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The Kinematics Theory of Balls and Light Applied to the Michelson Interferometer

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Abstract: The derivation of the light paths in interferometry involves the phenomena of the light at emission, propagation, and reflection. These phenomena are present in the Michelson interferometer with a particular geometry, as understood and explained by the kinematics of balls and light. The Michelson interferometer is at rest in Earth's inertial frame, which travels at a velocity v in the frame at absolute rest. The light from a source is split into a transmitted beam and a reflected beam. The derivation of the light paths of the transmitted and reflected waves illustrates, in the frame at absolute rest, each step in the emission, propagation, and reflection of both waves. This detailed derivation shows how the phenomena of emission, propagation, and reflection of light occur in the background of the frame at absolute rest, yielding simple wave paths in the inertial frame that are identical to those in the frame at absolute rest, where the interferometers are at rest.

Keywords: kinematics of light; ballistic law; emission of light; propagation of light; reflection of light; speed of light; observation of light

1. INTRODUCTION

The kinematics of balls and light [1] arises from a series of articles that study the emission, propagation, and reflection of light based on that of the balls with and without mass.

A source at rest or in motion emits waves of light in the absolute frame at a constant speed c, with the wavelength λ, period T, and frequency f, given by the Maxwell equations $c = \sqrt{\frac{1}{\mu_0 \varepsilon_0}}$ where μ_0 is the permeability and ε_0 is the permittivity of free space. At emission, the waves inherit the velocity of the source $v,$ such that in the inertial frame of the source, the waves travel identically for any magnitude of velocity v, including $v = 0$ m/s.

A wavefront is a chosen point at which a wave starts. Therefore, a wave is a continuous sequence of wavefronts or wave-points. The ballistic law gives the propagation velocity of these wave-points in the background of the absolute frame: The wave-points of a wave travel in the absolute frame at the propagation velocity c_{sa} as a vector sum of the emitted velocity c and the source's velocity v, $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$. The new wave travels at the same speed c, wavelength λ, period T, and frequency f in the absolute frame and in the inertial frame as if the source were at rest. Differently, the velocity of the wave-points travels in the absolute frame at another speed from c.

The study of the reflection offers the velocity of light reflected by a mirror for any incident angle the light makes with respect to the mirror and for any inclination of the mirror. The reflection of light may be considered when the reflecting mirror and the source have the same velocity v, or one of them is at rest, and another is in motion, or both are in motion at different velocities. Another distinction may be whether the mirror perceives the velocity v, therefore, engaged in reflection or not. Here, the source and mirrors are at rest in an inertial frame, a particular case, when the velocity v is not engaged in reflection. In this case, the same laws of light reflection apply in the absolute and inertial frames: the magnitudes of the incident and reflected velocities and their corresponding angles are equal, respectively. However, in the absolute frame, after the instant reflection, the velocity v continues to move each wave-point in its direction. The velocity of the reflected wavefronts c_{ra} is the vector sum of the reflected velocity c and the source's velocity v, $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. After reflection, the vector sum $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$ does not affect the magnitude and direction of the reflected velocity c by the mirror.

2. INTERFEROMETER AT THE INITIAL POSITION

The Michelson interferometer is at rest in an inertial frame that travels at the velocity v in the absolute frame. It has a particular geometry that comprises a beam splitter M_1 at an angle of $45°$, an opaque mirror M_2 perpendicular, and an opaque mirror M_3 parallel to a coherent beam of light emitted by a light source S. The beam of coherent light, emitted at the constant velocity c in the direction of the velocity v, splits at M_1 into the transmitted and reflected beams.

In the inertial frame, the point A belongs to the source S, the points B, C, and D belong to the mirrors M_1, M_2, and M_3, respectively, and the point E belongs to the screen Sc. Their corresponding points receive an index at each instant in the absolute frame.

For visualization, the interferometer geometry is depicted at a scale for lengths $AB = BE = L_1 = 4$ m and $BC = BD = L = 6$ m, and velocities $v = 1$ m/s and $c = 6$ m/s. The drawing grid is one square meter.

The emitted velocity c of a wavefront has its direction and magnitude, and the ballistic law gives the direction and magnitude of the propagation velocity of the wavefront and the following wave-points of a wave $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$. Both velocity c and velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ are shown in thin blue lines in the absolute frame. The velocity of the waves of $c = 6$ m/s and their paths are shown in thick red lines in the absolute and inertial frames.

Figures 1(a), 2(a)**,** 3(a), 4(a), and 5(a) presents the interferometer in the absolute frame, and Figures 1(b), 2(b), 3(b), 4(b), and 5(b) presents the interferometer in the inertial frame.

