Proposal for a new light speed anisotropy experiment based on time of flight method by continuous exchange of a short light pulse between two light transponders

Henok Tadesse, Electrical Engineer, BSc. , Ethiopia, Debrezeit, P.O Box 412
Mobile: +251 910 751339 or +251 912 228639
email: *entkidmt@yahoo.com* or *wchmar@gmail.com*

01 August 2019

Abstract

A new light speed anisotropy experiment is proposed that is based on time of flight technique. Two light transceivers (transponders) A and B are fixed to each end of a rigid rod. A short light pulse initially emitted by transponder A is detected by transponder B, upon which B is triggered to emit a light pulse, which in turn is detected by A, upon which A is triggered to emit another light pulse which will be detected by B, and so on. A short light pulse is continuously exchanged between two light transponders. An electronic counter counts the pulses emitted. Changing the orientation of the rod with respect to Earth's absolute velocity direction will cause a variation of the number of pulses counted in a given period of time (i.e. the frequency). The unique feature of this experiment is that Earth's absolute velocity can be determined, theoretically, with any desired accuracy. The new 'transponder' technique may reveal many of the mysteries of the speed of light, including light speed anisotropy and the dependence of group velocity of light on mirror velocity, which would not be possible or difficult otherwise. Conventional methods involve a single pulse with spatially separated emitter and detector and clock synchronization. The new technique involves a free running, continuous exchange of a short light pulse, with the frequency determined by the round trip time of the light pulse itself. Change in the (group) velocity of light is detected as change in the frequency of the light pulses.

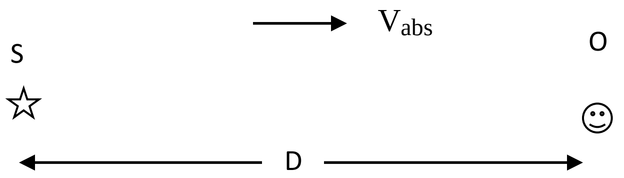
Introduction

Most of the light speed anisotropy experiments use interference techniques which are based on phase differences because of the difficulty associated with time of flight technique, which is the extremely small, difficult to measure difference in time of flight of light in different directions. The Michelson-Morley experiments all use interference methods. The Roland De Witte experiment is also based on phase comparison. The Silvertooth experiment is also based on phase changes caused by absolute motion [1]. Only the Marinov experiment is based on time of flight method. In this paper we propose a new method based on time of flight which will overcome previous difficulties.

Apparent Source Theory [1]

According to the new theory already proposed by this author, *the effect of absolute motion of an inertial observer is to create an apparent change in the position (distance and direction) of the point of light emission relative to the observer* [1].

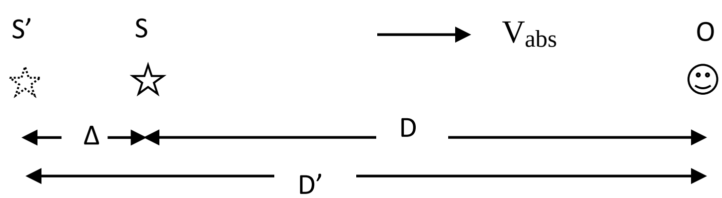
Imagine a light source S and an observer O, both at (absolute) rest, i.e. $V_{abs} = 0$.



A light pulse emitted by S will be detected after a time delay of

$$t_d = \frac{D}{c}$$

Now suppose that the light source and the observer are absolutely co-moving to the right.



The new interpretation proposed here is that the position of the source S changes apparently to S', *as seen by the observer, relative to the observer*.

During the time (t_d) that the source 'moves' from point S' to point S, the light pulse moves from point S' to point O, i.e. the time taken for the source to move from point S' to point S is equal to the time taken for the light pulse to move from point S' to point O.

$$\frac{\Delta}{V_{abs}} = \frac{D'}{c}$$

But

$$D + \Delta = D'$$

From the above two equations:

$$D' = D \frac{c}{c - V_{abs}}$$

and

$$\Delta = D \frac{V_{abs}}{c - V_{abs}}$$

The effect of absolute motion is thus to create an apparent change of position of the light source relative to the observer, in this case by amount Δ .

