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Article

The Kinematics Theory of Balls and Light

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Abstract

The kinematics theory of balls studies the emission, propagation, and reflection of balls in accordance with Newtonian laws. The emission of balls is based on the physics phenomenon that the balls inherit the velocity of the source, in addition to the emitted velocity relative to the source. The ballistic law governs the propagation velocity of balls from the moment of emission and thereafter. It states that, in the absolute frame, the propagation velocity of balls is the vector sum of the velocity of the balls emitted by the source and the velocity of the source. At the limit, when the mass of the balls converges to zero, the ballistic law applies to the hypothetical massless ball. Unlike the balls with mass, the massless balls consume no energy as their source moves from rest to a constant velocity and have no momentum after emission; there are no action-reaction forces at emission and reflection. The reflection of balls by a wall is given for any incidence angle of the balls' velocity relative to the velocity of the wall and for any inclination of the wall, not just the case of two balls' reflection in an elastic frontal collision. A natural extension of this study is to include massless entities such as light. The kinematics of light explains and proves in each inertial frame where a source of light and a mirror are at rest, why the speed of light is the universal constant *c* of electromagnetic nature given by Maxwell's equations, why each law of physics has the same form, and why no experiment in such a frame can prove its motion. It also explains experiments and observations that have been misunderstood for more than a century because, at that time and afterward, there was insufficient knowledge of light behavior to explain them correctly. Reprinted from Physics Essays Vol. 39 pp. 157 Year 2026, with permission of Physics Essays Publication (https://physicsessays.org/).

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1. Introduction

At the beginning of 1985, the "Velocity of light through a moving medium applied to the Fizeau experiment" was written. Since then, the study of light has been pursued occasionally.

From 2015 to 2019, the studies on Michelson-Morley's experiment, Fizeau's experiment, the observation of binary stars, and other light-related topics were approached in greater detail than in the authors' manuscripts, but with a similar understanding of the physics phenomena of their time, yielding no significant new results. However, these studies laid down the groundwork for understanding light reflection, emission, and propagation as mechanical phenomena in the years that followed.

This article summarizes the kinematics of balls, with and without mass, and of light, a concept emerging from a series of articles starting in early 2020. The study of the balls' reflection gives the velocity formula for a ball reflected by a wall for any incident angle the moving ball makes with the wall's moving direction, and for any inclination of the wall, not just the known formula for a two-ball frontal elastic collision. This study was essential when the reflection of hypothetical massless balls was applied to light as a massless entity. Like the balls with mass, the light inherits the velocity of the source at emission and maintains it afterward. By the end of 2023, experiments and observations that had been misunderstood for over a century were explained.

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2. Kinematics of Balls

2.1. Ball Brought from Rest to a Velocity v

Figure 1 exemplifies, in the absolute frame, a carrier that brings a ball from rest at the point O_1 to a velocity v at the point O_2. At O_2, the carrier stops, and the ball continues traveling at velocity v.

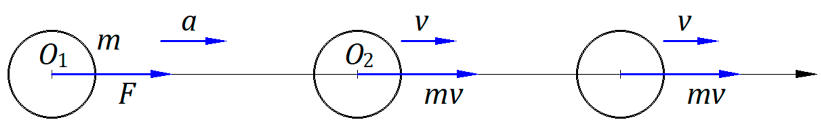

Figure 1. A ball brought from rest to a velocity v.

The constant force F created by the carrier acts on the ball of mass m such that it travels in a straight line a length $d = O_1O_2$ at constant acceleration a. During time t, as the speed of the ball increases from rest to v, the inertial force of the ball F_i acts with the same magnitude in the opposite direction to the force F that changes the ball's state. Energy E consumed to overcome F_i is given by the mechanical work L created by the force F along the length d, $L = F \times d = ma \times \frac{1}{2}at^2 = \frac{1}{2}mv^2$. While the ball is moved from rest to velocity v, it gains energy $E = L = \frac{1}{2}mv^2$ stored in its momentum $P = mv$, which opposes any force that changes its new state. Indeed, the integral of momentum $P = mv$ as a linear function with a constant slope m and a variable speed v from zero to a value v gives the energy gained by the ball, $\int_0^v mv\,dv = \frac{1}{2}mv^2 = E$. When the force F stops at O_2, the ball continues traveling at the velocity v, having momentum $P = mv$.

Suppose a carrier with balls of different masses accelerates from rest to a constant velocity v. At the velocity v, all balls move independently of the carrier and each other with the same velocity v, regardless of their mass. At the limit, when a ball's mass converges to zero, the hypothetical massless ball travels at the same velocity v. Unlike balls with mass, the massless balls accelerate from rest to a velocity v without any force acting on them, $F = 0$, without energy consumption, $E = 0$, and without momentum after that, $P = 0$. The hypothetical massless balls would only require a carrier that consumes energy for itself.

2.2. Ball Emitted at Velocity V by a Moving Source at Velocity v

Figure 2 illustrates, in the absolute frame, a source of balls at velocity v that emits at the point O_1 a ball at a velocity V in the direction O_1A_1. The kinematics of the emitted ball of mass m depends on two vector momenta. One momentum is given by $m\boldsymbol{v}$, which the ball already has while moving with the source, and another by $m\boldsymbol{V}$ at the emission. The vector sum of the two momenta is $\boldsymbol{P_{sa}} = m\boldsymbol{V} + m\boldsymbol{v}$, where $\boldsymbol{P_{sa}} = m\boldsymbol{V}_{sa}$ and $\boldsymbol{V}_{sa}$ is the ball's propagation velocity along the path O_1A_2 in the absolute frame. From the instantaneous point O_1, the momentum $m\boldsymbol{V}$ belongs to both the absolute and the inertial frames, while the momentum $m\boldsymbol{v}$ continues undisturbed in the absolute frame. At the instantaneous point O_2, the ball with the momentum $m\boldsymbol{V}$ traveled the path O_2A_2 in the absolute frame identical to the path OA in the inertial frame of the source at velocity V. The action and reaction forces between the source and the emitted ball at the instantaneous emission are not considered.

The vector equation of momentum $m\boldsymbol{V_{sa}} = m\boldsymbol{V} + m\boldsymbol{v}$ can be simplified to the vector equation of velocities $\boldsymbol{V_{sa}} = \boldsymbol{V} + \boldsymbol{v}$. At the limit, as the mass of a ball converges to zero, the equation of the vector velocities has the same form, $\boldsymbol{V_{sa}} = \boldsymbol{V} + \boldsymbol{v}$. In the case when the ball's mass is zero, no action and reaction forces are present between the source and the massless ball at the instantaneous emission.

Suppose in the absolute frame, a hypothetical source traveling at a velocity v emits balls of different masses at the same velocity V. Thus, each emitted ball, including massless ones, obeys the

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vector sum equation of momentum $m\boldsymbol{V}_{sa} = m\boldsymbol{V} + m\boldsymbol{v}$ and the vector sum equation of velocities $\boldsymbol{V}_{sa} = \boldsymbol{V} + \boldsymbol{v}$. For massless balls, the vector equation of momentum is obeyed because $m\boldsymbol{V}_{sa}$, $m\boldsymbol{V}$, and $m\boldsymbol{v}$ are zero.

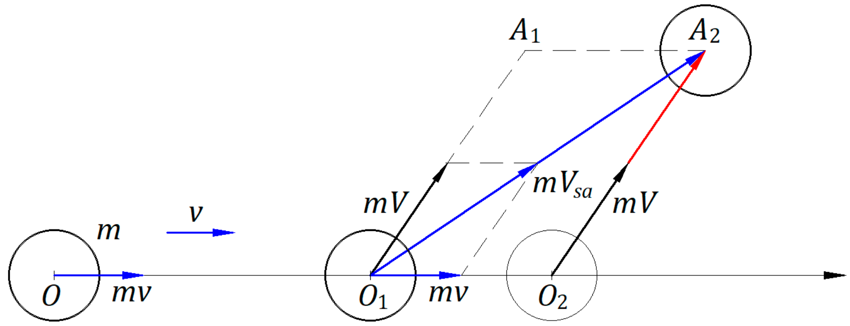

Figure 2. A moving source at velocity v emits a ball at a velocity V.