In Figure 1(a), the source emits waves at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$, with magnitude $c_{sa} = c + v$, because in this case, the direction of the emitted velocity c and the velocity of the source v coincide. The wave emitted at the instant point A_0 travels in time t_1 along the path $A_0B_1 = A_0B_0 + B_0B_1 \Rightarrow c_{sa}t_1 = L_1 + vt_1 \Rightarrow (c + v)t_1 = L_1 + vt_1$. Thus, the time $t_1 = L_1/c = 4/6 = 0.667$ s. During the time t_1, the source travels along the path A_0A_1, and the mirror M_1 along the path B_0B_1. Therefore, the path $A_0A_1 =$

$B_0B_1 = vt_1 = 0.667$ m, and the path $A_1B_1 = A_0B_0 = L_1$ is traveled by the wave in the time $t_1 = 0.667$ s at the velocity $c = L_1/c = 4/0.667 = 6$ m/s with the wavelength λ, period T, and frequency f.

Figure 1(a) depicts a transmitted wave traveling in the same direction as the velocity v, and a reflected wave traveling perpendicular to the mirror M_1, both starting at the point B of M_1 in the inertial frame and the corresponding instant point B_1 in the absolute frame.

Even if the source is located at the instant point A, it can theoretically be located at any cross-section of its light beam. Suppose hypothetically that the source is at B_1, when the transmitted wavefront starts traveling from M_1 to M_2 at the velocity $c_{sa} = c + v$ in the absolute frame. The length traveled by the wavefront from B_1 to reach M_2 is $B_1C_2 = L + vt \Rightarrow c_{sa}t = L + vt \Rightarrow (c + v)t = L + vt \Rightarrow ct = L \Rightarrow t = L_1/c = 1$ s. During the time $t = 1$ s, the source travels the path B_1B_2, and the mirror M_2 the path C_1C_2; therefore, $B_1B_2 = C_1C_2$. Along the path B_1B_2, the source emits the first train of wavelengths, which starts with the wavefront emitted at B_1 and ends with the last one-cycle wave at B_2. The wave traveled the path $B_2C_2 = L$ at the velocity $c = L/t = 6/1 = 6$ m/s with the wavelength λ, period T, and frequency f. Figure 1(b) shows this wave traveling in the inertial frame along BC. At B_2, the source begins emitting the second train of wavelengths identical to the first.

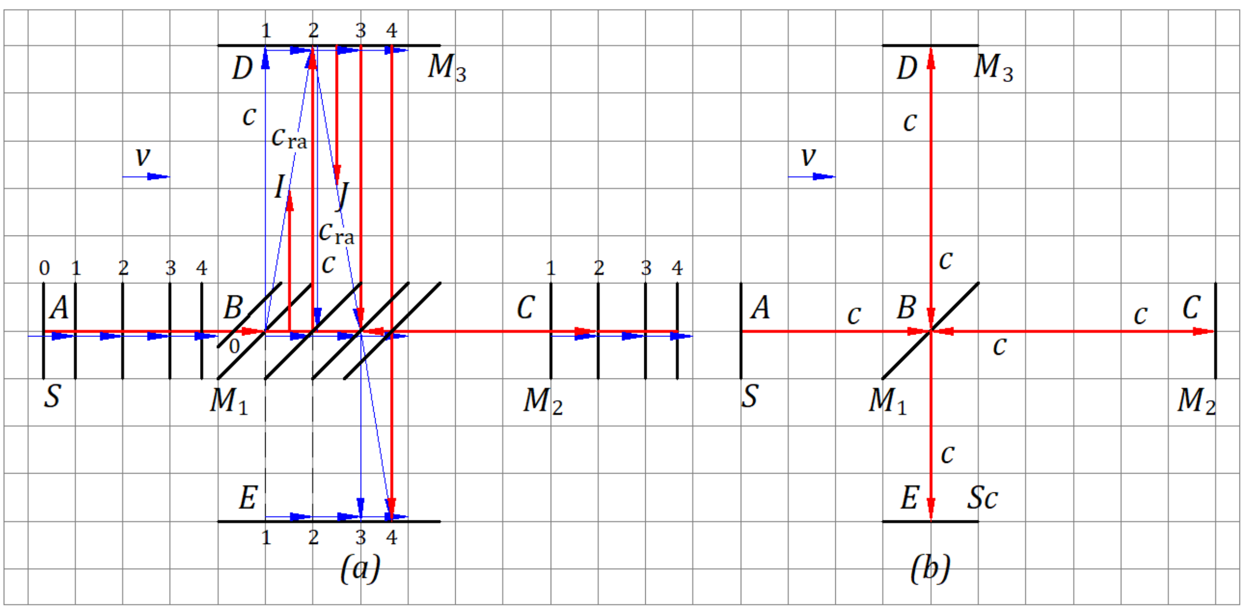

Figure 1. Light paths in the Michelson interferometer at the initial position: (a) In the absolute frame; (b) In the inertial frame.

