The Overlooked Phenomena in the Michelson-Morley Experiment

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Abstract.

We show that Michelson and Morley used an over simplified description and failed to notice that their calculation is not compatible with their own hypothesis that light is traveling at a constant velocity in all frames. During the last century, the Michelson-Morley equations have been used without realizing that two essential fundamental phenomena are missing in the Michelson-Morley demonstration. We show that the velocity of the mirror must be taken into account to calculate the angle of reflection of light. Using the Huygens principle, we see that the angle of reflection of light on a moving mirror is a function of the velocity of the mirror. This has been ignored in the Michelson-Morley calculation. Also, due to the transverse direction of the moving frame, light does not enter in the instrument at 90 degrees as assumed in the Michelson-Morley experiment. We acknowledge that, the basic idea suggested by Michelson-Morley to test the variance of space-time, using a comparison between the times taken by light to travel in the parallel direction with respect to a transverse direction is very attractive. However, we show here that the usual predictions are not valid, because of those two classical secondary phenomena, which have not been taken into account. When these overlooked phenomena are taken into account, we see that a null result, in the Michelson-Morley experiment, is the natural consequence, resulting from the assumption of an absolute frame of reference and Galilean transformations. On the contrary, a shift of the interference fringes would be required in order to support Einstein's relativity. Therefore, for the last century, the relativity theory has been based on a misleading calculation.

1 - Assessment of the Problem.

The aim of the Michelson-Morley experiment (1-10) is to verify "experimentally" whether the time taken by light to travel a distance in a direction parallel to the velocity of a moving frame, is the same as the time to travel the same distance in a perpendicular direction. The experiment is based on the assumption that the velocity of light is constant in an absolute frame considered at rest.

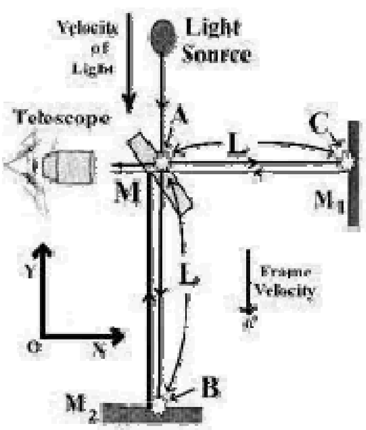

Figure 1

The Michelson-Morley apparatus (1) is illustrated on figure 1. After light is emitted by the light source, a central semi-transparent mirror M, splits the beam of light between two perpendicular directions. The distance L traveled between point A (on mirror M) and point B on mirror M_2 is equal to the distance L between the point A on mirror M and point C on mirror M_1.

In our experiment, let us consider that light moves downward at velocity c, while the moving frame also moves down but at velocity v, as illustrated on figure 1. In order to verify the hypothesis that the velocity of light is c with respect to an absolute frame of reference, (in opposition to a constant velocity equal to c in all moving frames), Michelson and Morley have calculated the time interval taken by light to travel in the longitudinal direction (between A and B) compared with the time for light to travel in transverse direction between A and C. Therefore they suggested building an interferometer to test their hypothesis as illustrated on figure 1. According to the Michelson-Morley predictions, who affirm that the optical distance traveled by light between each arms of the interferometer must be different when in motion, consequently, there must be a drift of interference fringes on mirror M where the beams join together, when the apparatus is rotating. No such drift, having the amplitude predicted by Michelson-Morley has ever been observed. Let us examine their calculation.

In the Michelson-Morley experiment, it is assumed that light travels at a constant velocity with respect to an absolute frame assumed at rest. In that experiment, Michelson and Morley calculate the time t(A➔B➔A) taken by light to complete the trip from A to B, and return from B to A, while the frame is moving at velocity v. We see that when the frame is moving away from the point of origin of light, light passes across the moving frame (from A➔B) at velocity (c-v), while covering the moving distance L. When light returns from B➔A, then light passes through the moving frame at velocity (c+v), while the equal distance L is again completed. These two time intervals are added in the following equation:

$$t(A \rightarrow B \rightarrow A) = t(A \rightarrow B) + t(B \rightarrow A) = \frac{L}{c-v} + \frac{L}{c+v} = \frac{2Lc}{c^2 - v^2} = \frac{2L}{c}\left(1 - \frac{v^2}{c^2}\right)^{-1} \quad (1)$$

Since the last term in brackets of equation (1) is larger than unity, light takes a longer time to complete that return trip, than when the frame velocity is zero. Therefore, light must travel an extra distance between locations $A \rightarrow B \rightarrow A$, when the system is in motion. Using a series expansion, equation (1) can be written:

$$t(A \rightarrow B \rightarrow A) = t_v = \frac{2L}{c}\left(1-\frac{v^2}{c^2}\right)^{-1} = t_o\left(1+\frac{v^2}{c^2}+..\right) \quad (2)$$

In equation (2), t_o is the time taken by light to travel the distance 2L, when the frame velocity is zero. Also t_v, is the time when the frame velocity is v. We have t_o, is equal to:

$$t_o = \frac{2L}{c} \quad (3)$$

When the light paths between locations $A \rightarrow C \rightarrow A$), move transverse to the light velocity c, in the absolute frame, the light path is seen as an isoscele triangle in the rest frame. Using geometry, we find that the time taken by light is then:

$$t(A \rightarrow C \rightarrow A) = \frac{2L}{(c^2 - v^2)^{1/2}} = \frac{2L}{c}\left(1-\frac{v^2}{c^2}\right)^{-1/2} \quad (4)$$

Equation (4) gives the time interval $t(A \rightarrow C \rightarrow A)$ for light to travel through the moving locations ($A \rightarrow C \rightarrow A$). Using a series expansion of equation (4), the time taken by light in the transverse direction can be written:

$$t(A \rightarrow C \rightarrow A) = t_v = \frac{2L}{c}\left(1-\frac{v^2}{c^2}\right)^{-1/2} = t_o\left(1+\frac{1}{2}\frac{v^2}{c^2}+..\right) \quad (5)$$

