"About Speed of Light in the Vacuum"

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Abstract

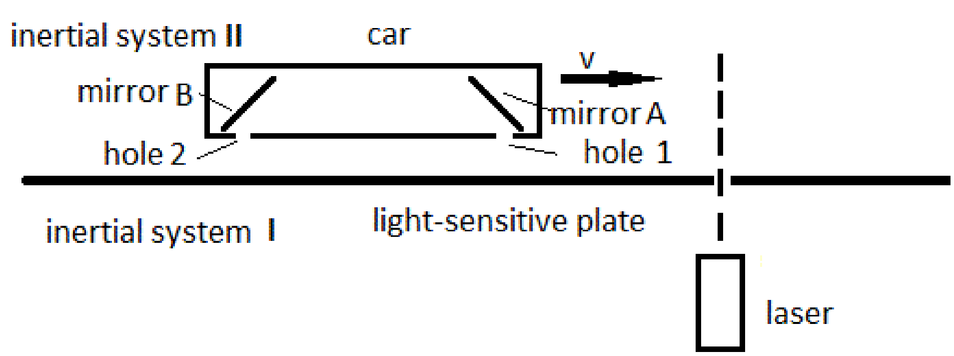
This article proves (in contrary to common belief) that light speed in vacuum is variable and not constant. Thus, the Michelson Morley experiment does not prove, that all inertial observers measuring the speed of light will get the same result. The proof is carried out by bringing to contradiction (reductio ad absurdum). The article assumes, that two inertial systems are equivalent, and the speed of light in each of them is constant and equal to *c*. Then, it is proved that it is impossible, and in one of them speed of light is different.

Initial Assumptions

We assume, that Michelson experiment was performed properly and resulting speed of light relative to the Earth (Michelson interferometer is stationary relative to the Earth) emitted by any source is equal to *c*. We also assume, that in inertial system moving relatively to Earth, the speed of that light is also constant and also equal to *c*.

Details of Experiment

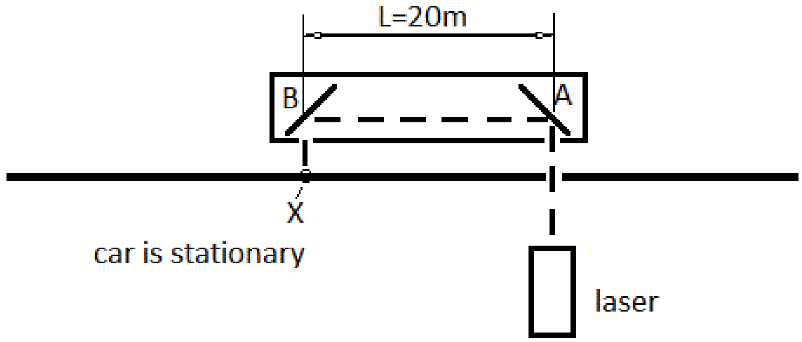
11We will examine two inertial systems. First system (I) is stationary relative to the Earth, and consists of laser and light-sensitive plate. Second system (II) consists of a car moving at a speed v relative to First system (I), and mirrors A and B that are located inside that car (Fig.1).



(Fig.1)

Car is closed (there are no windows) and is moving along the wall on which light-sensitive plate is placed. Inside the car is an observer. In the wall of the car are two small holes 1, 2, ø = 0.5mm spaced L = 20m. Laser is located behind the wall with light-sensitive plate, and the light emitted by it goes through a hole in the wall and plate to the other side. Laser beam is exactly perpendicular to that plate.

On Fig. 2 car is in such position, that laser light enters through the hole 1, is reflected from the mirror A, then it runs inside the car in direction of mirror B, parallel to the wall and plate, along the axis of car movement direction but with opposite vector. Next it reflects from mirror B, and exits the car through hole 2, marking the spot on light-sensitive plate (*X*). Path of laser light, together with surface of light-sensitive plate creates a rectangle, which shorter sides are extremely small. On all figures proportions are not maintained.