At the point C_2 of reflection, the incident velocity $c_i = c_{sa} - v = c + v - v = c$. The velocity c is the relative velocity of the wavefront with respect to the source and the mirror. The mirror M_2 perceives only the velocity c, and reflects the wavefront in the opposite direction at the same magnitude c in the absolute frame. After reflection, the velocity v continues to move the wavefront in its direction, such that the wavefront travels in the absolute frame towards B_3 at the propagation velocity c_{ra}, given by the vector difference of the reflected velocity $c_r = c$ and the source velocity v, $c_{ra} = c - v$. The length traveled by the wavefront from C_2 to reach M_1 is $C_2B_3 = L - vt \Rightarrow c_{ra}t = L - vt \Rightarrow (c - v)t = L - vt \Rightarrow ct =$

$L \Rightarrow t = L/c = 1$ s, which means that $C_2C_3 = B_2B_3$ and $C_3B_3 = C_2B_2 = L$. While the wavefront emitted at B_1 and reflected at C_2 travels the path C_2B_3 in 1 s at the velocity $c_{sa} = c - v$, the wavefront emitted at B_2 arrives at C_3. Therefore, the first train of wavelengths is comprised along the path C_3B_3. The wave traveled along the path $C_3B_3 = L$ at the velocity c with wavelength λ, period T, and frequency f. This wave, traveling along the path C_3B_3, is shown in the inertial frame of Figure 1(b) along CB.

The wavefront from C_2 to B_3 travels in the absolute frame at the velocity $c_{ra} = c - v$. Because the velocity of the mirror M_1 travels in the opposite direction to c_{ra}, the relative velocity of the wavefront with respect to the mirror is the velocity c. Therefore, the mirror perceives this relative velocity c and reflects the wavefront at the reflected velocity $c_r = c$ in the direction B_3E_3. After reflection, the velocity v continues to move the wavefront in its direction, such that the wavefront travels towards the screen at the propagation velocity c_{ra}, given by the vector sum of the reflected velocity $c_r = c$ in the direction B_3E_3 and the source velocity v, $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. Along the path B_3E_4, the wavefront keeps the same direction and magnitude of the velocity $c_r = c$. While the wavefront travels along the path B_3E_4, the wave travels the path B_4E_4 at the velocity c with wavelength λ, period T, and frequency f.

The source S and mirror M_1 travel in the absolute frame at the same velocity v. Thus, the light travels at the velocity c with respect to the source and the mirror. The mirror does not perceive the velocity v of the light, which is not engaged in reflection. At the point B_1, the velocity of the incident and reflected wavefronts is equal, $c_i = c_r = c$, and the incident angle and reflected angle are equal to $45°$ measured from the normal to the mirror at the point of reflection B_1. Thus, the wavefront at B_1 is reflected in the direction B_1D_1 perpendicular to M_3 at the velocity c. After reflection, the velocity v keeps the wavefront moving in the same direction with the same magnitude v. The wavefront travels along the propagation path B_1D_2 at the propagation velocity c_{ra}, given by the vector sum of the reflected velocity $c_r = c$ in the direction B_1D_1 and the source velocity v, $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. Along the path B_1D_2, the wavefront keeps the same direction and magnitude of the velocity $c_r = c$. After 0.5 s, the wavefront is at the point I. Suppose hypothetically that the source is at the instant point B_1 of the mirror M_1. While the wavefront travels the path B_1D_2 in 1 s at the velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$, the source travels along the path B_1B_2. Therefore, along the path B_1B_2, the source emits the first train of wavelengths reflected by the mirror M_1, which is comprised along the path B_2D_2, starting with the wavefront emitted at B_1 and ending with the last one-cycle wave at B_2, forming a wave that travels at the velocity c perpendicular to M_2, with the wavelength λ, period T, and frequency f. Figure 1(b) shows this wave in the inertial frame traveling along the path BD. At B_2, the source begins emitting the second train of wavelengths identical to the first.

The wavefront hits perpendicular M_3 at the point D_2 with the velocity c, and the velocity v is not perceived at the instant of reflection. Thus, the mirror M_2 reflects only the perceived velocity c in the opposite direction at the same magnitude c, according to the law of reflection. After reflection, the velocity v continues to move the wavefront in its direction such that the wavefront travels on the propagation path D_2B_3 at the propagation velocity c_{ra}, given by the vector sum of the reflected velocity $c_r = c$ in the direction D_2B_2 and the source velocity v, $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. Along the path D_2B_3, the wavefront keeps the same direction and magnitude of the velocity $c_r = c$. After 0.5 s, the wavefront is at the point J. While the wavefront travels the path D_2B_3 in 1 s at the velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$, the mirror M_3 travels along the path D_2D_3. Therefore, along the path D_2D_3, the mirror M_3 reflects the first train of wavelengths that is comprised along the path D_3B_3, forming a wave which starts with the wavefront emitted at B_1 and ending with the last one-cycle wave at B_2, traveling at the velocity c perpendicular to the velocity v with the wavelength λ, period T, and frequency f. Figure 1(b) shows this wave in the inertial frame traveling along the path DB. At the point B_3, the wavefront continues traveling at the same propagation velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$, reaching the point E_4 on the screen, as the transmitted wavefront reflected at B_3.

