The Light-Path Effect

Introduction

If I move away from an approaching signal, the signal takes longer to reach me.

This idea is underlying the experiments by Torr and Kolen in 1984 [1] and De Witte in 1991 [2]. Whilst the positive results of these experiments prove the existence of the effect that motion of an observer relative to a signal has onto the length of the path that a signal has to travel, this light-path effect is not yet part of mainstream theory. Working in the frequency domain with phase comparison, the mentioned experiments were only able to detect the components of the total velocity vector which vary over the duration of the experiment.
I see a need to deliver the complete and clear picture to enable incorporation of this proven effect into mainstream theory. I therefore thought up an improved experiment, which works in the time domain, to detect the total absolute velocity vector and distinguish its components. My novel approach of measuring the time intervals of signals along two perpendicular axes, will deliver these results that can only be obtained in the time domain, whilst for the same reason avoiding the failure of Michelson-Morley like experiments, yet breaking the axial symmetry.

No experiment of this nature has ever been conducted. A positive outcome will result in a modern improvement to existing theory and associated technological applications, if not enabling them for the first time.

Idea

Consider 2 spaceships connected by a rod which will break whenever the back engine starts first but will hold when the front engine starts first. If the engines are started with a signal from the center of the rod, whether the rod breaks or not does of course not depend on the motion of an external observer but only concerns the two-spaceship ensemble and depends on which engine is started first. There is no proven theory in existence to calculate which spaceship really starts first. This question depends on the length of the path the signal has to travel to reach the respective spaceship. Let us call this phenomenon the "light-path effect". For one dimensional motion this effect is described by

$$\Delta t = \frac{d/c}{1 - \frac{v}{c}} \qquad [1]$$

where Δt describes the time a signal takes to reach an observer along distance d at an absolute velocity v (which purely concerns the absolute motion of the two-spaceship ensemble), with a negative velocity indicating motion towards the signal. Absolute velocity can hence be understood as velocity relative to

EM radiation, where zero relative velocity indicates absolute velocity at speed c into the direction of the signal.

The experiment which I will propose, promises to prove this effect and to find the absolute velocity vector, to enable calculation of which engine really starts first.

However if motion has absolute meaning, then the light-path effect will reflect within matter itself. Experimental results suggest that this effect on matter can be modelled by a lightclock ticking perpendicular to its direction of motion [3]. Let us call this effect the "frequency effect" - described by

$$f = f_o * \sqrt{1 - \frac{v^2}{c^2}} \qquad [2]$$

where f describes the frequency of a clock at absolute motion at speed v if f_o is its rest frequency. But the existence of the frequency effect will impact the measurement of the light-path effect in the time domain, and thus requires analysis of their interplay to determine a viable experiment.

Analysis and Theory

When working in the time domain, employing the rotation of earth is problematic, as whilst the light-path gets longer, an atom ticks slower. When comparing the case of two opposite locations on earth such that the earth rotation respectively contributes its maximal positive and negative velocity component to the total velocity vector, the interplay between the light-path and the frequency effect leads to almost identical interval measurements at both points in the time-domain. Following from equation 2, if we for illustrative purpose assume the surface of earth to rotate at 500m/s parallel to our velocity vector of 300,000 m/s (diagram 1), the frequency of clocks relates by

$$f_A = f_B * \frac{\sqrt{1 - \frac{v_A^2}{c^2}}}{\sqrt{1 - \frac{v_B^2}{c^2}}} = f_B * \frac{\sqrt{1 - \frac{300{,}500^2}{300{,}000{,}000^2}}}{\sqrt{1 - \frac{299{,}500^2}{300{,}000{,}000^2}}} \qquad [3]$$

But for a return journey over a distance of approximately 200 meters at the speed of light this is equivalent to

$$\Delta t = \Delta cycles/f \;\approx 4.426045 * 10^{-15}\,\text{sec} \qquad [4]$$

for A<B. But the distances that light needs to travel at A versus B compares according to

