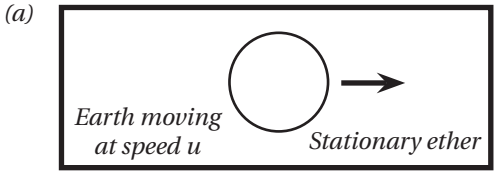
How a Simple Error in Michelson's Calculations in His Experiment Precipitated Einstein's Theory of Relativity

By Boris Milvich

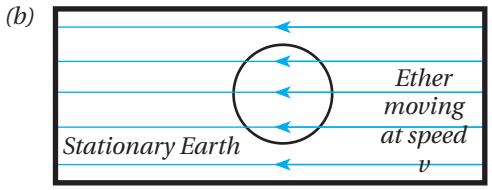
The beginning of a great confusion

Physicists at the end of the 19th century believed that all empty space on earth and interplanetary space was filled with a substance called the ether. This elusive substance was needed in order to explain the wave nature of light. It was reasoned that because sound waves require air for their propagation, a similar substance would have to exist in order for light to propagate as waves. Although the ether was a hypothetical substance, physicists firmly believed in its existence and searched for a way of detecting it.

It was assumed by most 19th century physicists that if the earth moved through the ether, as shown in *Fig. 1a* below, it would be the same as if the earth were at rest and the ether wind were blowing through the earth and a laboratory on it, as shown in *Fig. 1b*, taken from Ohanian's textbook, *Principles of Physics*. [1]



Earth is moving through the stationary ether



Earth is stationary as the ether wind is blowing through it

Figure 1

Professor Ohanian wrote:

> *"The motion of the ether past the Earth was called the ether wind by the nineteenth century physicists. If the Sun is at rest with the ether, then the ether wind would have velocity opposite of that of the Earth around the Sun — about 30 km/s; if the Sun is in (steady) motion, then the ether wind would vary with the seasons — smaller than 30 km/s during one-half of the year and greater than 30 km/s during the other half."*
>
> *"In the reference frame of the Earth, the ether flows past the Earth, forming the ether wind."* [1]

In other words, the ether wind is created by the motion of the earth through the stationary ether. The faster the speed of the earth, the greater the ether wind. Hence, *if the earth moves at the speed u=30,000 m/s around the sun, the ether wind would have the same speed, v=30,000 m/s, however, in the opposite direction.*

Professor Nolan wrote:

"If there is a medium called the ether that pervades all of space then the earth must be moving through the ether as it moves in its orbital motion about the sun. From the point of view of an observer on the earth the ether must flow past the earth, that is, it must appear that the earth is afloat in the ether current. The ether current concept allows us to consider an analogy of a boat in a river current." [2]

Mechanical properties of the ether wind

Mechanical properties of the ether wind and its effect on the light beams is often demonstrated with a vector presentation. One such vector presentation *(Fig.2)* was made by professor Hans Ohanian in his college textbook *Principles of Physics*. [3]

In this analysis there are two moving components:

1. The ether wind *v* acting from right to left and
2. Motion of the light beams at different velocities.

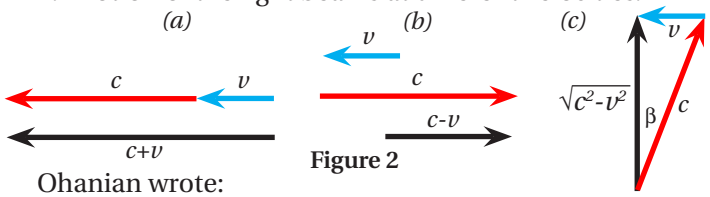


Figure 2

Ohanian wrote:

> "Experimenters attempted to detect this ether wind by its effects on the propagation of light. A light wave in a laboratory on the Earth would have a greater speed when moving downwind and a smaller speed when moving upwind or across the wind. If the speed of the ether wind 'blowing' through the laboratory is *v*, then the speed of light in this laboratory is *c+v* for a light signal with downwind motion, *c-v* for upwind motion, and $\sqrt{c^2-v^2}$ for motion perpendicular to the wind." [1]

If the initial direction of the beam traveling across the wind is perpendicular to the either wind (shown below in red), then the beam would travel along the hypotenuse shown as black arrow at velocity $\sqrt{c^2+v^2}$.

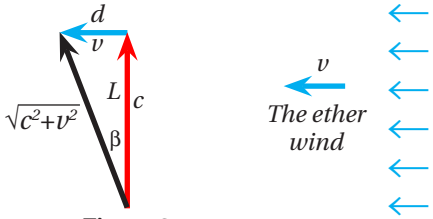


Figure 3

The angle of displacement of the vertical beam (β), due to the ether wind in *Fig. 2c* and *Fig. 3*, is determined by the magnitude of the ether vector *v* shown in blue.

The displacement *d* can be calculated using ratios:

$$d/v=L/c \quad \text{from where} \quad d=vL/c$$

If the ether wind *v* equals 30,000 m/s (the earth's velocity around the sun), length *L* is 11 m, and *c* is the velocity of light, 300,000,000 m/s, displacement *d* would amount to:

$$d=0.0011\ m \quad or \quad d=1.1\ mm$$

Two main properties of the ether wind

From the above vector presentation of the effects of the ether wind on the light beams we can conclude that the ether wind has 2 main characteristics or properties:

1. The ether wind can increase or decrease the velocity of the light beams.

2. The ether wind can change the direction of the light beam in the direction of the wind.

Using these properties and the above equations, the ether wind could have been detected and its speed measured in a much simpler way than by using Michelson-Morley interferometer and done a century or two earlier.

A simple experiment designed to detect and measure the ether wind could have been performed in Newton's time