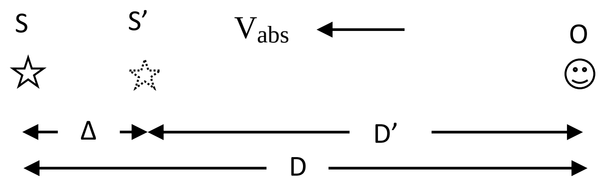
Once we have determined the apparent position of the source as seen by the co-moving observer, we can analyze the experiment by assuming that light was emitted from S' (not from S) and that the speed of light is constant relative to the apparent source.

Therefore, a light pulse emitted by the source is detected at the observer after a time delay of:

$$t_d = \frac{D'}{c} = \frac{D\frac{c}{c-V_{abs}}}{c} = \frac{D}{c - V_{abs}}$$

To the observer, the source S appears to be farther away than it physically is.

In the same way, for absolute velocity directed to the left:



$$\frac{\Delta}{V_{abs}} = \frac{D'}{c} \qquad and \qquad D - \Delta = D'$$

From which

$$D' = D\frac{c}{c + V_{abs}}$$

and

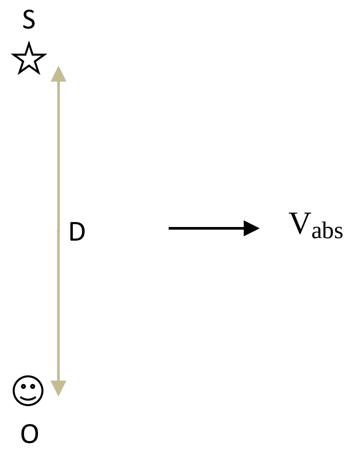
$$\Delta = D\frac{V_{abs}}{c + V_{abs}}$$

In this case, it appears to the observer that the source is nearer than it actually is by amount Δ.

Once we have determined the apparent position (S') of the source as seen by the co-moving observer, we can determine the time delay t_d. Therefore, a light pulse emitted by the source is detected at the observer after a time delay of:

$$t_d = \frac{D'}{c} = \frac{D\frac{c}{c+V_{abs}}}{c} = \frac{D}{c + V_{abs}}$$

Now imagine a light source S and an observer O as shown below, with the relative position of S and O orthogonal to the direction of their common absolute velocity.



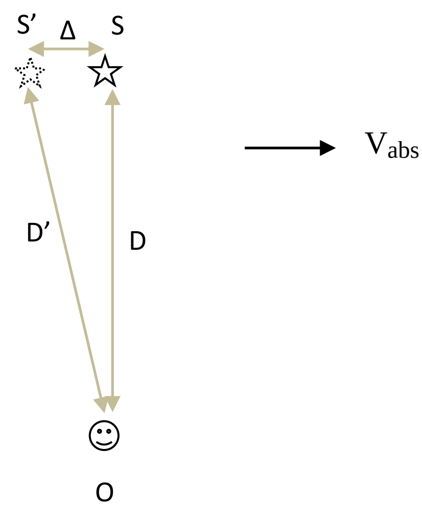
S and O are moving to the right with common absolute velocity V_{abs}.

If V_{abs} is zero, a light pulse emitted from S will be received by O after a time delay t_d

$$t_d = \frac{D}{c}$$

In this case, light arrives at the observer from the direction of the source, S.

If V_{abs} is not zero, then the source position appears to have shifted to the left as seen by the observer O.



In this case also, the effect of absolute velocity is to create an apparent change in the *position*(distance and direction) of the light source relative to the observer.

In the same way as explained previously,

$$\frac{D'}{c} = \frac{\Delta}{V_{abs}}$$

i.e. during the time interval that the light pulse goes from S' to O, the source goes from S' to S.