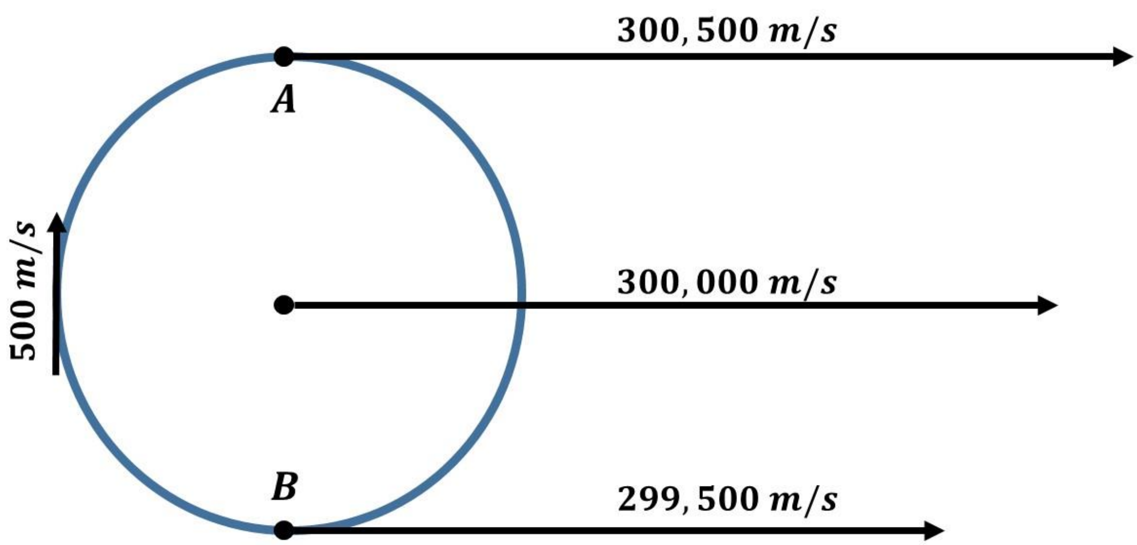
$$d_A = \frac{200m}{1 - \frac{300{,}500^2}{300{,}000{,}000^2}} \ and \ d_B = \frac{200m}{1 - \frac{299{,}500^2}{300{,}000{,}000^2}} \quad [5]$$

to yield a difference of

$$\Delta t = \Delta d / c \approx 4.446667 * 10^{-15} sec \quad [6]$$

for A>B. So the "difference" in the light-path effect between both points is almost cancelled by the difference in the frequency effect with only 0.5% measurable effect remaining. *Such is for an experiment in the time-domain. For an experiment in the frequency-domain as those conducted by Kolen and De Witte, these two effects do not cancel, as here the frequency effects leads to an overall scaling such that only the light-path effect remains as a detectable effect.*

Diagram 1:



Following similar analysis, the effects do not cancel for a 90 degree rotation. Considering the approximation in diagram 2, the frequencies of clocks at A and C will related according to

$$f_A = f_C * \frac{\sqrt{1 - \frac{v_A^2}{c^2}}}{\sqrt{1 - \frac{v_C^2}{c^2}}} \approx f_C * \frac{\sqrt{1 - \frac{300{,}500^2}{300{,}000{,}000^2}}}{\sqrt{1 - \frac{300{,}000^2}{300{,}000{,}000^2}}} \quad [7]$$