Laboratory and Earth at rest

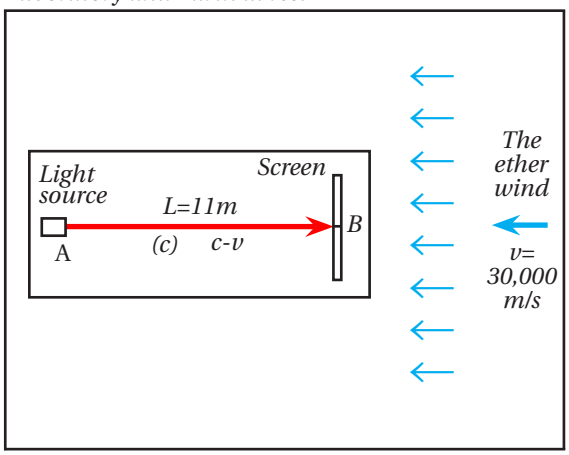


Figure 4

Laboratory and Earth at rest

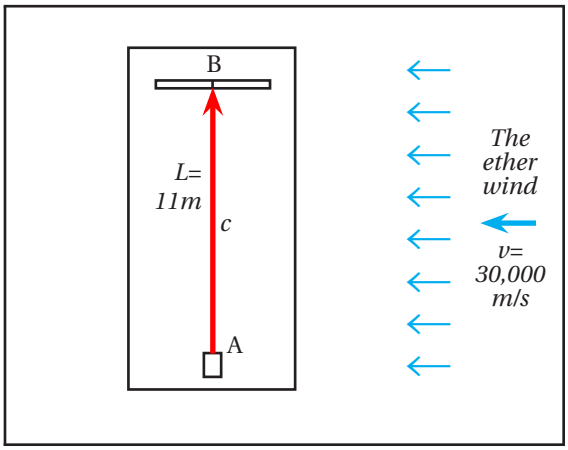


Figure 5

Laboratory and Earth at rest

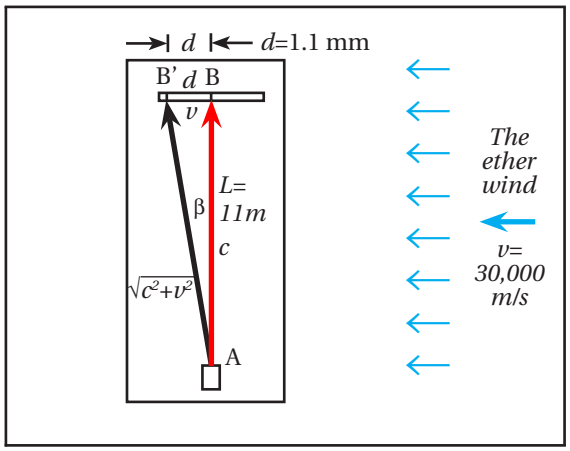


Figure 6

On an optical table in a laboratory, a pencil beam moving parallel to the supposed ether wind is directed toward a screen 11 m away *(Fig. 4)*. The length of 11 m in the next three figures could be achieved by using several mirrors, as it was done in the original Michelson-Morley experiment of 1887. It is shown here as one beam for making the drawings of the beam's displacement simpler and more comprehensive. Using mirrors, the experiment could have been performed on an optical table in a laboratory.

The light source and the screen are firmly fastened to the platform. The ether wind, acting parallel but in the opposite direction, would reduce the speed of the beam to c-v, but it would have no effect on its direction of travel. *Beam's initial direction is set in this orientation.*

Once again, the source, the screen and everything on the optical table are firmly fastened to it and cannot move.

When the optical table is rotated counter-clockwise and 90^0 relative to the motion of the ether wind *(Fig. 5)*, the ether wind moving at speed v would be acting broadside against the beam.

Important note: *When the optical table is rotated, nothing on the table is altered. The initial direction of the light beam, or the aim, remains along AB. The only thing that can affect light beam's direction of travel is the ether wind.*

As stipulated by the mechanical properties of the ether wind, the wind would change the direction of the beam to the left in the direction of the ether wind, as shown in *Fig. 6*.

The light beam would travel along the *hypotenuse* of a right triangle ABB', at speed $\sqrt{c^2+v^2}$, with a *plus* sign in the square root.

The beam will now arrive on the screen at B', a distance d from the original place of arrival at B before the rotation took place. As shown earlier, displacement d can be calculated using ratios:

$$d/v=L/c \qquad \text{from where} \qquad d=vL/c$$

If the speed of the ether wind v was the same as the motion of the earth around the sun, but in the opposite direction, 30,000 m/s, and the distance L was 11 m, the displacement would amount to:

$$d = 1.1 \text{ mm}$$

Three surprising realizations

1. The beam displacement d=1.1 mm in *Fig. 6* is huge in optical terms—it could be observed with the naked eye. Thus, the ether wind could have been detected and measured in an utterly simple way, a century or two before the MM experiment was performed.

2. If the ether wind did exist and we were able to determine the displacement d, the ether wind would have enabled us to determine the speed of the ether wind v and thus the speed of the earth though space from the above equation $d=vL/c$, from where $v=cd/L$.

3. These three figures represent the first leg of travel of the parallel beam in the MM experiment when rotated 90^0 from a parallel to a vertical orientation relative to the ether wind. They show that the vertical light beam must travel along the *hypotenuse* of a right triangle at speed $\sqrt{c^2+v^2}$ that has a *plus* sign in the square root. According to Michelson, however, the vertical beam would travel along the *side* of a right triangle at a speed that has the *minus* sign in its square root $(\sqrt{c^2-v^2})$. Let us take a closer look.

Mechanics of the new experiment to detect the ether wind applied to the MM experiment

Laboratory and Earth at rest

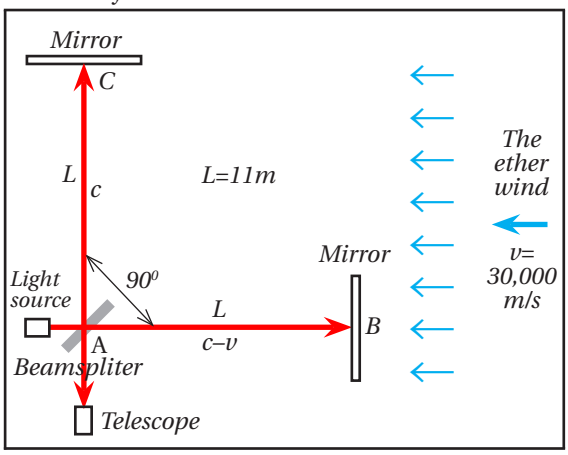


Figure 7

Laboratory and Earth at rest

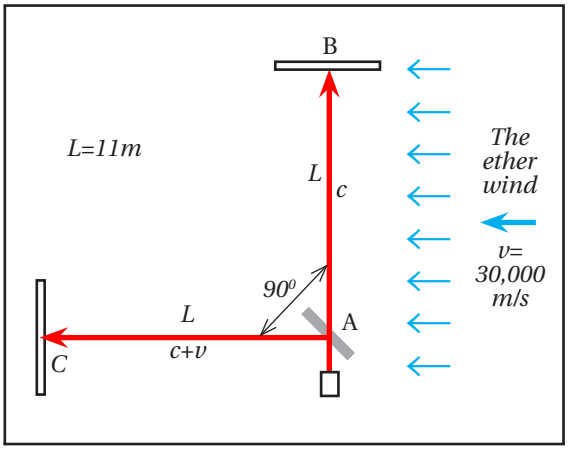


Figure 8

Laboratory and Earth at rest

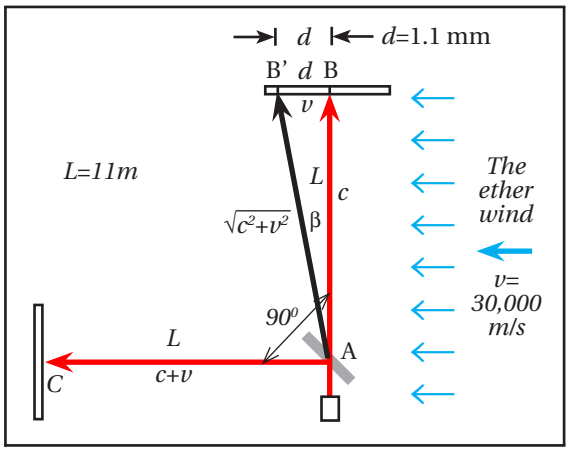


Figure 9

Michelson-Morley experiment was performed in 1887 with an interferometer where a beam of light is split by a beamsplitter into two beams traveling at 90⁰ to each other and in the direction of two mirrors positioned at an equal distance *(L)* from the beamsplitter (*Fig. 7*). The two beams reflect from the mirrors and reunite at the beamsplitter forming a fringe pattern.

The ether wind is blowing through the laboratory and the MM interferometer. The direction of the wind is from right to left. The source, the beamsplitter and the mirrors of the apparatus are firmly fastened to an optical table and cannot move.

The initial direction of the two split beams traveling along AB and AC form a 90⁰ angle, which is determined by the beamsplitter's design. This angle cannot be altered.

The travel times, speeds and distances traveled by the light beams in the MM experiment were *calculated by Michelson in 1870's using classical mechanics' equations of Galileo and Newton.*

The parallel beam in *Fig. 7* travels in the opposite direction of the ether wind so that its initial speed c will be reduced to c-v, but it will not change its direction of travel.

When the MM interferometer is rotated 90⁰ *(Fig. 8)*, initial direction or the aim of the two beams remains unchanged, that is, along AB and AC. Being the function of the beamsplitter design, the angle between the two beams also remains unchanged, 90⁰.

The ether wind is now acting broadside against the vertical beam and will displace it in the direction of the wind, that is, to the left and along AB', as shown in *Fig. 9*.

