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Experiment that invalidates the hypothesis that the reflection of light is a mechanical phenomenon

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Abstract: The purpose of this experiment is to verify the validity of the reflection of light as a mechanical phenomenon when the velocity of light is considered independent of its source velocity. The reflection of light as a mechanical phenomenon applied to the Michelson interferometer predicts zero or an undetectable fringe shift, but applied to the interferometer employed in this paper predicts a detectable fringe shift. The result of the experiment with this interferometer displays no fringe shift. Therefore, the result invalidates the reflection of light as a mechanical phenomenon when the velocity of light is considered independent of its source velocity.

1. Introduction

Reflection of light as a mechanical phenomenon applied to a particular Michelson interferometer [1], in which the beam splitter makes an angle of 45° with the direction of the rays from the source and one mirror is perpendicular and other one is parallel to this direction, respectively, predicts zero fringe shift. For this particular interferometer, the classical derivation predicts 4.00E–01 fringe shift.

Reflection of light as a mechanical phenomenon applied to the Michelson interferometer [2], for the same geometry of the light paths described by Michelson and Morley in their experiment, predicts 2.00E–05 fringe shift. Michelson and Morley predicts 4.00E–01 fringe shift for there experiment [3]. For high precision experiments, the geometry of this interferometer tends towards the geometry of the particular Michelson interferometer and the fringe shift tends towards zero.

The search result for an interferometer to predict a detectable fringe shift if the reflection of light is a mechanical phenomenon is given in this paper.

Sections 2 and 3 present the interferometer under test and derive the expected fringe shift of the experiment. Section 4 applies the result of sections 2 and 3 to the interferometer with the purpose of detecting Earth's revolution around the Sun and Earth's rotation around its axis.

2. Derivation of the light paths at the initial position of the interferometer

The drawings in this section present an interferometer consisting of two opaque and two semitransparent mirrors and a source of coherent light belonging to an inertial frame that travels at speed v. Figure 1 illustrates the interferometer as seen at the initial position, in the inertial frame. The following drawings depict different instances of the light paths in the fixed frame.

The speed of light in the fixed frame from its stationary source is the constant c. The wavelength of light is λ.

The rays of light are shown in red. The vectors of velocity v are shown blue at points of reflection.

As per the notations used in this study, points marked by a letter without an index correspond to the points as seen by an observer in the inertial frame. Points marked by a letter with an index are instances of inertial frame points in the fixed frame. Points with the same index belong to the same instance. The instances are not necessarily in time-sequential order.

2.1 Interferometer at the initial position in the inertial frame

In Figure 1, the source of light S emits parallel rays of light with velocity c in the opposite direction of velocity v of the inertial frame.

Points A, B, C and D are chosen on the beam splitter M_1, opaque mirror M_2, opaque mirror M_3, and beam splitter M_4, respectively, such that $ABCD$ is a square with a side length of L.

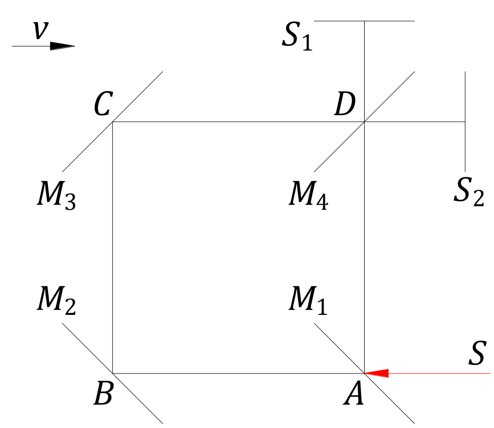

Figure 1. Interferometer as seen at the initial position in the inertial frame.

The rays of light from the source split on M_1. The rays that travel through M_1 are called transmitted rays and the rays directed toward beam splitter M_4 are called reflected rays. The transmitted and reflected rays interfere along their ways of interference from M_4 to screens S_1 and S_2.

2.2 Interferometer at the initial instance

Figure 2 depicts a ray from the source that splits at point E_1 on M_1 into the transmitted and reflected ray that interfere at point D of M_4. Point D is the chosen point at which the interference is studied.

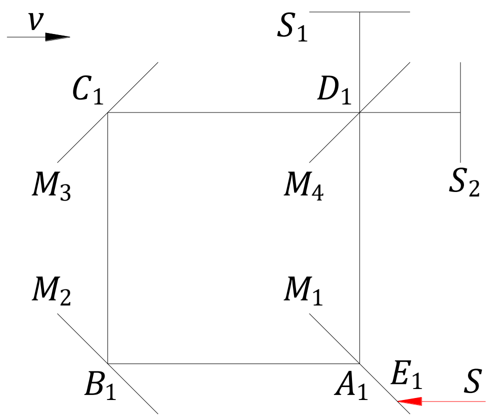

Figure 2. Interferometer at the initial instance.