But,

$$D^2 + \Delta^2 = D'^2$$

From the above two equations

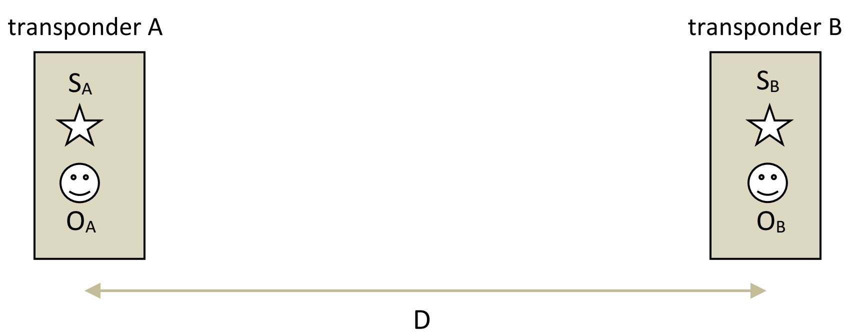
$$D' = D\frac{c}{\sqrt{c^2 - {V_{abs}}^2}} \text{ and } \quad \Delta = D\frac{V_{abs}}{\sqrt{c^2 - {V_{abs}}^2}}$$

Therefore, the time delay t_d between emission and reception of the light pulse in this case will be

$$t_d = \frac{D'}{c} = \frac{D}{\sqrt{c^2 - {V_{abs}}^2}}$$

Proposed experiment

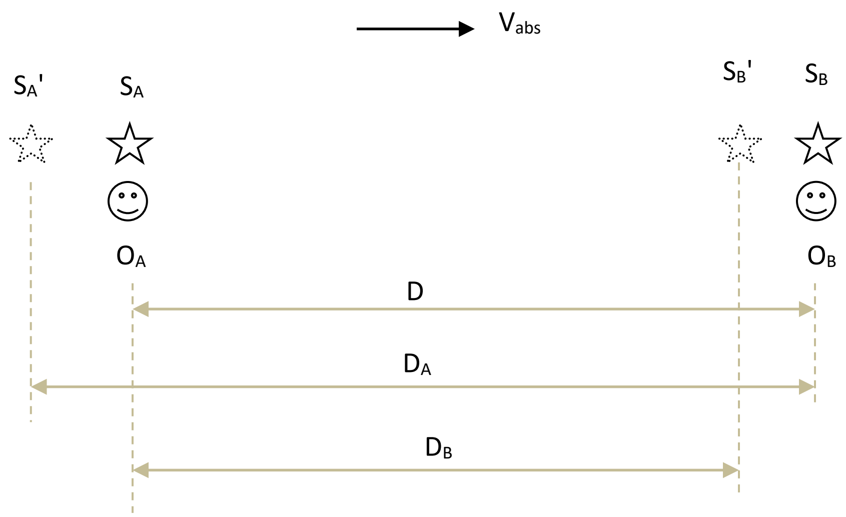
Consider two co-moving light transceivers (transponders) A and B, each fixed to the two ends of a rigid rod, with the distance between them being D. The detector of each transceiver detects light, upon which it will trigger the emitter (source) of the transceiver to emit a light pulse.



Initially S_A emits a short light pulse, which will be detected by O_B, which will trigger S_B to immediately emit a short light pulse, which will be detected by O_A, which will trigger S_A to immediately emit a short light pulse, which will be detected by O_B, and so on. An electronic counter counts the number of pulses in a given period of time.

If transceivers A and B are at absolute rest, the round trip time of light will be 2D/c , hence the frequency of the pulses will be f = 1/ (2D/c) = c / 2D.

If A and B are in absolute motion, say to the right, the apparent positions of each light source as seen by the other detector will be as shown below.



S_A' is the apparent position of S_A as seen by O_B , and S_B' is the apparent position of S_B as seen by O_A , where O_A and O_B are the detectors at A and B, respectively.

In this case, the round trip time of a light pulse emitted by A, re-emitted by B, and detected by A will be:

$$T_d = \frac{D_A}{c} + \frac{D_B}{c}$$

where

$$D_A = D\,\frac{c}{c - V_{abs}} \text{ and } D_B = D\,\frac{c}{c + V_{abs}}$$

Therefore,

$$T_d = \frac{D_A}{c} + \frac{D_B}{c} = D\,\frac{c}{c - V_{abs}} + D\,\frac{c}{c + V_{abs}} = \frac{2Dc}{c^2 - {V_{abs}}^2}$$

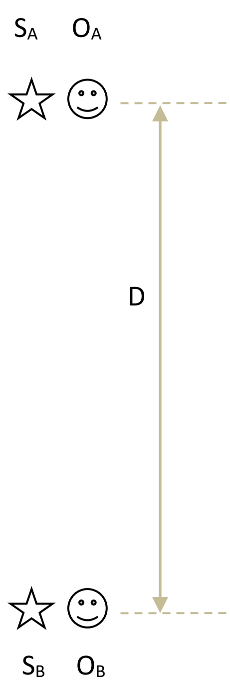
The frequency of the pulses will be:

$$\boxed{f = \frac{1}{T_d} = \frac{c^2 - {V_{abs}}^2}{2Dc}}$$

This is the frequency of the pulses when the rod is oriented towards the direction of absolute velocity, which is towards Leo constellation.