Our experiment shown in *Fig. 6* tells us that the vertical beam in the MM experiment must travel along the *hypotenuse* of the right triangle at speed $\sqrt{c^2+v^2}$, with the *plus* sign in the square root, as shown in *Fig. 9*. This figure is equivalent to *Fig. 6*.

Time to travel along the *hypotenuse* at the above speed in the new interpretation of the MM experiment can be found from the ratios:

$$L/c = AB'/\sqrt{c^2+v^2}$$

$$AB'c = L\sqrt{c^2+v^2}$$

$$AB' = L\sqrt{c^2+v^2}/c$$

Time = distance/speed

$$t_{AB'} = \frac{\frac{L\sqrt{c^2+v^2}}{c}}{\sqrt{c^2+v^2}} = \frac{L\sqrt{c^2+v^2}}{c\sqrt{c^2+v^2}}$$

$$t_{AB'} = L/c$$

Feynman's method:

$$(\sqrt{c^2+v^2}\,t)^2 = L^2+(vt)^2$$

$$(c^2+v^2)t^2 = L^2+v^2t^2$$

$$c^2t^2+v^2t^2-v^2t^2 = L^2$$

$$c^2t^2 = L^2$$

$$t = L/c$$

Total time for the vertical beam round-trip journey will be:

$$T_V = 2L/c$$

However, in Michelson's interpretation of his experiment, the vertical beam travels along the *side* of the right triangle at speed $\sqrt{c^2-v^2}$, with the *minus* sign in the square root.

Michelson's total round-trip vertical time was:

$$T_V = 2L/\sqrt{c^2-v^2} \quad \text{or} \quad T_V = 2L/c\sqrt{1-v^2/c^2}$$

Why do we have these speed and time discrepancies?

Michelson erroneously equated a mechanical system of two swimmers racing in a river to the mechanics of his famous experiment

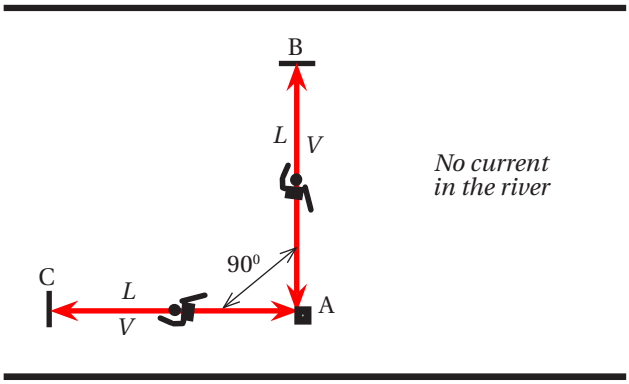


Figure 10

Michelson believed that the mechanical system of two swimmers racing in a river is equivalent to the mechanical system of the MM experiment, so that the travel times of the swimmers to their targets and back are identical to the travel times of the light beams in his experiment.

His daughter wrote:

> "As he (Michelson) later explained to his children: 'Two beams of light race against each other, like two swimmers, one struggling upstream and back, while the other, covering the same distance, just crosses the river and returns. The second swimmer will always win, *if there is any current in the river.*' It was crucial to the success of the plan to split a single light beam, send the two parts off at right angles, and, by means of mirrors, rejoin them to observe the fringes of interference and thus determine the 'winner' and measure by what length of time 'he' had won." [3]

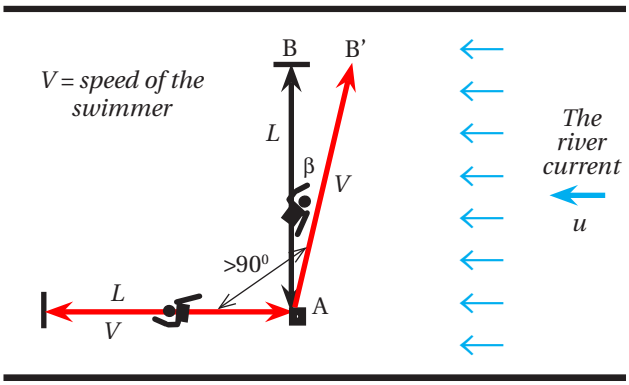


Figure 11

Michelson's swimmers' model of his experiment

When there is no current in the river *(Fig. 10)*, the swimmers would leave point A, swim to points B and C, equally distanced, and then back to A. Both swimmers would covered their distances in time *2L/V*.

In *Fig. 11*, current *u*, acting from right to left, is added.

In order to swim straight across the current and reach point B, the swimmer must change his direction of travel and swim slightly upstream in the direction of B' shown in red. Thus the swimmer travels along AB shown in black, which is the *side* of a right triangle ABB'. The beam travels at speed $\sqrt{c^2-v^2}$, contrary to what we saw in *Fig. 9*, where the vertical beam travels along the *hypotenuse* of the same triangle having a plus sign in the same square root.

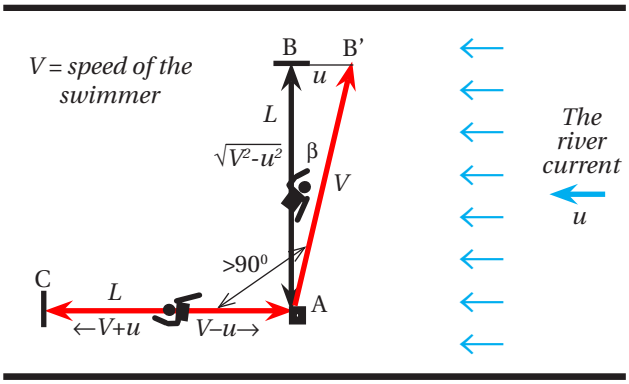


Figure 12

In the swimmers' model, the swimmer traveling across the current along AB would win the race.

This means that the swimmers' model predicts that in the actual MM experiment one beam would arrive back at the beamsplitter first and cause a fringe shift. This shift would indicate the existence of the ether and the ether wind.

Michelson believed that the mechanical system of two swimmers racing in a river is equivalent to the system of two beams in his famous experiment.

Therefore, he believed that the swimmers' travel times in the swimmers' model in Fig. 12 are identical to the travel times of the light beams in the MM experiment when the ether is blowing through the laboratory and his interferometer (Fig. 13-15).

All the drawings of the MM experiment found in physics textbooks and manuals on relativity are based on the swimmers' model shown in *Figure 12*.

But, is the swimmers' model 100% equivalent to the actual MM experiment where the ether wind blows through the laboratory and through the interferometer that are at rest?

Laboratory and Earth at rest

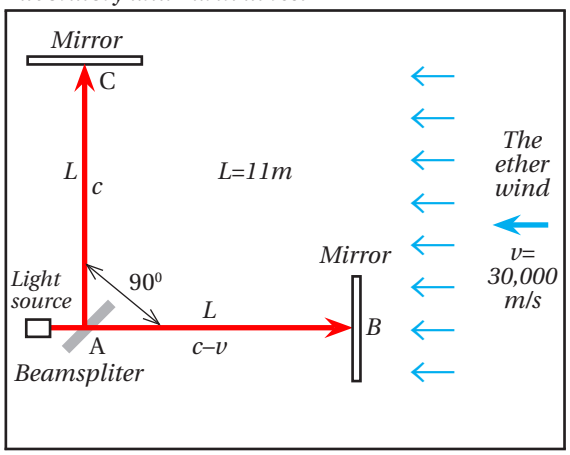


Figure 13

Laboratory and Earth at rest

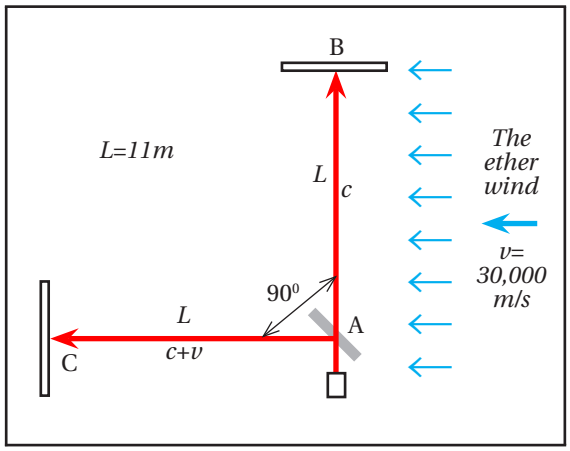


Figure 14

The drawing of the actual MM experiment when the ether wind is blowing from right to left and through a laboratory and the interferometer at rest is shown again in *Fig. 13*.