2.3. Ballistic Law Applied to Balls Emitted by a Source in Motion

Considering Subsections 2.1. and 2.2, we can understand the phenomenon acting on the balls emitted by a source formulated in the ballistic law of balls' propagation: A ball emitted at a velocity V by a source at a velocity v travels in the absolute frame at the propagation velocity $\boldsymbol{V}_{sa}$ given by the vector sum of the emitted velocity $\boldsymbol{V}$ and the source's velocity $\boldsymbol{v}$; $\boldsymbol{V}_{sa} = \boldsymbol{V} + \boldsymbol{v}$, unless a force acts on it. Velocity V_{sa} varies in direction and magnitude according to the direction of velocity V from the direction of velocity v.

Suppose a source at rest in the absolute frame emits spherical fronts of balls of the same mass at a speed V and period T uniformly distributed in space. Each spherical front of balls always has its center at the source.

Figure 3 illustrates a circular front of balls emitted into the plane of the paper by a source moving with velocity v in the absolute frame. The drawing shows the case for $v > V$ on a scale for $V = 2$ m/s and $v = 6$ m/s. At the initial instant, the source at the point O_1 emits the circular front of balls. After time $t = 2.5$ s, the ball source is at the point O_2.

When the source is at O_1, Figure 3 shows the instantaneous circle of the velocities V, with its center at O_1, which belongs to both the inertial and absolute frames. The instantaneous velocities V_{sa} originating at O_1 and ending on the circle with the center at the point O_1' belong to the absolute frame. Both circles have a radius of 2 m. After time $t = 2.5$ s, the ball front emitted at O_1 is on the circle with a radius of 5 m with the center at O_2.

Velocities V_{sa} apply to balls in the absolute frame. For example, the ballistic law acts on the ball emitted in the direction O_1B_1, and the propagation velocity V_{sa} of the ball along O_1B_1' is the vector sum of velocity V along O_1B_1 and common velocity v along O_1O_1'. The same reasoning applies to the velocity V_{sa} of any other ball.

The ballistic law of balls' propagation works in the background of the absolute frame and makes the phenomenon in the inertial frame of the source identical to one in the absolute frame. The circular front of the balls is emitted at the speed V, with balls uniformly distributed in the inertial frame. The circular front always has its center at the source. In the absolute frame, the circular front of the balls travels at velocity v, with its center always at the source location, expanding with a radius that increases linearly with time at a constant rate Vt.

The ballistic law governs the kinematics of balls, with mass and massless, and it can be extended to massless entities such as light. Therefore, the constant light speed c of an electromagnetic nature, given by Maxwell's equations, emitted in the absolute frame by a source in motion in any direction, replaces the emitted velocity V from mechanics. The velocity v of the source, of a mechanical nature, remains the same. Therefore, the propagation velocity of a wavefront in the absolute frame is the vector equation $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$, which applies in the absolute frame to each wavefront emitted in any direction; the velocity c_{sa} varies in direction and magnitude according to the direction of the velocity c of the emitted wavefront from the direction of the velocity v. In the source inertial frame, the phenomenon is identical to one in the absolute frame; each spherical wavefront always has its center at the source. Light travels at the speed c with wavelength λ, period T, and frequency f in any direction.

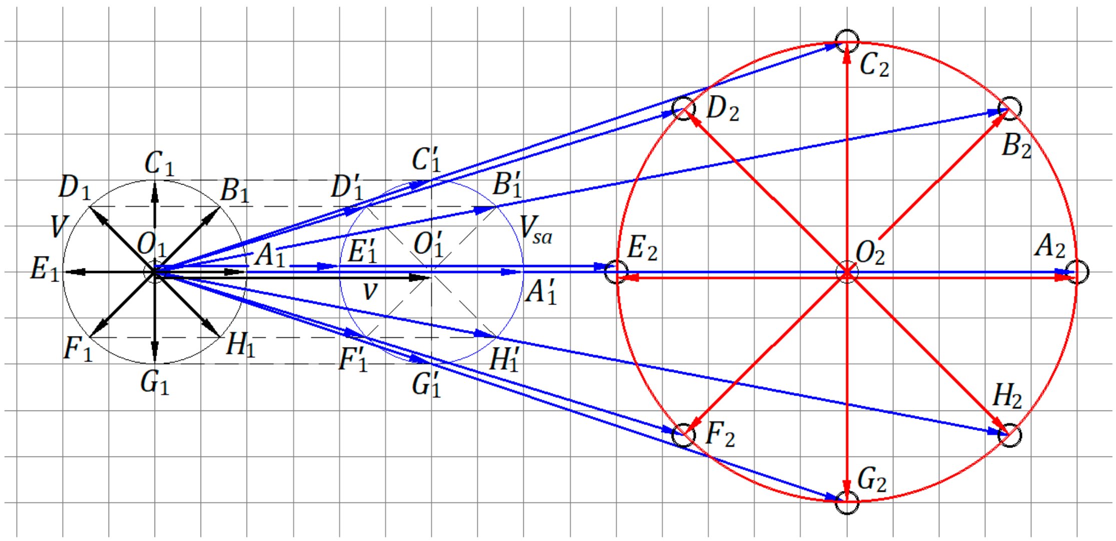

Figure 3. Ballistic law applies to balls emitted by a source in motion.

2.4. Elastic Collision of Two Balls Moving in Opposite Directions

In the absolute frame, two balls, one with mass m_1 traveling at velocity v_1 and the other with mass m_2 traveling at velocity v_2, are engaged in a frontal elastic collision, as shown in Figure 4. The velocities of the balls after collision are v_1' and v_2', respectively. The equations for the law of conservation of momentum and energy of the balls before and after the collision are as follows:

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2', \tag{1}$$

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2. \tag{2}$$

The two equations yield the solution for speed $v_1' = \frac{m_1 - m_2}{m_1 + m_2} v_1 + \frac{2m_2}{m_1 + m_2} v_2$ and $v_2' = \frac{2m_1}{m_1 + m_2} v_1 + \frac{m_2 - m_1}{m_1 + m_2} v_2$ [1].

For $m_1 \gg m_2$, the simplified solution $v_1' \cong v_1$ and $v_2' \cong 2v_1 - v_2$. The solutions are offered without considering the direction of the velocities. Considering the direction of v_1 positive, the direction of v_2 is negative, and the directions of v_1' and v_2' are positive, as shown in Figure 4. Therefore, the simplified solutions with approximation become $v_1' \cong v_1$ and $v_2' \cong v_2 + 2v_1$. At the limit when m_2 converges to zero, the simplified solutions are $v_1' = v_1$ and:

$$v_2' = v_2 + 2v_1. \tag{3}$$

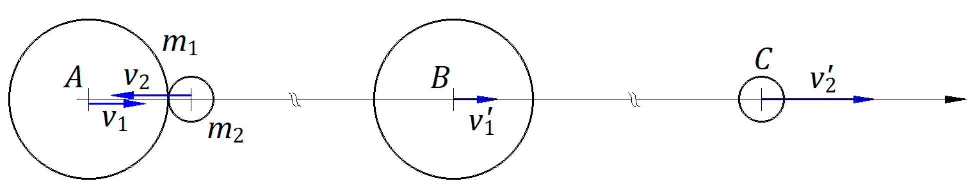

Figure 4. Elastic collision of two balls moving in opposite directions.