The transmitted wavefront and the reflected wavefront start their journey at the point B_1, traveling to the point B_3 on their different path lengths and velocities during the time $2t = 2$ s, then traveling together to the instant point E_4 of the screen at the same velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. The transmitted and reflected waves travel from the instant point B_1 to the instant point B_3, a distance of $2L$, during the time $2t$ at the velocity c, with wavelength λ, period T, and frequency f. Then the waves continue traveling perpendicular to the screen until they reach the instant point E_4. Therefore, the two waves are in phase at the points B_3 and E_4, yielding an interference image of maximum brightness.

The wavefronts travel the path B_3E_4 at the velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$ in the time t_1 in which M_1 travels the path $B_3B_4 = E_3E_4$, and the waves formed along the path $B_4E_4 = L_1$ travel this path at the velocity c during the time $t_1 = L_1/c = 4/6 = 0.667$ s. The path $B_3B_4 = E_3E_4 = vt_1 = 0.667$ m.

3. INTERFEROMETER ROTATED 90° FROM THE INITIAL POSITION

In Figure 2(a), the wavefront emitted at the instant point A_0 at the velocity c in the direction A_0B_0 travels the path A_0B_1 at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ during the time t_1 in which the source travels the path $A_0A_1 = B_0B_1$ and the wave formed along the path $A_1B_1 = L_1$ travels this path at the velocity c during the time $t_1 = L_1/c = 4/6 = 0.667$ s; the path $A_0A_1 = B_0B_1 = vt_1 = 0.667$ m.

The transmitted wavefront travels at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ along B_1C_2, and the first train of wavelengths travels along B_2C_2, which is the path BC in the inertial frame. At the point C_2, the mirror perceives only the velocity c of the wavefront and reflects it in the direction C_2B_2 at the velocity c. After reflection, the wavefront keeps the velocity v traveling at the velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$ along C_2B_3 while the first train of wavelengths travels along C_3B_3, which is the path CB in the inertial frame.

At the point B_1, the mirror M_1 perceives the velocity c of the wavefront from the source, and reflects it at the velocity c towards M_3. After reflection, the velocity v continues to move the wavefront in its direction, and the wavefront travels at the velocity $c_{ra} = c - v$. The wavefront travels to the point D_2 of the mirror of M_3 the path $B_1D_2 = B_1D_1 - D_1D_2 \Rightarrow c_{ra}t = L - vt \Rightarrow (c - v)t = L - vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_3 travels along D_1D_2, and the mirror M_1 travels along B_1B_2, which means $D_1D_2 = B_1B_2$ and $B_2D_2 = B_1D_1 = L$. Therefore, the first reflected train of wavelengths is comprised in the path B_2D_2. At the point B_2, the second train of wavelengths begins.

At the point D_2, the mirror M_3 perceives the velocity c from the incoming velocity $c_{ra} = c - v$ of the wavefront from M_1, and reflects it at the velocity c towards M_1. After reflection, the velocity v continues to move the wavefront in its direction, and the wavefront travels at the velocity $c_{ra} = c + v$. The wavefront travels to the point B_3 of the mirror M_1 the path $D_2B_3 = D_2B_2 + B_2B_3 \Rightarrow c_{ra}t = L + vt \Rightarrow$

$(c+v)t = L + vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_3 travels along D_2D_3, and the mirror M_1 travels along B_2B_3, which means $D_2D_3 = B_2B_3$ and $D_3B_3 = D_2B_2 = L$. Therefore, the first reflected train of wavelengths is comprised along the path D_3B_3. At the point D_3, the second train of wavelengths begins.