A beam of light is split by a beamsplitter at A into two beams oriented 90⁰ to each other so that one is oriented parallel and the other vertical to the direction of the ether wind.

When the interferometer is rotated counterclockwise 90⁰ relative to the ether wind *(Fig.14)*, the ether wind will be acting broadside against the vertical beam.

For the MM experiment to have the same travel times as in the swimmers' model, and ***mimic*** this model, the vertical beam has to change the aim, or direction of travel, slightly upstream in order to travel straight across, as shown in *Fig. 15*.

In the swimmer's model in *Fig. 12*, the swimmer traveling across the current makes a conscious choice at what angle to swim upstream in order to travel straight across the current.

However, there is no such an option in the MM experiment.

There is nothing in this experiment that could change the initial direction of travel, or to change the 90⁰ angle between the vertical and parallel beam except the ether wind.

Because the ether wind is acting broadside against the beam, it must change the initial beam's direction in the direction of the wind and travel along AB', as shown in *Fig. 9* and *Fig. 16*.

The vertical beam direction, speed and travel time shown in Michelson's model in *Fig. 15* are impossible and untenable.

This is simply an error.

According to Michelson and the theory of the existence of the ether and the ether wind, the ether wind affects the motion of the light beams, but has no effect of the motion of the interferometer.

In the swimmers' model, there are 2 changes of direction. One by the swimmer and then by the ether wind. In the actual MM experiment, only the ether wind can change the direction of the vertical beam.

Hence, the two models are *not* equivalent.

The only viable drawing of the MM experiment

The only viable drawing of the motion of the vertical beam in the MM experiment when the ether wind is blowing through the laboratory (and the apparatus) is shown in *Fig. 9* and repeated again below, in *Fig. 16*, where the vertical beam is displaced in the direction of the ether wind and travels along *hypotenuse* AB' and in time *L/c*.

Laboratory and Earth at rest

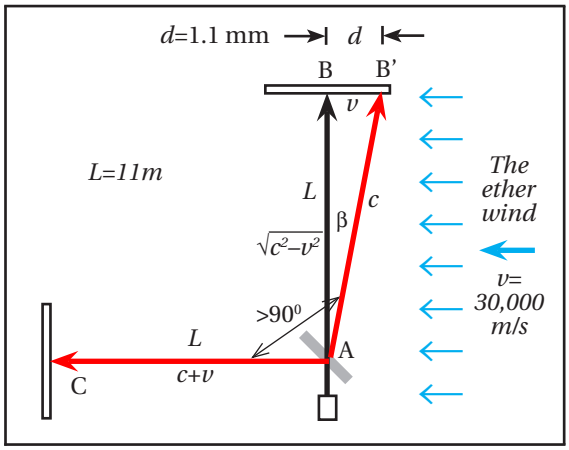


Figure 15

Laboratory and Earth at rest

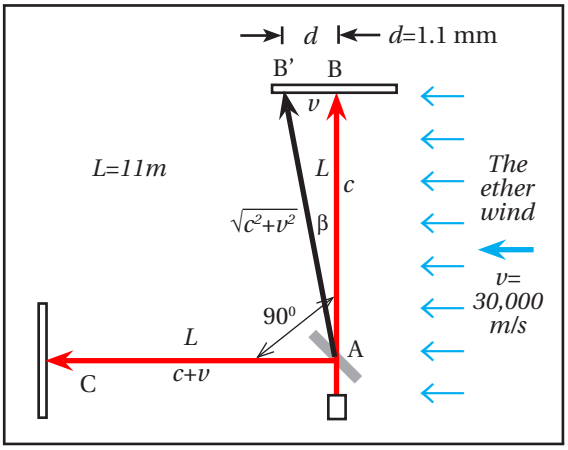


Figure 16

Proof #1 When the ether wind changes its magnitude, the vertical light beam cannot change its initial direction

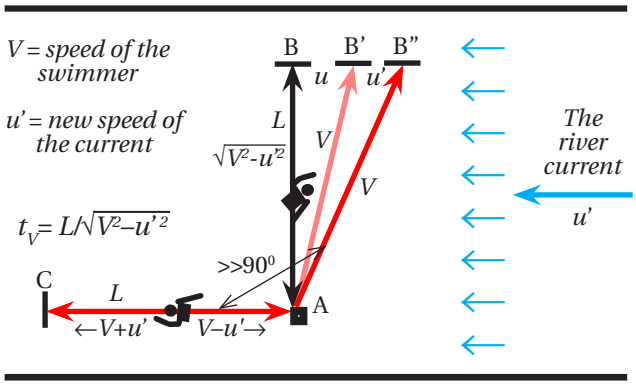


Figure 17

Change in the speed of the river current in the swimmers' model of the MM experiment

Suppose the current in the swimmers' model becomes faster so that speed u changes to speed u'.

The swimmer traveling across the current *(Fig. 17)* must now swim more upstream from A in the direction of B", in order to travel straight across and reach point B.

He makes a conscious choice of the swimming angle, while the initial direction of the 2nd swimmer remains parallel to the current.

The time to swim across current is now $L/\sqrt{V^2-u'^2}$

Laboratory and Earth at rest

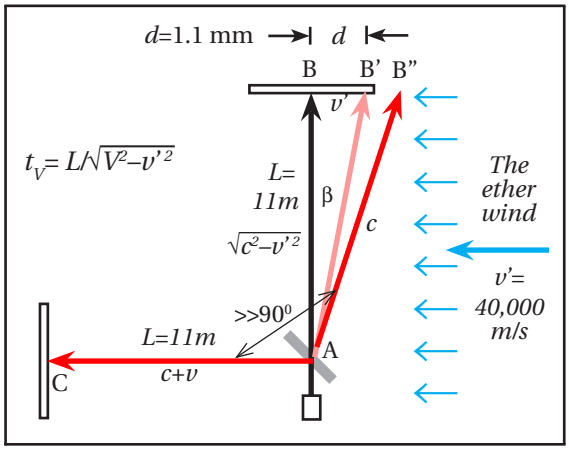


Figure 18

Change in the speed of the ether wind in the MM experiment according to the swimmers' model

It has been assumed for over a century that the same change in direction of the swimmer swimming across the current in *Fig. 17* would also happen to the vertical light beam in the actual MM experiment *(Fig. 18)*.

However, there is nothing in the MM experimental setup that is capable of changing the initial direction of the vertical light beam when the magnitude of the ether wind is increased. The only thing that was done in the actual experiment is the 90⁰ rotation of the whole setup. No other "tweaking " of any kind was done, nor can be done.

The ether wind is the only thing that can change the initial travel direction of the vertical light beam.

Therefore, the travel paths of the vertical light beam shown in *Fig. 18,* that mimics the swimmer model in *Fig. 17,* is untenable.

Hence, the mechanical system of two swimmers racing in a river is not equivalent to the actual MM experiment.