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When the ball of mass m_1 travels in the opposite direction, the simplified solutions for the balls are $v_1' = v_1$ and $v_2' = v_2 - 2v_1$, for the same positive direction.

The massless balls obey the law of conservation of momentum $m_1 v_1 = m_1 v_1'$, and the law of energy conservation $\frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 v_1'^2$. According to the equations of these two laws, massless balls have no momentum, and no energy is required to change their state. There are no action-reaction forces between the massless balls and the ball with mass.

A wall W can replace the ball of mass m_1 to study the reflection of massless balls in any direction, as in Figure 5. The mass of the wall can be ignored when studying massless balls.

Equation (3), $v_2' = v_2 + 2v_1$, is given in the frame at absolute rest, indicating that v_2 adds once to v_2' and v_1 twice.

In the wall's inertial frame, the incident speed of the massless ball relative to the wall is $v_{ii} = v_2 + v_i$, where v_i is the speed of the wall in the opposite direction of the incident velocity v_2; in Figure 5, $v_i = v_1$. The speed of the reflected massless ball is $v_{ri} = v_{ii} = v_2 + v_i$; velocities v_{ri} and v_{ii} are in opposite directions and equal in magnitude.

In the frame at absolute rest, the speed of the reflected massless balls is $v_2' = v_{ri} + v_r$, where v_r is the speed of the wall in the direction of the reflected massless ball; in Figure 5, $v_r = v_1$. The expression $v_2' = v_{ri} + v_r$, where $v_{ri} = v_2 + v_i$, yields the following equation:

$$v_2' = v_2 + v_i + v_r, \quad (4)$$

which is a comprehensive and explicit form of Eq. (3).

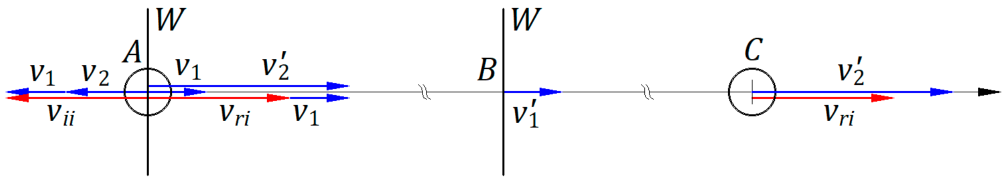

Figure 5. Elastic collision of a wall and a ball moving in opposite directions.

Equation (4) is derived from the collision of two balls. It offers the meaning of velocities v_i in the inertial frame and v_r in the absolute frame. It provides the massless ball's speed reflected in the absolute frame v_2', where v_2 is the emitted velocity of a massless ball by a source at rest in the absolute frame, coming from any direction to the wall moving direction. The wall may have an inclination other than 90° with respect to the velocity v. In this case, the angles of the incident speed v_i and the reflected speed v_r measured from the velocity v are different from 0°; therefore, the magnitudes of velocities v_i and v_r are different from v_1 of Figure 5.

Equation (4) applies to the reflection of hypothetical massless balls and light by a moving wall/mirror, and with approximation to the reflection of balls with mass by a moving wall in an elastic collision when the mass of the well $m_1 \gg m_2$ of the balls.

2.5. Elastic Reflection of a Ball by a Moving Wall

Figure 6 illustrates, in the absolute frame, a wall W moving at a velocity v and a ball traveling at a velocity V hitting the wall in an elastic collision; the wall's mass is much greater than the ball's mass. The wall reflects the ball in an elastic collision at the point A of the wall in the wall's inertial frame and its corresponding instantaneous point A_1 in the absolute frame. The angle of the ball's incident velocity and the angle of the ball's reflected velocity are equal to d, both measured from the normal to the wall at point A and its corresponding point A_1, according to the law of reflection. One second after the collision, the ball is at the point B_2, and the wall is at the point A_2.

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This section employs Eq. (4), $v_2' = v_2 + v_i + v_r$, in which the speed of the ball V replaces v_2 and the reflected speed V_{ra} of the ball in the absolute frame replaces v_2':

$$V_{ra} = V + v_i + v_r. \quad (5)$$

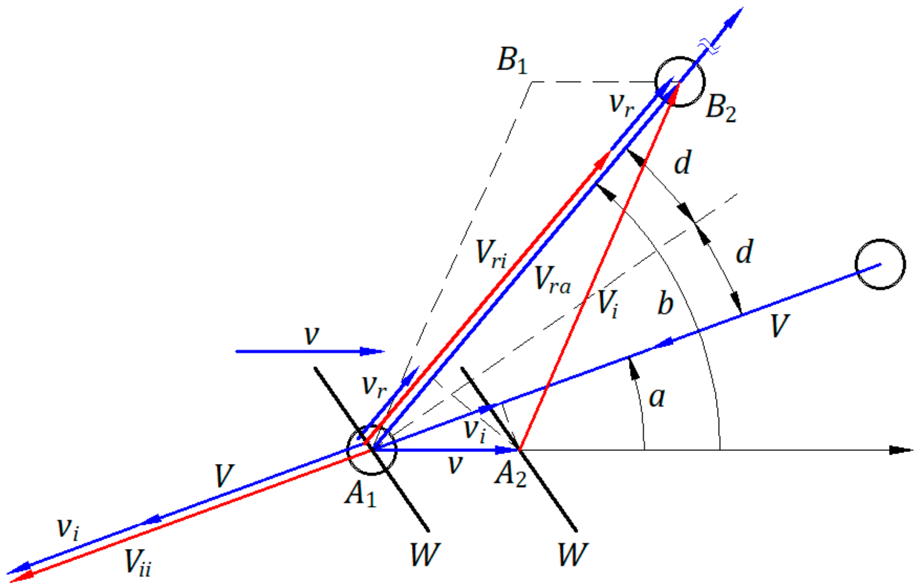

Figure 6. Elastic reflection of a ball by a moving wall.

In the inertial frame, in the instantaneous collision, the speed of the wall in the opposite direction to the incident ball is $v_i = v\cos a$, and in the absolute frame, the speed of the wall in the direction of the reflected ball is $v_r = v\cos b$. Another form of Eq. (5) is:

$$V_{ra} = V + v\cos a + v\cos b, \quad (6)$$

where angles a and b are measured counterclockwise from the velocity v.

In the absolute frame, the wall moved in one direction; however, the wall inclination reflects a ball in multiple directions. In the inertial frame of the wall, the velocity V_i of the ball is given by the vector subtraction of velocity V_{ra} and v, $\boldsymbol{V_i} = \boldsymbol{V_{ra}} - \boldsymbol{v}$. The triangle $A_1A_2B_2$ represents the ball's velocities at any time, and on another scale, the momentum triangle.

2.6. Emission, Propagation, and Reflection of Balls in the Absolute Frame and an Inertial Frame

Figure 7 illustrates a source of balls and a rigid wall, both at rest, in the absolute frame and an inertial frame. The source and wall have the same geometry, and each source is at the origin of its frame.

In the absolute frame $OXYZ$, the source at the origin O emits a ball at a velocity V_e of magnitude V at an angle a from the axis OX. After time t_1, the ball is at the point A on the wall W. At point A, the ball is reflected in an elastic collision at a velocity V_r of magnitude V and then travels along the path AB in time t_2. The ball travels paths OA and AB in time $t = t_1 + t_2$ at speed V. The ball continues to travel in the AB direction.

The inertial frame $O'X'Y'Z'$ travels at velocity v, and the source is at the origin O'. The origin O' and the points A and B belong to the inertial frame, and their instances in the absolute frame are given a corresponding index. The source at the point O_1' emits a ball at the velocity V_e of magnitude V in the direction $O_1'A_1$ at the angle a from the axis $O'X'$. The ball inherits the velocity v of the source, and travels on the path $O_1'A_2$ at the propagation velocity V_{sa}, given by the vector

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sum of the emitted velocity V_e and the source's velocity v. The velocity V_e does not change its direction O'_1A_1 and magnitude V along the path O'_1A_2.

