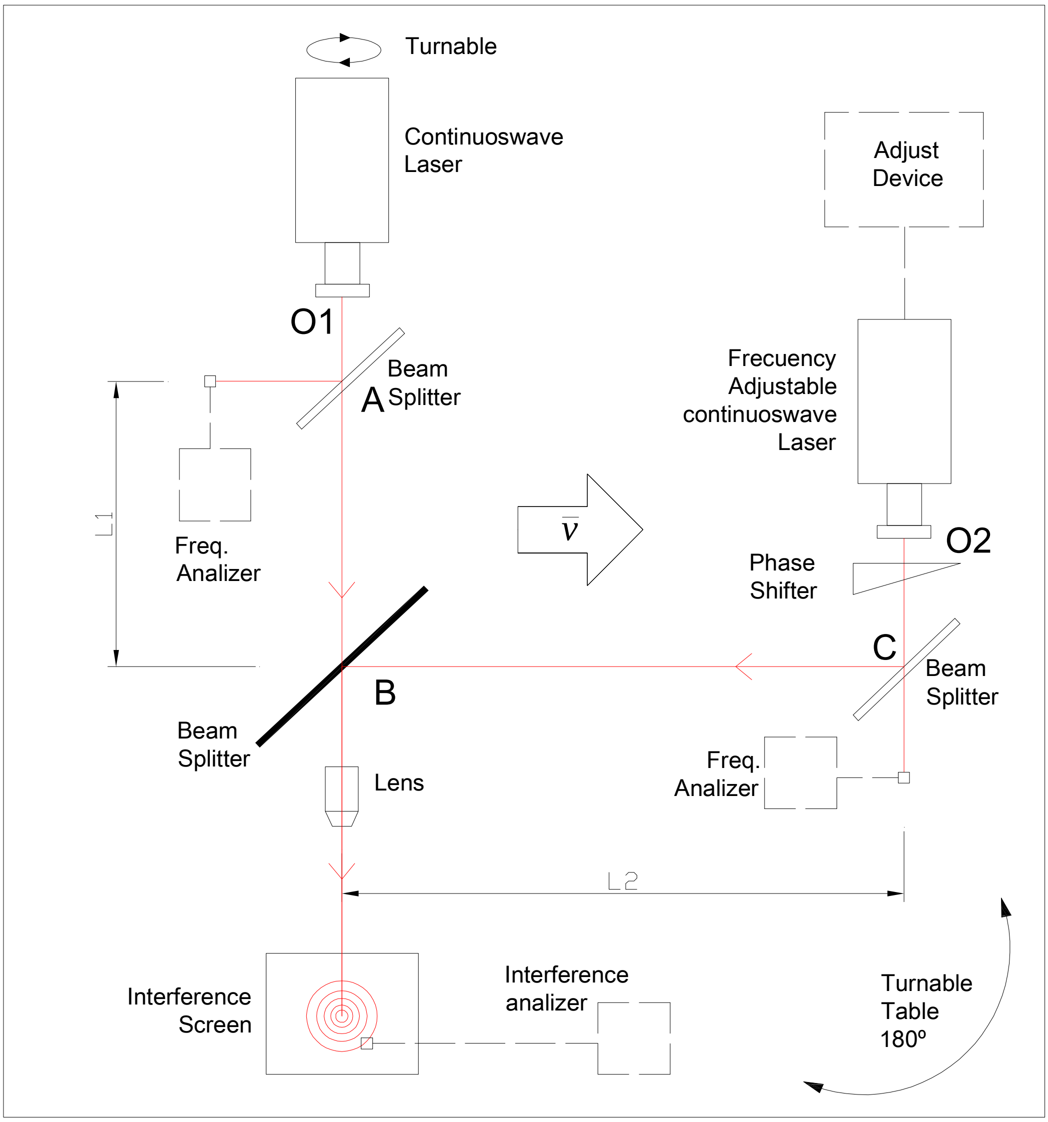

*Figure 9: Schematic of the proposed experimental set-up for checking the anisotropy of **c** with perpendicular beam compare.*

Following the procedure as seen in the previous section the resulting for a *L2=L* net space gap turning the setup 180º will be:

$$\Delta s = \lambda \cdot \left| Dtnw_{C\text{-}A} - Dtnw_{A\text{-}C} \right| = \frac{2L \cdot c \cdot v}{c^2 - v^2}$$

Which gives, for the same values of $\boldsymbol{v}$ and $\boldsymbol{c}$, a net space of:

$$\Delta s = \frac{2 \cdot 1 \cdot 3 \cdot 10^8 \cdot 3 \cdot 10^4}{9 \cdot 10^{16} - 9 \cdot 10^8} = 2{,}02 \cdot 10^{-4}\, m$$

Evidently, this is half of what was obtained before but still easily observable in an interferometry experiment.

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