(Fig.2)

Description of Experiment

Observations made in System I:

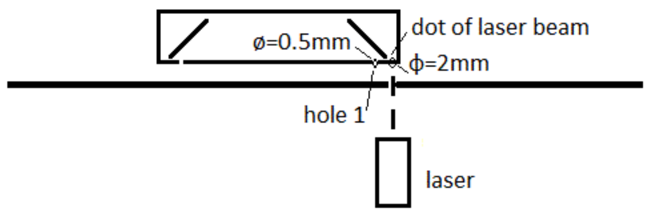
All measurements are made by a stationary observer in the system I. Assume that the car moves at a speed v = 0.01C (3000km/s). According to the Lorentz transformation and the Theory of Relativity such moving body is reduced/shortened (the distance between holes) $L_1 = L\sqrt{1-\left(\frac{v}{c}\right)^2}$

In our case this results to:

$$L_1=0.9999499987499*L=19.998999974999m.$$

We assume that L_1 = L = 20m (1mm shortening is omitted).
Lorentzian shortening is equal of about (L-L1) / L = ΔL / L = 0.00005

We consider the movement of a car. On Figure 3 we have shown spot of the laser light moving on the wall of the car at the speed –v (spot movement relative to a car). We assume that the spot has a diameter ϕ = 2 mm.



(Fig. 3)

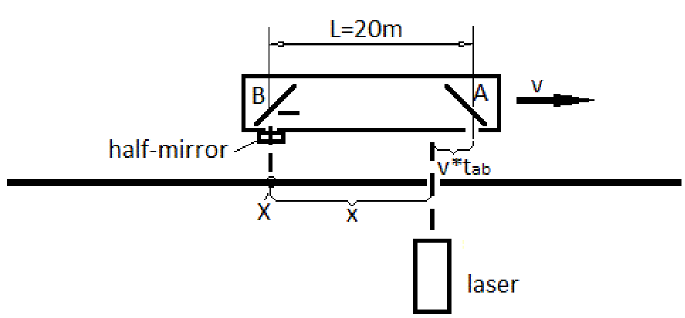
The time at which photons enter the hole 1 is (ϕ + ø) / v = Δt. It's the time during which circles with diameters ϕ and ø overlaps each other in any way. Last photon will enter the hole 1 after the time Δt from the moment first photon entered it. Thus, the first photon has already travelled road equal to: c * Δt = (ϕ + ø) * c/v = 100*2.5mm = 25cm. The resulting figure is the length of the beam of photons inside the vehicle. This length is shortened with increase of *v* (we consider the case where car is moving).

The time it takes for the beam of photons to travel from reflection point on mirror A, to reflection point on mirror B is equal to t_{ab}. The beam of photons with a length of 25cm needs to travel the distance of 20m. After reflecting from mirror B, photons will exit the car through hole 2 and irradiate spot (*X*) on light-sensitive plate.

It's easy to calculate that (*X*) will be in fact blurred over the plate, and the size of that blur will be of Δt*v = 2.5mm. The distance *x* measured from the laser (the hole in the plate) to *X* is:

$$x = c * t_{ab}.$$

During the t_{ab} car has moved by a distance of $v * t_{ab}$.
Now we will add half-mirror mounted in the hole 2 (see Fig. 4).



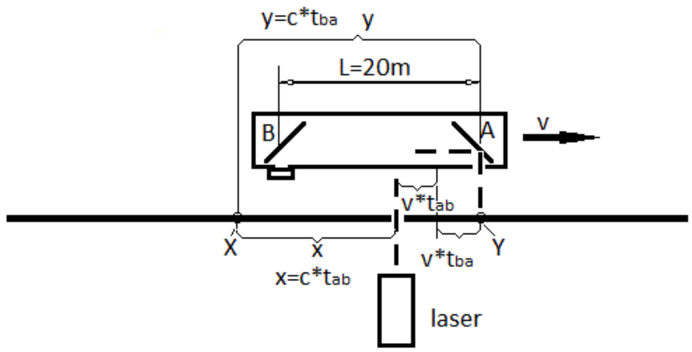
(Fig. 4)

Point *X* will be less irradiated ($^1/_2$ of photon beam) but it won't move. Other $^1/_2$ of photon beam will return and reflect from mirror B, then reflect from mirror A, and finally exit the car through hole 1 to irradiate the spot (*Y*) on light-sensitive plate. Distance between points (*X*) and (*Y*) (see Fig. 5) is equal to:

$$y = c * t_{ba} = x + (v * t_{ab}) + (v * t_{ba})$$

t_{ba} - time needed for photons to travel from reflection point on mirror B to reflection point on mirror A.

