The Michelson-Morley experiment
(reviewed and explained)

Jean DAVID 2001

And why did Earth suddenly stop moving . . . . . .

INTRODUCTION

At the end of the XIXth century, we supposed that the light waves moved on an immaterial support called "ether". By analogy in elements transported by a fluid, the speed of light, more exactly photons which compose her(it), had to change as they went down or went back up the current created by the movement of the Earth.

In 1881, Albert Michelson began, in association with Edward Morley, an experiment, a real one this time, to determine the effect of this wind of ether on the speed of light. Their idea: measure this speed following 2 directions, the movement of the Earth on its orbit and the perpendicular direction in this one. They expected then to find different values of speed for every orientation. In fact, they noticed that the measures were identical whatever is the direction of the beams. The Galilean combination of speeds did not seem to take place any more for light.

These results gave then reason to the theorists who advanced the idea of a speed of invariable light for every observer independently of the speed of movement of this one. To explain this " referential unchangingness ", Einstein proposed in its special theory of relativity the possibility of contraction or dilation of space and of time, renamed spatiotemporal continuum. Every observer possesses then his space-time which does not have absolute character anymore. The relation with the another referentiel is determined by their relative speed of movement. The conversion of coordinates from one to another is formulated by means of the coefficients of Lorentz.

But let us return to the experiment of Morley and Michelson. How did they realize these measures? Why don't several experiments realized later with more precision invalidate the results of the first days. Does the invariance of the various measures of the speed of light obtained really explain by the elasticated characteristic of time and of space?

I suggest you returning with me some years behind.

The interferometer

The precise measure of the speed of light turned out difficult because of its very important value. Compare the difference of speed between 2 beams demand some more of precision which no measuring device can give. On the other hand, we know that "by mixing" these same beams, we obtain detectable visual effects because of the difference of light phases due to the difference of distance of travel. A condition nevertheless: the coherence of the 2 beams in use.

The well-informed Michelson and Morley, for their famous experiment, based themselves on the principle of interference fringes obtained by the interaction of duplicated rays of light. But their device of test, the interferometer, has something particular. By a cunning set of mirrors, the 2 beams created from the same light source will go through practically perpendicular but same length routes before interacting on the arrival screen.

So in order to get two coherent beams of light, Michelson used in the center of its device a semi-transparent mirror positionned in 45° relative to the displacement of Earth. This mirror will deviate half of the original beam from the source towards the mirror M2 and will let the other half to go through it towards the mirror M1 placed behind. The distance L between the centre O of the semi-transparent mirror (called separator) and 2 mirrors M1, M2 is settled in a way that the 2 beams have the same round trip. Interference fringes appeared at the recombination of 2 beams of light in their arrival at Z.

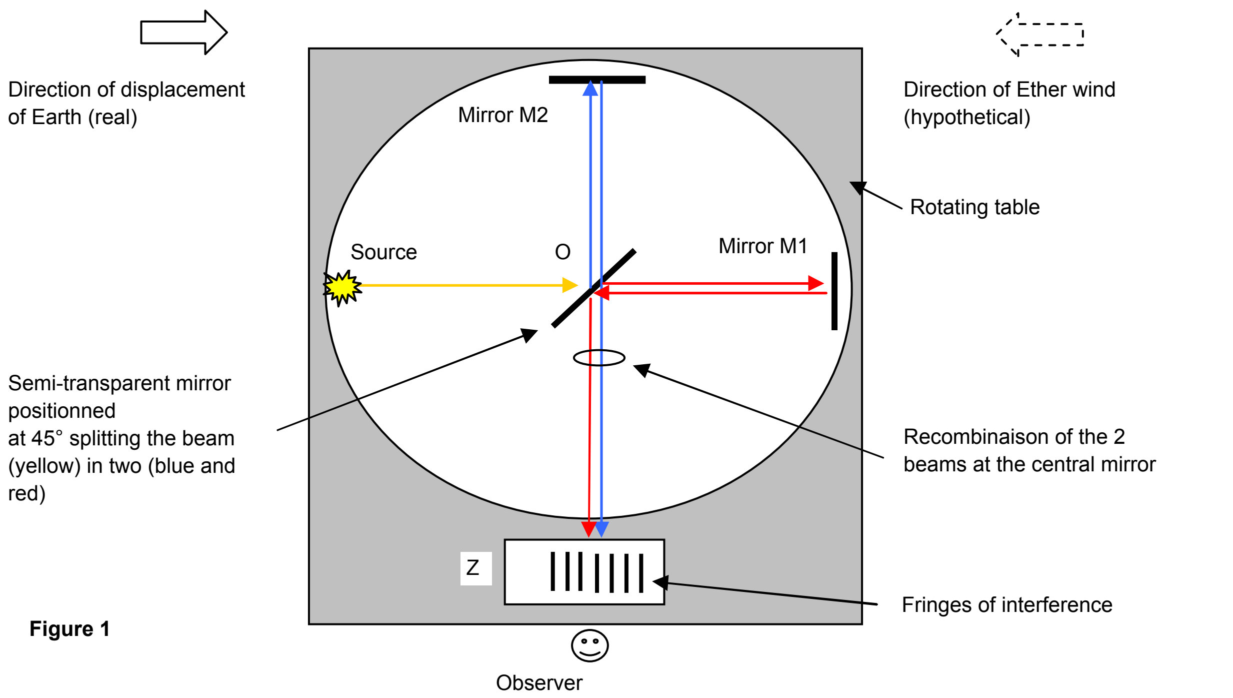


Figure 1

Because of the movement of the Earth, Michelson and Morley expected to notice a measurable change of the fringes when the whole device would be put in rotation, with regard to the mysterious current of ether, by 90 °, 180 ° or 270 °.

In their great surprise, fringes did not move as expected. Whatever the direction they oriented the device, both beams seemed to travel their way in the same speed. In spite of all the improvements of the conditions of measure, they had never been able to detect any influence of the movement of the Earth on the speed of light. It took place as if our Earth had stopped moving which, we all know, is false. Finally, we only conclude that ether does not exist and that the speed of light is the same for every observer, should he be moving or not relative to this light. But I suggest you to review in detail....

The Michelson and Morley experiment

And let us arise, as them, the question: how do the beams move after leaving the separator on their way to the mirrors and on their way back after reflection on mirrors M1 and M2?

A) First orientation (OM1 // direction of movement of the Earth):

During their way to the mirrors, these ones have moved with the movement of the Earth.
M1 moves away in front of the red beam.
M2 moves along but stays at the same distance of O, who also moved.
On the way back route, the separator gets closer to the red beam. The blue beam joins the point O without difference of route.

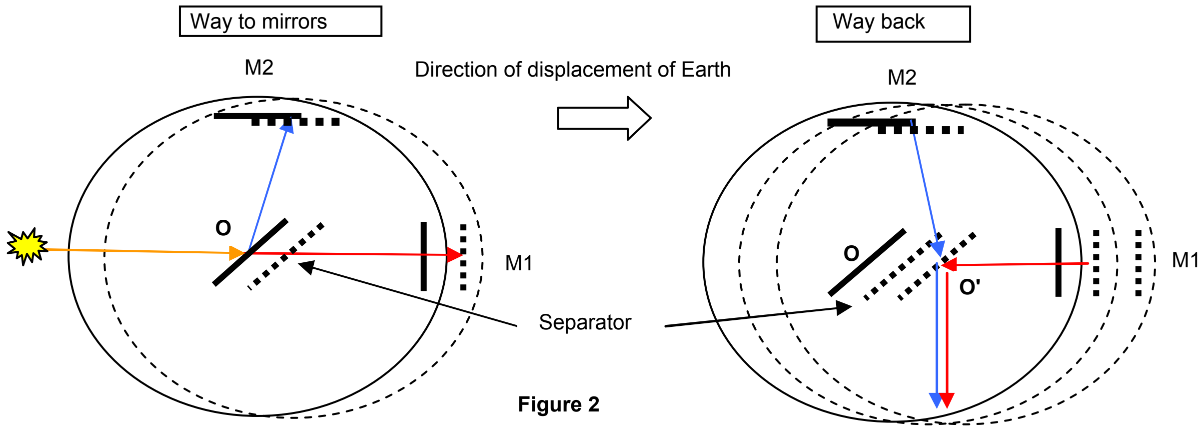


Figure 2

The red beam has a longer route than L
The blue beam travels the same distance in both ways.

The red beam has a shorter route than L

Let's calculate the travel time. Let L be the distance OM1 et OM2 and v the speed of Earth.