For a return journey over a distance of approximately 200 meters at the speed of light this is equivalent to

$$\Delta t_f \approx 0.000010672\, cycles = 1.16092978 * 10^{-15}\,\text{sec} \qquad [8]$$

for A<C. At position A the lightpath is parallel to the direction of motion, but at position C the lightpath is approximately perpendicular to the direction of motion. Considering this approximation, the distances that light needs to travel at A versus C compares according to

$$d_A = \frac{200m}{1-\frac{v_A^2}{c^2}} = \frac{200m}{1-\frac{300{,}500^2}{300{,}000{,}000^2}} \qquad [9]$$

and

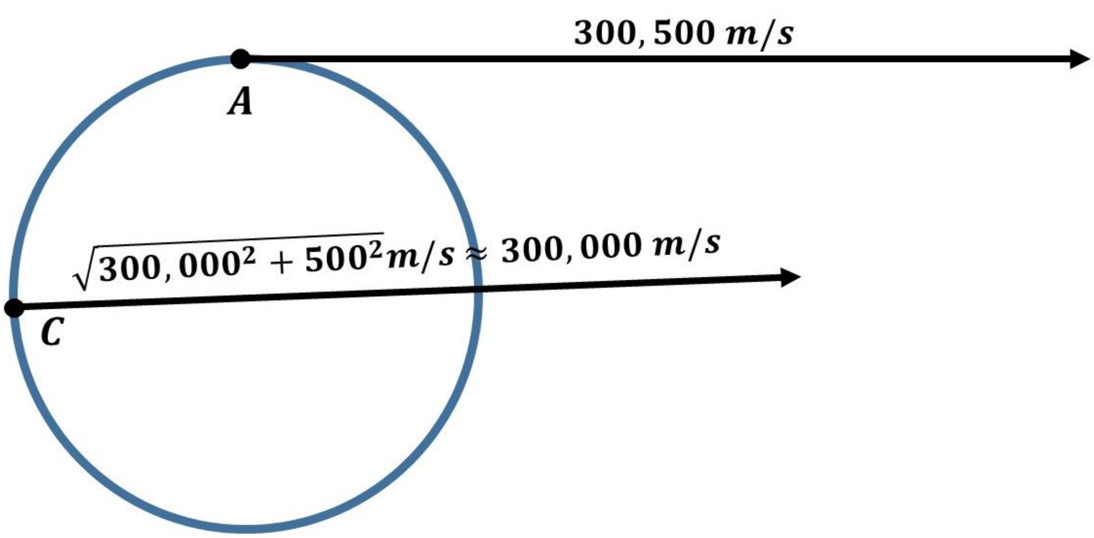
$$d_C = \frac{200m}{\sqrt{1-\frac{v_C^2}{c^2}}} \approx \frac{200m}{\sqrt{1-\frac{300{,}000^2}{300{,}000{,}000^2}}} \qquad [10]$$

to yield a difference of

$$\Delta t_d \approx 0.00010668m * c = 3.3556 * 10^{-13} sec \qquad [11]$$

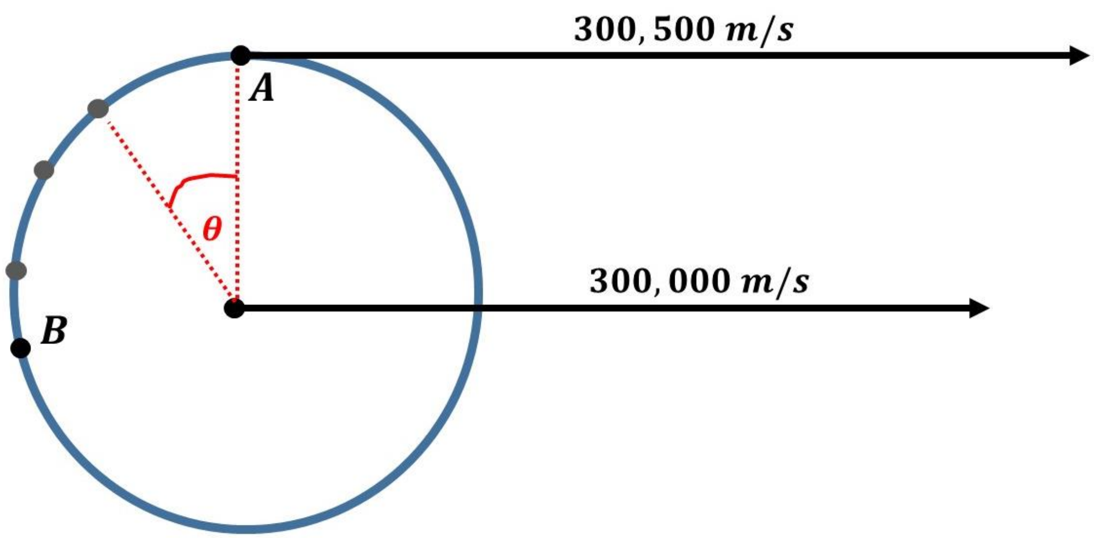
for A>C. Hence both effects do not cancel with an almost 100% measureable effect remaining. But this is only the case for comparison between positions A and C. As soon as we move away from C, the effect will tend to zero again.