$v * t_{ba}$ - the distance by which the car will move (and thus the mirror A) while beam of photons will be returning from mirror B to mirror A



(Fig. 5)

We have the following equation:

$$(c * t_{ba}) = (c * t_{ab}) + (v * t_{ab}) + (v * t_{ba})$$

After ordering and dividing by sides we receive:

$$(c * t_{ba}) - (v * t_{ba}) = (c * t_{ab}) + (v * t_{ab})$$

$$t_{ba} / t_{ab} = (c + v) / (c - v) \qquad (1)$$

In the formula (1) there is no *L*, so it does not matter whether the moving object deforms (extends or shortens) or not, the ratio of the length of time t_{ba} / t_{ab} depends solely on changing *v*.

From (1) we can see, that when car is not moving ($v = 0$):

$$t_{ba} = t_{ab} \quad / \; v=0$$

and when car is in motion:

$$t_{ba} > t_{ab} \quad / \; v>0$$

because the numerator in (1) is $2v$ higher than the denominator. We will calculate now t_{ba} i t_{ab}. From (1) we receive:

$$t_{ba} = t_{ab}\frac{1.01c}{0.99c} = 1.020202\ldots * t_{ab} \qquad (2)$$

In the example, value of t_{ba} is about 2% greater than the value of time t_{ab}. If v would be $^{1}/_{3} * c$ (the speed of electrons in a color picture tube) t_{ba} would double the t_{ab}, which is an important difference. With v tending towards c, t_{ba} / t_{ab} goes to infinity. With properly selected v, t_{ba} is suitably longer from t_{ab}.

There is a relationship:

$$L = (c * t_{ab}) + (v * t_{ab}) \qquad \text{(see Fig. 4)}$$

After conversion we receive:

$$t_{ab} = L / (c + v) = 20m / (1.01 * c) = 19.801980198\ldots / c = 66.006600\ldots ns$$
$$x = 19.8019801980m$$

And from (2):

$$t_{ba} = 67.3400673400\ldots ns \quad y = 20.20202020m$$
$$t_{ba} - t_{ab} = 1.34ns \quad \text{thus, the difference between roads is:} \quad y\text{-}x=40cm$$

The transit time of a photon, from the mirror A to B is 1.34ns (i.e. 2%) shorter than the transit time of a photon from the mirror B to A.

Observations made in System II:

All measurements made by the observer inside the car (the inertial system II) will be distinguished with character '.

The observer in the car sees the photon beam entering the car through hole 1, reflecting from mirror A and moving towards mirror B. Then beam reflects from mirror B and disappears in hole 2 just to immediately return two times weaker (½ photon beam) and move the reverse way (reflecting from B, moving towards A, to reflect from it and disappear in hole 1 again). Distance between reflection points on the mirrors (and holes 1 and 2) is L '. In general, we assume that the results of measurements are not identical to the corresponding measurement results obtained by the observer in the inertial system I. Thus:

$$L' \neq L$$

Time of photon beams transition from A to B and from B to A is marked as t'_{ab} and t'_{ba}, and the speed of light measured by an observer is equal to:

$$c'_{ab} = L'/t'_{ab}$$
$$c'_{ba} = L'/t'_{ba}$$

Because we believe that the observer in system II as a result of the measurement will also receive a value equal to the speed of light *c*, we get dependency:

$$L'/t'_{ab} = c'_{ab} = c = c'_{ba} = L'/t'_{ba}$$

From the above equation it follows that:

$$t'_{ab} = t'_{ba}$$

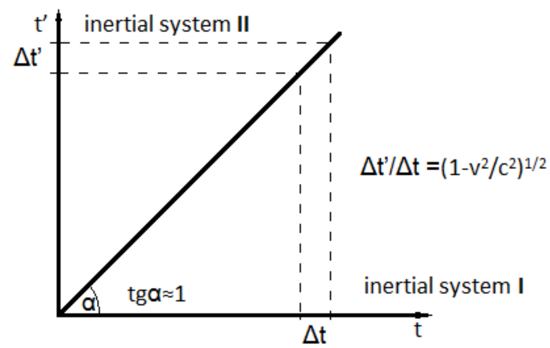
These are the times of photon beam travel, to which in first system (I) corresponds times t_{ab} and t_{ba}. **Both observers measure durations of the same phenomena using their own clocks (transition times of the same photons between the same mirrors).** In the above equations, there is no *v*. The observer in a second system (II), regardless of the size of *v*, has to measure times $t'_{ab} = t'_{ba}$ although their counterparts t_{ab} and t_{ba} may have different values of arbitrarily large proportion of dependent *v*. The ratio $t'_{ba} / t'_{ab} = 1$ regardless of the value of *v*, where the corresponding value for the time $t_{ba} / t_{ab} \rightarrow \infty$ with $v \rightarrow c$.

Let's consider the coordinate system, in which we describe the relationship of time in inertial system (II) of the passage of time in the inertial system (I). According to the Lorentz transformation, there is relationship describing the time dilation:

$$\Delta t' = \Delta t\sqrt{1-\left(\frac{v}{c}\right)^2} \qquad (3)$$

From the formula above, we can see that chart of the elapsed time in inertial system (II), depending on the time elapsed in inertial system (I) should be a straight line (Fig. 6). Formula

(3) has the same character as the formula for Lorentz contraction, and therefore, $\Delta t' / \Delta t = .9999499987499$. In practice, time in second inertial system has the same speed as in first inertial system.



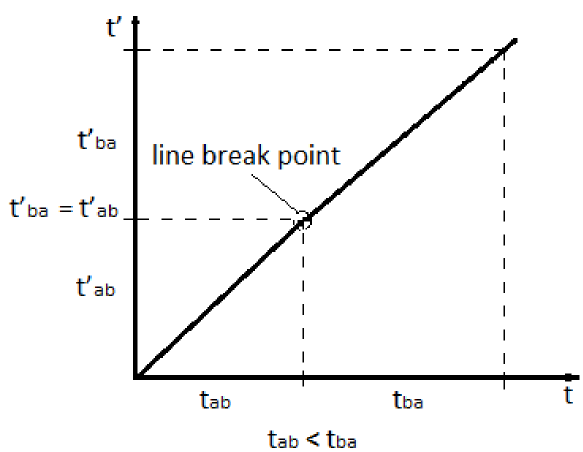
(Fig. 6)

Graph is inclined at angle α. $\frac{\Delta t'}{\Delta t} = \sqrt{1-\left(\frac{v}{c}\right)^2}$ $= tg\alpha \approx 1$

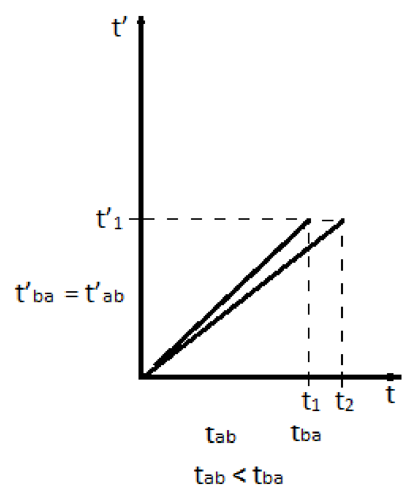
In our case, the dependence of the passage of time in a second inertial system (II) to the passage of time in the first inertial system (I) is not linear. We obtain the inequality:

$$t'_{ba}/t_{ba} < t'_{ab}/t_{ab}$$

($t_{ab} < t_{ba}$ and $t'_{ba} = t'_{ab}$) and on the plot we see broken line (Fig.7a)



(Fig. 7a)



(Fig.7b)

Chart can not be broken because it means that the unit of time elapsed in one inertial system, correspond to different passage of time in a second. Once this period may be shorter, and another time it may be longer. This relationship is random, because stretches of time t'_{ba} and t'_{ab} can be freely located on the time axis t', and to each other. On Figure 7b to one moment of time t'_1 correspond to two times t_1, t_2. (On Figure 7b proportions are not maintained - $t_{ba} = 1.02*t_{ab}$).