To reach mirror M1, the beam OM1 has to cover the distance L + vt1 (vt1 is the displacement of M1 during the time the red beam goes from O to M1, called time t1). We have then :

(1) $ct1 = L + vt1$ so $\mathbf{t1 = L / (c - v)}$

On the way back, the beam has to travel (L - vt2) before reaching O again. We have now :

(2) $ct2 = L - vt2$ so $\mathbf{t2 = L / (c + v)}$ (t2 is the time to travel back)

For the blue beam, travel times are determined as shown beside.

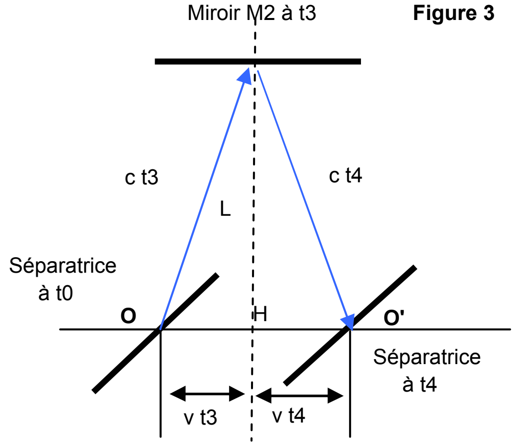


Figure 3

Way to mirror M2 :

(3) $(ct3)^2 = L^2 + (vt3)^2$
yields $\mathbf{t3 = L / \sqrt{(c^2 - v^2)}}$

Identically, we have for the way back :

(4) $(ct4)^2 = L^2 + (vt4)^2$
yields $\mathbf{t4 = L / \sqrt{(c^2 - v^2)}}$

Let's determine the overall travel time for these 2 beams.

We have :

(5) $TM1 = t1 + t2 = \mathbf{2\ L\ c\ /\ (c^2 - v^2)}$

and (6) $TM2 = t3 + t4 = \mathbf{2\ L\ c\ /} \sqrt{}\ \mathbf{(c^2 - v^2)}$

The ratio between these overall times is :

$TM1 / TM2 = \mathbf{1\ /} \sqrt{}\ \mathbf{(c^2 - v^2)}$

Is that reminding you something ? Of course, yes ! The famous coefficient by Lorentz !

But let's continue our investigation.

b) Second orientation (OM1 $\perp$ direction of earth moving**) by rotation of 90° :**

This time, it's the mirror M2 that is moving in front of the blue beam. M1 is now at the same position like the mirror M2 in the previous orientation.

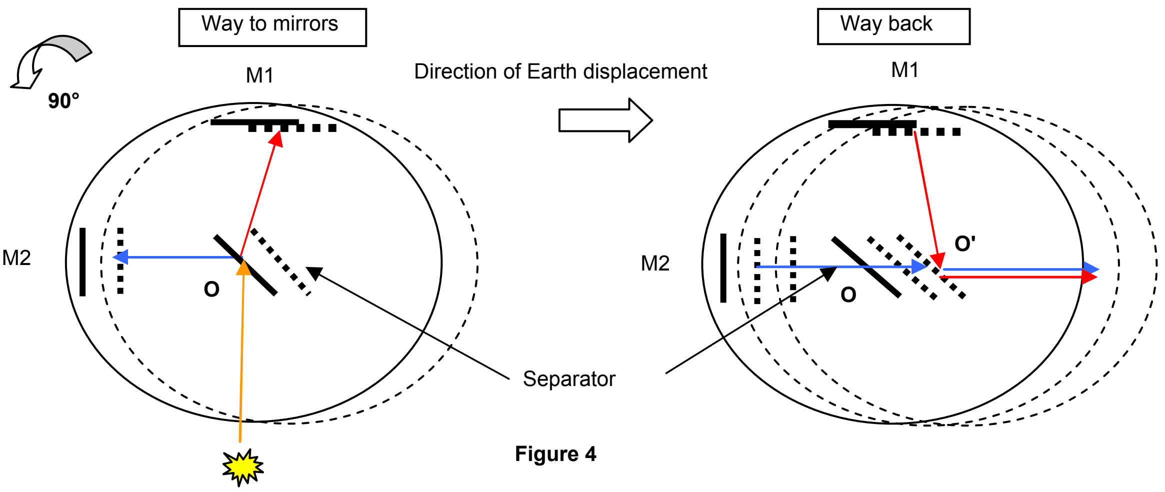


Figure 4

The blue beam is "accelerated" this way

The blue beam is "delayed" on the way back

The red beam covers the same distance, on the way to the mirror and the way back.

Total travel time for each beam is in this case :

(7) $TM1 = t1 + t2 = \mathbf{2\ L\ c\ /} \sqrt{}\ \mathbf{(c^2 - v^2)}$

and (8) $TM2 = t3 + t4 = \mathbf{2\ L\ c\ /\ (c^2 - v^2)}$

The ratio is now inverted :

$TM1 / TM2 = \sqrt{}\ (c^2 - v^2)$

After the 90° rotation, the light fringes did not almost move in spite of the variation of the ratio. Any valuable explanation?
If the fringes did not move when the device is rotated by 90°, it would mean that nothing has changed.
So, we have to conclude that there is equality of the two round trip distances. But how ?

And it is here that Mr Lorentz comes in ....

By taking into account that the speed of the light is constant, the relativistic argument to explain the equality of travel time for the 2 beams for these different orientations is that it should only be an effect of contraction of space in the same ratio in the axis of the movement of the Earth. This contraction will compensate for the difference of the distance on this direction with the route perpendicular to this one.