At the point O'_2, the ball is at A_2; it has traveled in the inertial frame along the path O'_2A_2 at speed $V_e = V$ in time t_1, and the direction O'_2A_2 makes angle a from the axis $O'X'$. Paths O'_2A_2 and $O'A$ are identical, and both equal OA in the absolute frame $OXYZ$. If the source emits other balls between points O'_1 and O'_2, these balls are on the path O'_2A_2.

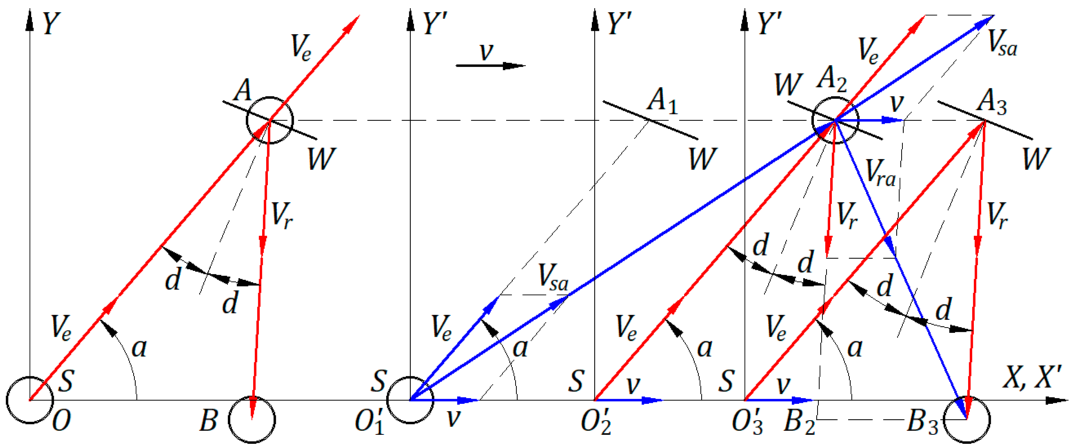

Figure 7. Emission, propagation, and reflection of balls in the absolute frame and an inertial frame.

In the elastic collision at the point A_2, the wall perceives only the magnitude and direction of the velocity V_e of the emitted ball because both the ball and the wall have the same velocity v. The incident and reflected angles d are measured from the normal to the wall at the collision point A_2 to the incident velocity V_e and reflected velocity V_r, both of magnitude V as in the absolute frame $OXYZ$. After reflection, the velocity v keeps the ball moving in the same direction with the same magnitude v. The ball travels on the propagation path A_2B_3 at the propagation velocity V_{ra}, given by the vector sum of the reflected velocity V_r along A_2B_2 and source velocity v. The velocity V_r does not change its direction A_2B_2 and magnitude V along the path A_2B_3. At the point O'_3, the ball is at B_3, and the direction O'_3A_3 makes angle a from axis $O'X'$. The ball has traveled the path $O'_3A_3 = O'_2A_2 = O'_1A_1 = O'A$ at speed $V_e = V$ in time t_1 and the path A_3B_3 at speed $V_r = V$ in time t_2. Path A_3B_3 is the path AB, in the inertial frame, which is identical to that one in the absolute frame $OXYZ$. At the point O'_3, the ball has traveled the paths $O'_3A_3 = O'A = OA$ and $A_3B_3 = AB$ in time $t = t_1 + t_2$ at speed V, as in the absolute frame $OXYZ$.

Newton's laws describe mechanical phenomena from a local perspective, which applies to everyday life. Newton's laws say nothing about phenomena observed by the human eye at a distance, which is comprised in the kinematics of light.

3. Kinematics of Light

The kinematics of light is studied in a series of articles [2–14] on light emission, propagation, reflection, refraction, observation, and traveling through a moving medium, and it is applied to fundamental experiments. The reflection of light as a mechanical phenomenon [2–4] was the first step. We searched for and found an experiment [14] that contradicts the light-reflection results of References [2–4]. However, if we consider that both the reflection and emission of light are mechanical phenomena, this experiment, the Michelson–Morley experiment, and others predict a zero-fringe shift in accord with experimental results. The experiment of Reference [14], presented in Appendix A, was the second step and a turning point in our complete understanding that the emission, propagation, and reflection of light are mechanical phenomena, even though it was published last.

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In the previous articles, we used the expressions "observer in the absolute frame" and "observer in an inertial frame," meaning that these hypothetical observers observe phenomena as they are in their respective frames. These expressions may be eliminated to avoid confusion with human observation and say how the phenomena are, as in Newtonian mechanics. The expression "local observer" is particularly essential.

A local observer perceives the phenomena through light coming directly from a source or reflected by objects from the observer's frame or others, as well as through partially reflected wavefronts of light by some particles of the transparent medium, such as air through which light travels. Therefore, a local observer may perceive a physics phenomenon differently from how Newton's laws describe it. Nevertheless, we understand reality better by applying Newtonian laws and local observations of light.

Electromagnetic theory gives the universal constant speed of light c emitted by a source at rest or in motion in the vacuum of the absolute frame. The emitted speed of light c behaves similarly to the emitted speed of balls V, as presented in Subsections 2.5. and 2.6.

3.1. Ballistic Law Applied to Light Emitted by a Source in Motion

The ballistic law of massless balls applies to light: A wavefront or a wave emitted at the velocity c by a source at the velocity v travels in the absolute frame at the propagation velocity $\boldsymbol{c_{sa}}$, given by the vector sum of the emitted velocity $\boldsymbol{c}$ and the source's velocity $\boldsymbol{v}$, $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$, unless a restriction arises in its propagation direction. The velocity c_{sa} varies in direction and magnitude depending on the direction of the velocity c from the direction of the velocity v.

Suppose a light source at rest in the absolute frame emits waves in all directions. The spherical wavefront always has its center at the source; waves are uniformly distributed from the source; and waves travel at the emitted speed c with wavelength λ, period T, and frequency f in any direction. The phenomenon is a sphere with the center at the source at rest, continuously expanding with a radius increasing in time by ct. At each fixed point, a local observer observes the wave coming from the source with a delay according to the time from its emission, traveling at the speed of c, wavelength λ, period T, and frequency f.

Figure 8 illustrates the circular wavefront emitted in the paper plane by a light source at the origin of an inertial frame that travels at the velocity v in the absolute frame. Figure 8 presents the case for $c > v$ at a scale for $c = 3$ m/s, $v = 2$ m/s. At the initial instant at the point O_1, the source emits a spherical wavefront. After a time $t = 4$ s, the source is at the point O_2.

When the source is at O_1, Figure 8 shows the instantaneous velocities c on the circle with the center at O_1, which belong to the inertial frame and absolute frame, and the instantaneous propagation velocities c_{sa} originate at O_1 and ending on the circle with the center at the point O_1', which belong to the absolute frame. Both circles have a radius of 3 m. At O_2, after 4 s from the initial instant, the circular wavefront emitted at O_1 has a radius of 12 m.

A specific velocity c_{sa} applies to each wavefront emitted in the absolute frame. The vector sum of velocity c of the wavefront emitted at O_1 in the direction O_1B_1 and the common velocity v along O_1O_1' gives the propagation velocity c_{sa} along the path O_1B_1' traveled in one second. This wavefront travels the path O_1B_2 in time $t = 4$ s at speed c_{sa} in the absolute frame and the path O_2B_2 at speed c in the inertial frame. The emitted velocity direction of the wavefront O_1B_1 does not change along O_1B_2. A local observer at the point B_2 observes the wavefront coming from O_2, not O_1. With the same reasoning, each velocity c_{sa} can be distinguished from the multiple lines.