Because of this difference, the time of travel of the swimmer swimming across the river current is different than the travel time of the vertical beam in the MM experiment.

Laboratory and Earth at rest

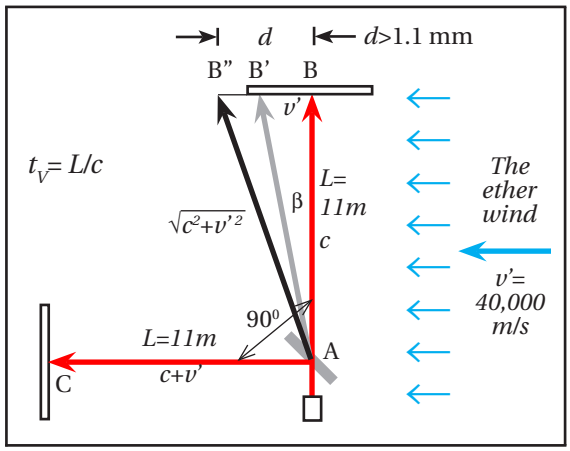


Figure 19

Correct model of the MM experiment when the ether wind changes its speed

The only viable outcome when the ether wind is increased is shown in *Fig. 19*, where the beam is further displaced in the direction of the wind and travels along the hypotenuse AB".

According to our new experiment to detect the ether wind shown in *Fig. 4-6,* the only thing that can change the direction of the vertical light beam is the magnitude of the ether wind. There is no other way of affecting the speed and direction of the light beams in the MM experiment when the ether wind is blowing through the laboratory.

When the speed of the ether wind is increased to v', the direction of the vertical beam would change and the angle of deflection would increase. The speed of the beam would also increase; however, the distance traveled would proportionally increase so that the travel time would remain unchanged, L/c.

Proof #2. Error in Ohanian vector analysis

Every vector presentation of the motion of the light beams in the MM experiment mimics the swimmers' model, where one swimmer swims slightly upstream in order to travel perpendicularly to the current. With his swimmers' model, Michelson had set the pattern for all future interpretations of his experiment. So is the case with Ohanian vector analysis when the laboratory and the interferometter are at rest and the ether wind is blowing through the laboratory.

Figures 20a and *20b* show the addition of vectors representing the parallel light beam shown in red and the ether wind shown in blue, when the beam travels first in the same direction as the ether wind, then in the opposite direction. The result of the additions, the resulting vectors, are shown in black.

Figure 20c shows the initial direction of the vertical light beam shown in red and traveling at an angle (upwind, as it is the case in the swimmers' model), forming greater than 90⁰ angle with the parallel beam.

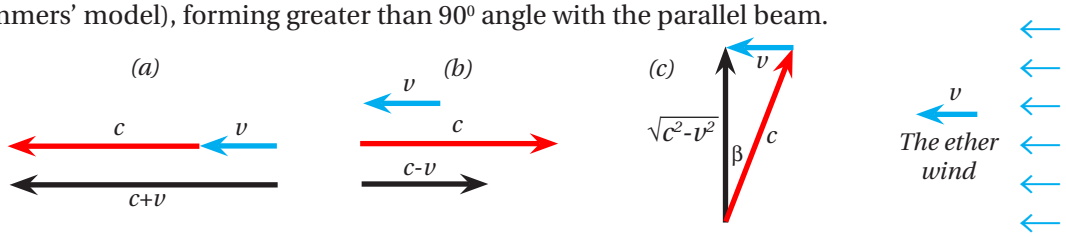


Figure 20

Because of the ether wind, the direction of the vertical beam changes in the above figure, so the beam travels perpendicularly to the ether wind and along the <u>*side*</u> of a right triangle, shown by a vector in black.

This is a vector presentation of the interactions in the swimmers' model.

In the actual MM experiment, however, *the vertical beam cannot change its initial direction of travel.*

MM interferometer is constructed with two arms forming a 90⁰ angle. This angle cannot be modified. *If we angle the the MM interferometer relative to the ether wind, so that its initial direction of the vertical beam is slightly upstream* (as in Michelson's two-swimmers model of the experiment or in the Ohanian drawing in *Figure 20c) we would also have to change the angle of the parallel beam, as shown in Fig. 21. We would then have to recalculate the parallel beams' travel time,* which no one has ever done. The vector additions would take a different form, as shown below.

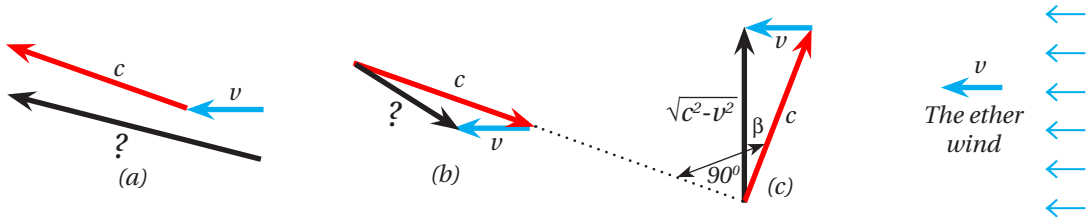


Figure 21

Therefore, if the initial direction of the vertical beam is at an angle relative to the ether wind, as shown in red in *Figure 21c* (and in *Figure 20c* in the Ohanian drawing), then the initial direction of the other beam, also shown in red, must form a 90⁰ angle with the initial direction of the vertical beam. However, it will not be parallel to the direction of the ether wind. That is, it will be at an angle relative to the ether vector shown in blue in *Figures 21a* and *21b*. These vector additions would yield different resulting velocities than those shown in black in the Ohanian drawing in *Figure 20*, and would result in different travel times.

The change in the angle of the vertical beam can only be accomplished by the ether wind or by changing the angle of the beamsplitter or the entire apparatus relative to the ether wind, which would affect both beams.

Ohanian vector presentation in *Figure 20* shows vector interactions in the swimmers' or the comparable model of the MM experiment, not in the actual one.

The only viable vector presentation of the MM experiment in the ether setting

The only viable vector presentation of the MM experiment when the laboratory and the interferometer are at rest and the ether wind is blowing trough the laboratory is shown below.

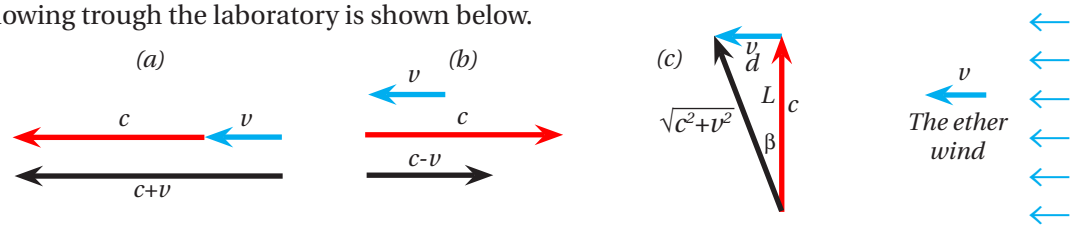


Figure 22

When the beam is projected perpendicularly to the direction of the ether wind *(Fig. 22c)*, the wind will displace the light beam in the direction of the ether wind so that it travels along the <u>*hypotenuse*</u> of a right triangle of velocities at velocity $\sqrt{c^2+v^2}$ and in time L/c.

Therefore, Michelson's velocity of the vertical beam ($\sqrt{c^2-v^2}$) and the time of travel ($L/\sqrt{c^2-v^2}$) cannot be correct.