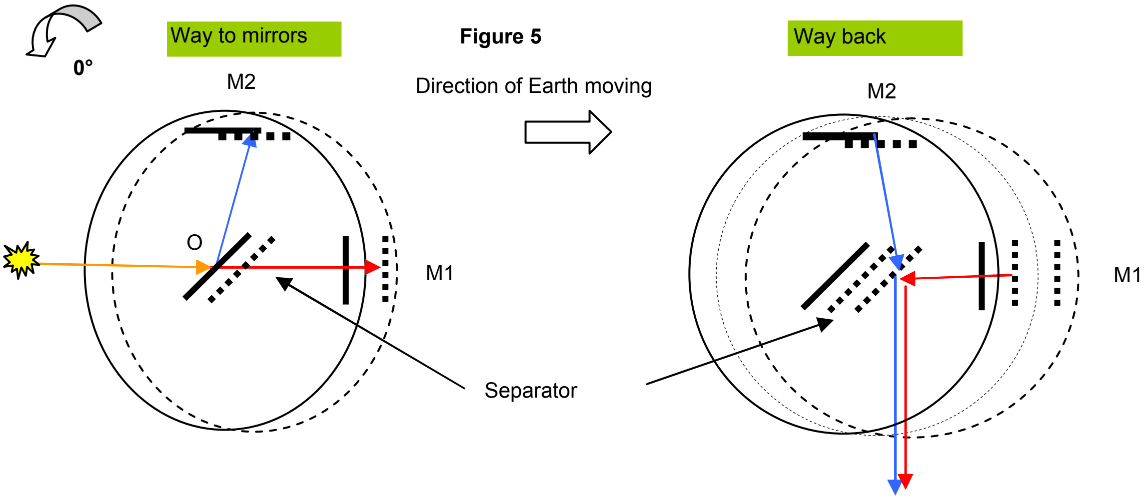


Figure 5

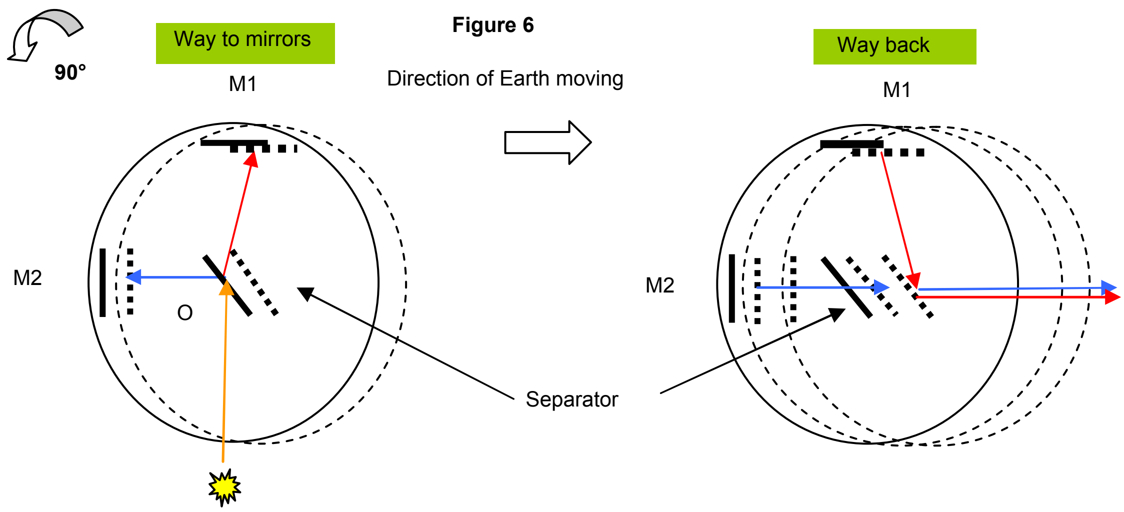
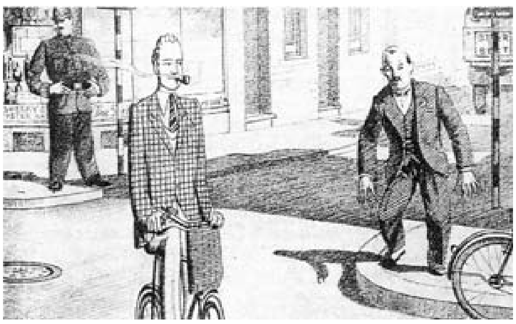


Figure 6

For a given observer (motionless by definition in his own referential), any object in movement undergoes a deformation (contraction) in the direction of its moving.

Elegant vision of things, is'nt it? But, as you suspected it certainly, I have ...

... another explanation.

Before proposing you another approach in what we called " the zero-result " of the experiment of Michelson-Morley, I am willing to make here some small reminders on the mode of propagation of light and its immediate consequences.

A) Propagation mode

- The light propagates in a straight line in the space (with or without ether, that is another problem). The characteristics of this straight line, that I shall call, below, the "**geodesic line**" of the beam, are fixed in a absolute manner in space at the time of the generation of the ray of light. It passes by the position of the source and that of the target at the moment of the emission.

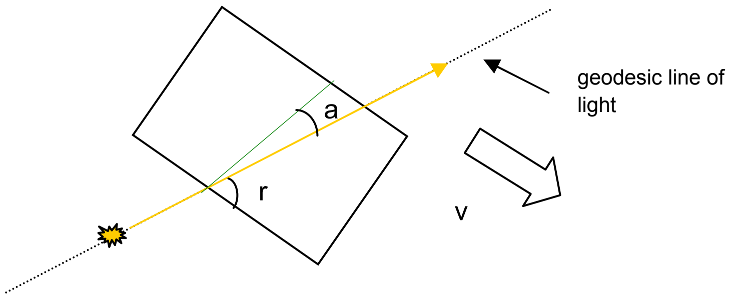
- It is independent from the movement and from the future of the source which generated it.

- Its speed in the space is considered as the superior limit speed of the objects of the Universe. Its value is important (300.000 km/s) but fixed. Its propagation from a location to another one in space is not instantaneous. Thus during the time of its moving, objects may move, too.

B) Immediate consequences

1 - As its speed is not infinite, its absolute trajectory seen from a mobile referential is a straigth line affected by a deviation towards the back of the direction of the movement. But you should not especially forget that the true trajectory of photons is its geodesic line of propagation.

Figure 7



The value of this deviation depends on the crossing angle which is formed by the geodesic line with the direction of the movement.

For an crossing angle r , we have:

$$\mathbf{a = arcsin (v.sin\ r / \sqrt{(v^2 + c^2 - 2\ vc.cos\ r)})}$$

The maximal angle of deviation, for r = 90°, is equal to :

$$\mathbf{a_{max} = arctan (v / c)}$$

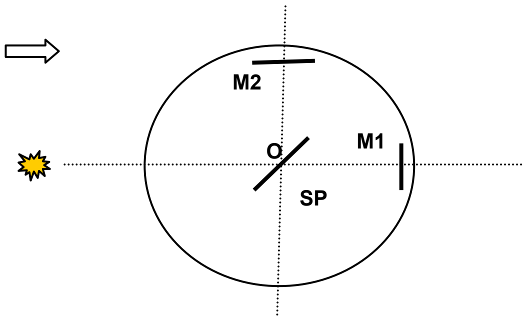
ex : The maximal deviation for the movement of the Earth (km/s 30) around the sun is about 20 second of arc.

2 - As the geodesic line of light constitutes a absolute reference in local space, by measuring the angle of deviation, we can deduct the proper speed of a system, conversely in what thought Galilee. I think that relativity creates a false symmetry of the real movements. The deviation will allow us to wipe out the ambiguity and to palliate the deficiency of our senses.

Studies of the routes of the beams through the mobile mirrors

To pass in the global study of the interferometer of Michelson-Morley, we have to know the exact route of the beams in the device conceived by these scholars. This one consists of a set of mirrors positioned at different angles with regard to the direction of movement of the Earth. As the device has to be rotated over 360°, their interaction with a beam of light depends on the orientation angle (r) which the device presents relative to this axis. By arbitrary choice, the angle r is equal to 0 ° when the axis OM1 is directed as below.

Direction of moving Earth



SP : separator at 45°
M1, M2 : miroirs

OM1 = OM2 = L

Figure 8

N.B. : We have 2 perpendicular lines OM1 and OM2. Whatever the movement of mirrors will be, let me insist that all the interactions will happen along these lines.

For the understanding of the final result, I prefer to detail the progress of beams from the moment they depart from the point O of the separator towards each mirror (way to mirrors) then from the points of reflection of every mirror towards the central mirror called SP (way back).

I noted t1, t2 respectively the time to go to the mirror M1 and back (axis OM1) and t3, t4 for the axis OM2. The respective round trip time for OM1 and OM2 will be noted TM1 (t1+t2) and TM2 (t3+t4). You will see that, because of the particular construction of the device (mirrors M1 and M2 perpendicular one to another and mirror SP at 45°), it was easy to me to deduct the formulae of calculation by using some simple trigonometric functions.

You will notice that I shall not mention in my presentations about hypothetical movement of ether which is here outside comment. Only the movement of the components of the device due to the Earth displacement during the propagation of the light beams and their interaction with the geodesic lines will allow me to reach the final goal: to show why Michelson and Morley were not able to notice movements of fringes when the interferometer was subjected to a rotation with regard to an initial position.

For that purpose, let us begin by following ....

The beams on their routes ....

Thus let us see some particular cases of interactions of a beam of light with each mirror individually for r = 0 °. Then let us generalize the formulas for any angle r.

1) Interaction with the mirror M1 (way to mirror)

After the separation at O, centre of SP mirror, the red beam have go through the distance OM1. The geodesic line OM1 constitutes the only absolute path of progressing. As the mirror moved during this time (t1) from M1 to M1 ', the red beam had to cover an additional distance equals to v.t1, v being the speed of the Earth. The total distance is then L + vt1, L being the distance of the arm OM1.

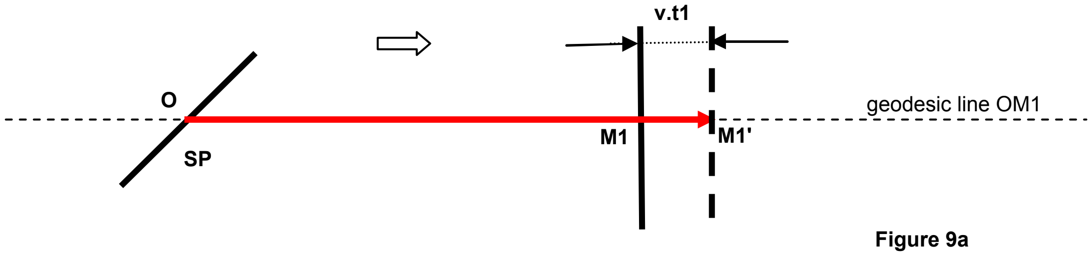


Figure 9a

We have : **t1 = L / (v - c)** for r = 0°

If we rotate the device by r, the mirror has moved a distance equals to v.t1 but the impact point located at the intersection of the geodesic and the mirror is now the point M1". We have to calculate the additional distance to be covered by the beam before reaching the mirror M1. It equals v.t1.cos r.