According to Michelson and Morley, we have seen in equation (2) that, when light moves parallel to the frame velocity (between $A \rightarrow B \rightarrow A$), light must travel during an additional time equal to: $t_o(v^2/c^2)$, with respect to the system at rest. However, in equation (5), when the direction of the frame is transverse to the velocity of light (between $A \rightarrow C \rightarrow A$), then the additional time, due to the proper velocity of the frame is different. It is now only half of the other value. The difference of time is $(t_o/2)(v^2/c^2)$. It is that difference of time interval between axes, which led Michelson and Morley to predict that there should be a shift of interference fringes between the arms of the interferometer. From equations (2) and (5), we see that, between the parallel direction ($A \rightarrow B$) and the transverse direction ($A \rightarrow C$), there is a difference of time equal to:

$$\Delta t(\text{between arms}) = \{t(A \rightarrow B \rightarrow A) - t(A \rightarrow C \rightarrow A)\} = t_o\frac{1}{2}\frac{v^2}{c^2} \quad (6)$$

There is a difference of distance ΔL, corresponding to the difference of time given in equation (6). That difference is equal to the velocity of light c, times the difference of time Δt (see equation (6)). Therefore, the difference of distance traveled by light between the parallel and transverse arm of the interferometer, as given by equation (3) and (6) gives:

$$\Delta L(\text{between arms}) = c\,\Delta t(\text{between arms}) = L\frac{v^2}{c^2} \quad (7)$$

When rotating the interferometer through ϕ = 90 degrees, the two beams ***exchange*** lengths, giving a total path difference ΔL(rotation 90^o) between the two rotating perpendicular axes. Using equation (7), the difference of path length ΔL(rotation 90^o) due to that rotation is:

$$\Delta L(\text{rotation } 90^o) = 2\Delta L(\text{between arms}) = 2L\frac{v^2}{c^2} \quad (8)$$

According to Michelson-Morley, equation (8) gives the difference of distance traveled by light between the parallel and the transverse direction, when the apparatus is rotated by 90^o. Following these calculations, the Michelson-Morley experiment was made and repeated by many researchers under various conditions and at different locations. Most importantly, it was observed experimentally that the observed shift of interference fringes was, if any, quite negligible, and therefore much smaller than predicted by Michelson and Morley. Consequently, scientists decided to consider some esoteric hypothesis to explain these experimental observations. We show here that this Michelson-Morley's demonstration is seriously over simplified. In fact we show below that the unexpected result is due to an erroneous prediction.

2 - Reflection of Light on a Moving Mirror.

We show here that there are at least two crucial physical phenomena, which have been ignored in the Michelson-Morley calculation. The importance of these phenomena changes radically the Michelson-Morley prediction. One of these phenomenon takes place on the reflected light on the semi transparent mirror M of the interferometer.

In the Michelson-Morley experiment, it is considered that light is reflected at 90° because the mirror is at 45°. However, we show here that it cannot be so, because of the proper velocity of the mirror. Whenever a mirror possesses a velocity with respect to the stationary frame in which light travels at velocity c, we see here that the usual laws of reflection on moving mirrors are not compatible with a constant velocity of light in that frame.

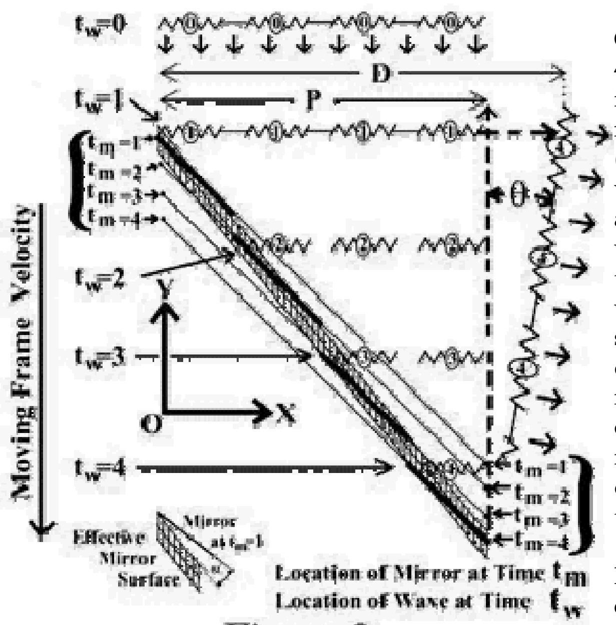

Figure 2

On figure 2, let us consider first the motion of mirror M at 45°, moving in the same downward direction as the incoming light. The position of the mirror at time (t_m =1) is represented by the narrow line between the pair of labels (t_m=1). At time t_w=0, (labeled with four 0's in the wavefront) we see the incoming wave. We consider light arriving progressively on mirror M. At time t_w=1, (labeled with 1's), we see that the incoming wavefront, just reaches the left hand side of mirror M. Since it takes time, for that wavefront, to move downward and reach the right hand side of the mirror, the mirror M moves a short distance downward, while the wavefront of light is moving down much faster. The continuous progression of the wavefront on the mirror (while the mirror is moving down) is illustrated in four steps. During each step, the (moving down) mirror is shown between each pair of labels t_m=1, t_m=2, t_m=3, and t_m=4.

Let us now consider the motion of the wavefront. The labels on each wavefront (t_w=0, 1, 2, 3 or 4) are repeated at each individual quarter of wavefront. After the initial time t_w=0, that same wavefront is shown at different later times at: t_w=1, t_w=2, t_w=3 and t_w=4, (inscribed on each segment) during light propagation. All wavefronts (labeled t_w=1, t_w=2, t_w=3 and t_w=4) drawn on figure 2 correspond to the same wavefront at different times.

