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The Doppler effect of light is applied in the kinematics theory of balls and light, and in the classical theory

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Abstract: The study of the Doppler effect, presenting light as a wave, makes a distinction between the propagation velocity of the wave and the propagation velocity of its wavefront. This distinction applies to each theory, regardless of the hypothesis on which it is founded. The kinematics of light, which makes this distinction, shows that at emission, waves inherit the velocity of their source, making them in the inertial frame of the star as if the star were at rest in the absolute frame; The waves travel with the same speed c, wavelength λ, period T, and frequency f in any direction, and each spherical wavefront is always centered in the source. The Doppler effect of light applied in the kinematics of light yields the same result. For the classical Doppler effect explanation for light and special relativity, which considers the speed of light to be the constant c, unaware of the distinction between the propagation velocity of a wave and the propagation velocity of its wavefront, the Doppler effect gives in the inertial frame of a star waves traveling at variable speeds and wavelengths, but with the same period and frequency. Consequently, each spherical wavefront has its center at the instant of its emission, not in the source, and the waves look like sound waves.

Keywords: kinematics of balls; kinematics of light; ballistic law; emission of balls; propagation of balls; emission of light; propagation of light; speed of light.

1. INTRODUCTION

The kinematics theory of balls and light [1] started with the kinematics of balls. A ball brought from rest to a velocity v by its source has the magnitude and direction of that velocity. Upon emission, the ball inherits and keeps the velocity v independent of the magnitude and direction of the emitted velocity V. After emission, the ball travels in the absolute frame with the propagation momentum $\boldsymbol{P_{sa}} = \boldsymbol{mV_{sa}}$ given by the two momenta, $\boldsymbol{mv}$ and $\boldsymbol{mV}$. Thus, $\boldsymbol{mV_{sa}} = \boldsymbol{mV} + \boldsymbol{mv}$, which offers the ballistic law of ball propagation in the absolute frame $\boldsymbol{V_{sa}} = \boldsymbol{V} + \boldsymbol{v}$. When the mass of a hypothetical ball converges to zero, it travels at the same velocity $\boldsymbol{V_{sa}} = \boldsymbol{V} + \boldsymbol{v}$. The hypothetical massless ball does not require mechanical energy to be moved from rest to the velocity v or at emission to get the velocity V, and has no momentum after emission. At the emission, there are no action-reaction forces. The energy is required only by the source and the emission device within the source. The kinematics of the hypothetical massless ball was extended to light as a massless entity.

For light, the emission device is the electromagnetic forces within the light source that emit waves at the velocity c of an electromagnetic nature. When the source is in motion, the wavefront of a wave and the following wave's wave-points, which are wavefronts, inherit the velocity v of a mechanical nature of the source, which they already have. Maxwell's equations give the emitted constant speed c of light as a wave in the vacuum of the absolute frame in which the source is at rest. The ballistic law can be extended to encompass all massless wavefronts of a wave, such as, in the absolute frame, their propagation velocity $\boldsymbol{c_{sa}}$ is the vector sum of the constant emitted velocity c and the velocity of the source v, $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$.

The kinematics of light approaches the mechanical aspect of each wavefront propagation, governed by the ballistic law, without affecting the wave propagation, maintaining the magnitude and direction of the emitted velocity c with respect to the source at all times. Therefore, the kinematics of light does not contradict the validity of the constant speed of light c as a wave in the absolute and inertial frame, even if the wavefront and the wave's wave-points, which are wavefronts, have variable speeds in the absolute frame. The electromagnetic theory is complete without mentioning the propagation velocity of light waves in the absolute frame and inertial frames, which is the subject of mechanical kinematics.

All figures show in the absolute frame two observers at rest, one located at the point O_1 and another at the point O_2, and a star as a source of light S in motion at the velocity v. Two of the figures have a third and a fourth observer at O_3 and O_4 also at rest. The drawings are at a scale for the star's velocity $v = 1$ m/s and the velocity of light $c = 4$ m/s. Each instantaneous point on the source S is assigned an index number. The same instant in time at other locations is denoted by a number receiving an index location.

For Figures 1(a), 1(b), 1(c), and 2, the length $S_0O_1 = 9$ m and the length $S_0O_2 = 15$ m, which do not affect observation, and for Figures 3(a), 3(b), 3(c), and 4, the length $S_0O_1 = S_0O_2 = 12$ m.

Each Figure 1(a) and 3(a) illustrates two wave cycles emitted at the point S_0 in opposite directions, given as a reference, shown in a thin line, and traveling at the velocity c with wavelength λ, period T, and frequency f, as if the source were at rest.