2.3 Interferometer at the second instance

Figure 3 depicts the second instance when the reflected ray at E_1 is at point D_2 of M_4.

The speed of light in the fixed frame after reflection by a mirror is calculated by $c_{rf} = c_s + v\cos a + v\cos b$ [1], where c_s is the speed of light in the fixed frame from a source or a mirror, v is the speed of the inertial frame, angle a corresponds to the opposite direction of the incident ray, and angle b to the direction of the reflected ray. The direction of angles a and b are outward in space from the point of reflection. Angles a and b are measured counterclockwise from the direction of the velocity vector v with its origin at the point of reflection.

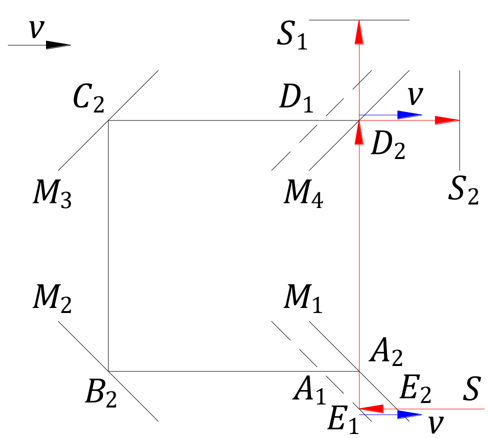

Figure 3. Interferometer at the second instance.

The speed of the reflected ray in the fixed frame along the path length E_1D_2 is $c_{rf1} =$

$c_s + v\cos a + v\cos b$, where c_s is the speed of light from the source c, angle a measured counterclockwise from the direction of the velocity vector v at E_1 to the opposite direction of the incident ray from the source is 0°, and angle b measured counterclockwise from the direction of the velocity vector v at E_1 to the direction of the reflected ray is 90°. Thus, the speed $c_{rf1} = c + v\cos 0° + v\cos 90° = c + v$.

In time t_1, M_1 travels from A_1 to point A_2 and M_4 from D_1 to D_2 with the speed v, and light travels from E_1 to D_2 with the speed $c_{rf1} = c + v$. The distance $A_2D_2 = L$. Time $t_1 = E_1D_2/c_{rf1} = (A_2D_2 + A_2E_1)/(c+v) = (L + A_2E_1)/(c+v)$.

From D_2, the ray of light travels to screen 1 with the speed $c_{rf1} = c + v$ and to screen 2 with the speed $c_{rfS2} = c_s + v\cos a + v\cos b$, where $c_s = c_{rf1} = c + v$, angle a measured counterclockwise from the direction of the velocity vector v at D_2 to the opposite direction of the incident ray from E_1 is 270°, and angle b measured counterclockwise from the direction of the velocity vector v at D_2 to the direction of the reflected ray is 0°. Thus, the speed $c_{rfS2} = (c+v) + v\cos 270° + v\cos 0° = c + 2v$.

2.4 Interferometer at the third instance

Figure 4 depicts the third instance when the light from E_1 is at point F_3 of M_2.

The speed of light in the fixed frame along the path length E_1F_3 is the speed of light from the source c. In time t_2, M_1 travels from A_1 to point A_3, E_1 to E_3 and M_2 from B_1 to point B_3 with the speed v, and the light travels from E_1 to F_3 with the speed from the source c. The distance $E_3F_3 = L$. It can be written that $E_1F_3 = E_3F_3 - E_1E_3 \quad \Rightarrow \quad ct_2 = L - vt_2 \quad \Rightarrow \quad t_2 = L/(c+v)$.

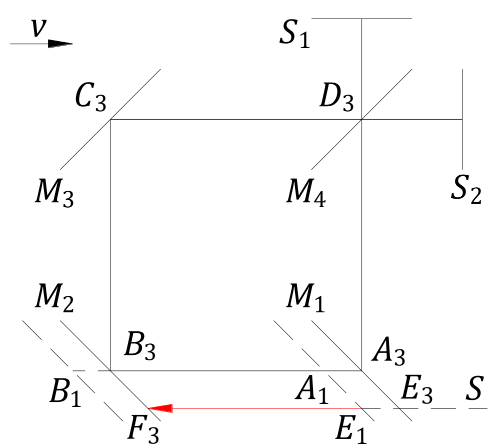

Figure 4. Interferometer at the third instance.