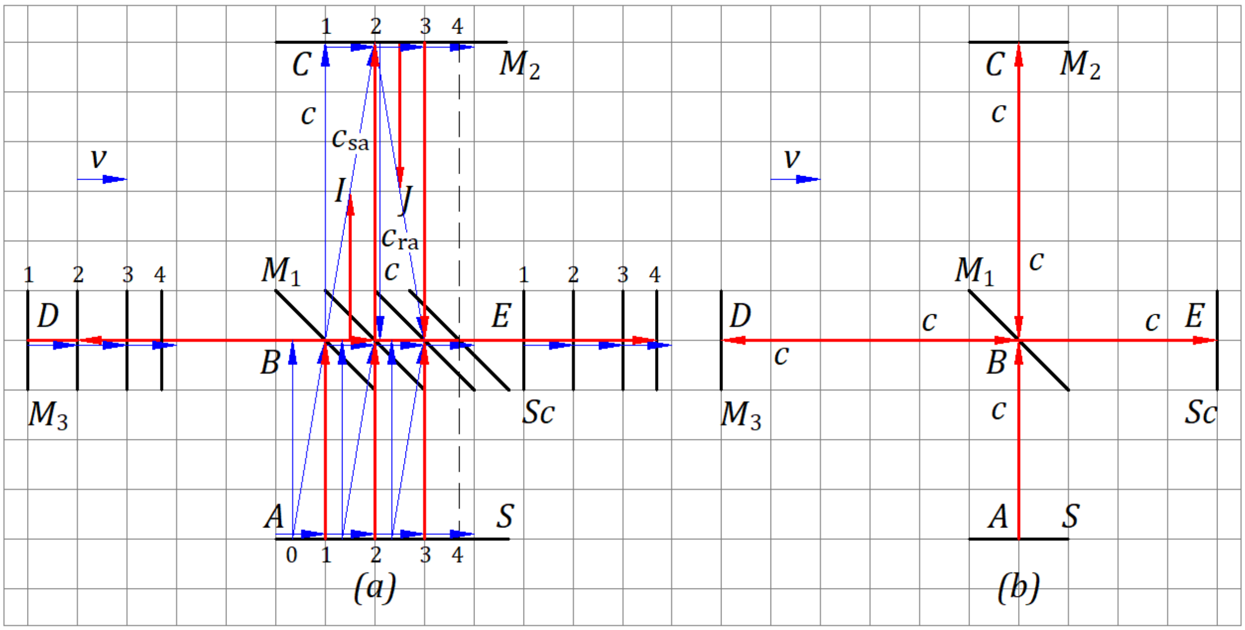

Figure 2. Light paths in the Michelson interferometer rotated 90° from the initial position: (**a**) In the absolute frame; (**b**) In the inertial frame.

Both wavefronts at the instant point B_3 arrive simultaneously and in phase. The transmitted wavefront and the reflected wavefront travel at the velocity $c_{ra} = c + v$ in the time t_1, the path $B_3E_4 = L_1 + vt_1 \Rightarrow c_{ra}t_1 = L_1 + vt_1 \Rightarrow (c+v)t_1 = L_1 + vt_1 \Rightarrow t_1 = L_1/c = 4/6 = 0.667$ s. During the time t_1, the mirror M_1 travels along the path B_3B_4, and the screen along the path E_3E_4. Thus, $B_3B_4 = E_3E_4 = vt_1 = 0.667$ m.

4. INTERFEROMETER ROTATED 180° FROM THE INITIAL POSITION

In Figure 3(a), the source emits waves in the opposite direction to the velocity v. The source emits waves at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$, with the magnitude $c_{sa} = c - v$ in this case.

A wave emitted at the instant point A_0 travels the path $A_0B_1 = A_0B_0 - B_0B_1 \Rightarrow c_{sa}t_1 = L_1 - vt_1 \Rightarrow (c-v)t_1 = L_1 - vt_1$ during the time t_1. Thus, the time $t_1 = L_1/c = 4/6 = 0.667$ s. During the time t_1, the source travels along the path A_0A_1, and the mirror M_1 travels along the path B_0B_1. Therefore, $B_0B_1 = A_0A_1 = vt_1 = 0.667$ m, and the path $A_1B_1 = A_0B_0 = L_1$ is traveled by the wave during the time $t_1 = 0.667$ s at the velocity $c = L_1/c = 4/0.667 = 6$ m/s.

At the point B_1, the transmitted wavefront travels from B_1 to C_2 of mirror M_2 at the velocity $c_{sa} = c - v$ the path $B_1C_2 = B_1C_1 - C_1C_2 \Rightarrow c_{sa}t = L - vt \Rightarrow (c-v)t = L - vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_2 travels along C_1C_2, and the mirror M_1 travels along B_1B_2, which means

$B_1B_2 = C_1C_2$ and $B_2C_2 = B_1C_1 = L$. Therefore, the first transmitted train of wavelengths is comprised along the path B_2C_2. At the point B_2, the second train of wavelengths begins.

At the point C_2, the mirror M_2 perceives the velocity c from the incoming velocity $c_{ra} = c - v$ of the wavefront from M_1, and reflects it at the velocity c towards M_1. After reflection, the velocity v continues to move the wavefront in its direction, and the wavefront travels in the absolute frame at the velocity $c_{ra} = c + v$. The wavefront travels to the point B_3 of the mirror M_1 the path $C_2B_3 = C_2B_2 + B_2B_3 \Rightarrow c_{ra}t = L + vt \Rightarrow (c + v)t = L + vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_2 travels along C_2C_3, and the mirror M_1 travels along B_2B_3, which means $C_2C_3 = B_2B_3$ and $C_3B_3 = C_2B_2 = L$. Therefore, the first train of wavelengths is comprised along the path C_3B_3 At the point C_3 begins the second train of wavelengths.

