Error in Michelson and Morley Experiment

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Michelson and Morley carried out an experiment in 1887 to determine if the theory of ether is correct. The experiment shows that the speed of light is constant in all directions. However, an error in this experiment was introduced by the calculation of the elapsed time for light to travel between two moving mirrors in the rest frame of ether. Both Michelson and Morley assumed that the speed of light is not altered upon reflection by a moving mirror. This critical error produced a small variation in the distance traveled by the light between mirrors in the rest frame of ether. As a result, Lorentz transformation was proposed to explain the concept of length contraction.

I. INTRODUCTION

In 1887, Michelson and Morley carried out an experiment to verify the existence of ether. The result was published in their paper,"On the Relative Motion of the Earth and the Luminiferous Ether"[1]. They assumed ether existed and proceeded to calculate the reflection of light in the rest frame of ether. They described the motion of laboratory in the rest frame of ether with such phrase, "velocity of the earth in its orbit".

With the whole laboratory moving through ether, the elapsed time for the light to move between two mirrors was calculated. However, unknown to Michelson and Morley, there was an error in their equations. The speed of the reflected light was incorrect. Both Michelson and Morley assumed that the reflected light moves as fast as the incident light. This is true in the rest frame of the laboratory but not true in the rest frame of ether.

The error introduced a discrepancy between the distances calculated in the rest frame of the laboratory and the rest frame of ether. Many physicists scrambled to interpret this new idea of length contraction. As a result, Lorentz transformation was proposed[2].

II. PROOF

A. Rotation Symmetry

In their experiment, all instruments are situated on a stone platform as described by Michelson and Morley in this description: "The stone a (fig. 5) is about 1.5 meter square and 0.3 meter thick. It rests on an annular wooden float bb, 1.5 meter outside diameter, 0.7 meter inside diameter, and 0.25 meter thick. The float rests on mercury contained in the cast-iron trough."

This stone platform rotates freely. All equipments on the stone platform are stationary relative to the rest frame of the stone platform. Consequently, rotation symmetry ensures that physics on this isolated stone platform in any orientation remains invariant. For example, total momentum will be conserved in any orientation of the stone platform. The interference pattern will also be conserved in all orientations of the stone platform. If ether exists and flows in certain direction, the effect of ether on certain orientation of this stone platform may be observable. However, no such effect was observed. The conclusion of this experiment was that there was no ether.

From the interference pattern, Michelson and Morley concluded that the speed of light is conserved in all orientations on this isolated stone platform. This is a direct property of rotation symmetry. Physics in an isolated system is independent of the external observers.

However, many physicists mistakenly interpret this conclusion to imply that the speed of light is also conserved in all reference frames.

B. Reflection From Moving Mirror

Upon finishing the measurement of the speed of light, the experiment proceeded to describe the reflection of light by a moving mirror in the rest frame of ether.

Both Michelson and Morley assumed that the speed of light remains invariant upon reflection. This is true only if the mirror is stationary relative to the light source. A moving mirror will change the speed of light upon reflection[3].

In 2018, Su discovered that the radio signal reflected by an approaching car will accelerate[4]. The frequency of the radio signal increases with the new speed[7]. Such frequency variation is used in radar speed gun to calculate the speed of approaching car.

In 2019, Su verified that the light reflected by an approaching mirror will also accelerate[3]. Let the mirror move at the speed of v relative to the rest frame of the light source. If the speed of the incident light normal to the mirror is c, then the speed of the reflected light, also normal to the mirror, will be c+2v[3].

The original equations[1] in Michelson-Morley experiment are shown below. Note that V is the velocity of light in the rest frame of ether. v is the speed of the earth in its orbit. The stone platform moves at the speed of v relative to the rest frame of ether.

T_1 is time light occupies to pass from a to c[1].

$$T_1 = \frac{D}{V - v} \tag{1}$$

T_2 is time light occupies to return from c to a, (fig. 2. in the original paper)[1].

$$T_2 = \frac{D}{V + v} \tag{2}$$

There is an error in equation (2). T_2 is calculated with a wrong value for the speed of reflected light. In the rest frame of the stone platform, the speed of light is invariant upon reflection. However, In the rest frame of ether, the speed of reflected light depends on the motion of the reflecting mirror[3].

With the correct value[3], V-2v, to replace the incorrect value, V, for the speed of the reflected light, the elapsed time for reflected light to travel between mirrors can be calculated correctly as

$$T_2 = \frac{D}{(V - 2v) + v} = \frac{D}{V - v} = T_1 \tag{3}$$

The total distance traveled by light in the rest frame of ether is

$$T_1 * V + T_2 * (V - 2v) = T_1 * (2V - 2v) \tag{4}$$

From equations (1,4),

$$T_1 * (2V - 2v) = \frac{D}{V - v}(2V - 2v) = 2D \tag{5}$$

The total distance traveled by light in the rest frame of the stone platform is

$$D + D = 2D \tag{6}$$

From equations (5,6), the distance traveled by the light is conserved in both rest frames. *The distance can not be contracted by the choice of reference frame.*

C. Elapsed time between Mirrors

From equation (3),

$$T_2 = T_1 \tag{7}$$

It takes the same amount of time for the light to travel between two moving mirrors in both directions in the rest frame of ether.

In the rest frame of the stone platform, the light always takes the same amount of time to travel between two stationary mirrors. This is the conservation of the elapsed time as discovered by Su in 2019[5], 2018[7], and 2017[8]. *The elapsed time is conserved in all reference frames.*

III. CONCLUSION

Rotation symmetry in the Michelson-Morley experiment incidentally allows many physicists to mistakenly believe that the speed of light is invariant in all inertial reference frames.

The speed of light is constant in every direction but only in the rest frame of the light emitter. Upon reflection by a moving mirror, light will travel at a different speed[3] with a different frequency[7]. The mirror will either accelerate or slow down the light. The speed of light depends on the reference frame.

The error in Michelson-Morley experiment resulted in the incorrect speculations of length contraction and the constant speed of light, both of which were adopted by the theory of special relativity[6]. The source of both speculations is Lorentz transformation which was proposed to explain the calculation error, length contraction.

Lorentz transformation claims that two simultaneous events can not be simultaneous in another inertial reference frame because of time dilation. *This is proved to be incorrect by the conservation of the elapsed time*[5]. If the elapsed time is zero in one inertial reference frame, it is also zero in another inertial reference frame. Two simultaneous events are always simultaneous in another reference frame.

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