Each emitted wavefront inherits the velocity of the source in the absolute frame, such that in the source inertial frame, waves in any direction travel at the emitted speed c with wavelength λ, period T, and frequency f. The phenomenon in the inertial frame of the source is like that in the absolute frame when the source is at rest. In the absolute frame, the spherical wavefront of the inertial frame travels at the velocity v, continuously expanding with a radius increasing in time by ct.

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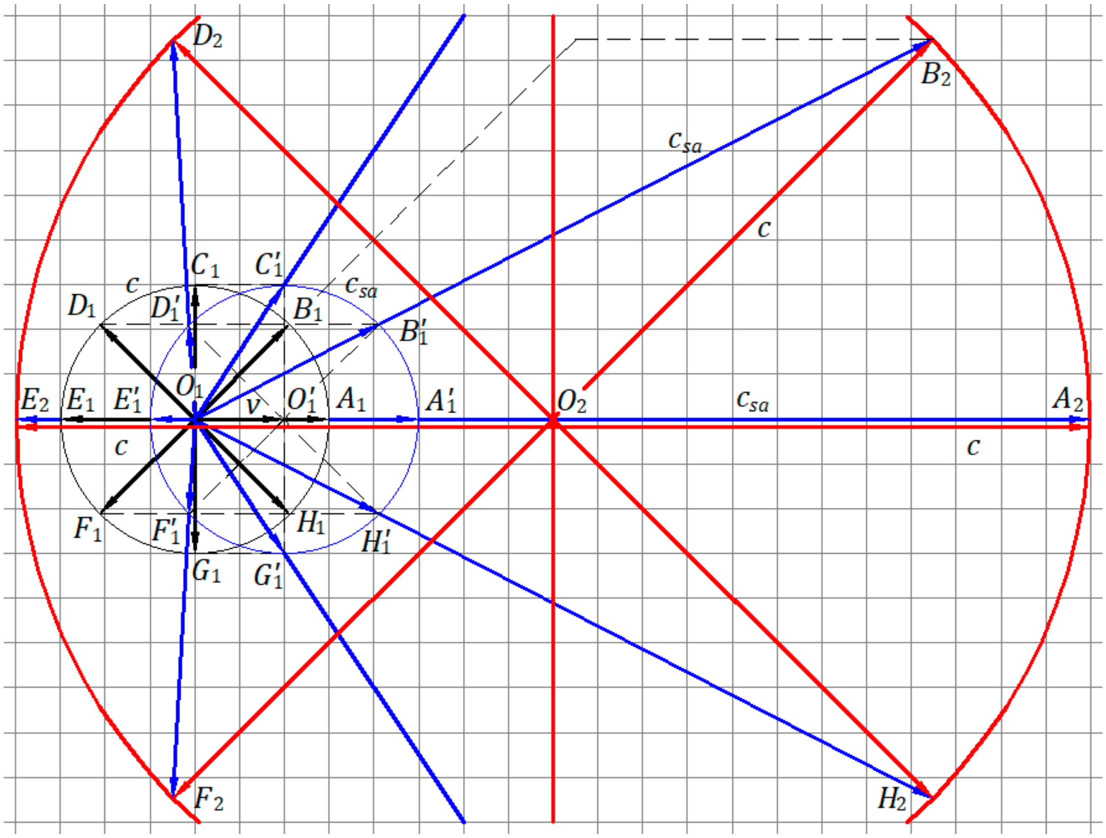

Figure 8. The ballistic law of light's propagation applies to wavefronts of light emitted by a source in motion.

3.2. Reflection of Light by a Moving Mirror

Figure 9 illustrates, in the absolute frame, a mirror M traveling at velocity v and the source S of coherent light at rest. The wavefronts reflected at point A of the mirror belongs to waves originating from the sequential points of the source.

This section employs Eq. (4), $v'_2 = v_2 + v_i + v_r$, in which the electromagnetic speed c replaces v_2 and the reflected speed c_{ra} of the wave in the absolute frame replaces v'_2:

$$c_{ra} = c + v_i + v_r. \tag{7}$$

In the inertial frame of the mirror, in the moment of collision, the speed of the mirror in the opposite direction to the incident light is $v_i = v\cos a$. In the absolute frame, the speed of the mirror in the direction of the reflected light is $v_r = v\cos b$. Another form of Eq. (7) is:

$$c_{ra} = c + v\,cos\,a + v\,cos\,b, \tag{8}$$

where angles a and b are measured counterclockwise from the velocity v.

A second after the collision at A_1, the wavefront from A_1 is at B_2, and the mirror is at A_2. The wavefronts reflected between A_1 and A_2 travel in the absolute frame in the direction A_1B_2 at speed c_{ra}. In the inertial frame of the mirror, the wavefronts travel at velocity $\boldsymbol{c_i}$ given by the vector subtraction of the wavefronts' velocity $\boldsymbol{c_{ra}}$ and the velocity $\boldsymbol{v}$ of the source, $\boldsymbol{c_i} = \boldsymbol{c_{ra}} - \boldsymbol{v}$. A local observer at the point B_2 perceives the wavefront as coming from A_1, not from the actual location of the mirror at A_2. According to the angle a, the reflected light travels as a contracted/dilated and deformed wave at different speeds and wavelengths, but at the same period T and frequency f; along A_2B_2 of Figure 9, the wave is contracted.

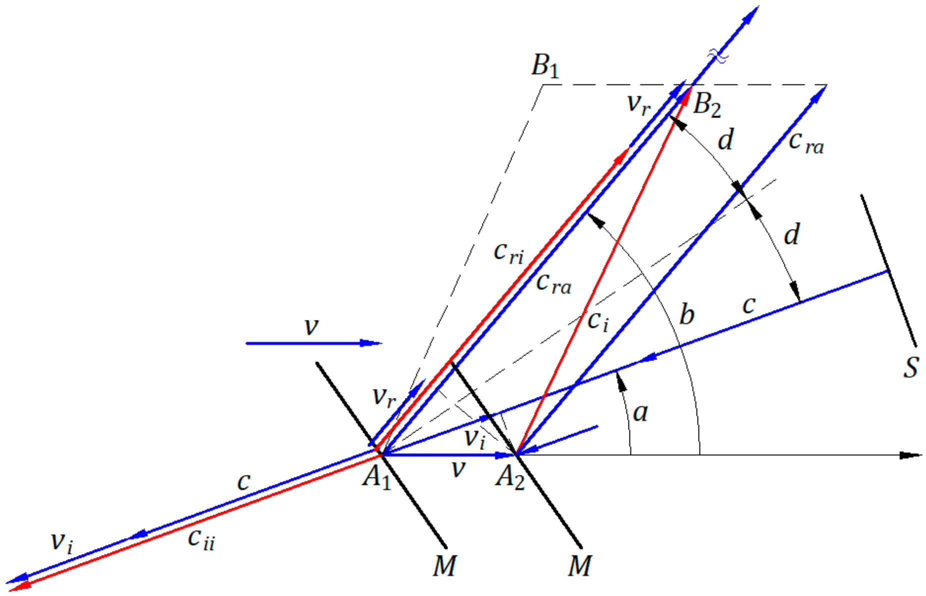

Figure 9. Reflection of light by a moving mirror.

The source may not be at rest; therefore, the speed of light propagation in the absolute frame $c_{sa} \neq c$. In this case, the mirror may also perceive the source's velocity, not only the emitted velocity. Ref. 6 approaches this general consideration.

3.3. Emission, Propagation, and Reflection of Light as Mechanical Phenomena in the Absolute Frame and an Inertial Frame

The study of the emission, propagation, and reflection of light is based on that of massless balls, as described in Subsection 2.6. The mechanical velocity v is the same as that for massless balls. The emitted velocity c replaces the velocity V of the balls.