Let us consider the progression of the wavefront. At time t_w=1, (on figure 2) the left hand side of the wavefront of light just reaches the left hand side (bold segment) of mirror M, (segmented in four parts). At that time, the first segment (bold line) of the mirror is at mirror location t_m=1. Then, the wavefront keeps moving down. At time t_w=2, the second quarter of the same wavefront reaches the second quarter of the mirror, (see bold segment at mirror location t_m=2), which has then moved downward due to the velocity of the mirror. Similarly, at time t_w=3, the third segment of the wavefront reaches the third section of the mirror, (see bold segment at mirror location t_m=3), which moved still further down during that time. Finally, at time t_w=4, the reflection of the wavefront on the mirror is completed after the fourth quarter of the wavefront is reflected on the fourth section of the mirror (bold segment at mirror location t_m=4), which has moved still further down due to the mirror velocity. Consequently, even if the mirror makes exactly an angle of 45 degrees with respect to the incoming wave, that wave is reflected by a mirror making effectively a larger angle, because the mirror has the time to move down, during the time of reflection on the whole surface of the mirror. The "effective moving mirror" is illustrated on figure 2, as the sum of the four bold segments of the moving mirror, formed by the wide set of narrow lines (crossed by three parallel lines), covering the average location of the four bold sections of the mirror. That effective mirror makes an affective angle □ (with respect to 45 degrees) as illustrated on figure 2. The angle □ between the instantaneous and the effective moving angle of the mirror is shown separately on figure 2 (bottom left). It can be shown that this angle □, represents half of the increase of the angle □ of reflection of light due to the mirror velocity. However, here, the angle of reflection of light will be calculated using a more direct method.

Let us calculate the change of angle of the reflected wavefront, after reflection, due to the velocity of the moving mirror. The projected width of the wavefront on mirror M is equal to P (see fig. 2). The "instantaneous" position of the mirror with respect to the wavefront is exactly 45°. Since light is moving downward at a velocity (c-v) with respect to the moving frame, let us calculate the time interval T_1 needed to reach the opposite edge of the mirror. Since the mirror is at 45°, the vertical distance (of projection) P is the same. The time T_1 taken by light to travel the vertical distance P is:

$$T_1 = \frac{P}{c-v} \qquad (9)$$

We can see that the change of distance P in the vertical direction, due to the motion of the mirror leads to a correction implying a higher power of v/c, which is negligible. During the same time T_1, while light travels downward toward the right hand side of the mirror, the previously reflected light on the left hand side of the same mirror travels horizontally toward the right hand side. The horizontal velocity of light is equal to c. Let us calculate that horizontal distance D, traveled by light at velocity c, during the same time interval T_1. Using equation (9), we find:

$$D = cT_1 = c\frac{P}{c-v} \approx P\left(1+\frac{v}{c}\right) \qquad (10)$$

The distance D is illustrated on figure 2. In equation (10), we take into account that the relative velocity of the mirror (which is the velocity of the Earth around the sun) is very small (i.e. 1/10000) compared with the velocity of light. Higher powers of v/c are neglected when appropriate (as seen in equation (10).

Let us use the Huygens method of light propagation. From figure 2, we see that, after reflection on the upper left corner of the mirror, the Huygens wave method show that light has traveled a larger horizontal distance D, than the X-coordinates "P" on the right hand side of the mirror. Therefore this produces the angle θ on the reflected wavefront. From equation (10), we find that the additional distance (D-P) is:

$$D - P = P\frac{v}{c} \qquad (11)$$

From figure 2 and equations (10) and (11), the tangent of angle θ is:

$$\tan\theta \approx \theta = \frac{D-P}{D} = \frac{P\frac{v}{c}}{P\left(1+\frac{v}{c}\right)} \approx \frac{v}{c} \qquad (12)$$

Therefore, light is reflected at (90°+θ), when the static angle of the mirror at 45 degrees is moving at velocity v. Figure 2 also illustrates the wavefront (of the wave drawing) (label t_w=4) after total reflection by the moving mirror with the additional angle θ due to the mirror having an effective angle θ.

It is important to realize that the angle θ also appears when the moving frame travels in different directions. Instead of having the mirror moving downward in figure 2, using the same method, we can show that the increase of angle θ of the wavefront is the same when the mirror moves toward the left hand side. Using the same method as above, we can also show that when the mirror is moving in a direction opposite to the velocity of light (upward) or toward the right hand side, the effective angle of deflection of light then decreases by the angle θ degrees.

The demonstration which shows that the change of angle of deflection of light reflected on a mirror moving in the transverse direction is given in the appendix of this paper.

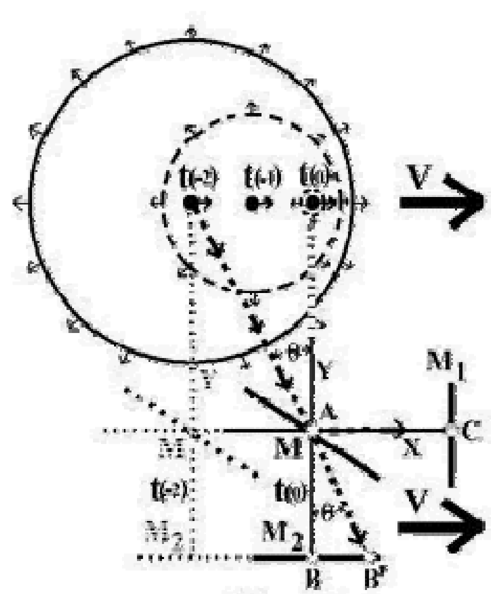

Figure 3

3– Shifted Direction of Light in a Transverse Direction.

There is a second phenomenon which also has been ignored in the Michelson-Morley experiment.