2. THE DOPPLER EFFECT OF LIGHT IS APPLIED IN THE KINEMATICS THEORY OF BALLS AND LIGHT

2.1. The wavefront is emitted in the opposite direction of the velocity $\boldsymbol{v}$

In Figure 1(a), the source emits a wavefront from S_0 at the velocity c in the opposite direction of the velocity v. The wavefront inherits the velocity v, and the propagation velocity of the wavefront c_{sa} given by the ballistic law is $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ with the magnitude of $c_{sa} = c - v = 3$ m/s. The source travels at a velocity $v = 1$ m/s along the path S_0S_1 in 1 s. The wavefront emitted at the instant point S_0 in the direction S_0O_1 travels at the velocity $c_{sa} = c - v = 3$ m/s along the path from S_0 to the instant point 1_1, in 1 s, $S_01_1 = 3$ m. The instant point S_1 marks the end of the first wave cycle emitted by the source. The first dilated wavelength from S_1 to the instant point 1_1, $S_11_1 = \lambda$, is given by the sum of the lengths $S_01_1 = 3$ m and $S_0S_1 = vt = 1$ m, $\lambda = S_01_1 + S_0S_1 = 4$ m. Therefore, the first wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c - v = 3$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_1 = \frac{c_{sa}}{\lambda} = \frac{c-v}{cT} = \frac{1}{T}\frac{c-v}{c} = f\frac{c-v}{c} = 0.750$ Hz.

In Figure 1(b), the source emits a wavefront from S_1 at the velocity c in the opposite direction of the velocity v. The wavefront travels at the same velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ with the magnitude of $c_{sa} = c - v = 3$ m/s. The source travels at a velocity $v = 1$ m/s along the path S_1S_2 in 1 s. The wavefront emitted at the instant point S_1 in the direction S_1O_1 travels at the velocity $c_{sa} = c - v = 3$ m/s along the path from S_1 to the instant point 2_1 in 1 s, $S_12_1 = 3$ m. The instant point S_2 marks the end of the second wave cycle emitted by the source. The second dilated wavelength from S_2 to the instant point 2_1, $S_22_1 = \lambda$, is given by the sum of the lengths $S_12_1 = 3$ m and $S_1S_2 = vt = 1$ m, $\lambda = S_12_1 + S_1S_2 = 4$ m. Therefore, the second wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c - v = 3$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_1 = f\frac{c-v}{c} = 0.750$ Hz. The end of the first wave cycle travels at the velocity $c_{sa} = 3$ m/s in time $t = T = 1$ s from S_1 to the instant point 2_1 in 1 s.

In Figure 1(c), the source emits a wavefront from S_2 at the velocity c in the opposite direction of the velocity v. The wavefront travels at the same velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ with the magnitude of $c_{sa} = c - v = 3$

m/s. The source travels at a velocity $v = 1$ m/s along the path S_2S_3 in 1 s. The wavefront emitted at the instant point S_2 in the direction S_2O_1 travels at the velocity $c_{sa} = c - v = 3$ m/s along the path from S_2 to the instant point 3_1 in 1 s, $S_23_1 = 3$ m. The instant point S_3 marks the end of the third wave cycle emitted by the source. The third dilated wavelength from S_3 to the instant point 3_1, $S_33_1 = \lambda$, is given by the sum of the lengths $S_23_1 = 3$ m and $S_2S_3 = vt = 1$ m, $\lambda = S_23_1 + S_2S_3 = 4$ m. Therefore, the third wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c - v = 3$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_1 = f\frac{c-v}{c} = 0.750$ Hz. The end of the second wave cycle travels at the velocity $c_{sa} = 3$ m/s in time $t = T = 1$ s from S_2 to the instant point 3_1. The observer at O_1 observes the frequency in the absolute frame.

In the inertial frame of the star, the wave travels at the velocity $c = 4$ m/s with wavelength $\lambda = 4$ m, period T, and frequency f. Note that the source velocity v produces the dilation of the wavelengths to λ.