Figure 10 illustrates a light source and a reflecting mirror, both at rest, in the absolute frame and an inertial frame. The source and mirror have the same geometry, and each source is at the origin of its frame.

In the absolute frame $OXYZ$, the source at the origin O emits a wavefront at velocity c_e of magnitude c at an angle a from the axis OX. After time t_1, the wavefront is at the point A of the mirror M. At the point A, the wavefront is reflected at velocity c_r of magnitude c, then it travels the path AB in time t_2. The light travels along the paths OA and AB in time $t = t_1 + t_2$ at speed c, wavelength λ, period T, and frequency f.

The inertial frame $O'X'Y'Z'$ travels at velocity v, and the source is at its origin O'. The points A and B and origin O' belong to the inertial frame, and their instances in the absolute frame are assigned corresponding indices. The source emits a wavefront at the velocity c_e of magnitude c in direction $O_1'A_1$ at the angle a from axis $O'X'$. The wavefront travels on the propagation path $O_1'A_2$ at the propagation velocity c_{sa}, given by the vector sum of the emitted velocity c_e and the source's velocity v. The velocity c_e does not change its direction $O_1'A_1$ and magnitude c along the path $O_1'A_2$.

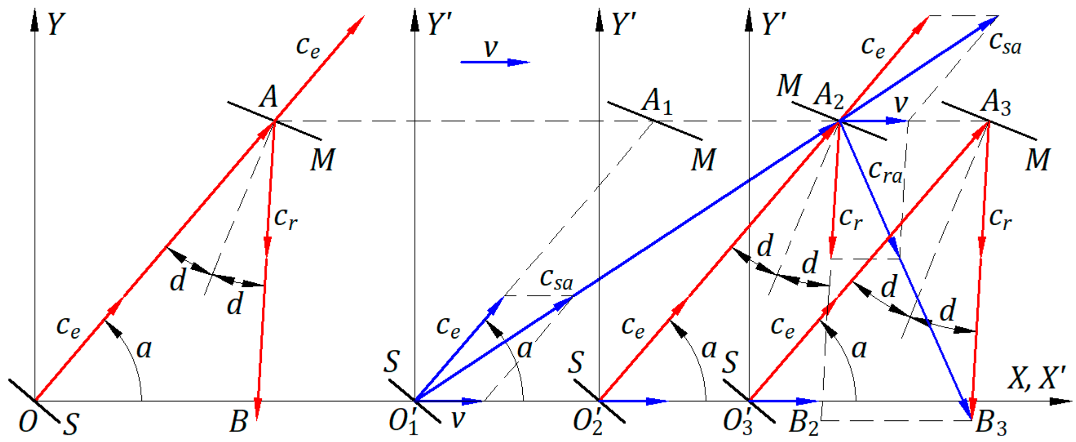

Figure 10. Emission, propagation, and reflection of light in the absolute frame and an inertial frame.

At the point O_2', the wavefront is at A_2; it has traveled the path $O_2'A_2$ at speed $c_e = c$ in time t_1, and the direction $O_2'A_2$ makes angle a from axis $O'X'$. Paths $O_2'A_2$ and $O'A$ are identical in the inertial frame, and are equal to OA in the absolute frame $OXYZ$. The points of the wave emitted in the direction $O_1'A_1$ at the point O' between O_1' and O_2' are on the path $O_2'A_2$, forming a wave.

At the point A_2 of the reflection, the mirror perceives only the magnitude and direction of the emitted velocity c_e, or it can be said that the velocity v is not engaged in reflection, because the wavefront and the mirror have the same velocity v. The incident and reflected angles d are measured from the normal to the mirror at the collision point to the incident velocity c_e and reflected velocity c_r, both of magnitude c. After reflection, the velocity v keeps the wavefront moving in the same direction with the same magnitude v. The wavefront travels on the propagation path A_2B_3 at the propagation velocity c_{ra}, given by the vector sum of the reflected velocity c_r in the direction A_2B_2 and source velocity v. The velocity c_r does not change its direction A_2B_2 and magnitude c along path A_2B_3. At the point O_3', the wavefront emitted from O_1' is at B_3, the direction $O_3'A_3$ makes angle a from axis $O'X'$, and the wavefront has traveled the path $O_3'A_3 = O_2'A_2 = O_1'A_1 = O'A$ at speed $c_e = c$ in time t_1 and the path A_3B_3 at speed $c_r = c$ in time t_2. Path A_3B_3 is the path AB in the inertial frame, which is identical to that one in the absolute frame $OXYZ$. At the point O_3', the wavefront has traveled the path $O_3'A_3 = O'A$ and $A_3B_3 = AB$ in the time $t = t_1 + t_2$ at speed c, with wavelength λ, period T, and frequency f, as in the absolute frame $OXYZ$. In the inertial frame, a local observer at the point A observes the light coming from the origin O', and another at the point B observes the light from the point A.

3.4. Discussions

The kinematics of light distinguishes between its emission and propagation. Maxwell's equations give the universal constant speed of the emitted light $c_e = c$ in any direction in the vacuum of the absolute frame. When the source is at rest in the absolute frame, the waves travel at the emitted speed $c_e = c$ with wavelength λ, period T, and frequency f. When the source is in motion, the waves are emitted in the absolute frame at velocities $\boldsymbol{c}$ of the same magnitude c with their individual directions and inherit the common source's velocity $\boldsymbol{v}$ of mechanical nature. According to the ballistic law, the velocities of their propagation are given by $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$. In the inertial frame of the source, the waves travel at the speed c with wavelength λ, period T, and frequency f in any direction as those in the absolute frame.

In the inertial frame of a source, a mirror at rest perceives only the emitted velocity of a wave $c_e = c$, which is reflected accordingly at a velocity $\boldsymbol{c_r} = \boldsymbol{c}$. The reflected wave continues to inherit the source's velocity $\boldsymbol{v}$ of mechanical nature, such that in the absolute frame at rest, the waves travel at velocity $\boldsymbol{c_{ra}} = \boldsymbol{c} + \boldsymbol{v}$. In the source's inertial frame, the reflected waves travel as those in the absolute

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frame in which the source is at rest, with the same speed c, wavelength λ, period T, and frequency f.

The ballistic law, applicable to massless balls and light, is embedded in mechanics because it is derived from mechanics. It works in the absolute frame, which is the background of any source's inertial frame and acts on each massless ball and light wave emitted by the source, creating in the source's inertial frame a phenomenon identical to that one in the absolute frame when the source is at rest. Therefore, the kinematics of light explains and confirms the principle of relativity according to which no experiment in an inertial frame can prove its motion. It also explains why the laws of physics have the same form in each inertial frame, and why the speed of light in such a frame is the constant c when the source and the reflecting mirror are at rest.

It is convenient to compare the physics phenomena from inertial frames with those in the frame at absolute rest, which is an inertial frame at zero speed. The phenomena in each inertial frame are similar to those in the frame at absolute rest. Therefore, each inertial frame can be considered a local frame at absolute rest for itself and for any other inertial frame, which travels at a known relative velocity with respect to the local frame at absolute rest. It can be concluded that the light travels at the velocity c in the inertial frame of the source in which it was emitted, not in any other inertial frame.

3.5. Experiments and Observations that Support Kinematics of Light as a Mechanical Phenomenon

The kinematics of light explains experiments and observations that have been previously explained with an insufficient and incorrect understanding.

3.5.1. Michelson–Morley Experiment

According to the understanding of his time, Michelson derived the light paths within his interferometer [15] by assuming the ether at rest, in which the light travels at the constant speed c given by Maxwell's equations. Therefore, the speed of light emitted by a source and reflected by a mirror has the same magnitude in the hypothetical ether at rest, regardless of whether the source and mirror are at rest or in motion. The Michelson–Morley experiment predicted a fringe shift that was not confirmed by the experimental results.