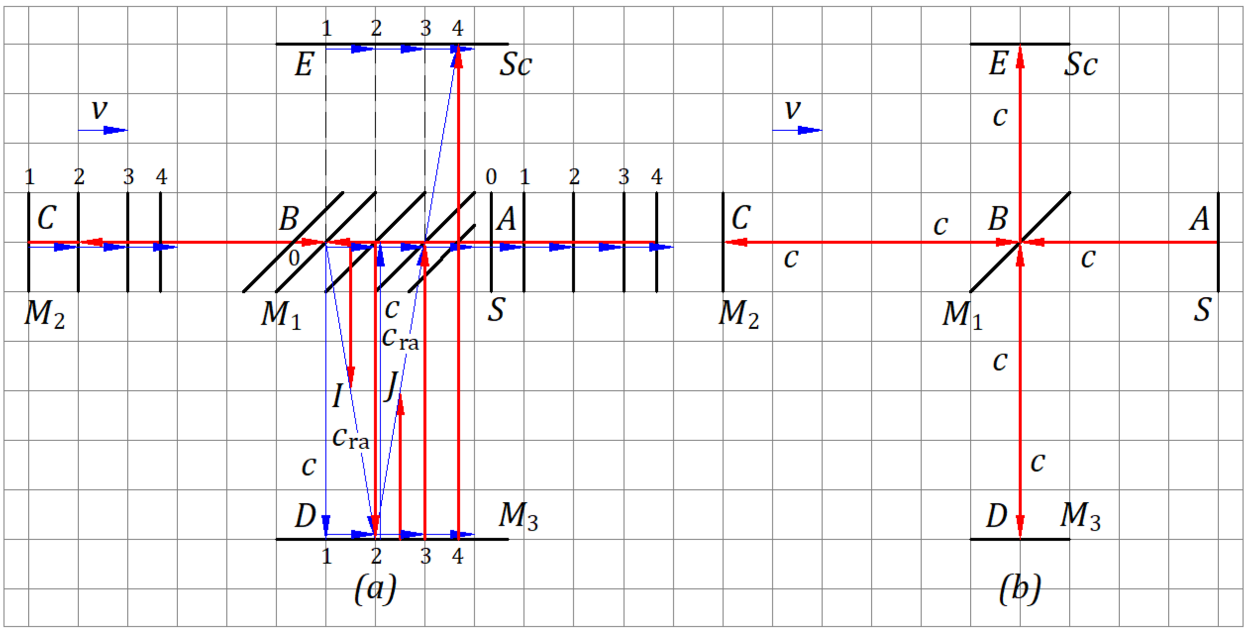

Figure 3. Light paths in the Michelson interferometer rotated 180° from the initial position: (**a**) In the absolute frame; (**b**) In the inertial frame.

The wavefront from the source travels at the velocity $c_{sa} = c - v$. At the point B_1, the mirror perceives only the velocity c of the wavefront and reflects it in the direction B_1D_1 at the velocity c. After reflection, the wavefront keeps the velocity v traveling at the velocity $\boldsymbol{c_{ra} = c + v}$ along B_1D_2 while the first train of wavelengths travels along B_2D_2, which is the path BD in the inertial frame. At the point D_2, the mirror perceives only the velocity c of the wavefront and reflects it in the direction D_2B_2 at the velocity c. After reflection, the wavefront keeps the velocity v traveling at the velocity $\boldsymbol{c_{ra} = c + v}$ along D_2B_3 while the first train of wavelengths travels along D_3B_3, which is the path DB in the inertial frame.

The wavefronts travel the path B_3E_4 at the velocity $\boldsymbol{c_{ra} = c + v}$ during the time t_1 in which M_1 travels the path $B_3B_4 = E_3E_4$, and the waves formed along the path $B_4E_4 = L_1$ travel this path at the velocity c during the time $t_1 = L_1/c = 4/6 = 0.667$ s. The path $B_3B_4 = E_3E_4 = 0.667$ m.

5. INTERFEROMETER ROTATED 270° FROM THE INITIAL POSITION

In Figure 4(a), the wavefront emitted at the instant point A_0 at the velocity c in the direction A_0B_0 travels the path A_0B_1 at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ during the time t_1 in which the source travels the path $A_0A_1 = B_0B_1$ and the wave formed along the path $A_1B_1 = L_1$ travels this path at the velocity c during the time $t_1 = L_1/c = 4/6 = 0.667$ s. The path $A_0A_1 = B_0B_1 = vt_1 = 0.667$ m.

The transmitted wavefront travels at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ along B_1C_2, and the first train of wavelengths travels along B_2C_2, which is the path BC in the inertial frame. At the point C_2, the mirror perceives only the velocity c of the wavefront and reflects it in the direction C_2B_2 at the velocity c. After reflection, the wavefront keeps the velocity v traveling at the velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$ along C_2B_3 while the first train of wavelengths travels along C_3B_3, which is the path CB in the inertial frame.

At the point B_1, the mirror M_1 perceives the velocity c of the wavefront from the source, and reflects it at the velocity c towards M_3. After reflection, the velocity v continues to move the wavefront in its direction, and the wavefront travels at the velocity $c_{ra} = c + v$. The wavefront travels to the point D_2 of the mirror M_3 the path $B_1D_2 = B_1D_1 + D_1D_2 \Rightarrow c_{ra}t = L + vt \Rightarrow (c + v)t = L + vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_1 travels along B_1B_2 and the mirror M_3 travels along D_1D_2, which means $D_1D_2 = B_1B_2$ and $B_2D_2 = B_1D_1 = L$. Therefore, the first reflected train of wavelengths emitted from the source is comprised in the path B_2D_2. At the point B_2, the second train of wavelengths begins.