Diagram 2:



As we should avoid to misuse the claim as a premise to derive convincing results, we should first establish proof with perpendicular axes as depicted in diagram 7. We can then employ the rotation and revolution of earth to help find the full vector and distinguish its 4 components. To integrate this effect over time for an experiment which wished to integrate repeat measurements over some small amount of time, we need to integrate over the angle of rotation (see diagram 3).

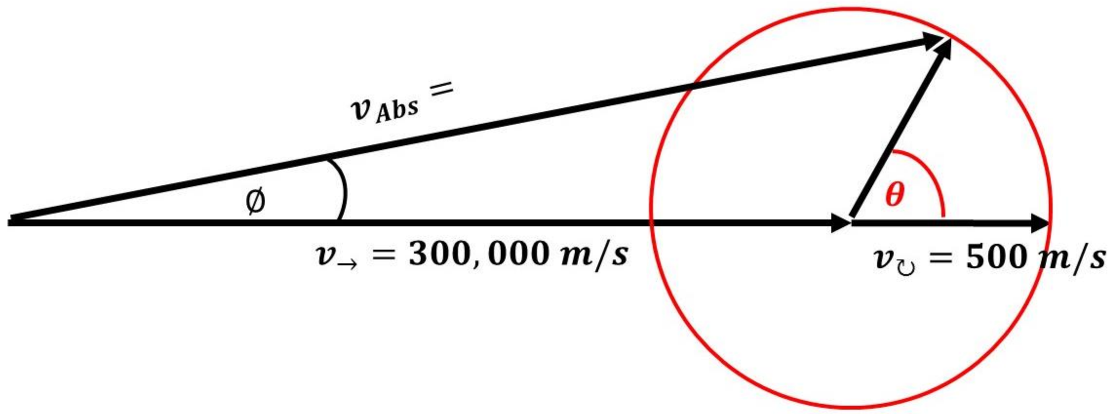
Diagram 3:



Considering different angles of rotation, the frequencies of clocks will always relate by the same formula which is identical to equation 3 - whilst however the location B is variable. All we need to do here is find a general formula for the absolute velocity of the clocks at a variable location B. Such is done in diagram 4 resulting in the formula for the velocity at our variable point B as

$$v_B = \sqrt{v_{\rightarrow}^2 + v_{\circlearrowright}^2 - 2v_{\rightarrow}v_{\circlearrowright}cos(\pi - \theta)} \qquad [12]$$

Diagram 4:



$$v_{Abs} = \sqrt{v_{\rightarrow}^2 + v_{\circlearrowright}^2 - 2v_{\rightarrow}v_{\circlearrowright}cos(\pi - \theta)}$$