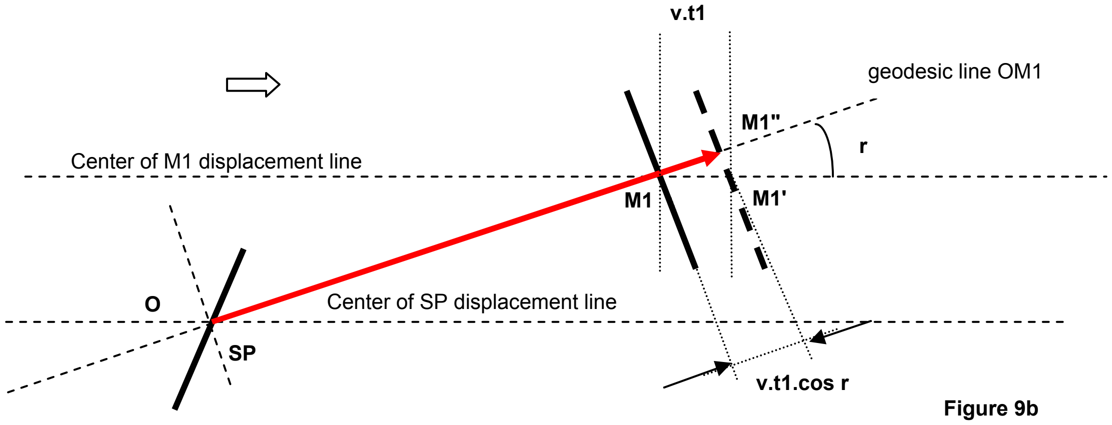


Figure 9b

The total distance is then L + v.t1.cos r.

We can yield the time t1 for the beam to reach M1.

c.t1 = L + v . t1 . cos r c = speed of light

then :

t1 = L / (c - v . COS r)

Let's see that the beam on its way to the mirror M1 has a perpendicular incidence when it reaches the impact point M1". The optical path backway will always be the geodesic path OM1.

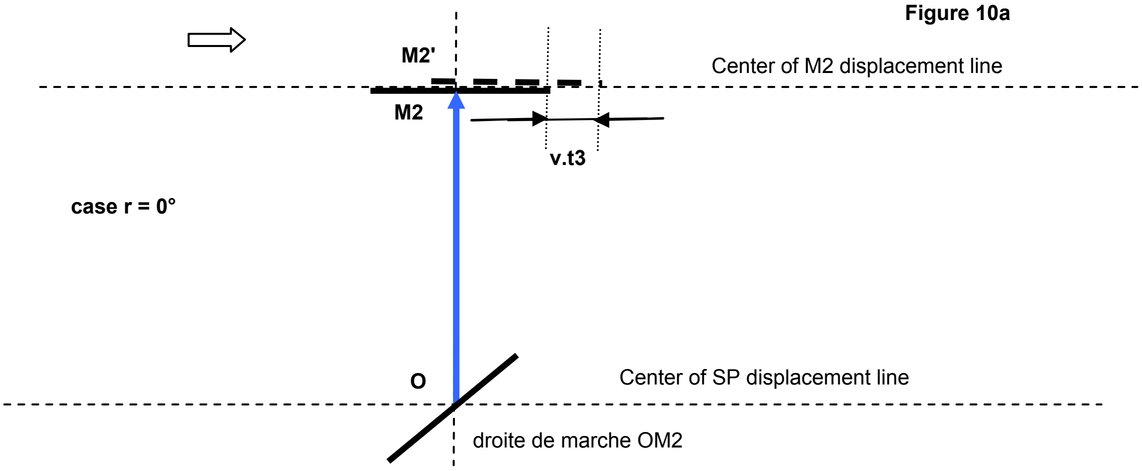
Thus, first difference with the path model, that I will call "incline path", used by the relativists.
But let's go on with the mirror M2.

2) Interactionwith the mirror M2 (way to mirrors)

After the separation at O, center of the central mirror SP, the beam is reflected at 90°. The geodesic path OM2 constitutes the only absolute way of light propagation. As the mirror moved a distance of v.t3, the intersection with the geodesic path is point M2'. In case r=0°, the distance to be gone through to reach the mirror is L (OM2 = OM2'). The correponding time t3 is then :

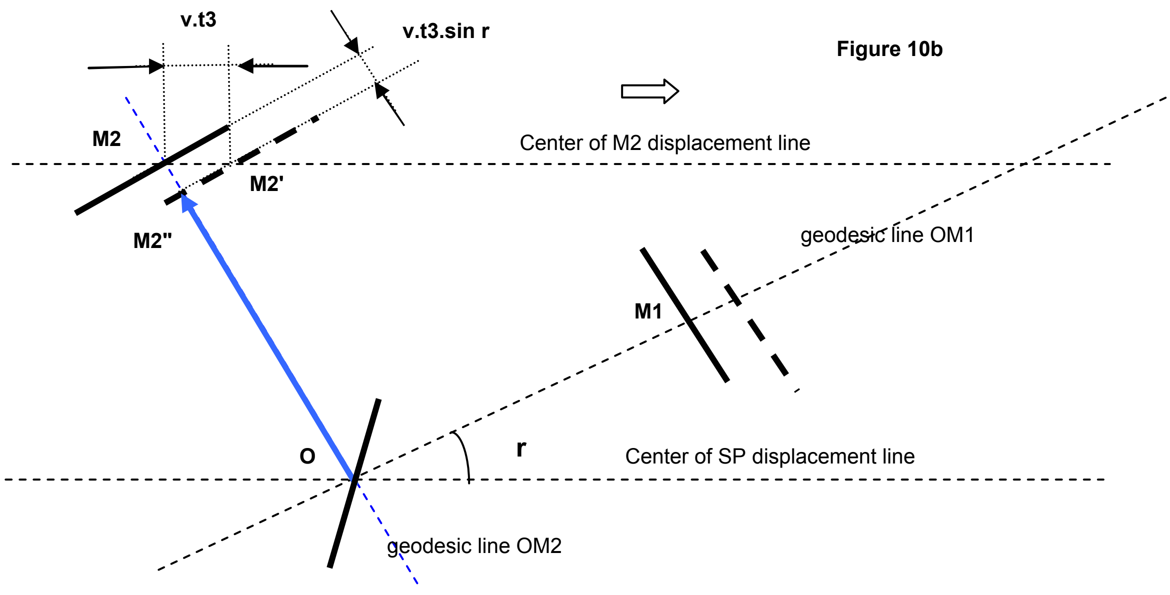
$$t3 = L / c \qquad (r = 0°)$$

Figure 10a



Let's rotate the device by r degrees. The mirror M2 moved a distance of v.t3 and the intersection point with the geodesic line OM2 is M2". The beam has a shorter distance to cover to reach the mirror M2. The distance M2M2" is equal to v.t3.sin r.

Figure 10b



The total distance to reach the mirror M2 is then : L - v.t3.sin r

We have : $c.t3 = L - v . t3 . \sin r$

so, time t3 to reach the mirror M2 : **t3 = L / (c + v . SIN r)**

Don't forget that the light path for the way back is the line OM2. (same remark as for M1)

3) Interaction with central mirror SP (way back from M1)

While the beam is on its way to M1, the separator mirror has moved vt1 ahead. After the impact at M1' with an incidence of 90°, the beam is reflected back but it keeps following the original geodesic path OM1. M1' became the source point. At its impact on the mirror SP, this one will have advanced a distance of v(t1+t2). In case r=0°, the distance covered by the beam is equal to OM1' minus the displacement of SP (OO") during t1+t2. We can write down :

$$ct2 = (L + vt1) - v(t1+t2) = L - vt2$$

The time for wayback travel is then equal to :

$$\mathbf{t2 = L / (c + v)}$$

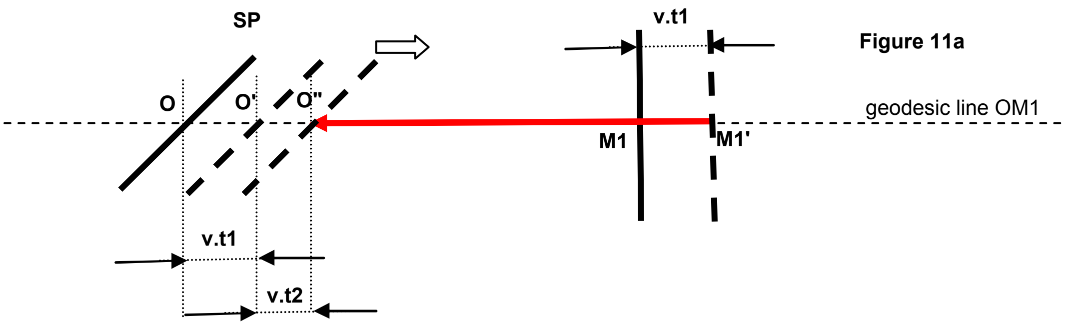


Figure 11a

If the device is rotated by an angle r, the geodesic line OM1 (or M1"O) will intercept the positions of SP at time t=t1 at O' and at time t= t1+t2 at O".