Proof #3. Feynman's method of graphically explaining the Michelson-Morley experiment *hides an error*

Richard Feynman presented in his *Lectures on Physics* [4] his interpretation of the MM experiment in the ether setting, along with a diagram of the experiment *(Fig. 23b)*. Feynman wrote: *"If the apparatus is at rest in the ether, the times would be precisely equal, ..."*, as shown in *Figure 23a.*

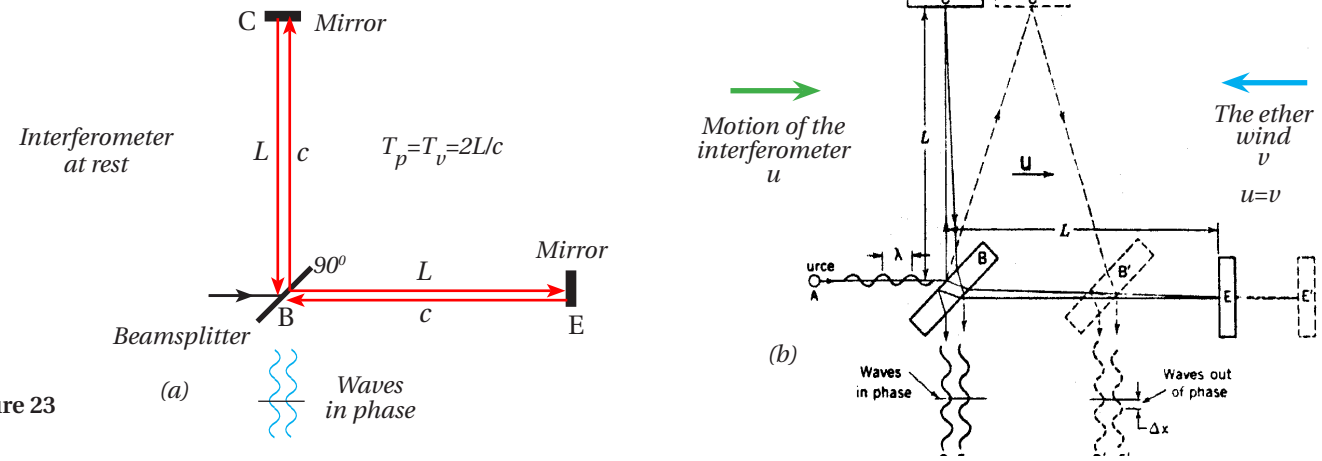


Figure 23

Feynman continued: *"... but if it (the interferometer) is moving to the right with a velocity u, there should be the difference in the times" (Fig. 23b)*. (Motion of the interferometer *u* and the ether wind *v* with arrows were added.)

If we are sitting at a desk with this page in front of us, we would see the apparatus moving from left to right, representing a new moving frame of reference where the earth and the inteferomitter are now moving through the ether. A detailed version of the drawing is shown below.

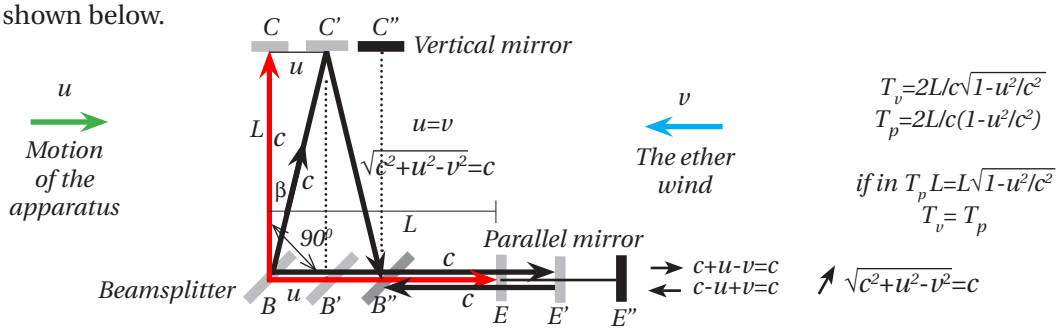


Figure 24

Feynman took into consideration the ether wind *v* canceling the motion of the earth *u* to arrive at velocity of the light beam *c* in all directions, but the effect of the ether wind on the direction of the motion of the vertical beam is missing.

Vector presentation of the Feynman's model of the MM experiment shows the error in his model

Feynman's model has three moving components. They are:

1. Motion of the earth and the apparatus at velocity *u*.
2. The ether resistance or the ether wind *v* acting or moving in the opposite direction.
3. Motion of the light beams in all directions at velocity *c*.

The three moving components in the *vertical beam* interaction can be represented as three vectors: shown in *Figure 25*.

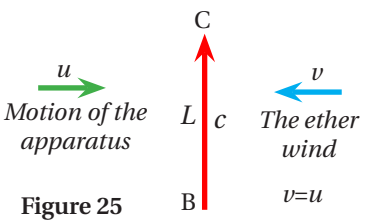


Figure 25

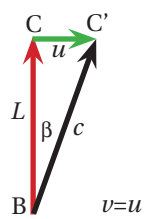


Figure 26

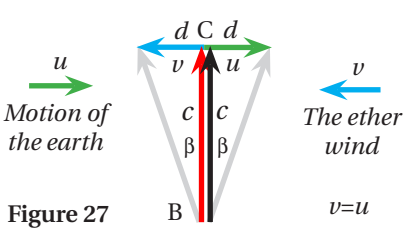


Figure 27

However, when the 3 moving components in Feynman's model are presented as 3 vectors, only 2 moving components are taken into consideration *(Fig.26)*. *The ether wind vector is missing.* The correct vector addition is shown above in *Figure 27*. The change of direction caused by the motion of the earth is suppose to be cancelled by the ether wind. Hence, the beams' speed *c*.

Without realizing, Feynman presented a diagram of the relativistic model of the MM experiment, where there is no ether, where light beams travel at speed *c* in all directions, unaffected by the motion of the source and where there are 2 moving components, motion of the earth and motion of the light beams, represented by 2 vectors.

This and the fact that the light beams travel at the same speed *c* in all directions in both models, explains the erroneous belief that the ether and the relativistic model of the MM experiment are identical, belief that has existed to this day.

Proof #4. Three distinct mechanical systems require three distinct vector additions in the motion of the vertical light beam of the MM experiment

1. Model according to Newton's classical mechanics

According to Newton, the ether has no effect on the motion of the light beams as they travel like any other particles of matter. In this model, there are *2 moving components*:

1. **Motion of the earth and the apparatus at velocity *u* and**
2. **Initial direction of motion of the vertical beam at the initial velocity *c*.**

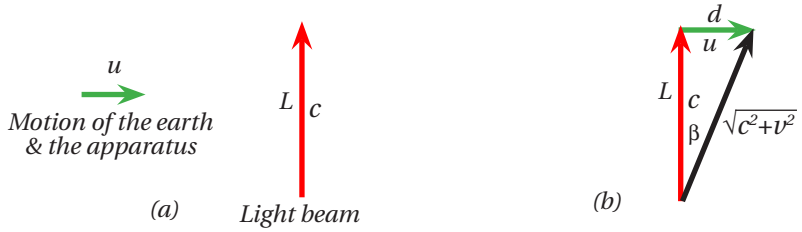


Figure 28

Figure 28a shows the two vectors representing the motion of the interferometer *u* and the velocity of the light beam *c*. The addition of these two vectors is shown in *Figure 28b*, which yields the resulting vector and resulting velocity shown in black with the *plus* sign in the square root.

2. The ether model of the MM experiment

The ether model has *3 moving components*.