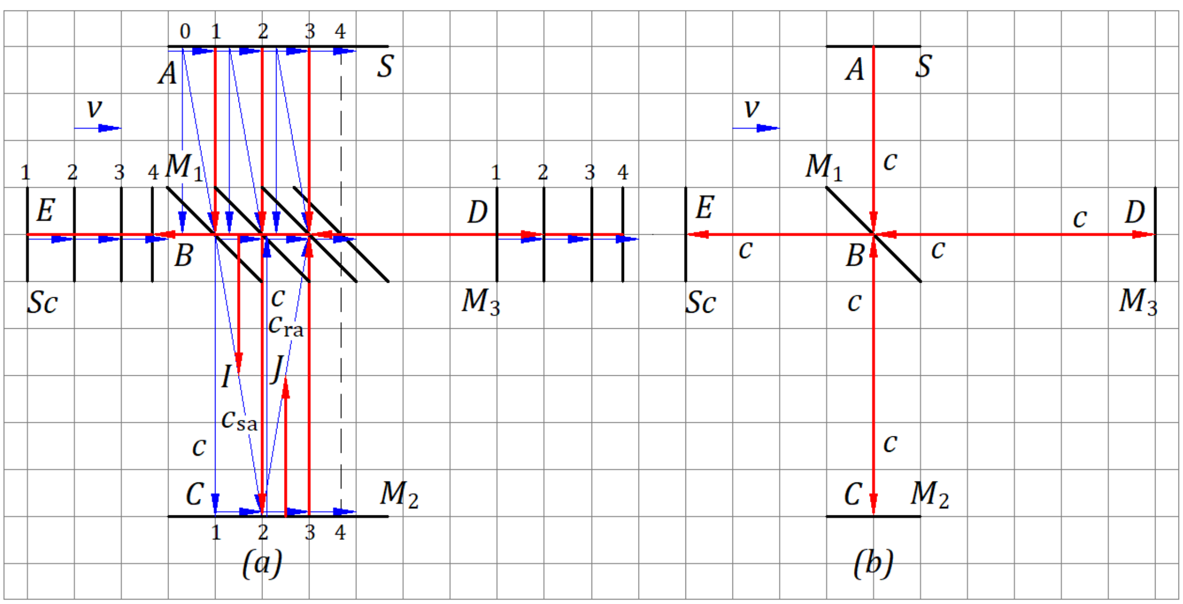

Figure 4. Light paths in the Michelson interferometer rotated 270° from the initial position: (**a**) In the absolute frame; (**b**) In the inertial frame.

At the point D_2, the mirror M_3 perceives the velocity c from the incoming velocity $c_{ra} = c + v$ of the wavefront from M_1, and reflects it at the velocity c towards M_1. After reflection, the velocity v continues to move the wavefront in its direction, and the wavefront travels at the velocity $c_{ra} = c - v$. The wavefront travels to the point B_3 of the mirror M_1 the path $D_2B_3 = D_2B_2 - B_2B_3 \Rightarrow c_{ra}t = L - vt \Rightarrow (c - v)t = L - vt \Rightarrow t = L/c = 1$ s. During the time t, the mirror M_3 travels along D_2D_3, and the mirror M_1 travels along B_2B_3, which means $D_2D_3 = B_2B_3$ and $D_3B_3 = D_2B_2 = L$. Therefore, the first reflected train of wavelengths emitted from the source is comprised along the path D_3B_3. At the point D_3, the second train of wavelengths begins.

Both wavefronts and waves arrive at the instant point B_3 at the same time and in phase. The wavefronts travel perpendicular to the screen at the velocity $c_{ra} = c - v$ in the time t_1. The path $B_3E_4 = L_1 - E_3E_4 \Rightarrow c_{ra}t_1 = L_1 - vt_1 \Rightarrow (c - v)t_1 = L_1 - vt_1 \Rightarrow t_1 = L_1/c = 4/6 = 0.667$ s. During the time t_1, the screen travels along the path E_3E_4, and the mirror M_1 along the path B_3B_4. Thus, $E_3E_4 = B_3B_4 = vt_1 = 0.667$ m.

6. INTERFEROMETER ROTATED 30° FROM THE INITIAL POSITION – GENERAL GEOMETRY

The phenomena of emission, propagation, and reflection are self-explanatory in Figure 5(a). It can be observed that the velocities $\boldsymbol{c_{sa}}$ and $\boldsymbol{c_{ra}}$ along with their corresponding path lengths, vary with the interferometer's rotation. At the same time, the transmitted and reflected waves travel the interferometer arm lengths at the constant velocity c for any angle of rotation. Similarly, the waves travel the length from the source S to the mirror M_1 and from M_1 to the screen S_{sc} at the same velocity c.