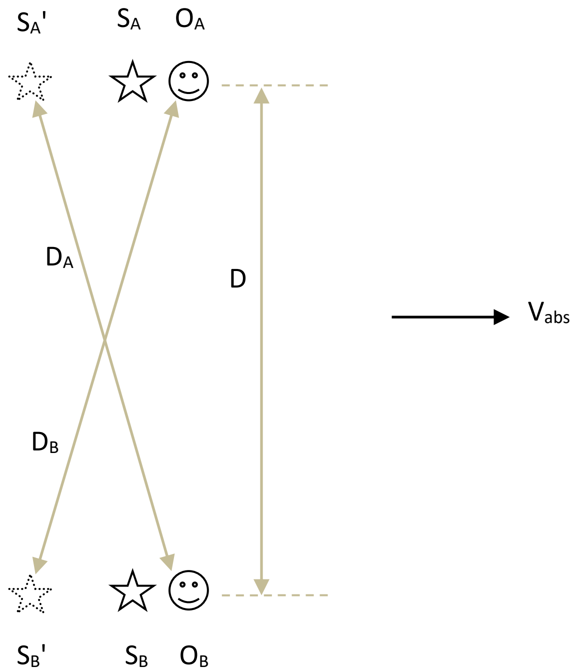
Note that the distance between S_A and O_A(and between S_B and O_B) is assumed to be very small, and much less than D, so that both can be assumed to be at the same point in space.

Now let the rod be oriented perpendicular to Earth's absolute velocity.



As before, if A and B are at absolute rest, the round trip time of light will be 2D/c , hence the frequency of the pulses will be f = 1/ (2D/c) = c / 2D.

If A and B are in absolute motion, say to the right, the apparent positions of each light source as seen by the other detector will be as shown below.



The round trip time of a light pulse emitted by S_A , detected by O_B, which in turn will be emitted by S_B and detected by O_A will be:

$$T_d = \frac{D_A}{c} + \frac{D_B}{c}$$

where

$$D_A = D_B = D \frac{c}{\sqrt{c^2 - {V_{abs}}^2}}$$

Therefore,

$$T_d = \frac{D_A}{c} + \frac{D_B}{c} = \frac{2D}{\sqrt{c^2 - {V_{abs}}^2}}$$

The frequency of the pulses in this case will be:

$$\boxed{f = \frac{1}{T_d} = \frac{1}{\left(\frac{2D}{\sqrt{c^2 - {V_{abs}}^2}}\right)} = \frac{\sqrt{c^2 - {V_{abs}}^2}}{2D}}$$

This is the frequency of the pulses when the rod is oriented perpendicular to the direction of absolute velocity.

Thus, the reading of an electronic counter which counts the pulses for a fixed interval of time will change as the orientation of the rod relative to the absolute velocity vector is changed.

For example, let V_{abs} = 390 km/s and D = 3m.

The frequency of the pulses when the rod is parallel with the absolute velocity vector will be:

$$f_{parallel} = \frac{c^2 - {V_{abs}}^2}{2Dc} = \frac{300000^2 - 390^2}{2 * 0.003 * 300000} = 49999915.5000000Hz$$

The frequency of the pulses when the rod is perpendicular to the absolute velocity vector will be:

$$f_{perpendicular} = \frac{\sqrt{c^2 - {V_{abs}}^2}}{2D} = \frac{\sqrt{300000^2 - 390^2}}{2 * 0.003} = 49999957.7499821Hz$$

The difference in frequency will be:

$$f_{perpendicular} - f_{parallel} = 49999957.7499821 - 49999915.5000000 = 42.24998\ Hz$$

Therefore, in one second the difference in the counter readings will be about 42.24998. In 30 minutes, for example, the difference will be 42.24998*30*60 = 76049.964counts.