Let us consider figure 3. Just as hypothesized by Michelson and Morley, figure 3 illustrates light moving at velocity c with respect to a stationary frame. After emission, that light forms circular wavefronts around the instantaneous location of the emitter. Then, the circular wavefronts get bigger with time. However in the problem here, the "light source" is not stationary, but moves sideways on Earth at the same time as the interferometer. On figure 3, we illustrate that both, the light source and the interferometer move at velocity v toward the right-hand side.

Let us consider a wavefront of light emitted at time t(-2). Of course, at the instant light is emitted, the mirror M of the Michelson-Morley interferometer, is located just below the light source, where the interferometer is shown (ghost image). Two units of time later, at t(0), that spherical wavefront of light [emitted at t(-2)] reaches mirror M of the Michelson-Morley interferometer (new location of the interferometer drawn with dark lines). Simultaneously, the light emitting source also moves toward the right hand side. Therefore, both the source and the interferometer still have similar relative positions (same vertical axis) as seen experimentally. This description corresponds to the Michelson-Morley experimental apparatus.

We see that light reaching location A on mirror M, originates from a location where the source of light was located two units of time previously. We see clearly that light makes an angle θ with respect to the Y-axis, in order to reach the mirror M at location A of the interferometer and beyond, (toward B'). Therefore due to the velocity of the frame, even if the source of light is instantaneously always located exactly above the mirror M of the interferometer, it must be understood that light traveling toward mirror M_2, either can be considered to move at velocity c at the angle θ in the rest coordinates, or at velocity [c Cosθ] along the Y axis of the moving coordinates. Of course, as seen on figure 3, these two calculations are indistinguishable. However, the function Cosθ has been ignored in the moving frame by Michelson and Morley. This will be taken into account below in figure 5.

Let us recall that the M-M calculation is a completely classical calculation (not relativistic). Recalling that the M-M calculation is totally classical, "with an absolute frame" whatever the observations of the moving observer are, let us consider again how much time light takes to travel from point A on mirror M to mirror M_2 (figure 3), independently of the location on the surface of mirror M_2. We see that even if the observer in the moving frame perceives that light moves along his moving Y axis, the time interval taken by light to travel that distance is (L/Cosθ)/c (because the frame is moving). Since this is a classical calculation, there is no space-time distortion involved in that calculation, as expected for the M-M calculation.

It seems that we are so much involved with relativity theory, that we sometimes overlook "when" exactly we must apply relativity or classical physics. It is not because the moving observer cannot see directly the angle θ that the time interval between mirrors M and M_2 is changing! The transit time is longer because, in the M-M experiment, light traveling from mirrors M to M_2 must necessarily travel at the angle θ.

A similar phenomenon happens when two fast cars, emitting sounds in stationary air, are moving parallel. The observer in both cars will detect sounds, apparently coming from a direction perpendicular to their velocity, but the time interval taken by sound before reaching the opposite car increases as (L/Cosθ) with the velocity of the cars.

The fact that the light path reaching the interferometer makes an angle θ with respect to the observed direction inside the moving frame is related to another well known phenomenon, discovered by Bradley [11] in 1725. This phenomenon explains how an observer in the moving frame can see light coming from a direction which is parallel to the Y-axis, even if in fact, the light source is an angle θ. Consequently, it becomes obvious that light takes more time to travel between mirrors M and M_2 than when the frame is at rest. This is taken into account below.

4 - Application to the Michelson-Morley Apparatus.

Figure 4, represents the Michelson-Morley apparatus moving in a direction parallel to the velocity of light. On figure 4-A, the interferometer moves downward away from the light source.

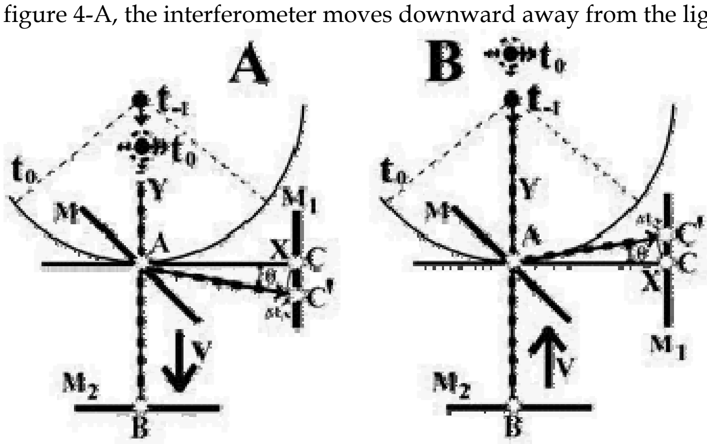

Figure 4

The velocity of light is c in the background frame at rest. Therefore, as in the Michelson-Morley apparatus, both, the source of light and the interferometer move with respect to that background. On figure 4-A, the emitted wavefront expands and form circles around the instantaneous position where the light source is located at the moment of emission. On figure 4, half the light is reflected from location A on mirror M, toward mirror M_1, and the other half is transmitted through mirror M, toward mirror M_2. Light paths are illustrated as bold dashes on a narrow line.

Figure 4 shows the moving interferometer and the wavefront as seen from the rest frame, at time t=0, at the instant light, emitted earlier, reaches the mirror M of the interferometer. That light was previously emitted at time t=-1. On figure 4-A, the frame is moving downward. It is moving upward on figure 4-B.