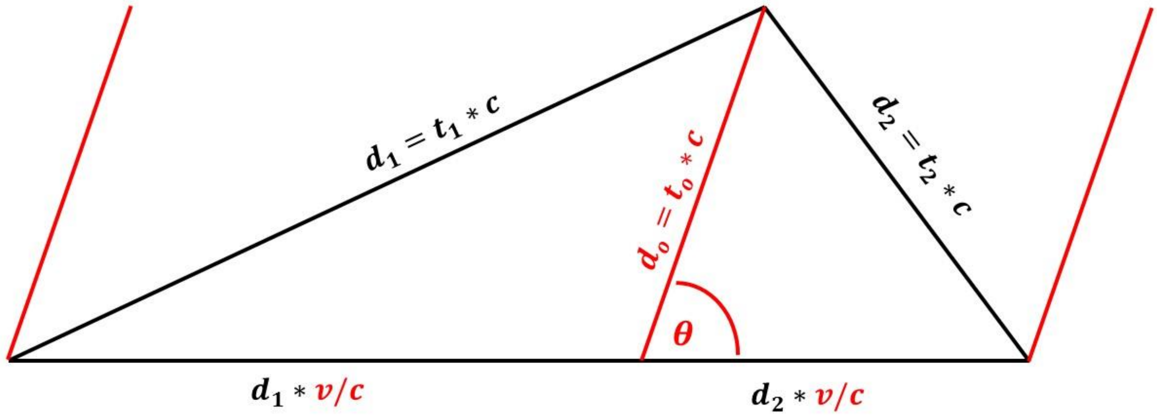
Now we can correctly relate clock frequencies at any angle of earth rotation and integrate to find the clock frequency difference over the duration of our experiment. Such however is only relevant if for example we have only one experimental arm available and are forced to employ the rotation of earth.

But in any case we need to derive a general formula for the length of the lightpath at different angles of rotation, to derive a formula for the average light path length over the duration of our experiment. We do such in diagram 5, where knowns are depicted in red color, and the red line represents the orientation of the lightpath to an approximately horizontal direction of absolute motion of our variable point for all angles - according to the approximation depicted in diagram 2. The resultant general formula to express the lightpath length for the return journey is

$$d_{general} = d_1 + d_2 = \frac{\sqrt{2} * \sqrt{2c^2 d_o^2 + v^2 d_o^2(cos(2\theta) - 1))}}{c - \frac{v^2}{c}} \quad [13]$$

where we need to mind to express the velocity v in equation 13 as of equation 12.

Diagram 5:



$$d_{general} = d_1 + d_2 = \frac{\sqrt{2} * \sqrt{2c^2 d_o^2 + v^2 d_o^2(\cos(2\theta) - 1))}}{c - \frac{v^2}{c}}$$

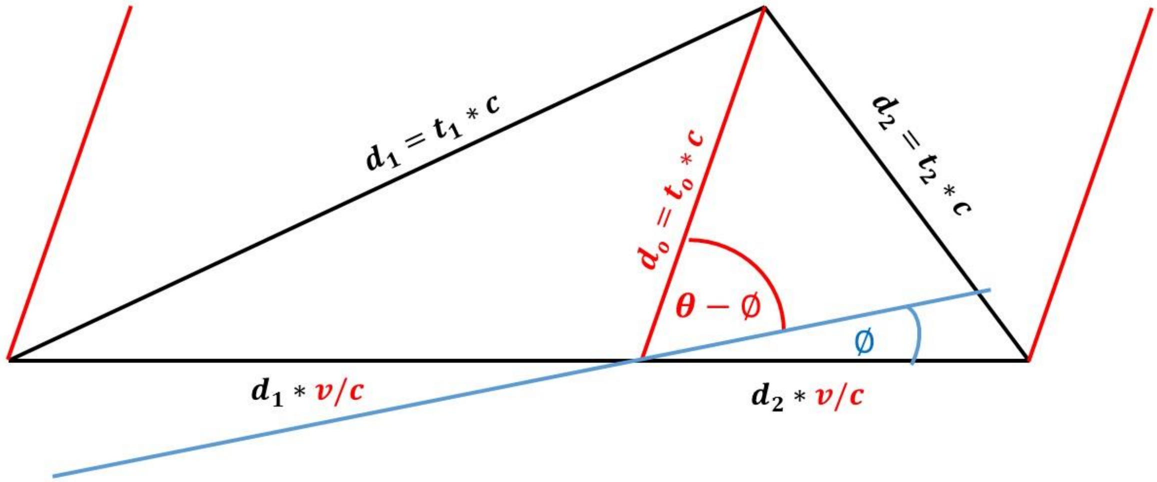
If we however, approximation free, would want to meticulously consider the change in the direction of absolute motion of our point due to the rotation of earth, such would be considered as depicted in diagram 6 for which we need to refer back to diagram 4 and the angle ∅. The angles used in diagram 6 consistently represent the same angles as used earlier on in the manuscript. This corrects the general formula to