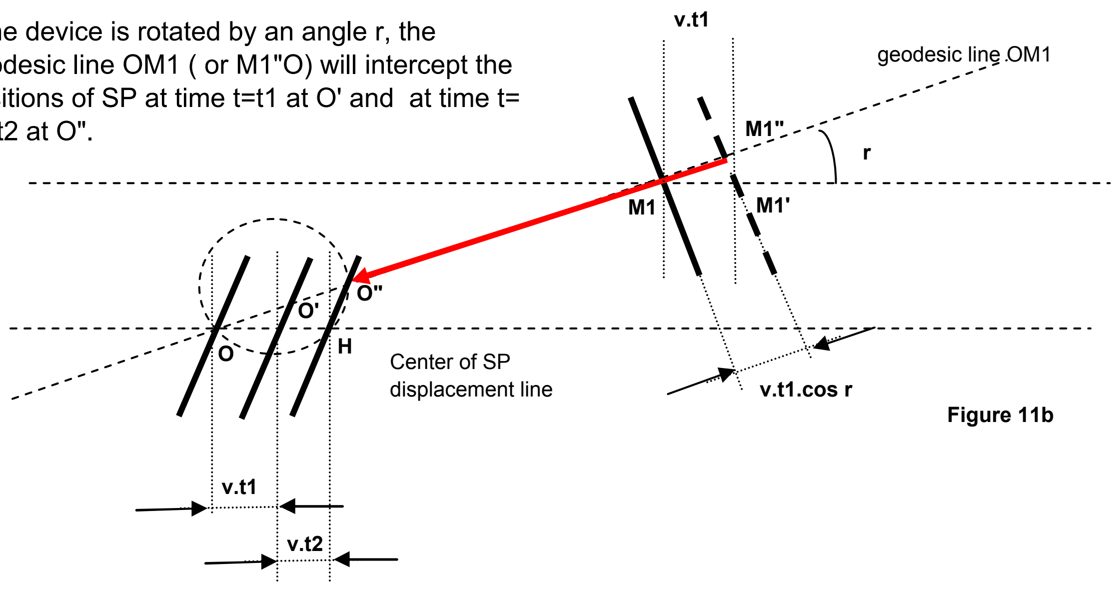


Figure 11b

You can demonstrate that the distance OO" is equal to **v.(t1+t2).(sin r+ cos r)** [cf. Annex A]
The locus of the impact point O" on the miroir SP is a cercle going through the summits of a square of OH side, H is the position of the center of SP at time t= t1+t2.

The way back is : $M1"O" = OM1" - OO" = (L + v.t1.\cos r) - v.(t1+t2).(\sin r + \cos r)$

We can deduct the value t2, time for the beam to cover M1"O" :

$$c.t2 = (L + v.t1.\cos r) - v.(t1+t2).(\sin r + \cos r)$$

or : **t2 = (L - v . t1 . SIN r) / (c + v . (SIN r + COS r))**

4) Interaction with central mirror SP (way back from M2)

While the beam is on its way to M2, the separator mirror has moved vt3 ahead. After the impact at M1' with an incidence of 90°, the beam is reflected back but it keeps following the original geodesic path OM2. M2' became the source point. At its impact on the mirror SP, this one will have advanced a distance of v(t3+t4).

In case r = 0°, the distance parcourue covered by the beam is equal to OM2' **plus** the displacement of SP (OO") during t3+t4 (OH = OO").

We can write :

ct4 = M2'O + OO" = L + v.(t3+t4) = L + v.t4 + v.t3

As t3 = L / c   (case r =0°)

ct4 = L + v.t4 + v.L / c

The tiem to go back t4 is equal to :

t4 = L (1 + v /c) / (c - v)

or :   **t4 = L (c + v) / c (c - v)**

Let's see the general case.

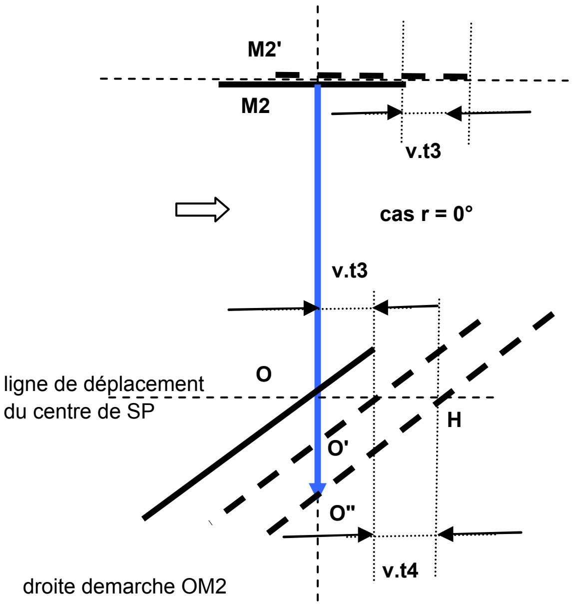


Figure 12a

Just like for mirror M1, the beam on its wayback don't reach the SP mirror at O because this one has moved v(t3+t4). The impact happens at O". The distance to cover is then M2"O + OO". For, by demonstration, OO" is equal to v(t3+t4)(sin r + cos r).

We have now : M2"O"" = (L - v.t3.sin r) + v.(t3 + t2).(sin r + cos r) = c.t4

It yields t4, for a given orientation angle r : **t4 = (L + v . t3 . COS r) / (c - v . (SIN r + COS r))**

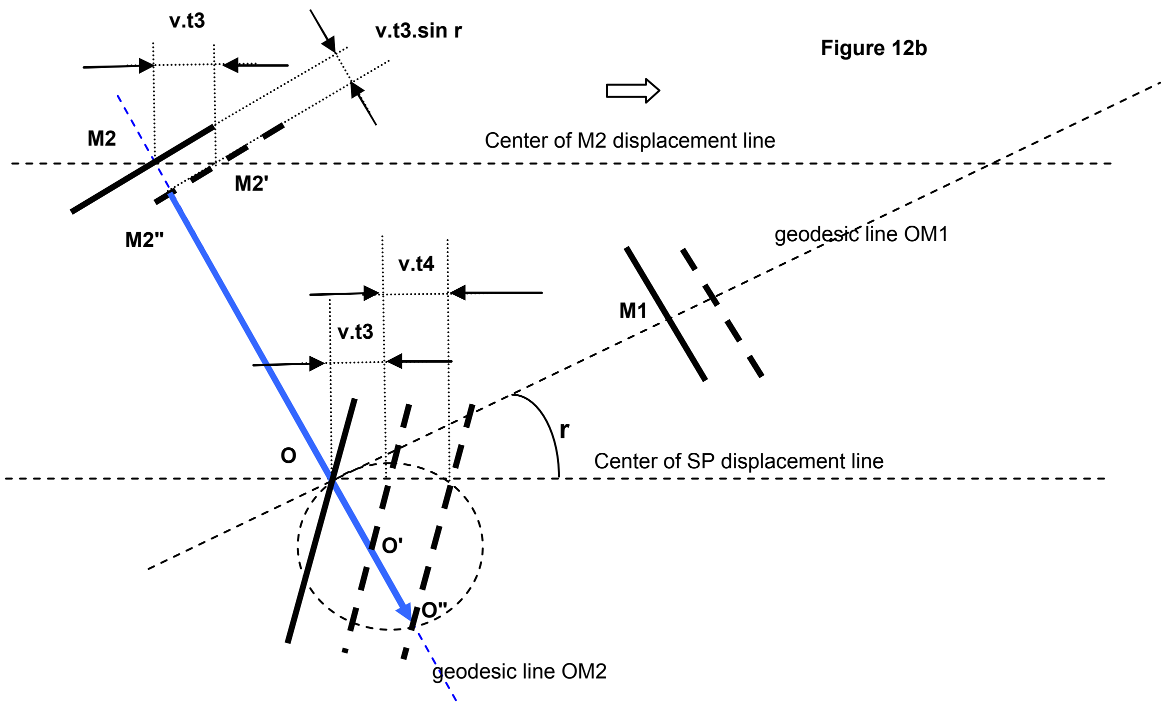


Figure 12b

Récapitulatif

For a given orientation angle r, the travel times of the beams are computed as below :