1. **Motion of the earth and the apparatus at velocity *u*,**
2. **The ether resistance or the wind acting or moving in the opposite direction at velocity *v***
3. **Initial direction of motion of the vertical beam at the initial velocity *c*.**

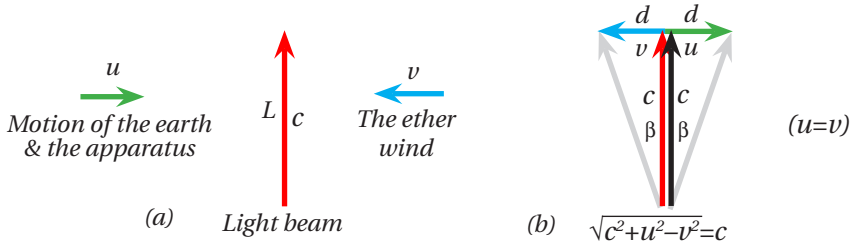


Figure 29

Having equal but opposite effect, the ether wind cancels the effects of the motion of the earth on the ***velocity*** and ***direction*** of the vertical light beam, so that the beam travels at velocity *c* along the initial direction. The addition of the three vectors in *Figure 29a* yields the resulting vector shown in black *(Fig. 29b)* that has the same direction and magnitude as the vector that represents the initial velocity *c* shown in red. Once again, according to the theory of the existence of the ether and the ether wind, the ether wind affects the motion of the light beams, but has no effect of the motion of the interferometer.

3. Einstein's model of the MM experiment

In Einstein's model, the ether and the ether wind do not exist and the light beams travel at a constant velocity *c* in all directions, unaffected by earth's motion. This model has *2 moving components*:

1. **Motion of the earth and the apparatus at velocity *u*,**
2. **Initial direction of motion of the vertical beam at the initial velocity *c*.**

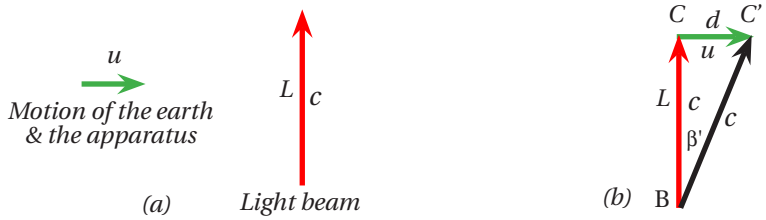


Figure 30

The addition of the two vectors in *Figure 30a* yields the resulting vector shown in black in *Figure 30b*. This is a highly unusual addition because the magnitude of the resulting vector in black is represented by the same velocity *c* as the initial vector shown in red. This addition represents the essence of Einstein's concept that light cannot travel faster than the velocity *c*, yet it will travel along the longer distance AC' in the same amount of time. (This paradox is the subject of another paper.)

The above 3 distinct vector additions, with 3 distinct mechanical systems and with 3 distinct mechanical characteristics mandate 3 distinct diagrams of the MM experiment.

Proof #5. Three distinct vector interactions require three distinct diagrams of the Michelson-Morley experiment

1. Diagram according to Newton's classical mechanics

According to Newton, there is no ether and light travels like particles of matter. There are *2 moving components* here:

1. **Motion of the earth and the interferometer at speed *u* and**
2. **Motion of the light beams at different speeds than speed *c*.**

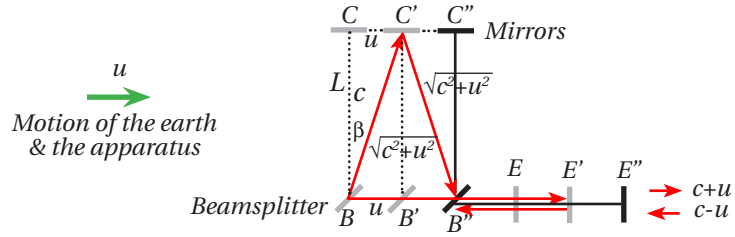


Figure 31

$t_{BC'}=L/c$
$t_{C'B''}=L/c$
$t_{BE'}=L/c$
$t_{E'B''}=L/c$
$T_p=T_v=2L/c$

Due to the motion of the earth, the vertical beam travels along the hypotenuse of the two right triangles at the speed that has plus sign in the square root and in time *2L/c*. Along the parallel path, the motion of the earth will add its speed component to the parallel beam *(c+u)*, than reduce the speed on the way back to the beamsplitter *(c–u)*. The total time of travel will be the same as for the vertical beam *(2L/c)*. In other words, the two beams reunite at the beamsplitter at the same time and in the same phase, thus preventing any phase shift in the experiment and in agreement with its results.

2. The ether diagram of the MM experiment

The ether model has *3 moving components*:

1. **Motion of the earth and the interferometer at speed *u*,**
2. **The ether resistance or the wind acting or moving in the opposite direction at speed *v* and**
3. **Motion of the beams in all directions at speed *c*.**

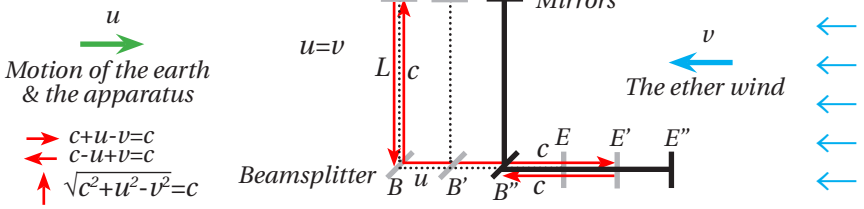


Figure 32

$t_{BC'}=L/c$
$t_{C'B''}=L/c$
$t_{BE'}=L/(c-u)$
$t_{E'B''}=L/(c+u)$
$T_v=2L/c$
$T_p=2L/c[1-(u^2/c^2)]$

According to mechanical characteristics of the ether, having equal but opposite effect of the motion of the earth, the ether wind cancels the effects of the motion of the earth on the <u>speed</u> and <u>direction</u> of the beams so that the they travel at a constant speed *c* in all directions. Due to the ether, the vertical beam would be left behind as the interferometer is displaced to the right. The beams would reunite at the beamsplitter at different times, which would cause the fringe shift.

3. Diagram of the MM experiment according to Einstein's theory

The light beams travel at a constant speed *c* in all directions, unaffected by earth's motion. Einstein's model has *2 moving components:*

1. **Motion of the earth and the interferometer at speed *u*,**
2. **Motion of the light beams in all directions at speed *c*.**

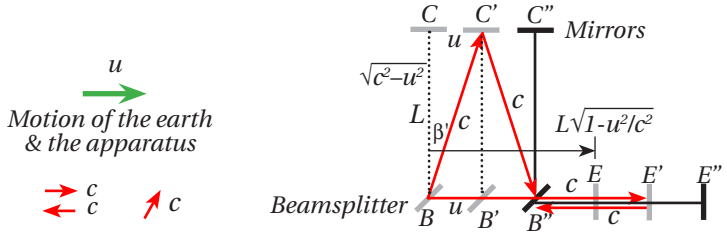


Figure 33

$t_{BC'}=L/\sqrt{c^2-u^2}$
$t_{C'B''}=L/\sqrt{c^2-u^2}$
$T_V=2L/\sqrt{c^2-u^2}$
$T_V=2L/c\sqrt{1-u^2/c^2}$

$t_{BE'}=L/(c-u)$
$t_{E'B''}=L/(c+u)$
$T_p=2Lc/(c^2-u^2)$
$T_p=2L/c(1-u^2/c^2)$

If L contracts to $L\sqrt{1-u^2/c^2}$
$T_p=2L\sqrt{1-u^2/c^2}/c(1-u^2/c^2)$
$T_p=2L\sqrt{1-u^2/c^2}/c\sqrt{1-u^2/c^2}\sqrt{1-u^2/c^2}$

$T_p=T_V=2L/c\sqrt{1-u^2/c^2}$

Motion of the earth would cause the vertical beam to travel along AC' and C'B" at speed *c* and meet the parallel beam at B", traveling also at speed *c* in both directions. Because of this speed, the two beams arrive at the beamsplitter at different times. The concept of contractions of the parallel length was introduced so that the two beams arrive at the same time and, thus, explain the absence of the fringe shift in the actual experiment.