Figure 4-A illustrates light emitted from the source at time t(-1). Later, at time t(0) we see that the frame has

moved down. Then, at time t(0), the wavefront, which was emitted at t(-1), forms a circle just reaching location A on mirror M of the Michelson-Morley interferometer. As illustrated on figure 4-A, when light moves through mirror M toward location B on mirror M_2, the velocity of the frame is parallel to the velocity of light. Light passes directly from A on mirror M toward point B on mirror M_2. We have seen above in equation (2) that when the moving frame moves parallel to the velocity of light, the time taken by light between mirrors is equal to:

$$t(A \rightarrow B \rightarrow A) = t_0\left(1+\frac{v^2}{c^2}+..\right) \qquad (13)$$

However, in the case of light reflected on mirror M toward mirror M_1, we have seen above on figure 2 that, due to the velocity of the mirror, light is not reflected at 90°. As demonstrated in section 2, (equation 12), that light is reflected at an additional angle θ. Therefore light is not traveling from A➔C➔A. Instead, due to the velocity of the mirror, light is traveling from A to C′ and return to A as shown on figure 4-A. Using figure 4, let us calculate the extra time taken by light due to the extra distance at the angle θ instead of the horizonal path. The relationship between the distance A➔C➔A and A➔C′➔A is:

$$\frac{A \rightarrow C' \rightarrow A}{A \rightarrow C \rightarrow A} = \frac{1}{Cos\theta} \qquad (14)$$

Using a series expansion of Cos θ, we get from equation (14)

$$\frac{A \rightarrow C' \rightarrow A}{A \rightarrow C \rightarrow A} = \frac{1}{Cos\theta} = 1+\frac{1}{2}\frac{v^2}{c^2}+... \qquad (15)$$

Since the times t(A➔C′➔A) and t(A➔C➔A) for light to travel (at velocity c) is proportional to the distance, we have from equation (14)

$$\frac{t(A \rightarrow C' \rightarrow A)}{t(A \rightarrow C \rightarrow A)} = \frac{A \rightarrow C' \rightarrow A}{A \rightarrow C \rightarrow A} = 1+\frac{1}{2}\frac{v^2}{c^2}+... \qquad (16)$$

which is equal to:

$$t(A \rightarrow C' \rightarrow A) = t(A \rightarrow C \rightarrow A)\left(1+\frac{1}{2}\frac{v^2}{c^2}+...\right) \qquad (17)$$

Substituting equation (5) in equation (17) gives:

$$t(A \rightarrow C' \rightarrow A) = t_0\left(1+\frac{1}{2}\frac{v^2}{c^2}+..\right)\left(1+\frac{1}{2}\frac{v^2}{c^2}+...\right) \qquad (18)$$

which is equal to:

$$t(A \rightarrow C' \rightarrow A) = t_0\left(1+\frac{v^2}{c^2}+..\right) \qquad (19)$$

Equation (19) shows that the time for light to travel, in the transverse direction along A➔C′➔A, is the same time as in the parallel direction given in equation (13). Therefore the number of wavelengths of light along the horizontal light path is the same as the number along the transverse light path. The phenomenon of reflection on moving mirrors ignored by Michelson and Morley produce an effect, which is exactly equal to the difference of time, and which was erroneously interpreted as an agreement with relativity in modern physics.

Let us also consider the case when light and the observer's frame are moving in the opposite direction, as illustrated on figure 4-B. Consequently, as explained on figure 2, due to the proper upward velocity of mirror M, the angle θ of the beam of light is in the opposite direction, with respect to the X-axis, compared with when the frame is moving downward. As a consequence of this shift in light direction by the angle θ, we get the same increase of distance in the direction of θ and the same time interval as calculated in equation (19). Therefore, the total time interval t(A➔C′➔A) is exactly the same as given in equation (19). There exists no change of transit time between the arms of the interferometer, contrary to the Michelson-Morley oversimplified calculation.

5 – Moving Frame in the Transverse Direction to Incident Light.

We now use figure 5 to see the trajectory of light entering the interferometer moving in a transverse direction, at velocity V, with respect to the light source.

On figure 5-A, we see the light source at time t(-1), so that the spherical wavefront of light reaches the mirror M of the interferometer at time t(0). We see that, at the moment light reaches mirror M, the source of light has now moved to location t(0). However, the new light just emitted at t=0 did not have the time to reach the interferometer yet. Light reaching the interferometer must always be emitted previously so that light has enough time to travel to the interferometer.

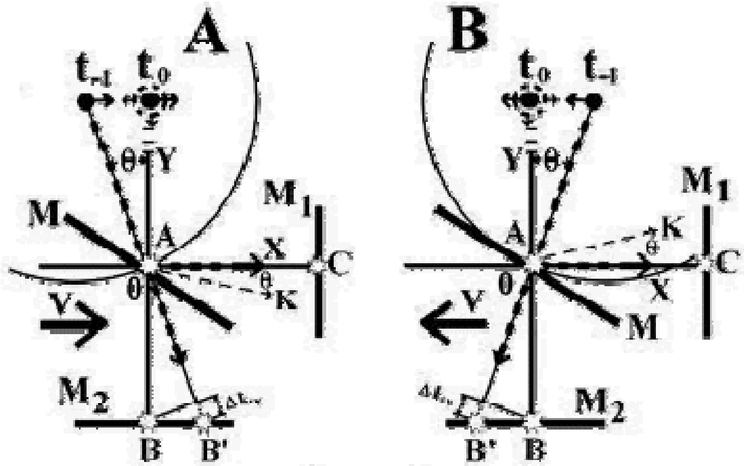

Figure 5

Figure 5 shows the moving interferometer and the wavefront as seen from the rest frame, at time t=0, at the instant light, emitted previously at (t-1), reaches the mirror M of the interferometer. On figure 5-A, the frame is moving toward the right hand side. That frame is moving toward the left hand side direction on figure 5-B. We notice that at the instant t=0, the light source (t_o) and mirror M, (at location A) are located exactly in a direction along the Y-axis, just as explained on figure 4. This is necessary to satisfy the Michelson-Morley description that requires that the light source must be located at 90^o with respect to the frame velocity.

Consequently, in that case, contrary to figure 4, due to the frame velocity, light cannot then move parallel to that Y-axis, due to the transverse motion of the frame. On figure 5, we have now a new angle □, with respect to the Y-axis, due to the velocity of the moving frame. Therefore, since light reaching the interferometer comes from a transverse direction, light necessarily arrives on the interferometer at the angle □, with respect to the Y-axis, as illustrated also on figure 3.