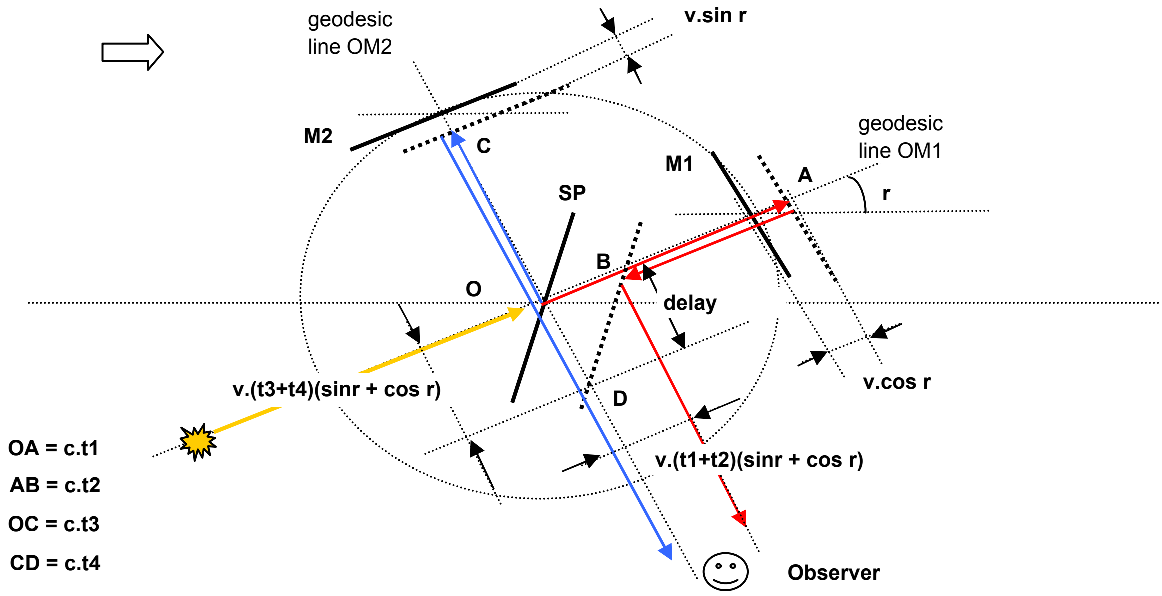
$t1 = L / (c - v . COS\ r)$

$t2 = (L - v . t1 . SIN\ r) / (c + v . (SIN\ r + COS\ r))$

$t3 = L / (c + v . SIN\ r)$

$t4 = (L + v . t3 . COS\ r) / (c - v . (SIN\ r + COS\ r))$

But before going on, let's see how those paths are schematized in the global device.



What can we remark ?
1) The beams stays perpendicular to the mirrors M1 et M2 for any value of r.
2) All the impacts of the beams (A, B, C, D) on the mirrors only happen along their geodesic lines.
3) We have an delay between the 2 beams at impact points B and D on the separator on the direction towards the observer.

Let's calculate t1+t2 and t3+t4 as a function of r. I gave L = 5 meters. This corresponds to the extent of Michelson's device. But we'll see that this value does not matter for the final result.

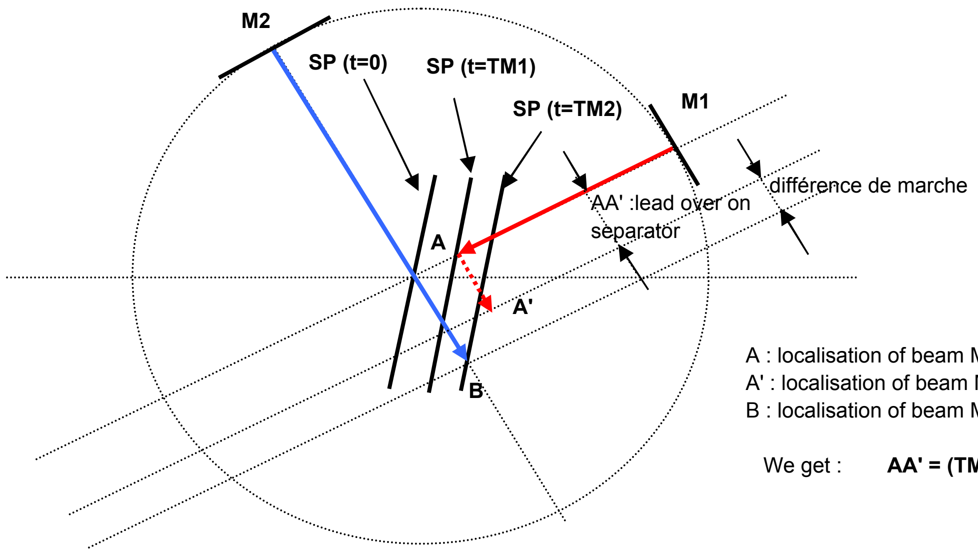
L (in m) = 5 v (in m/s) = 30000 c (in m/s) = 300000000

r (in °)	r (in rd)	t1	t2	t3	t4	TM1=t1+t2	TM2=t3+t4	TM1<TM2
0	0	1,6668E-08	1,6665E-08	1,66667E-08	1,667E-08	3,33333E-08	3,33367E-08	**yes**
45	0,785398163	1,6668E-08	1,66631E-08	1,66655E-08	1,66702E-08	3,3331E-08	3,33357E-08	**yes**
90	1,570796327	1,6667E-08	1,66633E-08	1,6665E-08	1,66683E-08	3,333E-08	3,33333E-08	**yes**
135	2,35619449	1,6665E-08	1,66655E-08	1,66655E-08	1,66655E-08	3,3331E-08	3,3331E-08	**no**
180	3,141592654	1,6665E-08	1,66683E-08	1,66667E-08	1,66633E-08	3,33333E-08	3,333E-08	**no**
225	3,926990817	1,6665E-08	1,66702E-08	1,66678E-08	1,66631E-08	3,33357E-08	3,3331E-08	**no**
270	4,71238898	1,6667E-08	1,667E-08	1,66683E-08	1,6665E-08	3,33367E-08	3,33333E-08	**no**
315	5,497787144	1,6668E-08	1,66678E-08	1,66678E-08	1,66678E-08	3,33357E-08	3,33357E-08	**no**
360	6,283185307	1,6668E-08	1,6665E-08	1,66667E-08	1,667E-08	3,33333E-08	3,33367E-08	**yes**

Lead over on separator

As seen in the table of values above, depending on the angle r applied to the device, the allover time TM1 can be lesser than TM2. This means that the beam going to and back from the mirror M1 will reach, in these cases, the separator before the beam on the M2 mirror. The M1 beam will have a lead over the M2 beam. The lead is equal to (TM2-TM1) times c. Do you still follow me ? Now, in order to obtain the difference between the 2 paths, we have to locate the positions of the front of the 2 beams at the same moment, haven't we? I have chosen arbitrarily the moment of impact of the backward beam, that is the longest time to reach the separator.

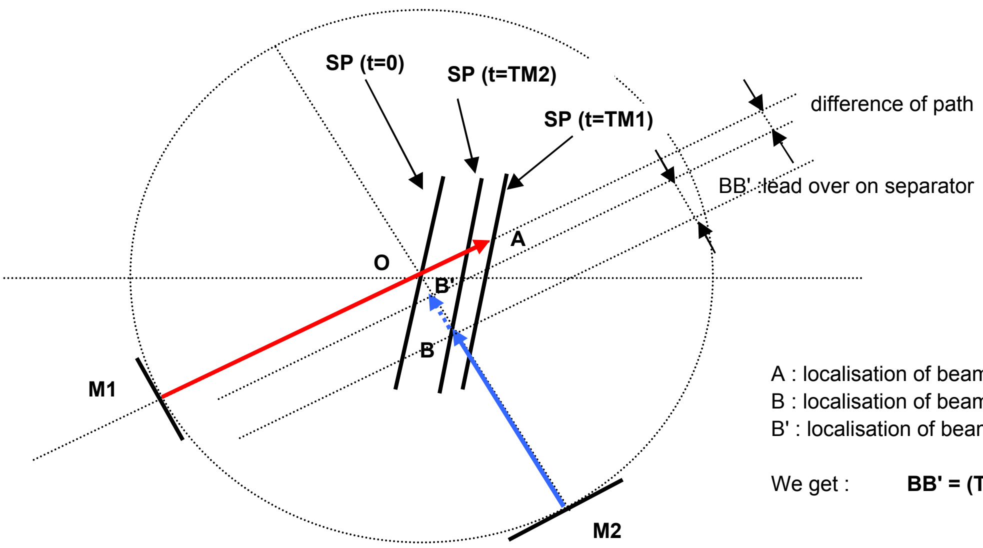
case TM2 > TM1 (0° < r < 90° and 315° < r < 360°)