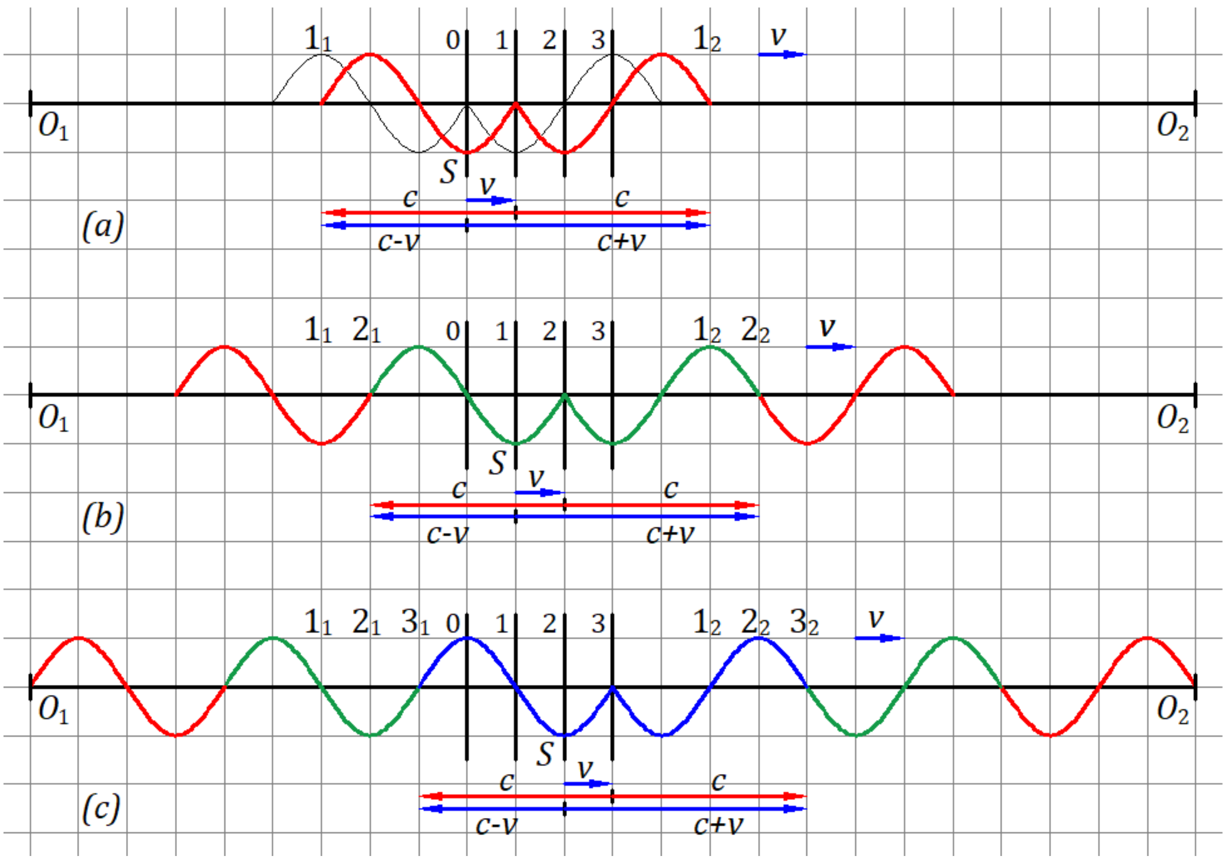

Figure 1. The Doppler effect of light is applied in the kinematics theory of balls and light. (**a**) The first emitted wave cycle. (**b**) The second emitted wave cycle. (**c**) The third emitted wave cycle.

2.2. The wavefront is emitted in the direction of the velocity $\boldsymbol{v}$

In Figure 1(a), the source emits a wavefront from S_0 at the velocity c in the direction of the velocity v. The wavefront inherits the velocity v, and the propagation velocity of the wavefront c_{sa} given by the ballistic law is $\boldsymbol{c_{sa} = c + v}$, with the magnitude of $c_{sa} = c + v = 5$ m/s. The source travels at a velocity $v = 1$ m/s along the path S_0S_1 in 1 s. The wavefront emitted at the instant point S_0 in the direction S_0O_2 travels at the velocity $c_{sa} = c + v = 5$ m/s along the path from S_0 to the instant point 1_2 in 1 s, $S_01_2 = 5$ m. The instant point S_1 marks the end of the first wave cycle emitted by the source. The first contracted wavelength from S_1 to the instant point 1_2, $S_1 1_2 = \lambda$, is given by the subtraction of the length $S_0 S_1 = vt = 1$ m from the length $S_0 1_2 = 5$ m, $\lambda = S_0 1_2 - S_0 S_1 = 4$ m. Therefore, the first wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c + v = 5$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_2 = \frac{c_{sa}}{\lambda} = \frac{c+v}{cT} = \frac{1}{T}\frac{c+v}{c} = f\frac{c+v}{c} = 1.250$ Hz.

In Figure 1(b), the source emits a wavefront from S_1 at the velocity c in the direction of the velocity v. The wavefront travels at the same velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ with the magnitude of $c_{sa} = c + v = 5$ m/s. The source travels at a velocity $v = 1$ m/s along the path $S_1 S_2$ in 1 s. The wavefront emitted at the instant point S_1 in the direction $S_1 O_2$ travels at the velocity $c_{sa} = c + v = 5$ m/s along the path from S_1 to the instant point 2_2 in 1 s, $S_1 2_2 = 5$ m. The instant point S_2 marks the end of the second wave cycle emitted by the source. The second contracted wavelength from S_2 to the instant point 2_2, $S_2 2_2 = \lambda$, is given by the subtraction of the length $S_1 S_2 = vt = 1$ m from the length $S_1 2_2 = 5$ m, $\lambda = S_1 2_2 - S_1 S_2 = 4$ m. Therefore, the second wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c + v = 5$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_2 = f\frac{c+v}{c} = 1.250$ Hz. The end of the first wave cycle travels at the velocity $c_{sa} = 5$ m/s in time $t = T = 1$ s from S_1 to the instant point 2_2.