On figure 5-A, after reflection on the moving mirror M, light travels in the direction of M_1. Due to the velocity of the mirror explained on figure 2, and equation (12), light is reflected on mirror M, with an angle of incidence (with respect to the mirror surface) which is no longer 45^o, but it is (45^o-□). Therefore, the angle of reflection is also (45^o-□). This is illustrated on figure 5-A as the direction of the dashed line A→K. However, we have seen in the last paragraph of section 2 that due to the velocity of the mirror, the angle of reflection is reduced by the angle □. Consequently, the moving mirror reflects light in the direction of the X-axis along the path A→C→A, as shown on figure 5-A. Since the direction of light along A→C→A is parallel to the X-axis, and that light moves parallel to the frame velocity, the time taken by light to travel between A→C→A is given by equation (2).

We must notice that due to the rotation of the apparatus, the notation (label) A→B→A in equation 2 becomes A→C→A after the rotation of the frame, as illustrated on figure 5. Therefore, the time t(A→C→A) to move across the distance A→C→A given by equation (2) becomes now:

$$t(A \to C \to A) = t_0\left(1+\frac{v^2}{c^2}+..\right) \qquad (20)$$

Let us now study on figure 5-A, light moving through mirror M, between mirrors M and M_2. We have seen above that due to the transverse velocity of the moving frame with respect to light, light reaching mirror M makes angle □ with respect to the Y-axis.

That angle □ is needed, to be compatible with the Michelson-Morley description which has located the light source exactly on the Y-axis. This is similar to figure 3 when the light source on the Y-axis produces a light beam making an angle □ with respect to the Y-axis. This is different of figure 4, in which case, a light source (at t_o) on the Y-axis produces a light beam parallel to the Y-axis. Therefore, light between mirrors M and M_2 travels between A→B'→A. Before calculating the time for light to travel between A→B'→A, let us calculate first the time to travel between A→B→A. We see on figure 5-A that light traveling between A→B→A is in a transverse direction with respect to the frame velocity. We have seen that in the case of a transverse direction between light and the moving frame, equation (5) gives the time taken by light to travel the distance between A→B→A along the Y-axis. We also must notice that due to the rotation of the apparatus, the labels A→C→A in equation (5) becomes A→B→A in the rotated frame corresponding to figure 5. Therefore, the time t(A→B→A) taken by light to travel along the path A→B→A is:

$$t(A \rightarrow B \rightarrow A) = t_0\left(1+\frac{1}{2}\frac{v^2}{c^2}+..\right) \qquad (21)$$

However, light does not travel exactly along direction A→B→A. Instead due to the frame velocity, light travels between A→B′→A. Therefore we must take into account that because light travels a longer distance at the angle θ, it takes a longer time to complete that new path. Let us calculate the time taken by light, between A→B′→A, due to the angle θ. Using figure 5, we find that the relationship between the distance A→B→A and A→B′→A is:

$$\frac{A \rightarrow B' \rightarrow A}{A \rightarrow B \rightarrow A} = \frac{1}{\mathrm{Cos}\theta} \qquad (22)$$

Using a series expansion of Cos θ, equation (22) gives:

$$\frac{A \rightarrow B' \rightarrow A}{A \rightarrow B \rightarrow A} = \frac{1}{\mathrm{Cos}\theta} = 1+\frac{1}{2}\frac{v^2}{c^2}+... \qquad (23)$$

Since the time t(A→B→A) for light to travel across the distance A→B→A is proportional to distance (at velocity c), equation (23) gives:

$$\frac{A \rightarrow B' \rightarrow A}{A \rightarrow B \rightarrow A} = \frac{t(A \rightarrow B' \rightarrow A)}{t(A \rightarrow B \rightarrow A)} = 1+\frac{1}{2}\frac{v^2}{c^2}+... \qquad (24)$$

Equation (24) gives:

$$t(A \rightarrow B' \rightarrow A) = t(A \rightarrow B \rightarrow A)\left(1+\frac{1}{2}\frac{v^2}{c^2}+...\right) \qquad (25)$$

Considering the rotation, t(A→C→A) in equation (5) becomes now t(A→B→A). Taking into account that change of label due to rotation, equation (5) in equation (25) gives:

$$t(A \rightarrow B' \rightarrow A) = t_0\left(1+\frac{1}{2}\frac{v^2}{c^2}+..\right)\left(1+\frac{1}{2}\frac{v^2}{c^2}+...\right) \qquad (26)$$

Equation (26) gives:

$$t(A \rightarrow B' \rightarrow A) = t_0\left(1+\frac{v^2}{c^2}+..\right) \qquad (27)$$

Equation (27) gives the time for light to travel between A→B′→A.

Using a similar demonstration as above, we can see on figure 5-B, that, when the direction of motion of the moving frame is reversed, the time for light to travel between A→B′→A, is also the same, as given in equation (27). In a few words, we see that the angle of incidence with respect to the mirror is now ($45^o+\theta$) due to the velocity of the moving frame moving toward the left hand side direction. The light would be reflected along the direction A→K on figure 5-B. However, since the frame is moving toward the left hand side direction, we have seen in the last paragraph of section 2 that the angle of reflection is increased by the angle θ. Therefore, the reflected beam of light is reflected along the X-axis. This is similar to the problem calculated on figure 5-A.

In the case of light moving downward on figure 5-B, the angle θ with respect to the Y-axis is similar to the problem in figure 5-A. There is only a change of sign of the angle θ. Consequently, the time taken by light to travel the distance A→B′→A is again similar to the case of figure 5-A.

Consequently in all cases, the time taken by light to travel between mirrors is always the same.

6 - Analysis of the New Results.