A : localisation of beam M1 at t = TM1
A' : localisation of beam M1 at t = TM2
B : localisation of beam M2 at t = TM2

We get : **AA' = (TM2 - TM1) . c**

case TM1 > TM2 (135° < r < 315°)



A : localisation of beam M1 at t = TM1
B : localisation of beam M2 at t = TM2
B' : localisation of beam M2 at t = TM1

We get : **BB' = (TM1 - TM2) . c**

Final result

Let's calculate now the total path of the 2 beams :

a) for -45° < r < 135°
beam M1 path = TM1*c + lead AA' soit TM1*c + (TM2 - TM1)*c ou TM2*c = beam M2 path

b) for 135° < r < 315°
beam M2 path = TM1*c + lead BB' soit TM2*c + (TM1 - TM2)*c ou TM1*c = beam M1 path

We have equality for the 2 paths at any given angle r. Their difference is **ZERO**.

r (in °)	TM1=t1+t2	TM2=t3+t4	TM1-TM2	Lead AA'	Lead BB'	Global M1	Global M2	Difference
0	3,33333E-08	3,3337E-08	-3,33333E-12	0,001	0	10,0010001	10,0010001	**0**
45	3,3331E-08	3,3336E-08	-4,71405E-12	0,001414214	0	10,00070726	10,00070726	**0**
90	3,333E-08	3,3333E-08	-3,33333E-12	0,001	0	10,0000001	10,0000001	**0**
135	3,3331E-08	3,3331E-08	0	0	0	9,999292943	9,999292943	**0**
180	3,33333E-08	3,333E-08	3,33333E-12	0	0,001	10,0000001	10,0000001	**0**
225	3,33357E-08	3,3331E-08	4,71405E-12	0	0,001414214	10,00070726	10,00070726	**0**
270	3,33367E-08	3,3333E-08	3,33333E-12	0	0,001	10,0010001	10,0010001	**0**
315	3,33357E-08	3,3336E-08	0	0	0	10,00070716	10,00070716	**0**
360	3,33333E-08	3,3337E-08	-3,33333E-12	0,001	0	10,0010001	10,0010001	**0**

Let's have a look at the last column corresponding to the difference of the 2 paths.

The difference is ZERO for any given value of orientation angle r .

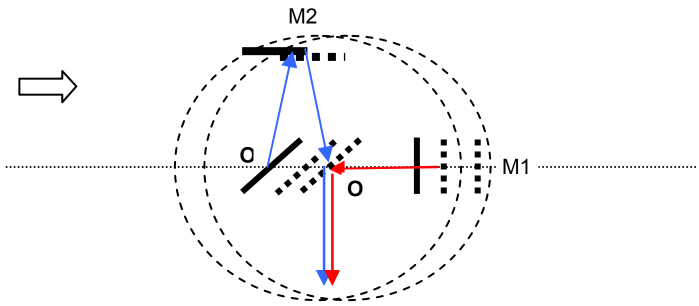
That may explain why Michelson and Morley had not been able to detect any change of the fringes in their interferometer. Because the global distances covered by the 2 beams are identical in length for any orientation of the device relative to the direction of movement of Earth.

Besides, ***the result is independent of the length of the interferometer arms and above all, it is independent of the speed of Earth*** . You can verify by changing L and v values.

Apparently, the Michelson interferometer does not allow us to detect any movement of Earth. Even if the perpendicular paths seem to be judiciously chosen to differentiate the effects, these ones are zeroed by the movement of the components of the device taken along with Earth..

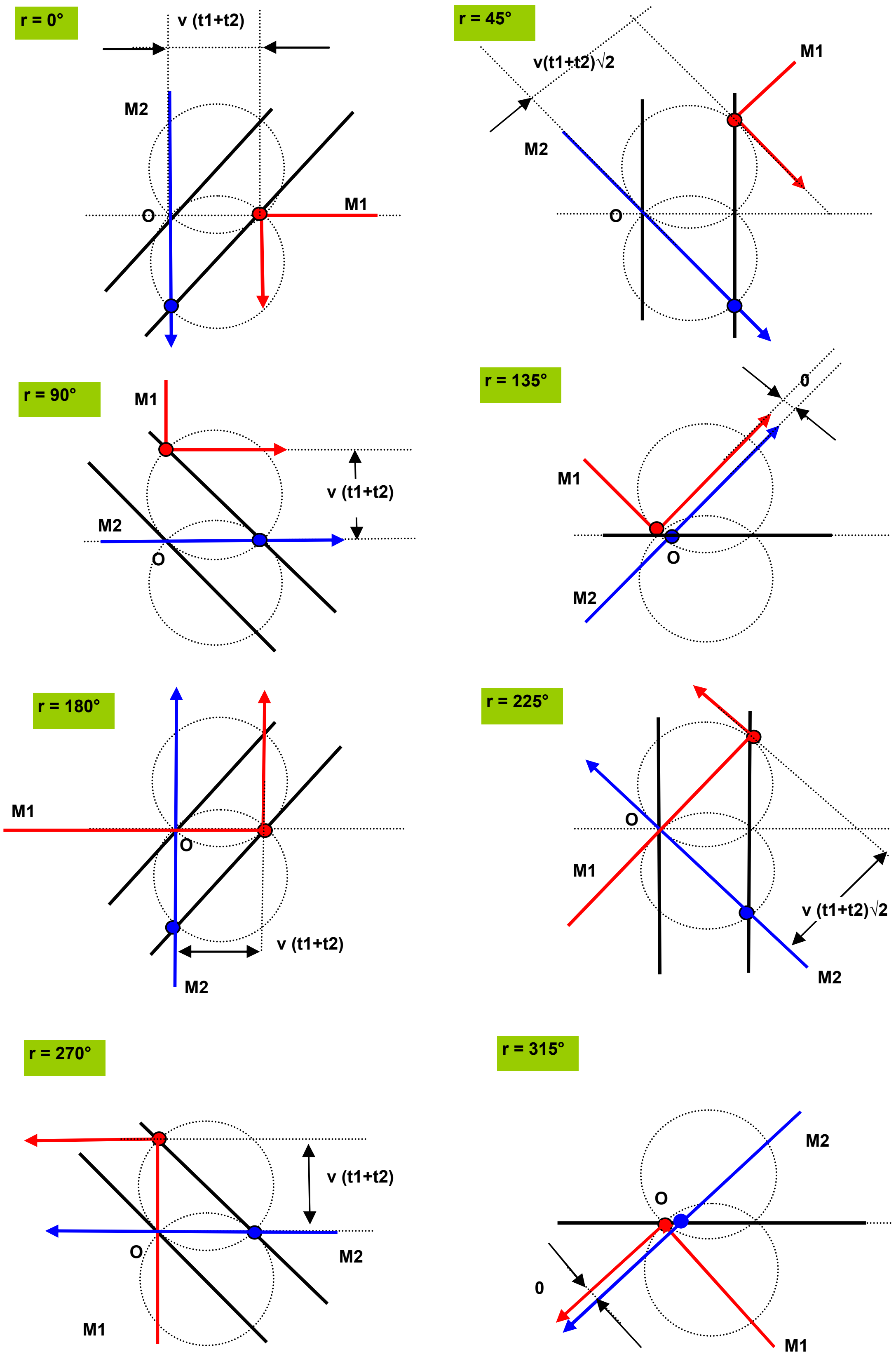
But if there is no difference between the 2 paths, why did Michelson still obtain interference fringes ?

If the beams really go "slantwise", and if the respective impacts are identical at O and if a space contraction effectively make the 2 beams to be aligned at the exit of the device, then there must not be any interference at all, must be it not?

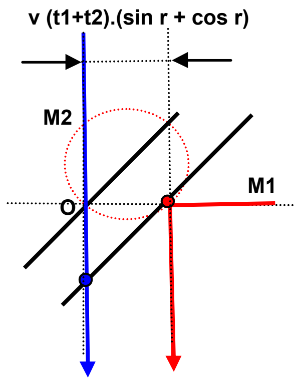


Why is there interferences ?