The presented interferometer has a particular geometry. An interferometer arm's length, or the length of the source to the mirror M_1, or the length of the mirror M_1 to the screen, or any combination of these, may vary, but they keep the same wave path lengths for any rotation; therefore, a constant fringe image. For the mirrors' inclination with respect to the velocity v, the study in the absolute frame may be performed using geometries similar to those in Reference [2]. However, an inertial frame is a local frame at absolute rest to itself and to any other frame. Therefore, the rotation of an interferometer in an inertial frame gives the same fringe shift for any angle without doing any derivation.

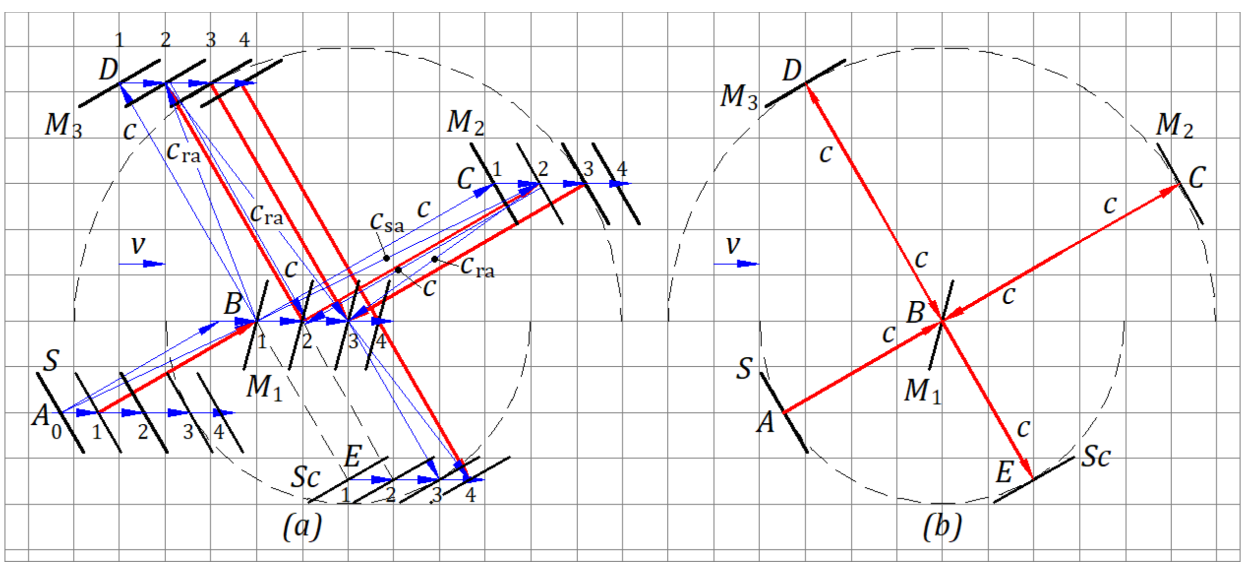

Figure 5. Light paths in the Michelson interferometer rotated 30° from the initial position: (**a**) In the absolute frame; (**b**) In the inertial frame.

7. DISCUSSION

The kinematics of balls and light proves that an inertial frame is a local frame at absolute rest for itself and for any other inertial frame. Figures 1(a) through 5(a) show the detailed derivation of the light paths in the background of the absolute frame, and their simplicity in the inertial frame in Figures 1(b) through 5(b), which is much easier to work with. These cases illustrate the complex task that the simplicity of the ballistic law performs anywhere throughout the universe at all times.

In the absolute frame, the propagation of the wave-points of a wave is not observed. Still, the wave originating at the source in motion is observed to travel at all times at the emitted velocity c, with its direction and magnitude relative to the source, and with wavelength λ, period T, and frequency f, expanding in space at a rate of ct. In the inertial frame of the source, the wave is observed as in the absolute frame, except that the source is at rest.

The kinematics of light and Maxwell's equations support each other. Maxwell's equations give the velocity of light waves c emitted in free space in the absolute frame, whether the source is at rest or in motion. The ballistic law governs the propagation velocity of the unseen wave-points of the waves according to the source's velocity v of mechanical nature, and without changing the magnitude or direction of the emitted waves' velocity with respect to the source. Without the ballistic law, a source in motion emits a wave in a direction, and it travels in another direction with respect to the source.

The purpose of this article is to understand the phenomenon of the formation and propagation of a wave at the speed c with wavelength λ, period T, and frequency f in the absolute and an inertial frame, and to justify why the phenomena in the inertial frames are the same as in the absolute frame. The kinematics of light proves that the speed of light is a constant c in each inertial frame in which the source of light and the reflecting mirror are at rest. It also proves that any experiment in an inertial frame cannot put in evidence its motion, and that the mechanical and electromagnetic laws are the same in any inertial frame. All the above conclusions have been, more or less, intuitively understood and accepted by physicists.

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References

1. Filipescu F. D. The kinematics theory of balls and light – February 2026. *Phys. Essays* **2026**, 39, 2, 156.
2. Filipescu F. D. Opposing hypotheses of the reflection of light applied to the Michelson interferometer. *Phys. Essays* **2021**, 34, 3, 389.