We have shown here that, in the Michelson-Morley experiment, using classical physics, the time for light to travel between any pair of mirrors, in any direction, is always the same, independently of the direction of the moving frame and also independently of having light moving either parallel or transverse to the frame velocity. In any direction, that time interval Δt between mirrors is always equal to:

$$\Delta t = t_0\left(1+\frac{v^2}{c^2}+..\right) \qquad (28)$$

More specifically, in equations (20) and (27), when the velocity of the frame is perpendicular to the direction of light penetrating in the instrument, we have shown that the times for light to travel between the horizontal and vertical mirrors are identical. We have shown that this is always true whether the frame is moving toward the right hand direction or the left hand direction. Furthermore we have seen above in equations (13) and (19), that when light penetrates into the instrument in a direction parallel to the frame velocity, the times for light to travel between the parallel or transverse arm of the interferometer are also always identical. We have also shown that this is always true, whether the frame is moving parallel or anti-parallel with respect to the velocity of light. We must conclude that the times taken by light to travel between any pair of mirrors are always the same, independently of any rotation of the interferometer in space.

Therefore, according to classical physics, the rotation of the Michelson-Morley apparatus in space should never show any drift of interference lines. On the contrary, a positive shift of interference fringes with the amplitude compatible with the Michelson-Morley predictions is required in order to be compatible with Einstein's relativity. Such a shift of interference fringes due to a rotation has never been observed. The absence of an observed drift of interference fringes invalidates Einstein's relativity.

We have seen above that the prediction presented by Michelson and Morley are based on a model which ignores two important fundamental phenomena. These disregarded phenomena are the law of reflection of light on the moving mirror and also the deviation of the observed direction of light coming from a moving system.

Relativity theory, astrophysics, and most of modern physics in the 20th century has been based on the belief that a null result in the Michelson-Morley experiment is an argument in favor of relativity theory. We see now that the contrary is true. An enormous amount of human effort and an unbelievable amount of money for research has been based on that erroneous prediction published in 1887. It is inconceivable that the original demonstration has never been seriously reconsidered. This is the result of an extremely dogmatic attitude of the physics establishment against a few scientists whose status were threatened and even ruined because they dared to reconsider some fundamental principles of physics.

It is also important to mention that the non-zero result observed in the Michelson-Morley experiment does not provide any proof of existence of ether. The presence of ether appears totally useless, when an appropriate model is used. Without matter nor radiation, space is nothing. Other experiments[12-17] have already shown that everything in physics can be explained using classical physics without the ether hypothesis.

We acknowledge that, the basic idea suggested by Michelson-Morley to test the variance of space-time, using a comparison between the times taken by light to travel in the parallel direction with respect to a transverse direction is very attractive. However, this test is not valid, because there are two classical secondary phenomena, which have not been taken into account. Just one year before the commemoration of the 1905 Einstein's paper, we must realize that the relativity theory relies on a ghost experiment.

The calculations above do not include all the possible physical mechanisms that can possibly perturb the light path in the Michelson-Morley apparatus. However, we strongly suspect that all other mechanisms produce effects, which are enormously smaller than the phenomena overlooked by Michelson and Morley. Of course, we have seen in this paper that there exists a fourth order term (v^4/c^4), that has been neglected here. This high order term is much too small to be observed. We can also mention the Fizeau effect, which is known to drag light traveling in a moving medium as a function of the index of refraction. The empirical equation of the Fizeau effect is known in the case of a medium moving parallel to the direction of light. We have verified that these other phenomena also make a negligible contribution to an assumed drift of fringes. However, that Fizeau drag phenomenon seems to be totally unknown when the medium moves perpendicular to light velocity. Finally, the misalignment of the mirrors of the interferometer might also have some effect on the fringes observed[18] in the Michelson-Morley experiment.

It is important to recall that the overlooked phenomena described here also have important implications in other fundamental experiments[19] in relativity. For example, in the Lorentz transformation[19], which usually predicts length contraction along the velocity axis of moving matter with respect to the transverse axis, it has been shown that the predictions are also in error, due to a secondary phenomenon explained in this present paper. We know also that the Brillet and Hall experiment [20] is also a test for the anisotropy of space. The Brillet and Hall experiment [20] has also been carefully studied and similarly, it has been shown [21], that a corresponding phenomenon is changing the light path inside a Fabry-Pérot etalon. Consequently, in that case again, the null change of frequency observed experimentally, corresponds to an absolute frame of reference, while an anisotropic relativist space would require an observed shift of frequency.

Appendix

Reflection of Light on a Mirror Moving in a Transverse Direction.

On figure A, let us consider the motion of mirror, moving horizontally when light moves downward. The initial position of the mirror at time (t_m =1) is represented on figure A by the narrow line between the pair of labels (t_m=1) at the moment the wavefront reaches the left hand side of the mirror. The continuous progression of the wavefront on the mirror, while the mirror is moving to the right hand side, is illustrated in four steps. During each step, the sideways moving mirror is shown moving toward the right hand side direction, between each pair of labels t_m=1, t_m=2, t_m=3, and t_m=4.