The actual experimental setup may consist of two identical such systems (each system consisting of two light transceivers connected to each end of a rigid rod) , one oriented parallel to the Earth's absolute velocity and the other perpendicular to it. The two systems are started simultaneously and then, say after 30 minutes, stopped simultaneously, and the readings of the two counters compared.

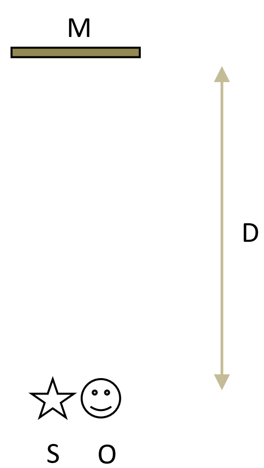
One reason to use two identical systems oriented perpendicular to each other simultaneously, instead of using one system at different times, involves the high frequency of the light pulses. The frequency of the pulses in the above example is around:

$$f = \frac{1}{T} = \frac{1}{\frac{2D}{c}} = \frac{c}{2D} = \frac{300000\ \frac{Km}{s}}{2 * 0.003\ Km} = 50\ MHz$$

For such a high pulse frequency, even a small error in the nominally equal time intervals at two different times will easily mask the effect of absolute motion. Moreover, using two identical systems simultaneously largely eliminates the effect of the environment, such as temperature.

Note that we have assumed, for simplicity, instantaneous emission of a light pulse by the transceivers upon triggering by a detected pulse. In an actual experiment, the finite delay between detection and re-emission of a light pulse should be taken into account.

To determine this time delay between light detection and re-emission experimentally, the following setup is used. According to Apparent Source Theory [1] , absolute motion does not affect experiments in which the light source and the detector are so close together that they can be considered to be at the same point in space. Also, absolute motion of an observer/detector results in an apparent change in source position, and not mirror position, i.e. the actual/physical position of the mirror is taken in the analysis of the experiment [1].



Initially, a short light pulse is emitted by the source S, which will travel to mirror M, and reflected back to the detector O. Upon detecting the light pulse, detector O immediately triggers source S to emit a short light pulse again, which will travel to the mirror, reflected back and detected by O, which triggers source S and so on. A counter counts the number of pulses emitted. If we don't consider the finite time delay between detection and re-emission, the round trip time will be:

$$T = \frac{2D}{c}$$

To determine the finite delay between detection and re-emission, we let the counter (the system) run for a fixed length of time, say one second, and then stop it. Let the value of the counter be N at the end of one second. The period in this case will be:

$$\tau = \frac{1\ second}{N} = \frac{1}{N}\ seconds$$

The time delay Δ between detection and re-emission will be the difference between τ and T .

$$\Delta = \tau - T$$

The longer the time the system runs, for example one minute instead of one second, the more accurately the value of Δ can be determined.

Determination of direction and magnitude of absolute velocity

Our discussion so far assumed that we know the direction and magnitude of absolute velocity, which is towards Leo constellation and 390 Km/s , respectively. However, to independently determine Earth's absolute velocity, we follow the following procedure. First the direction of the absolute velocity is determined. To find the direction of absolute velocity, we need to find the plane in which rotation of the rod does not cause any change in the counter value for a fixed period of time. This means that, for any orientation of the rod in this plane, there will always be the same number of counts in a given fixed period of time. The absolute velocity is perpendicular to this plane. Once we find the direction of absolute velocity we can determine the magnitude of absolute velocity by orienting the rod parallel and perpendicular to the absolute velocity and finding the difference in the counter values for a fixed period of time in the two cases, as discussed before.

We can use one of the following equations to determine V_{abs} .