For the first time in the history of the MM experiment, the three drawings of this experiment according to three different theories and three different mechanical systems are presented here side by side. The new and correct ether diagram of this experiment in *Figure 32* is also presented here for the first time.

Proof #6. The ultimate proof — The summary from the first three pages

The proposed experiment to detect and measure the ether wind in a simple way, as presented at the beginning of this treatise, also represents the simplest and the most convincing proof of the error made in the calculations of the vertical time in the MM experiment.

It was generally assumed that if the earth was moving through the stationary ether it would be correct to assume that if the earth was at rest, the ether would be blowing through the earth and a laboratory on the earth, as shown below.

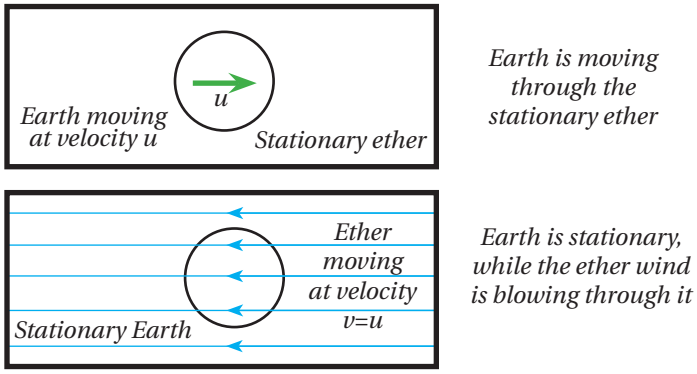


Figure 39

Furthermore, it was believed that the ether wind was capable of changing the velocity of the light beams and the direction of travel of the vertical beam in the directions of the wind, as shown below, in a vector presentation found in many physics textbooks, where the initial direction of the vertical beam shown in red is either at an angle or vertical relative to the direction of the ether wind.

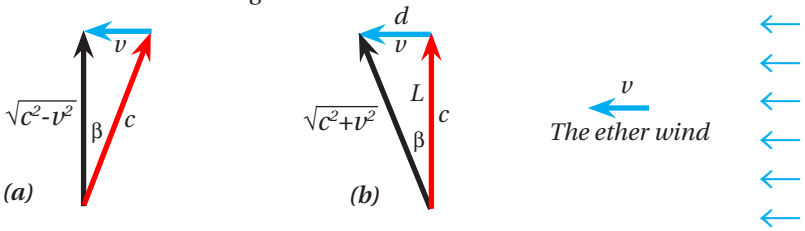


Figure 40

Following the above mechanical properties of the ether, an experiment could be designed to detect the ether and measure the velocity of the earth through space in a very simple way.

On a platform in a laboratory *(Fig. 41)*, a pencil beam of light is projected in the opposite direction of the ether wind which would reduce the velocity of the light beam to *c-v*, but it will not change its direction of travel.

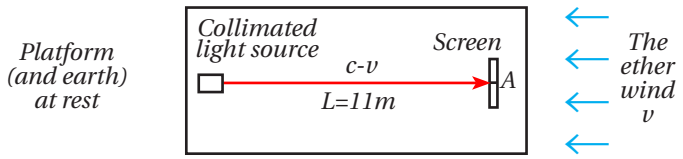


Figure 41

The platform is now rotated 90⁰ counterclockwise so that the ether wind is acting broadside against the beam.

When the platform is rotated 90⁰, no changes or "tweaking" of any kind would be done to the setup. Only the ether wind can change the direction of the light beam.

Platform (and earth) at rest

Ether wind acting broadside against the beam

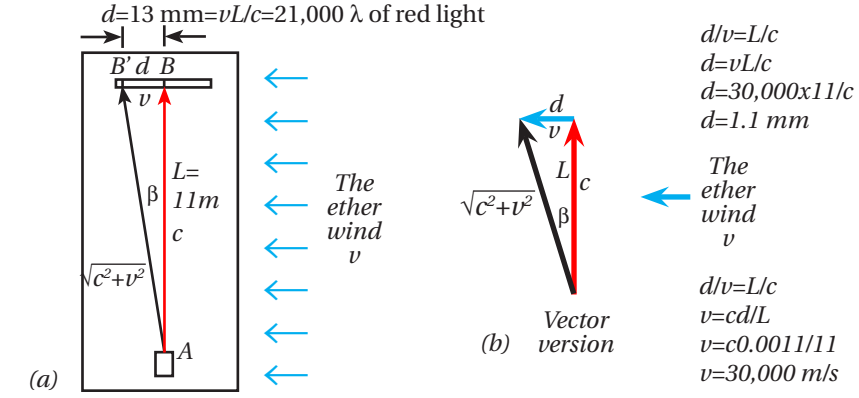


Figure 42

The light beam with its initial direction along AB and the ether wind form a right triangle of velocities. The ether wind is acting broadside against the light beam and would displace it to the left so that it travels along the hypotenuse of the right triangle ABB' at velocity $\sqrt{c^2+v^2}$ that has *plus* sign in the square root.

The magnitude of the beam displacement *d* could have enabled us to prove the existence of the ether and enable us to determine the velocity of the earth through space. If the displacement *d* were 1.3 mm, the speed of the earth through space would be 30,000 m/s. If *d* were 13.2 mm, the speed of the earth would be about 360,000 m/s, the same speed as determined by COBE satellite experiment.

Because the above beam and the ether-wind interaction is identical to the interaction of the parallel beam and the ether wind when the interferometer in the MM experiment is rotated 90⁰, and because the beam in *Figure 42* must travel at velocity $\sqrt{c^2+v^2}$, and in time *L/c*, this experiment provides an incontestable proof of the errors in Michelson's calculations of the vertical time in his experiment.

Conclusion

The proofs presented in this paper show that, according to the mechanical characteristics of the ether (as understood by Michelson, Lorentz, Eddington and explained in practically every physics textbook), the total vertical time in the MM experiment, as calculated by these physicists, cannot be $2L/c\sqrt{1-u^2/c^2}$ but it must remain $2L/c$ regardless of the speed of the earth and regardless of whether or not the ether wind is acting in the experiment. They also prove that the calculations of the vertical time in the MM experiment done by Michelson, Lorentz, Eddington, Feynman and many other physicists is incorrect and that a major error of enormous consequences was made in the interpretation of this experiment.

The new drawing of the MM experiment, drawn according to the mechanical characteristics of the ether *(Fig. 32)*, shows here for the first time, that not only would the beams reunite at the beamsplitter at different times than originally calculated by Michelson in 1887, the vertical beam would be displaced 2.2 mm from the predicted rendezvous point with the parallel beam at the beamsplitter.

Referring to the MM experiment, Einstein wrote: *"This was the first path which led me to the special theory of relativity."* [5] However, he did not notice the error in the interpretation of the MM experiment or the error in the magnitude of Lorentz's contraction needed to explain the null results of this experiment. Einstein incorporated Lorentz's theory of contractions, his theory of the slowing of time with speed and his transformation equations, now known as Lorentz-Einstein transformation equations, into his theory of relativity. In other words, considering the consequences the MM experiment had produced, the theory of relativity emerged from one of the greatest errors in the history of science.

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[3] Dorothy Michelson Livingston, *The Master of Light*, Charles Scribner's Sons, NY, 1997, p. 77.

[4] Richard Feynman, *Lectures on Physics*, Allan Wydle, Reading, MA, 1963, Vol. 1, p.15.3.

[5] Albert Einstein, *How I Created the Theory of Relativity*, Physics Today, Vol., 8. p. 45-47