For that, let's look at some diagrams of the beam impacts on the separator.



We can see that, on their way to the interference screen, the beams are colinear but as their impact points on the separator are not identical, we have a variation of gap between these points depending on orientation angle r.



The locus of the impact points of the 2 beams (M1 and M2) on the separator SP, as a function of r, are circles going through O and with respective diameters : $v(t1+t2)\sqrt{2}$ et $v(t3+t4)\sqrt{2}$.

As the M2 beam always goes through point O, the gap with the M1 beam is the distance from O to a point on the locus circle of the impact points of M1 beam.

Its value is then : $\mathbf{e = v \cdot (t1 + t2) \cdot (\sin r + \cos r)}$

We have then interference fringes even from the 2 coherent beams because of this nonzero value gap. But those fringes must only change in proportion of this value.

Let's calculate the value of the interfringe i for a light with wavelength λ equal to 0,6 µm and a distance from point O to screen D = 5 m for differents values of r.

We have the relation :

$$\mathbf{i = \lambda . D / e} \qquad \text{with} \qquad e = v.(t1+t2).(\sin r + \cos r)$$

The speed of Earth can be deducted from the measured value of the interfringe i. We have :

$$\mathbf{v = \lambda . D / i.(t1+t2).(\sin r + \cos r)}$$

Values of i λ (in m) = 6,00E-07 et D (in m) = 5

r (in °)	r (in rd)	sinr+cosr	TM1 = t1+t2	e	i
0	0	1	3,33333E-08	0,001	3,00E-03
45	0,785398163	1,41421356	3,3331E-08	0,001414114	2,12E-03
90	1,570796327	1	3,333E-08	0,0009999	3,00E-03
135	2,35619449	0	3,3331E-08	0	
180	3,141592654	-1	3,33333E-08	-0,001	3,00E-03
225	3,926990817	-1,41421356	3,33357E-08	-0,00141431	2,12E-03
270	4,71238898	-1	3,33367E-08	-0,0010001	3,00E-03
315	5,497787144	0	3,33357E-08	0	
360	6,283185307	1	3,33333E-08	0,001	3,00E-03
					3,00E-03

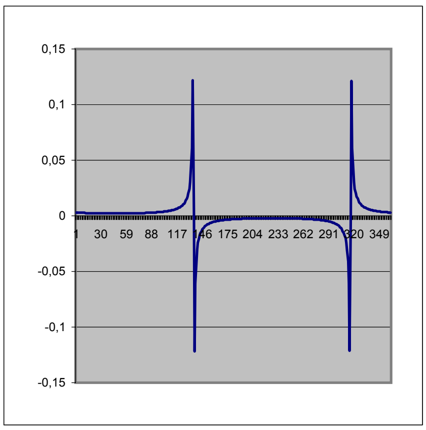
Δ i (0°, r)
r=90,180,270
3,00E-07
4,34E-19
3,00E-07
Moyenne = 2,00E-07

We can see that for positions 0°, 90°, 180° et 270°, the value of the interfringe is about 3 mm. The average variation of the interfringe is small (about 0,2 µm) that could explain the "null" result for Michelson.

Besides, **for the values of r = 135° and 315°, the 2 beams hit the same point O : there must be vanishing of the fringes.** Indeed, at these positions, the 2 mirrors M1 et M2 are situated symetrically relative to the axe of Earth movement. The effects of the Earth movement on the beams are identical for the 2 paths.

I know that this is a weak point in my explanation where I do not have any practical confirmation. If it appears that there is no vanishing of the fringes at these points, I must humbly admit the relativistic argument of an elastic universe. But a doubt is possible so I think that my point of view is worth exposing.

Variation of i (as a function of r)



Conclusion

The representation of the beam "slantwise", that you can find in the thought experience by Einstein, does not correspond with what I have learned in optical topics. But it allows relativistic theoricians to explain the difference between the 2 paths visually. The "null" result of Michelson experience could only be explained by using Lorentz's transformation. You can see that we can yield the same result if we apply the real light path (geodesic line) to the experience as as we used to do with traditional optical laws learned in school.

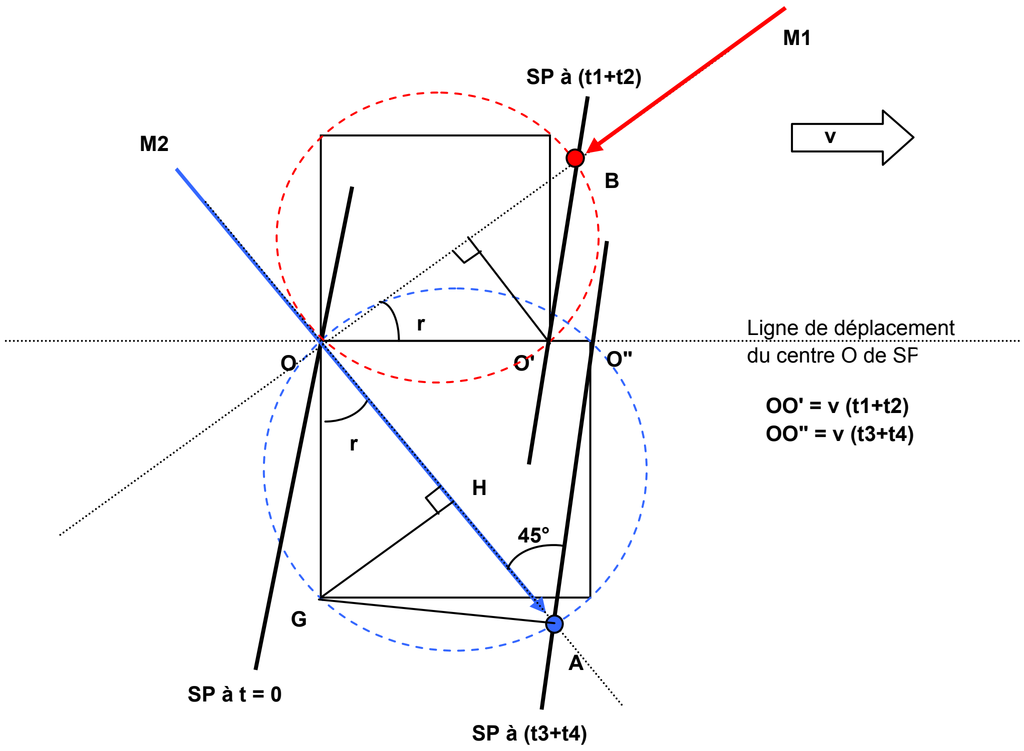
Next to what we have seen, the interferometer created by Michelson does not seem to allow the difference between the 2 optical paths. Anyway the orientation of the device is, the 2 beams will get out of it perfectly aligned. Besides, you can get interference fringes only if you have a gap betwwen the 2 impact points (Young's experience). This condition is not verified in the relativistic hypothesis of "slantwise" beams. If the Lorentz transformation reveals true, we must have then no interferences at all because of the unicity of the impact point.

What I can learn from above is that light speed is not independent from the observer movement, as Einstein said. For we admit that no objects can go faster than light, we know that our champion does not have an infinite value. As a consequence, speed addition and subtraction must be applied to light as for any moving object. The "null" result from Michelson and Morley's experience is a perfect verification.

Annex A

After reflexion on the mirrors M1 and M2, the 2 beams come back to the central mirror (separator). As the incidence angle is perpendicular to the mirrors by construction, the beams on their way back will follow the same path than the way to the mirrors.

Because of the movement of the separator, you can assimilate this wayback distance for one of the beam (blue) as a distance from O to the mirror ***plus*** a additional distance OA to reach the separator and for the other beam (red), as a distance from O to the mirror ***minus*** another distance OB.



The locus of the impact points of the beams M1 and M2 are circles that circumscribe the squares with sides equal respectively to v(t1+t2) et v(t3+t4) and going through O.

Let's project orthogonally the point G on the segment OA at H.

We have **OH/OG = cos r** and **GH/OG = sin r** with **OG = v(t3+t4)**

We have OAO" = 45° (by construction), the triangle HGA is isosceles. We get : HG = HA.

So, the distance OA = OH + HG = v(t3+t4).cos r + v(t3 + t4). sin r

then **OA = v(t3+t4)(sin r + cos r)**

We can get, in the same way, that :

OB = v(t1+t2)(sin r + cos r)

VERY IMPORTANT

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