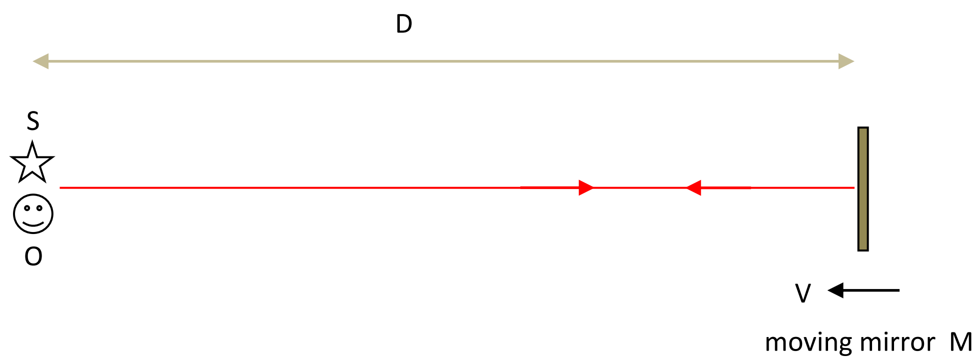
$$f_{parallel} = \frac{c^2 - V_{abs}{}^2}{2Dc} \qquad \dots\dots\dots\dots \quad (1)$$

$$f_{perpendicular} = \frac{\sqrt{c^2 - V_{abs}{}^2}}{2D} \qquad \dots\dots\dots\dots\dots \quad (2)$$

Testing the dependence of group velocity of light on mirror velocity

So far we were concerned with testing the anisotropy of the speed of light caused by absolute motion of the observer, by continuous exchange of a short light pulse between two transponders. However, Apparent Source Theory predicts that the (group) velocity of light is independent of source velocity, but varies with observer absolute velocity and mirror velocity. In this section we propose an experiment to test the dependence of group velocity of light on mirror velocity.

The experiment is based on the same basic technique described above: accumulation of small additional time delays (or advances) caused by mirror velocity by emitting a short light pulse, detecting light reflected from a *moving* mirror, re-emission up on triggering by detected light pulse, detecting light reflected from a moving mirror, and so on.



Initially, a short light pulse is emitted by the light source S. Light reflected from the moving mirror is detected by detector O. Detector O, upon detecting the light pulse, immediately triggers source S, upon which S emits another light pulse and the cycle continues. An electronic counter counts the number of pulses detected (or emitted).

Let the average distance between the source (and the observer) and the mirror be D. For simplicity, we assume that light will always be reflected from distance D while the mirror is moving towards the observer with velocity V. (In an actual experiment the position of the mirror will continuously change from pulse to pulse).

The round trip time for a stationary mirror is:

$$T = \frac{2D}{c}$$

The round trip time in the case of moving mirror will be:

$$T' = \frac{D}{c} + \frac{D}{c + 2V} = \frac{2D}{c} \frac{c + V}{c + 2V}$$

Note that according to ballistic (emission) theory light reflected from a mirror moving with velocity V directly towards or away from an observer will have a velocity of c ± 2V relative to the observer.

The frequencies in the two cases will be:

$$f = \frac{1}{T} = \frac{1}{(\frac{2D}{c})} = \frac{c}{2D}$$

and

$$f' = \frac{1}{T'} = \frac{c}{2D} \frac{c + 2V}{c + V}$$

The difference between the frequencies in the two cases will be:

$$\Delta f = f' - f = \frac{c}{2D} \frac{V}{c + V}$$

For D = 10m , V = 10 m/s :

$$\Delta f = 0.5\ Hz$$

The difference in the number of pulses counted in a time period *t* will be will be :

$$N = 0.5 * t$$

For example, in one hour:

$$N = 0.5 * 3600 = 1800\ pulses$$

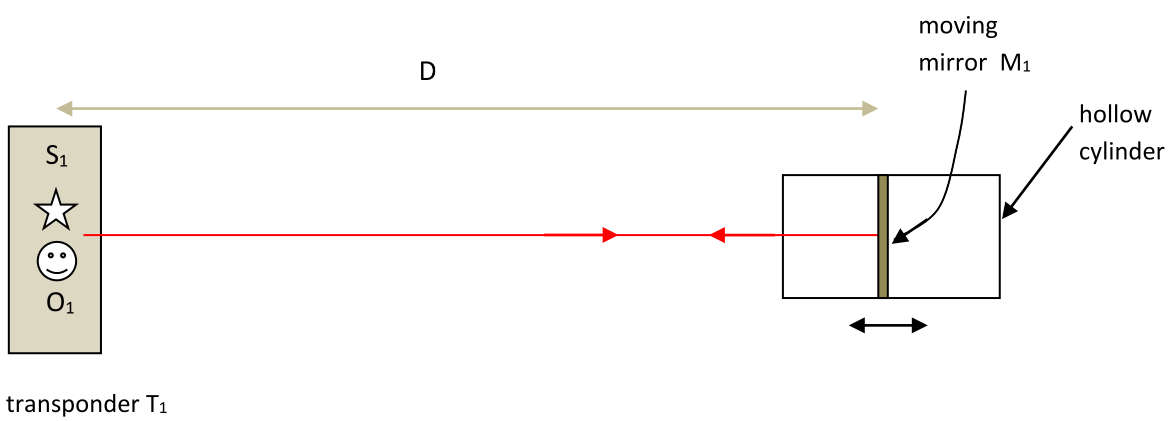
In 24 hours this will be:

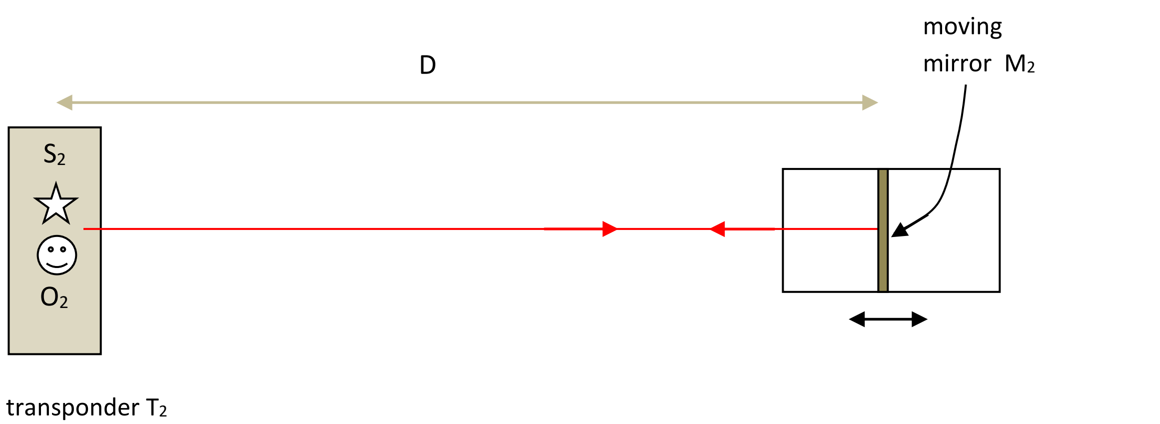
$$N = 0.5 * 3600 * 24 = 43200\ pulses$$

The light pulse width should be of the order of one nanosecond.

In the above analysis, we have assumed that the mirror is moving towards the observer with velocity V, with the distance of the mirror always being D , which is not possible. We made this assumption for the sake of simplicity. Actually, the mirror distance D will continuously vary and therefore the point of reflection (distance D) will be different for every light pulse. We propose an actual experiment as follows.

As shown below, an actual proposed experiment consists of two identical setups, each with a mirror M moving back and forth (reciprocating) inside a cylinder, similar to the cylinder and piston of a car engine. The mechanical driving mechanism is not shown in the figure.





The motions of the mirrors in the two setups are 180^0 out of phase. When one mirror is moving to the left the other is moving to the right, and vice versa.

Now, to test the ballistic hypothesis for the case of mirror moving to the left (i.e. towards the observer/detector O), the experiment will proceed as follows. Assume that at time $t = 0$, the mirror M_1 is at its right end position, just starting to move leftwards.

Initially, at $t = 0$, a short light pulse is emitted by light source S_1 when the mirror M_1 is moving to the left. Light reflected from M_1 is detected by detector O_1, which immediately triggers S_1 , which re-emits another light pulse. The light pulse will be reflected from M_1 again, detected by O_1 , which triggers S_1 again, which emits another light pulse, and so on. This process continues all the time the mirror M_1 is moving to the left. Note that during this time mirror M_2 is moving to the right (away from the observer).