2.5 Interferometer at the forth instance

Figure 5 depicts the forth instance when the light reflected at F_3 is at point C_4 of M_3.

The speed of the reflected ray in the fixed frame along the path length F_3C_4 is $c_{rf3} = c_s + v\cos a + v\cos b$, where c_s is the speed of light from the source c, angle a measured counterclockwise from the direction of the velocity vector v at F_3 to the opposite direction of the incident ray from the source is 0°, and angle b measured counterclockwise from the direction of the velocity vector v at F_3 to the direction of the reflected ray is 90°. Thus, the speed $c_{rf3} = c + v\cos 0° + v\cos 90° = c + v$.

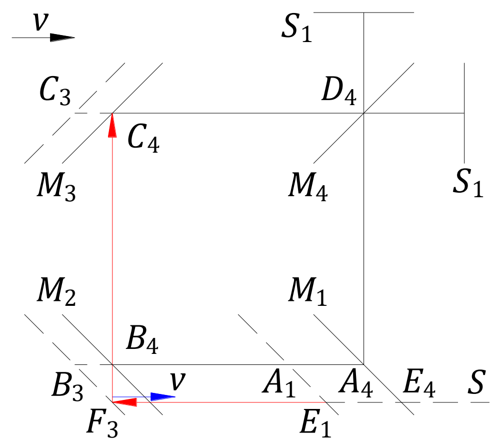

Figure 5. Interferometer at the forth instance.

In time t_3, M_2 travels from B_3 to B_4 and M_3 travels from C_3 to C_4 with the speed v, and light travels from F_3 to C_4 with the speed $c_{rf3} = c + v$. The distance $B_4C_4 = L$. Time $t_3 = F_3C_4/c_{rf3} = (B_4C_4 + B_4F_3)/(c + v) = (L + B_4F_3)/(c + v)$. The distance $B_4F_3 = A_2E_1$. Thus, time $t_3 = t_1$.

2.6 Interferometer at the fifth instance

Figure 6 depicts the fifth instance when the light reflected at C_4 is at point D_5 of M_4.

The speed of the reflected ray in the fixed frame along the path length C_4D_5 is $c_{rf4} = c_s + v\cos a + v\cos b$, where c_s is the speed of light from mirror M_3, $c_s = c_{rf3} = c + v$, angle a measured counterclockwise from the direction of the velocity vector v at C_4 to the opposite direction of the incident ray from the mirror M_3 is 270°, and angle b measured counterclockwise from the direction of the velocity vector v at C_4 to the direction of the reflected ray is 0°. Thus, the speed $c_{rf4} = c_{rf3} + v\cos 270° + v\cos 0° = (c + v) + v\cos 270° + v\cos 0° = c + 2v$.

In time t_4, M_3 travels from C_4 to C_5 and M_4 from D_4 to D_5 with the speed v, and light travels from C_4 to D_5 with the speed $c_{rf4} = c + 2v$. The distance $C_4D_4 = L$. It can be written that $C_4D_5 = C_4D_4 + D_4D_5 \Rightarrow (c + 2v)t_4 = L + vt_4 \Rightarrow t_4 = L/(c + v)$.

From point D_5, the ray of light travels to screen 2 with the speed $c_{rf4} = c + 2v$ and to screen 1 with the speed $c_{rfS1} = c_s + v\cos a + v\cos b$, where $c_s = c_{rf4} = c + 2v$, angle a measured counterclockwise from the direction of the velocity vector v at D_5 to the opposite direction of the incident ray from C_4 is 180°, and angle b measured counterclockwise from the direction of the velocity vector v at D_5 to the direction of the reflected ray is 90°. Thus, the speed $c_{rfS1} = (c + 2v) + v\cos 180° + v\cos 90° = c + v$.

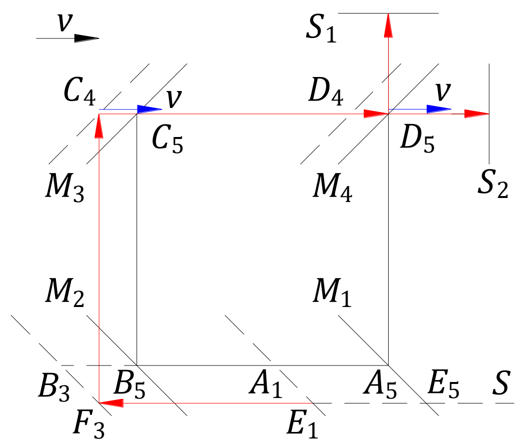

Figure 6. Interferometer at the fifth instance.