The kinematics of light proves that in an inertial frame where a source of light and a mirror are at rest, the speed of light is constant c of electromagnetic nature. Therefore, the kinematics of light predicts a zero-fringe shift in the Michelson–Morley experiment, which agrees with the experimental results.

3.5.2. Experiment Performed at CERN, Geneva

Without rejecting Ritz's ballistic theory [16], the emission, propagation, and reflection of light in inertial frames [5] explain the experiment performed at CERN, Geneva, in 1964 [17]. Figure 11 illustrates this phenomenon using a straightforward approach.

Figure 11. A boson as a carrier decaying at a mechanical speed v near the speed of light c.

When a boson B of mass m is accelerated at a mechanical speed v near the constant speed of light c, it decays into a particle A of mass m and one massless photon. At speed v, the direction of the particle A is forced to change, and the photon continues moving freely at the mechanical speed v. Bosons are just carriers that give photons their mechanical speed v near the constant speed of light

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c. Bosons are not sources of light and cannot emit photons at the speed c of electromagnetic nature. This experimental result confirms the ballistic law of light's propagation.

3.5.3. Observation of a Star in the Universe

Figure 12(a) illustrates the observation of a star by an observer on Earth according to the ballistic law of light's propagation. Both the star and Earth are moving at a velocity v. Suppose that, in the initial instance, the star is at point A_1 and Earth is at point B_1, when the star emits a wavefront of light in the direction A_1B_1 at the emitted speed c.

After a time t_1 from the initial instance, the star travels the path A_1A_2, and the Earth travels the path B_1B_2, both of which have equal length L_1. The ballistic law causes the wavefront emitted in the direction A_1B_1 to propagate along the path A_1B_2. At B_2, a local observer perceives the wavefront as coming from A_2. Therefore, the star is observed at its actual location.

Figure 12(b) illustrates the observation of a star in the universe based on the hypothesis that the speed of light is independent of the source's motion. Suppose that, at the initial instance, the star at point A_1 emits a wavefront of light in the direction A_1B_3 at the emitted speed c.

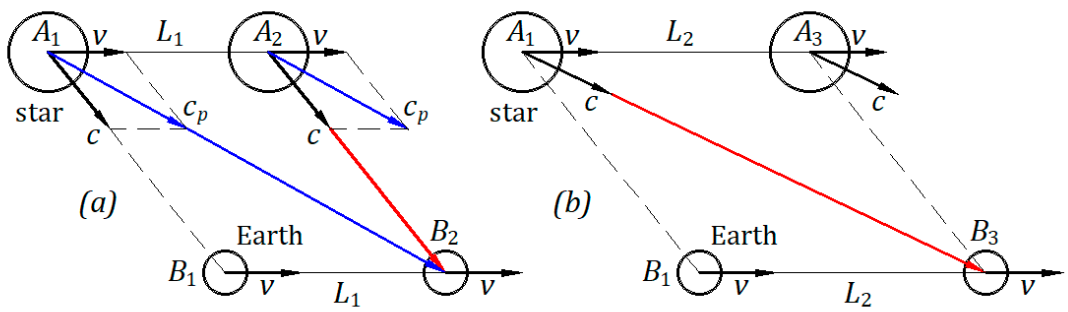

Figure 12. Observation of a star in the universe, considering: (a) the ballistic law of light's propagation and (b) the constancy of light speed.

After a time t_2 from the initial instance, the star travels the path A_1A_3 and the Earth travels the path B_1B_3, both of equal length L_2. The wavefront, emitted in the direction A_1B_3, reaches the point B_3, where a local observer perceives the wavefront as coming from A_1. Therefore, the star is observed at its initial location, not at its actual location, which means that the hypothesis of the constancy of the speed of light creates irregularities that are unobserved by astronomers. These irregularities differ from those that De Sitter incorrectly predicted [18,19].

3.5.4. Observation of a Star's Orbit

The emission of light as a mechanical phenomenon was applied to the observation of a star's orbit [6]. Figure 13 depicts an actual star's orbit with the center at the point O_s of radius R in the plane of the paper and an imaginary circle of radius OA' with the center at the point O and with its plane parallel to and in front of the paper plane.

The distance $d = OO_s$ is perpendicular to the orbit and the imaginary circle plane. The observer at rest is located at the point O. The observed star orbit of radius R_O is centered at O_s. The view is from the observer's back right, providing a clear view of the actual and observed orbits. The distances in each set of the lengths ($AA' = A''O = EE' = E''O = \ldots$) and ($AO = EO = \ldots$), including all other similar distances corresponding to the points $B, C, D, F, G,$ and $H,$ are equal.

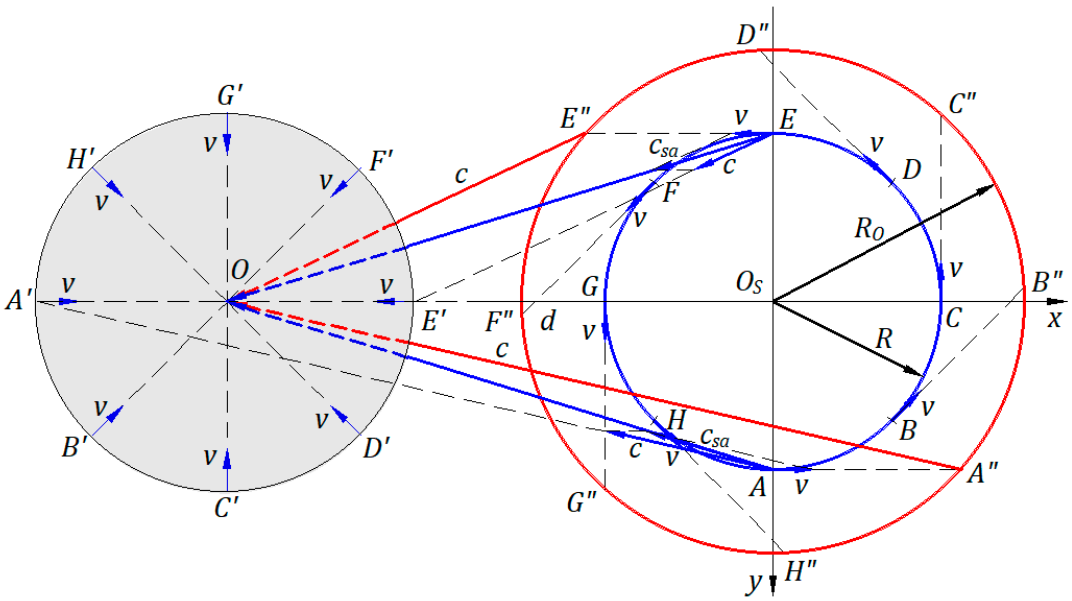

Figure 13. Observation of a star's orbit.

The waves emitted by the star in motion inherit the velocity v of the star corresponding to each orbital point, and travel through different paths to the local observer O. At the point A, the star emits a wavefront of light at the velocity c in the direction AA', but this wavefront travels along the path AO at the propagation velocity c_{sa}. The direction AA' and the magnitude of the velocity c do not change along the path AO. At the point O, the observer observes the wavefront originating from the point A'' traveling at speed c towards him. At the point E, the star emits a wavefront of light at the velocity c in the direction EE', $EE' = AA'$; this wavefront travels along the path EO, $EO = AO$, at the same propagation velocity c_{sa}. The direction EE' and the magnitude of the velocity c do not change along the path EO. At the point O, the observer sees the wavefront coming from the point E'' traveling at speed c along the path $E''O = A''O$. The observer perceives the same observation at each point in the circular orbit.