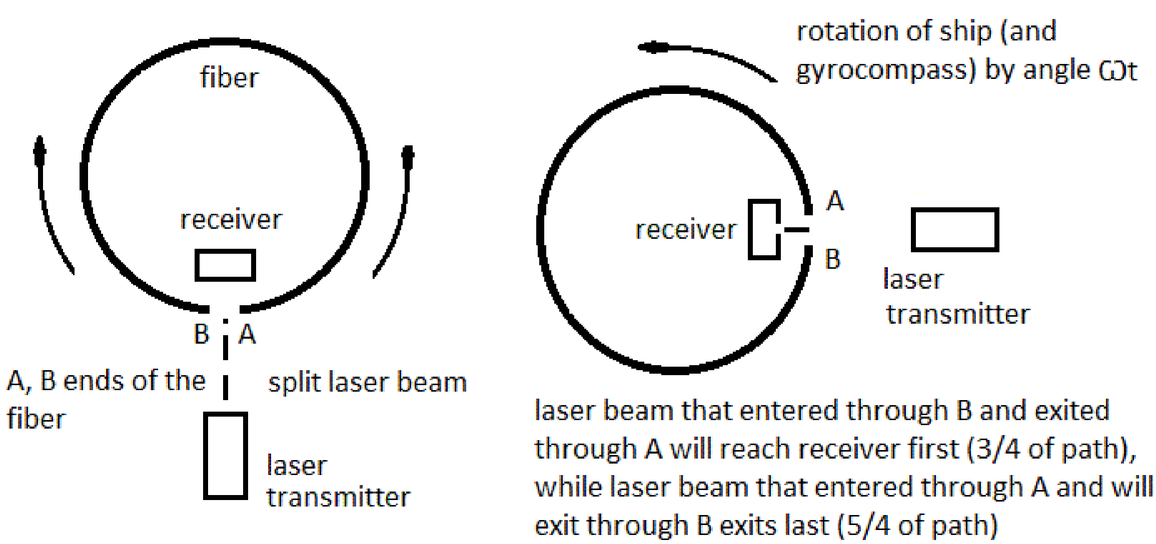
Experiment Conclusion

Observer in inertial system II (in moving car) won't be able to measure:

$$t'_{ba} = t'_{ab}$$

Therefore, $c'_{ba} \neq c'_{ab}$. At least one of the speeds of light c'_{ba} or c'_{ab} is different from c. If the speed of light near the Earth is fixed relative to the earth, it is not fixed to the small object moving relative to the earth, which is our car.

The fact that the speed of light is not constant was used by engineers in the construction of the fiber optic gyrocompass, although public believe is that it works due to Sagnac effect. Figure 8 shows the principle on which such compass works.



(Fig. 8)

Upon rotation (turning of the ship), ends of the fiber are moved, and one of the light beam reaches the end of the fiber with a delay, relative to the second beam of light travelling in the opposite direction.

Both laser beams are placed on the two ends of fiber at the same time. Based on the delay in reception of the beams at opposite ends of the fiber, steering angle in relation to the original course is calculated. The light travels at a constant speed relative to the Earth, but not to the source and the course of the photon. Fiber itself may be any reflective tube with vacuum in the middle.

Final Conclusion

In our reasoning we used the Lorentz transformation, which itself assumes a constant speed of light. If the speed of light is not constant, we must ask ourselves a question whether the transformation is correct? No, it is not. But this is not the topic of this article. What is important is the formula (3), which is correct (it needs to be proved). The nature of the formula (3) is linear (and it needs to have such characteristic). Only this formula is necessary to prove the reasoning. In the article, data have been chosen in such a way, that the result is a significant time difference $t_{ba} - t_{ab} = 1.34ns$ (and thus $(t_{ba} - t_{ab})/ t_{ab} \approx 2\%$) with minimal, negligible time dilation $(\Delta t - \Delta t')/\Delta t$ and Lorentzian shortening $\Delta L / L$ of the order of 0.05 ‰ (1mm shortening of section with a length of 20m). Thus, the mere Lorentz transformation does not play a major role. Correct derivation of the formula (3) and Lorentz transformation is the subject of another article devoted to the special theory of relativity.