The speed $c_{rfS1} = c_{rf1} = c + v$ and $c_{rfS2} = c_{rf4} = c + 2v$, thus, the rays that interfere along the way to screen 1 and 2, respectively, have the same speed and interfere.

The difference of time of the transmitted and reflected rays $\Delta t_1 = t_2 + t_3 + t_4 - t_1 = t_2 + t_4 = L/(c+v) + L/(c+v) = 2L/(c+v)$.

3. Derivation of the light paths with the interferometer rotated 180° from its initial position

3.1 Interferometer at the initial instance

Figure 7 depicts a ray from the source that splits at point E_1 on M_1 into the transmitted and reflected ray that interfere at point D of M_4. Point D is the chosen point at which the interference is studied.

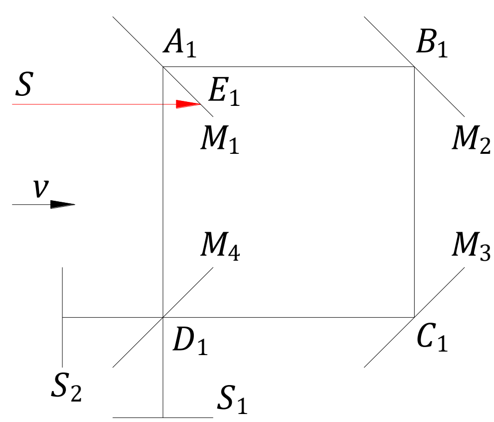

Figure 7. Interferometer at the initial instance.

With a similar reasoning as in section 2, the time for instances two through five are as follows: the time $t_3 = t_1$ and the time $t_2 = t_4 = L/(c-v)$.

The difference of time of the transmitted and reflected rays $\Delta t_2 = t_2 + t_3 + t_4 - t_1 = t_2 + t_4 = L/(c - v) + L/(c - v) = 2L/(c - v)$.

The difference of time $\Delta t_{12} = \Delta t_2 - \Delta t_1 = 2L/(c - v) - 2L/(c + v) = 2L(c + v - c + v)/(c^2 - v^2) = 4Lv/(c^2 - v^2)$, and the fringe shift $N_{12} = c\Delta t_{12}/\lambda$.

4. Experimental results

The experiments were performed for two geometries of the light paths on the same particle board base of 22″ x 48″; one geometry on the board at a time. The individual support of each mirror consists of wood parts glued together and then to the base. The mirrors can be adjustable within their wood support. The source of light has a circular cross section beam with adjustable divergent. The light from source is green with wavelength $\lambda = 532\ nm$.

4.1 First experimental geometry

First geometry looks for the Earth's revolution around the Sun.

The distance $AB = CD = L = 2$ ¾" $= 0.0698\ m$. This distance was chosen to be at minimum for the mirror dimensions of 2″ high x 3″ wide. The distance $AD = BC = 36" = 0.9144\ m$ does not affect the fringe shift and was chosen to be as long as possible such that the diameter size of the light beams that interfere to be as close as possible for a better interference image.

For $c = 3.00E + 08\ m/s$ and $v = 3.00E + 04\ m/s$, the difference of time $\Delta t_{12} = 4Lv/(c^2 - v^2) = 9.3133E - 14\ s$. The predicted fringe shift $N_{12} = c\Delta t_{12}/\lambda = 5.25E + 01$.

At rest, an insignificant continuous fringe shift was observed compared to the predicted 52.5 fringe shift. The experiment was performed at midday and midnight, but at random times as well, by rotating the interferometer 360°. The observed fringe shift by rotating the interferometer was definitely zero.

4.2 Second experimental geometry

Second geometry tried to put in evidence the Earth's rotation around its axis.

The distance $AB = CD = L = 11" = 0.2794\ m$. This distance was chosen to be at maximum allowed by experimental base to predict the highest fringe shift possible. The distance $AD = BC = 42" = 1.0668\ m$ does not affect the fringe shift and was chosen to be as long as possible the base permitted for a better interference image.

For $c = 3.00E + 08\ m/s$ and $v = 4.60E + 02\ m/s$, the difference of time $\Delta t_{12} = 4Lv/(c^2 - v^2) = 5.7122E - 15\ s$. The predicted fringe shift $N_{12} = c\Delta t_{12}/\lambda = 3.22E + 00$.

The experiment was performed at different times of the day and night by rotating the interferometer 360°. The observed fringe shift by rotating the interferometer was definitely zero as well.

5. Conclusion

The results of these two experiments, with the interferometer and derivations of the predicted fringe shift presented in this paper, invalidate that the reflection of light is a mechanical phenomenon when the velocity of light is considered independent of its source velocity.

References

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