In Figure 1(c), the source emits a wavefront from S_2 at the velocity c in the direction of the velocity v. The wavefront travels at the same velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ with the magnitude of $c_{sa} = c + v = 5$ m/s. The source travels at a velocity $v = 1$ m/s along the path $S_2 S_3$ in 1 s. The wavefront emitted at the instant point S_2 in the direction $S_2 O_2$ travels at the velocity $c_{sa} = c + v = 5$ m/s along the path from S_2 to the instant point 3_2 in 1 s, $S_2 3_2 = 5$ m. The instant point S_3 marks the end of the third wave cycle emitted by the source. The third contracted wavelength from S_3 to the instant point 3_2, $S_3 3_2 = \lambda$, is given by the subtraction of the length $S_2 S_3 = vt = 1$ m from the length $S_2 3_2 = 5$ m, $\lambda = S_2 3_2 - S_2 S_3 = 4$ m. Therefore, the third wave cycle travels in the absolute frame at the velocity of the wavefront $c_{sa} = c + v = 5$ m/s with the wavelength $\lambda = 4$ m in time $t = T = 1$ s, and frequency $f_2 = f\frac{c+v}{c} = 1.250$ Hz. The end of the second wave cycle travels at the velocity $c_{sa} = 5$ m/s in time $t = T = 1$ s from S_2 to the instant point 3_2. The observer at O_2 observes the frequency in the absolute frame.

In the inertial frame of the star, the wave travels at the velocity $c = 4$ m/s with wavelength $\lambda = 4$ m, period T, and frequency f. Note that the source velocity v produces the contraction of the wavelengths to λ.

2.3. The wavefront is emitted perpendicular to the velocity v

Figure 2 shows the first wavefront emitted at S_0 at the velocity c perpendicular to the direction of velocity c. The first wavefront inherits the velocity of the source and travels at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ towards O_3. After a second, the first wavefront is at 1_4, the first wave traveled along the path $S_1 1_4$, and a second wavefront is emitted at S_1 at the same velocity and in the same direction. After 2 s from S_0, the first wavefront is at O_3, and the second wavefront is at 2_4. The first and the second wave cycles travel along the path $S_2 O_3$ in 2 s at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$. Therefore, the light waves travel in the inertial frame in any direction at the velocity c with wavelength λ, period T, and frequency f, as derived from the kinematics theory of balls and light. Figure 2 also presents the wavefront that travels along the length $S_0 O_4$ at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ and the wave along the length $S_2 O_4$ at the velocity c; the wave, as a sinusoidal shape, is not shown.

In the case of Subsection 2.1. and 2.2, the observers at O_1 and O_2 continuously observe a sinusoidal wave. Suppose the star is at O_1 traveling in the same direction. A wave emitted at O_1 arrives at O_3, followed by all others between O_1 and O_2. Therefore, an observer at O_3 may be able to detect a shift in frequency from blue to red by rotating continuously to observe the instantaneous wavefront of each wave. At O_3, the wavefronts of the sequential sinusoidal waves form a deformed sinusoidal wave. Still, the observer approximately sees sinusoidal waves whose frequency changes slowly over time.