The points A, B, C, D, E, F, G, and H are observed at the corresponding points A'', B'', C'', D'', E'', F'', G'', and H'', points which offer in this particular case the observed orbit with the center at O_s. The local observer sees the star's orbit rotated; it has a larger diameter than the actual orbit, and the observed orbital speed is greater than v, so the observed orbit is traveled in the same real time. The observed circular orbit increases with increasing distance d. This observation compensates for the fact that objects appear smaller than they are as the distance increases. The speed of light from any point on the observed orbit to the observer is constant c. Therefore, no time irregularities exist to refute Ritz's ballistic theory [16] as De Sitter [18,19] explained. Observing a star's orbit supports the ballistic law of light's propagation.

The circular orbit of a star is observed as an ellipse when the distance d is not perpendicular to the star's orbit plane.

3.5.5. Miller Experiment

Studying the emission, propagation, and reflection of light in inertial frames [5] helps to predict zero fringe shifts for any location and altitude in Earth's inertial frame. This explains Miller's experiments [11] at the Cleveland Laboratory in 1924 [20], which employed light from local sources, as well as sunlight; the fringe shift with sunlight was of the order of 10^{-8}. The fringe shifts of 0.08 in 1921 and 0.088 in 1925, recorded by Miller using local sources at a high altitude on Mount Wilson, remain unexplained.

3.5.6. Airy Experiment

In addition to the interactions of the emission and reflection of light with matter, there are other examples, such as the velocity of light traveling in the direction and opposite to it through a moving medium [12] and the refraction of light when it travels from one medium to another, both at rest, according to Snell's law. Airy's experiment presents the transversal dragging of light by a moving medium. Observing the star γ Draconis, Airy [21] expected to adjust the telescope's inclination after introducing a water-filled tube along its axis. However, this was unnecessary. Considering the dragging of light by moving water and the experimental results, the Fresnel dragging coefficient of $1-\frac{1}{n_1^2}$ was obtained from a mechanical perspective [12], where n_1 is the refractive index of the medium.

3.5.7. Majorana Experiment

Majorana's experiment [22] in Earth's inertial frame employs a fixed light source. The light travels through three stages, each consisting of a movable and a fixed mirror, and then enters a Michelson interferometer with unequal-length arms. The movable mirrors are mounted on a rotational disk that moves in both directions. A fringe image is observed when the disk is at rest. When the disk is rotated from maximum speed in one direction to another, a 0.71 fringe shift is observed.

Like the Michelson interferometer, Majorana's experimental device offers an outstanding contribution to the physics of light, despite changes in the interpretation of the experiment over time. Majorana misunderstood the phenomenon within the device and the significance of the fringe shift observed during the experiment, claiming that it supports special relativity. The reflection of light as a mechanical phenomenon [2–4], applied in the Majorana experiment [22] proves that the speed of light changes at each stage, causing a fringe shift in the Michelson interferometer. Reference [13] approximates rotational mirrors as linear-motion mirrors and derives a shift of 0.27 fringes. However, the observed fringe shift of 0.71 confirms that the speed of light varies as a propagation speed, rejecting the hypotheses of the constancy of light speed.

5. Conclusions

The ballistic law is based on the physics phenomenon that balls and light inherit the velocity v of their source at emission in the absolute frame. The mathematical expression of the ballistic law provides the propagation velocity of balls and light, given by the vector sum of the ball's and light's velocities emitted by their sources and their sources' velocities. Thus, the emitted velocity of light c is maintained after emission, and the velocity v is like a mechanical carrier that changes the propagation velocity of light accordingly. Therefore, there are no contradictions with Maxwell's equations because the emitted velocity of light remains constant c for any direction of the propagation velocity c_{sa}. The ballistic law is reasonable and understandable, without explanation, and it is fundamental in mechanics, like the Newtonian laws.

Matter creates the light. As a mechanical phenomenon, the kinematics of light naturally presents light in its interactions with matter at emission, reflection, refraction, and when traveling through a moving medium. Light and any other electromagnetic radiation can be considered massless matter or fields, and the kinematics of light can be included in mechanics.

The kinematics of light explains and proves in each inertial frame where a source of light and a mirror are at rest, why the speed of light is the universal constant c of electromagnetic nature given by Maxwell's equations, why each law of physics has the same form, and why no experiment in such a frame can prove its motion.

Mechanics presents phenomena as they are. This article presents phenomena as they are in mechanics and as they are perceived by a local observer, thereby helping to understand reality correctly. The understanding that the human eye perceives the emitted velocity c of a source, not its propagation, is essential to understanding physics phenomena.

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The velocity of light emitted by the source does not change its direction and magnitude along the direction of light propagation. To achieve a clear vision, the human eye adjusts itself toward the emitted light, which does not necessarily coincide with the direction toward the source. In the case of Subsection 3.5.4. and Reference [6], the human eye observes an enlarged orbit that excludes De Sitter irregularities [18,19], which no longer contradicts Ritz's ballistic theory [16]. In Subsection 3.5.3, the observed emitted constant speed of light c, given by the kinematics of light, yields a universe close to reality. In contrast, the constancy of light speed c, incorrectly understood as the propagation of light, yields a backward-in-time image of the universe that astronomers do not observe.

The kinematics of light confirms the constancy of time passage in the universe and the variability of light speed in the form of wave propagation in the absolute frame.

Acknowledgement: I am grateful to the person who set me on the right path and inspired me to study the emission, propagation, and reflection of light as mechanical phenomena.

Appendix A: Experiment on the Reflection and Emission of Light

References [2,3] present a particular geometry of the Michelson interferometer in which the beam splitter is at $45°$ to the source's rays, one opaque mirror is perpendicular to the source's rays, and the other is parallel to them. Reference 4 employs the Michelson interferometer with a general geometry.

The ether theory considers that light travels at a constant emitted speed c, limited by the presence of the ether. The reflection of light by a moving mirror as a mechanical phenomenon [2,3] considers the speed of light independent of the source's speed, and the reflection speed of light is variable in the absolute frame.

Applying the ether theory, both interferometers predict a fringe shift of 0.40, which is not confirmed by experiments. Applying the reflection of light as a mechanical phenomenon,[2] the interferometer with a particular geometry predicts zero fringe shift, and the other one a 0.40×10^{-4} fringe shift, results that are acceptable.

To confirm or reject this conclusion, we searched for another interferometer, presented in Figure 14. Even if this article was published last, it was written before the publication of References [2,3].

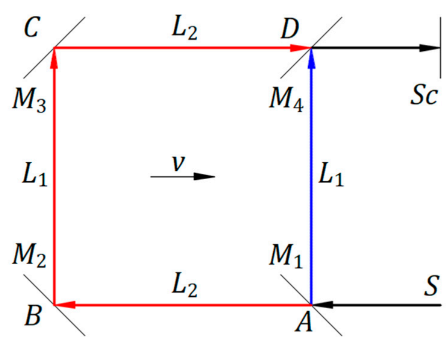

Figure 14. Schematic of the interferometer.

Figure 14 illustrates the interferometer[11] at rest in an inertial frame at velocity v. The beam splitter M_1 splits the light from the source. The transmitted rays travel from M_1 to the opaque mirrors M_2 and M_3, the beam splitter M_4, and the screen Sc. The reflected rays travel from M_1 to the beam splitter M_4 and then to the screen Sc. All four mirrors make a 45° angle with the incoming rays. Employing light reflection as a mechanical phenomenon, the theoretical fringe shift yields 210 fringes. This high fringe shift leaves no doubt about the experimental result of a zero-fringe shift. Therefore, the hypothesis that light reflection is a mechanical phenomenon is incorrect. If we only apply the ether theory to this interferometer, the theoretical fringe shift is zero according to the experimental results.

However, this result led us to consider both the reflection and emission of light, as mechanical phenomena [5] that explain the Michelson–Morley experiment and others presented in this article.

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