When the mirror M_1 just starts to reverse direction to the right (i.e. when it is at the left end position), a sensor (a limit switch) sends a signal to transponder T_1 (not shown in the figure), upon which T_1 immediately stops emitting the light pulses and passes this signal to transponder T_2 . T_2 takes over, continuously emitting a short light pulse towards mirror M_2 and detecting the reflected pulse, re-emitting, and so on, in the same way as T_1 above. Note that mirror M_2 is just starting to move towards the left (it is at its right end position) when T_2 takes over. In the same way as for T_1 , when M_2 is at the left end position, a limit switch signal will be sent to T_2 , which immediately stops emitting the light pulses and passes the signal to T_1, which will takeover.

The above processes can continue for as long as desired. There is an electronic counter for each transponder, counting the number of pulses emitted. The total counter value for a given period of time will be the sum of the two counter values.

The above experiment is for the case of mirrors moving to the left, i.e. towards the observer. The experiment is repeated for mirrors moving to the right. The dependence of the group velocity of light on mirror velocity will be manifested by a difference in the number of pulses counted in the two cases of mirror moving to the left and mirror moving to the right, in a given period of time.

To get the order of value of this difference, assume that the average distance of the mirror is D. We also assume that the speed of the mirrors is constant V in both cases.

The round trip time in the case of mirror moving to the left (towards the observer) will be:

$$T_L = \frac{D}{c} + \frac{D}{c+2V} = \frac{2D}{c}\,\frac{c+V}{c+2V}$$

The round trip time in the case of mirror moving to the right (away from the observer) will be:

$$T_R = \frac{D}{c} + \frac{D}{c-2V} = \frac{2D}{c}\,\frac{c-V}{c-2V}$$

The frequencies in the two cases will be:

$$f_L = \frac{1}{T_L} = \frac{c}{2D}\frac{c+2V}{c+V}$$

and

$$f_R = \frac{1}{T_R} = \frac{c}{2D}\frac{c-2V}{c-V}$$

The difference between the frequencies in the two cases will be:

$$\Delta f = f_L - f_R = \frac{c}{2D}\left(\frac{c+2V}{c+V} - \frac{c-2V}{c-V}\right)$$

Assume that the average distance and average velocity are D = 10m , V = 10 m/s , respectively.

$$\Longrightarrow \Delta f = 1\ Hz$$

The difference in the number of pulses counted in a time period *t* will be will be :

$$N = 1 * t = t$$

For example, in one hour:

$$N = 1 * 3600 = 3600\ pulses$$

In 24 hours this will be:

$$N = 1 * 3600 * 24 = 86400\ pulses$$

Thus, if a difference occurs in the number of pulses counted in the two cases (mirrors moving to the left and mirrors moving to the right) in a given period of time, this confirms the dependence of group velocity of light on mirror velocity and proves Apparent Source Theory.

In a real experiment, the point of reflection (distance) continuously varies from pulse to pulse and also the mirror velocity will continuously vary from pulse to pulse, so the analysis is more involved and a computer numerical method should be used.

As noted before, two identical such systems should be run in parallel (a total of four transponders and four mirrors) than using a single system at different times.

Discussion

The new 'transponder' technique introduced in this paper can also be applied to the Fizeau experiment, using time of flight method instead of interference method. It can also be applied to test aberration of light for absolutely co-moving terrestrial light source and observer, as predicted by Apparent Source Theory[1].

Conclusion

The new experiment proposed in this paper is basically based on integrating (accumulating) the extremely small differences between the time of flight of light in two directions, which would be difficult to measure by using conventional time of flight methods in which the time elapsed between spatially separated emitter and detector is measured. The new method uses two spatially separated light ‘transceivers’ (or ‘transponders’) , instead of spatially separated emitter and detector , with the emission, detection and re-emission cycle continuing for as long as desired. A short light pulse is continuously exchanged between two light transponders. This technique enables determination of the magnitude and direction of Earth’s absolute velocity with high accuracy. An experiment to test the dependence of the group velocity of light on mirror velocity using the same 'transponder' technique has also been proposed. The new 'transponder' technique proposed in this paper can reveal the mysteries of the speed of light, which would not be possible by conventional methods which involve a single light pulse, with spatially separated emitter and detector, and clock synchronization.

Thanks to God and the Mother of God, Our Lady Saint Virgin Mary

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