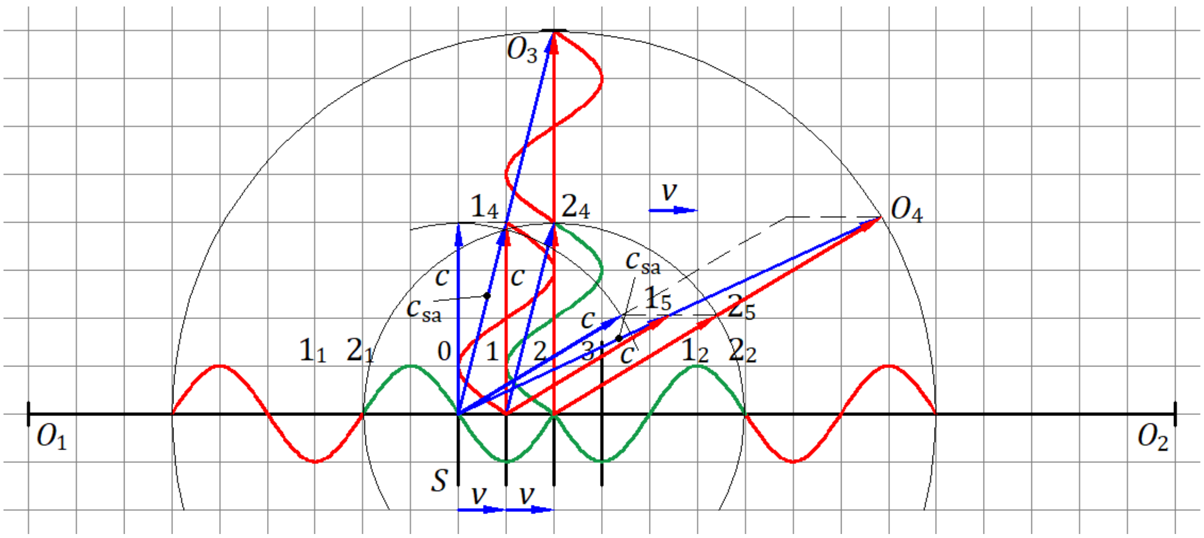

Figure 2. The Doppler effect of light is applied in the kinematics theory of balls and light when a wavefront is emitted perpendicular to the direction of the source's velocity.

3. THE DOPPLER EFFECT OF LIGHT IS APPLIED IN THE CLASSICAL THEORY

In the classical theory, the speed of light is the constant c with no distinction between the velocity of a wave and the velocity of its wavefront and the following wave-points. However, the detailed study of the Doppler effect at the level of the wave makes this distinction, giving in the absolute frame in the same direction and the same velocity c to the emitted wavefront and its propagation, and in the absolute and inertial frame, the propagation velocity of the wave as a vector difference $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, as it is described below.

3.1. The wavefront is emitted in the opposite direction of the velocity $\boldsymbol{v}$

The wavefront emitted in the direction S_0O_1 travels at the vector difference $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, which in this case has the magnitude $c_{sa} = c + v$.

In Figure 3(a), the source travels at the velocity $v = 1$ m/s along the path S_0S_1 in 1 s. The wavefront emitted at the instant point S_0 in the direction S_0O_1 travels at the velocity $c = 4$ m/s along the path from S_0 to the instant point 1_1 in 1 s, $S_01_1 = \lambda = 4$ m. The instant point S_1 marks the end of the first wave cycle emitted by the source. The first dilated wavelength from S_1 to the instant point 1_1, $\lambda_1 = S_11_1$, is given by the sum of the lengths $S_01_1 = 4$ m and $S_0S_1 = vt = 1$ m, $\lambda_1 = S_01_1 + S_0S_1 = \lambda + vt = 5$ m. Therefore, the first wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_1 = \lambda + vt = 5$ m in time $t = T = 1$ s, and frequency $f_1 = \frac{c}{\lambda_1} = \frac{c}{\lambda+vt} = \frac{1}{T}\frac{c}{c+v} = f\frac{c}{c+v} =$ 0.800 Hz. Note that $\lambda_1 = \lambda + vt = (c+v)t$ and $c_{sa} = c + v$ is the magnitude of $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, for this case.

In Figure 3(b), the source travels at the velocity $v = 1$ m/s along the path S_1S_2 in 1 s. The wavefront emitted at the instant point S_1 in the direction S_1O_1 travels at the velocity $c = 4$ m/s along the path from S_1 to the instant point 2_1 in 1 s, $S_12_1 = \lambda = 4$ m. The instant point S_2 marks the end of the second wave cycle emitted by the source. The second dilated wavelength from S_2 to the instant point 2_1, $\lambda_1 = S_22_1$, is given by the sum of the lengths $S_1 2_1 = \lambda = 4$ m and $S_1 S_2 = vt = 1$ m, $\lambda_1 = S_1 2_1 + S_1 S_2 = \lambda + vt = 5$ m. Therefore, the second wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_1 = \lambda + vt = 5$ m in time $t = T = 1$ s and frequency $f_1 = f\frac{c}{c+v} = 0.800$ Hz. The end of the first wave cycle travels at the velocity $c = 4$ m/s in time $t = T = 1$ s from S_1 to the instant point 2_1.

In Figure 3(c), the source travels at the velocity $v = 1$ m/s along the path $S_2 S_3$ in 1 s. The wavefront emitted at the instant point S_2 in the direction $S_2 O_1$ travels at the velocity $c = 4$ m/s along the path from S_2 to the instant point 3_1 in 1 s, $S_2 3_1 = \lambda = 4$ m. The instant point S_3 marks the end of the third wave cycle emitted by the source. The third dilated wavelength from S_3 to the instant point 3_1, $\lambda_1 = S_3 3_1$, is given by the sum of the lengths $S_2 3_1 = 4$ m and $S_2 S_3 = vt = 1$ m, $\lambda_1 = S_2 3_1 + S_2 S_3 = \lambda + vt = 5$ m. Therefore, the third wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_1 = \lambda + vt = 5$ m in time $t = T = 1$ s, and frequency $f_1 = f\frac{c}{c+v} = 0.800$ Hz. The end of the second wave cycle travels at the velocity $c = 4$ m/s in time $t = T = 1$ s from S_2 to the instant point 3_1. The observer at O_1 observes the frequency in the absolute frame.