$$d_{general} = d_1 + d_2 = \frac{\sqrt{2} * \sqrt{2c^2 d_o^2 + v^2 d_o^2(cos(2(\theta - \emptyset)) - 1))}}{c - \frac{v^2}{c}} \qquad [14]$$

where again we need to mind the correct expression for the velocity from equation 12. But furthermore we now have to express the angle ∅ as an expression of θ, which we can do when applying the law of sines to diagram 4 to arrive at

$$\emptyset(\theta) = arcsin(\frac{v_{\circlearrowright} sin(\pi - \theta)}{v_{\rightarrow}^2 + v_{\circlearrowright}^2 - 2v_{\rightarrow} v_{\circlearrowright} cos(\pi - \theta)}) \qquad [15]$$

Diagram 6:



$$\boldsymbol{d_{general} = d_1 + d_2 = \frac{\sqrt{2} * \sqrt{2c^2 d_o^2 + v^2 d_o^2(\cos(2(\theta - \emptyset)) - 1)}}{c - \frac{v^2}{c}}}$$

We now are ready to integrate over the angle theta to form an average to match experimental data accumulated over time. Considering our meticulous considerations in the above, the exact formula would look the following:

$$\bar{d}_{return} = \frac{\sqrt{2}}{\theta_2 - \theta_1} \int_{\theta=\theta_1}^{\theta_2} \frac{\sqrt{2c^2 d_o^2 + v^2 d_o^2(cos(2(\theta - \emptyset(\theta))) - 1)}}{c - \frac{v^2}{c}} d\theta \qquad [16]$$

Where v follows from equation 12 and $\emptyset$ follows from equation 15. As an approximation we could most likely consider

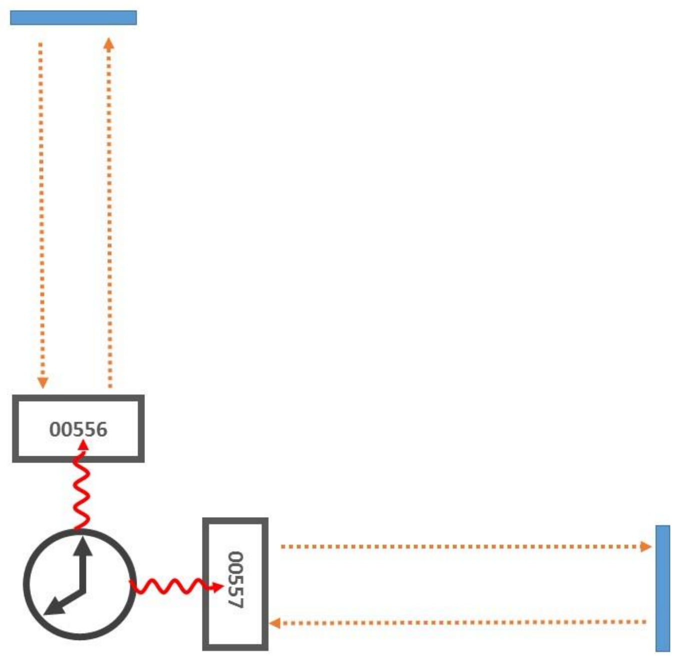
$$\bar{d}_{return} = \frac{\sqrt{2}}{\theta_2 - \theta_1} \int_{\theta=\theta_1}^{\theta_2} \frac{\sqrt{2c^2 d_o^2 + (v_{\rightarrow} + v_{\circlearrowright} cos\theta)^2 d_o^2(cos(2\theta) - 1)}}{c - \frac{(v_{\rightarrow} + v_{\circlearrowright} cos\theta)^2}{c}} d\theta \qquad [17]$$