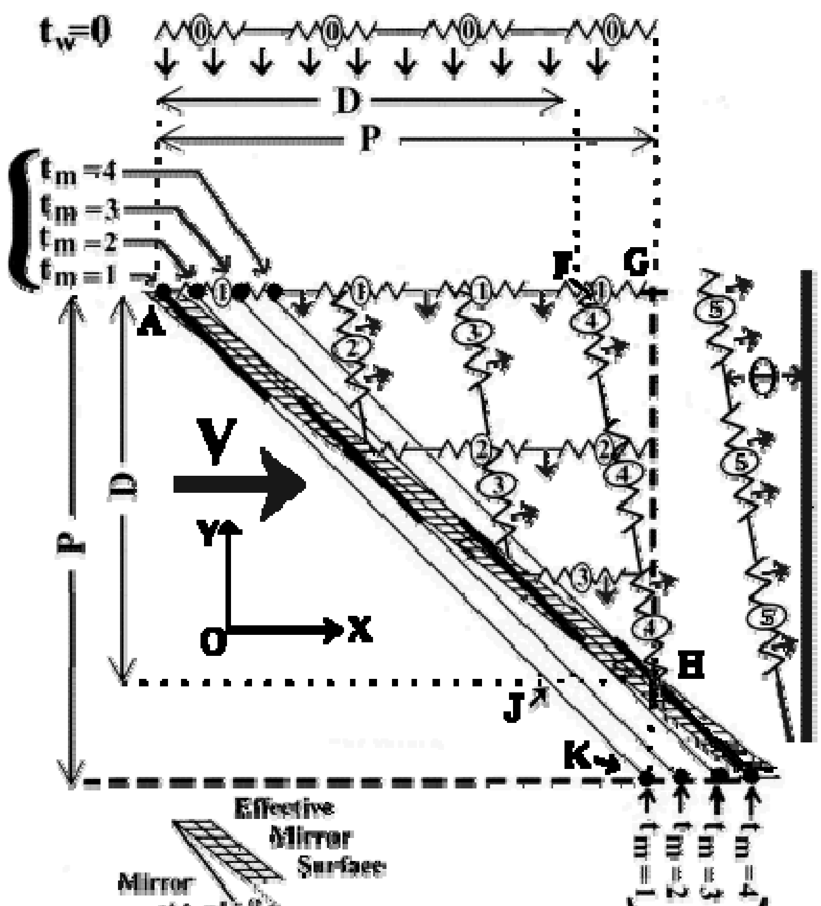

Figure A

Let us now consider the motion of the wavefronts. The labels on each wavefronts (t_w=0, 1, 2, 3, 4 and 5) are repeated at each individual quarter of wavefront. After the initial time t_w=0, that same wavefront is shown at different later times at: t_w=1, t_w=2, t_w=3, t_w=4 and t_w=5 during light propagation. All wavefronts on figure A correspond to the same wavefront at different times.

Let us consider the progression of a wavefront. At time t_w=1, (on figure A) the left hand side of the wavefront #1 of light just reaches the left hand side (bold segment) of mirror M. At that time, the first segment (bold line) of the mirror is at mirror location t_m=1. Then, the wavefront keeps moving down. At time t_w=2, the mirror, is still moving to the right hand side, and the second quarter of the same wavefront reaches the second quarter of the mirror.

However, due to the motion of the mirror toward the right hand side, the wavefront is reaching the mirror at an earlier time, as can be seen on figure A. Similarly, at time t_w=3, the third segment of the wavefront reaches the third section of the mirror, (see bold segment at mirror location t_m=3), which moved still further to the right hand side. Finally, at time t_w=4, the reflection of the wavefront on the mirror is completed after the fourth quarter of the wavefront is reflected on the fourth section of the mirror (bold segment at mirror location t_m=4), which has moved still further to the right due to the mirror velocity.

Consequently, even if the mirror makes exactly an angle of 45^o with respect to the incoming wave, that wave is reflected by a mirror making effectively a different angle, because the mirror has the time to move to the right hand side, during the total time of reflection on the whole surface of the mirror.

The “effective mirror” is illustrated on figure A as the sum of the four bold segments of the mirror, which makes an affective angle □. The effective angle of that moving mirror is illustrated on figure A, by the wide set of narrow lines (crossed by three parallel lines), covering the average location of the four bold sections of the mirror.

The angle □ between the real and the effective angle of the mirror is shown separately on figure A (bottom left). It can be shown that this angle □, represents half of the increase of the angle □□of reflection of light due to the mirror velocity. However here, the angle of reflection of light is calculated using the Huygens' principle as seen in section 2 above.

Let us calculate the angle of the reflected wavefront, taking into account the velocity of the moving mirror. The projected width of the wavefront on mirror M is equal to P (see fig. A). The "instantaneous" angle of the mirror with respect to the wavefront is exactly 45^o. However, since the mirror is moving to the right hand side, while the wavefront moves downward, light will not reach the opposite side at the same time as when the mirror is stationary. In fact, since the mirror is moving, we see on figure A that, compared with a stationary mirror, light reaches the mirror at an earlier time, at location H. Light travels only from G to H.

At rest, the vertical and horizontal components of the mirror at 45^o are equal to P.
We see that, since the angle of the moving mirror is 45^o, the horizontal distance (J-H) is equal to the vertical distance (H-K).

$$(J-H)=(H-K) \qquad (1A)$$

The time interval T_1 is equal to the time for light to travel the distance P. During that time interval, the mirror M travels the distance J-H. Therefore, using equation (1A), we have:

$$T_1=\frac{P}{c}=\frac{(H-K)}{v} \qquad (2A)$$

Equation (2A) gives:

$$(H-K)=\frac{v}{c}P \qquad (3A)$$

Equation (3A) shows that the distance traveled by light is shorter, before hitting the mirror at location H, when the mirror is moving. Let us compare this time interval for light travel, with the distance A-G, after a Huygens reflection on point A). Using the Huygens principle again, the wavefront re-emitted at location A cannot reach location G (after traveling distance P) during the same time interval light reaches the mirror at H. Due to the mirror motion, (G-H) is now shorter than (A-G). After the Huygens reflection on point A, light travels only the shorter distance (A-F). Therefore we have:

$$(F-G)=(H-K) \qquad (4A)$$

Therefore after reflection, at the moment light is finally reflected at location H (forming the wavefront #4), the reflected wavefront makes an angle θ with respect to the vertical axis. This gives:

$$\theta=\frac{(F-G)}{D}\cong\frac{(H-K)}{P}=\frac{v}{c} \qquad (5A)$$

A moment later, the wavefront #5 escapes from the surface of the mirror at the angle θ. One must conclude that light reflected on a moving mirror makes an extra angle of reflection θ, as given in equation (5A). Using the same demonstration, we see that changing the direction of the velocity v of the mirror also changes the sign of the angle θ. This demonstration explains the behavior of light on figure 5.

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