In the inertial frame of the star, the wave travels at the velocity $c = c + v = 5$ m/s with the wavelength $\lambda_1 = \lambda + vt = (c + v)t = 5$ m, period T, and frequency f. Note that the source velocity v produces the dilation of the wavelengths from λ to λ_1.

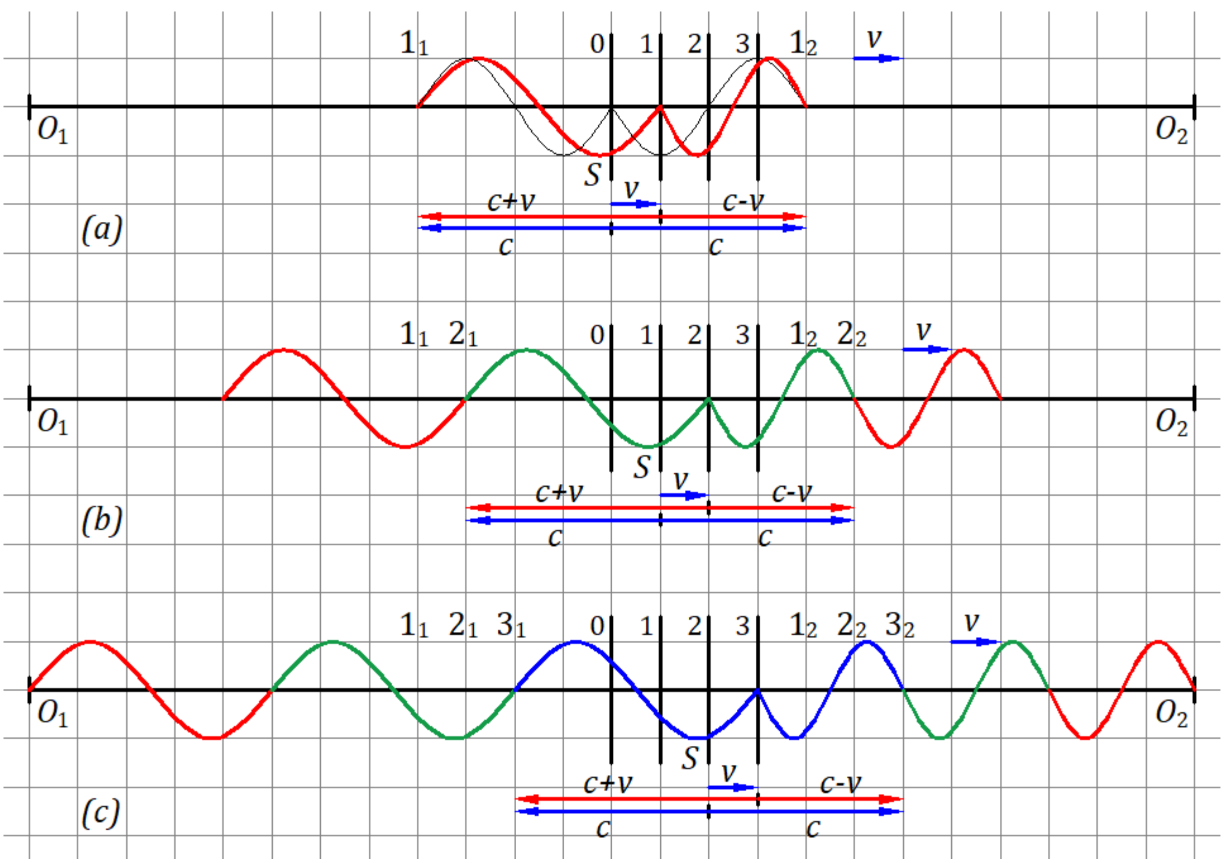

Figure 3. The Doppler effect of light is applied in classical theory. (**a**) The first emitted wave cycle. (**b**) The second emitted wave cycle. (**c**) The third emitted wave cycle.

3.2. The wavefront is emitted in the direction of the velocity $\boldsymbol{v}$

The wavefront emitted in the direction S_0O_1 travels at the vector difference $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, which in this case has the magnitude $c_{sa} = c - v$.