To explain how to go from here let us assume an ideal experimental setup where initially one out of two perpendicular axes (see diagram 7) is parallel to the direction of absolute motion whilst the other axis always remains perpendicular to the direction of absolute motion. When averaging repeat measurments over say 1 hour, to predict a correct time-of-flight difference between the two axes, we need to employ formula 16 for the distance associated to the initially parallel arm and formula 10 for the perpendicular arm and calculate a time difference as in formula 11. Over this small duration of the experiment the frequency of the clock will change, but such will impact both arms alike for each measurement and is therefore irrelevant for an experiment which compares two arms. If however we would have only one arm available, we would need to translate the average frequency difference to an average measured time difference, as we did before, to make correct predictions for the experimental outcome.

Experimental Concept

The most suitable experimental setup looks the following

Diagram 7:



A frequency-standard is located at the junction of the axes, feeding an output frequency into two time-interval counters which have a resolution high enough to count the inputted frequency. The counting is started via a diode by a laser signal, which then travels along the respective arms of the experimental axes until it hits a second diode to stop the counting. The signals is reflected N times to achieve a measureable time interval difference. I predict that the counters will count a different time interval. For the ideal case of no experimental error, an illustrative prediction considering optimal alignment whilst assuming the previous velocities and a clock to mirror distance of 100 meters, would look the following:

$$d_{\parallel} - d_{\perp} = \frac{200m}{\left(1 - \frac{300{,}500^2}{300{,}000{,}000^2}\right)} - \frac{200m}{\sqrt{1 - \frac{300{,}500^2}{300{,}000{,}000^2}}} \approx 0.0001004m \qquad [18]$$

If the light-path differs by $0.0001004m$ then the travel time differs by

$$\Delta t = \Delta d / c \approx 3.3467 * 10^{-13} sec \qquad [19]$$

Illustratively, for d=100 meters, we hence need $N = 1000$ bounces to achieve a difference of 3 counts if using a 10 Ghz input signal and resolving it.

Considering that LIGO relies on a similar methodology to amplify the signal, our experiment is practically possible. The length of the arms will have to be decided in conjunction with the engineering of the signal reflection and the quality of the frequency standard and counters that can be afforded. If we can work within a millimeter of accuracy, the error from starting the counting via the same laser signal sent via equal length optical fibers onto the diodes which start both counters, will not impact the experiment. Whilst a rotatable experiment would be optimal it may be less practical to achieve.

Perspective

No experiment of this time-of-flight nature has ever been performed before! Considering the results of Kolen's and De Witte's experiments which prove variations in the one way time of flight of a signal between two clocks – a positive outcome appears almost certain. Our two way experiment will be free of the shortcomings of experiments conducted in the frequency domain, but will deliver purest time-of-flight information, unbiased by other potentially hithero unknown factors associated to the frequency domain. Thus, in either case, the experiment would deliver valuable results.

Whilst obtaining a valuable yes/no answer, we may face difficulties in determining the exact vector. Should we however succeed with this task to a satisfying degree, I would like to carry clocks around the world to confirm predictions arising from our adjusted physical understanding which promise improvement over existing theory especially in the westwards direction.

References

[1] P. T. Kolen and D. G. Torr, 1984 "An Experiment to Measure Relative Variations in the One-Way Velocity of Light." *Precision Measurement and Fundamental Constants II: 675-679*

[2] R. Cahill, 2006 "The Roland De Witte 1991 Detection of Absolute Motion and Gravitational Waves" *Progress in Physics 3: 60-65*

[3] H. Edwards, 2017 "On the Absolute Meaning of Motion" *Results in Physics 7:4195-4212.*

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