In Figure 3(a), the source travels at the velocity $v = 1$ m/s along the path S_0S_1 in 1 s. The wavefront emitted at the instant point S_0 in the direction S_0O_2 travels at velocity $c = 4$ m/s along the path from S_0 to the instant point 1_2 in 1 s, $S_01_2 = \lambda = 4$ m. The instant point S_1 marks the end of the first wave cycle emitted by the source. The first contracted wavelength from S_1 to the instant point 1_2, $\lambda_2 = S_11_2$, is given by the subtraction of the length $S_0S_1 = vt = 1$ m from the length $S_01_2 = 4$ m, $\lambda_2 = S_01_2 - S_0S_1 = \lambda - vt = 3$ m. Therefore, the first wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_2 = \lambda - vt = 3$ m in time $t = T = 1$ s, and frequency $f_2 = \frac{c}{\lambda_2} = \frac{c}{\lambda - vt} = \frac{1}{T}\frac{c}{c-v} = f\frac{c}{c-v} = 1.33$ Hz. Note that $\lambda_2 = \lambda - vt = (c - v)t$ and $c_{sa} = c - v$ is the magnitude of $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, for this case.

In Figure 3(b), the source travels at the velocity $v = 1$ m/s along the path S_1S_2 in 1 s. The wavefront emitted at the instant point S_1 in the direction S_1O_2 travels at velocity $c = 4$ m/s along the path from S_1 to the instant point 2_2 in 1 s, $S_12_2 = \lambda = 4$ m. The instant point S_2 marks the end of the second wave cycle emitted by the source. The second contracted wavelength from S_2 to the instant point 2_2, $\lambda_2 = S_22_2$, is given by the subtraction of the length $S_1S_2 = vt = 1$ m from the length $S_12_2 = 4$ m, $\lambda_2 = S_12_2 - S_1S_2 = \lambda - vt = 3$ m. Therefore, the second wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_2 = \lambda - vt = 3$ m in time $t = T = 1$ s, and frequency $f_2 = f\frac{c}{c-v} = 1.33$ Hz. The end of the first wave cycle travels at the velocity $c = 4$ m/s in time $t = T = 1$ s from S_1 to the instant point 2_2.

In Figure 3(c), the source travels at the velocity $v = 1$ m/s along the path S_2S_3 in 1 s. The wavefront emitted at the instant point S_2 in the direction S_2O_2 travels at velocity $c = 4$ m/s along the path from S_2 to the instant point 3_2 in 1 s, $S_23_2 = \lambda = 4$ m. The instant point S_3 marks the end of the third wave cycle emitted by the source. The third contracted wavelength from S_3 to the instant point 3_2, $\lambda_2 = S_33_2$, is given by the subtraction of the length $S_2S_3 = vt = 1$ m from the length $S_23_2 = 4$ m, $\lambda_2 = S_23_2 - S_2S_3 = \lambda - vt = 3$ m Therefore, the third wave cycle travels in the absolute frame at the velocity of the wavefront $c = 4$ m/s with the wavelength $\lambda_2 = \lambda - vt = 3$ m in time $t = T = 1$ s, and frequency $f_2 = f\frac{c}{c-v} = 1.33$ Hz. The end of the second wave cycle travels at the speed $c = 4$ m/s with the wavelength $\lambda_2 = 3$ m in time $t = T = 1$ s from S_2 to the instant point 3_2. The observer at O_2 observes the frequency in the absolute frame.

In the inertial frame of the star, the wave travels at the velocity $c = c - v = 3$ m/s with the wavelength $\lambda_2 = \lambda - vt = (c - v)t = 3$ m period T, and frequency f. Note that the source velocity v produces the contraction of the wavelengths λ to λ_2.

3.3. The wavefront is emitted perpendicular to the direction of the velocity $\boldsymbol{v}$

Figure 4 shows the first wavefront emitted at S_0 in the direction S_0O_3 at the velocity c. After 1 s, the first wavefront is at the instant point 1_4, the first wave traveled along the path S_11_4, and a second wavefront is emitted at S_1 at the same velocity and in the same direction. After 2 s from S_0, the first wavefront traveling at the velocity c is at O_3, and the velocity of the wave along the path S_2O_3 is $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, whose magnitude is greater than the speed c. Therefore, the light waves travel in the inertial frame at variable speeds and wavelengths, but constant period T and frequency f. Figure 4 also presents the wavefront that travels along the length S_0O_4 at the velocity c and the wave along the length S_2O_4 at the velocity $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, conform to the Doppler effect; the wave, as a sinusoidal shape, is not shown.

The spherical wavefront emitted at S_0 has its center always at this instant. After two seconds, the spherical wavefront includes points O_3 and O_4, and the star is at an instant point S_2 where a new wavefront starts. After a second from S_2, the new wavefront has the center at S_2, and the source is at S_3. Therefore, the waves resemble sound waves when the sound source travels in Earth's inertial frame.

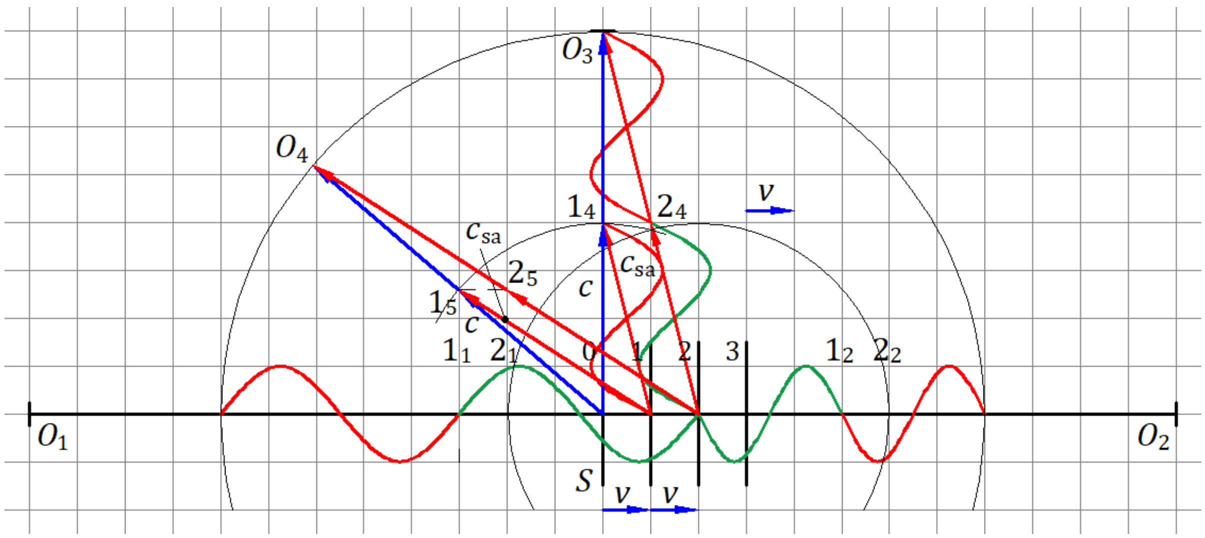

Figure 4. The Doppler effect of light is applied in the classical theory. A wavefront is emitted perpendicular to the direction of the source's motion.

In the case of Subsection 3.1. and 3.2, the observers at O_1 and O_2 continuously observe a sinusoidal wave. Suppose the star is at O_1 traveling in the same direction. A wave emitted at O_1 arrives at O_3, followed by all others between O_1 and O_2. Therefore, an observer at O_3 may be able to detect a shift in frequency from blue to red by rotating continuously to observe the instantaneous wavefront of each wave. At O_3, the wavefronts of the sequential sinusoidal waves form a deformed sinusoidal wave. Still, the observer approximately sees the waves as sinusoidal, with their frequency changing slowly over time.

4. DISCUSSION

Figure 2 presents, in the absolute frame, the wavefront emitted at velocity c, perpendicular to velocity v, and its propagation velocity at the vector sum $\boldsymbol{c_{sa}} = \boldsymbol{c} + \boldsymbol{v}$ along the path S_0O_3, and in the absolute and inertial frame, the propagation velocity c of the wave given by the vector difference $\boldsymbol{c} = \boldsymbol{c_{sa}} - \boldsymbol{v}$, conform to the kinematics of light along the path S_2O_3. Figure 2 also presents the wavefront that travels along the path S_0O_4 and the wave along the path S_2O_4, as a general geometry. Figure 4 presents, in the absolute frame, the wavefront emitted at S_0 and its propagation along the direction S_0O_3 at the same velocity c, and the wave propagation along the path S_2O_3 at the velocity $\boldsymbol{c_{sa}}$ given by the vector difference $\boldsymbol{c_{sa}} = \boldsymbol{c} - \boldsymbol{v}$, conform to the Doppler effect. Figure 4 also presents the wavefront that travels along the path S_0O_4 and the wave along the path S_2O_4, as a general geometry.

Reference 2 presents the formation of a wave propagating in a straight line, without its sinusoidal shape, at emission and reflection for a train of wavelengths given by the kinematics of light. However, by displaying waves of light as sinusoidal shapes, the Doppler effect clearly reveals the phenomenon of wavelength dilation and contraction with results specific to each theory.

The Subsections 2.2. and 2.1. give, in the absolute frame, the propagation velocity of the wavefronts equal to the propagation velocity of the waves, $c_{sa} = c \pm v_s$, with wavelength λ, period T, and frequency $f_o = \frac{c_{sa}}{\lambda} = f\frac{c \pm v_s}{c}$, correspondingly. For $\pm v_s$, the plus sign is when the source travels towards the observer, and the minus sign is when the source travels away from the observer. In the inertial frame, the waves travel at the speed c with wavelength λ, period T, and frequency f in both directions and any other direction, as shown by the wave traveling along the path S_2O_4 of Figure 2.

The Subsections 3.2. and 3.1. give, in the absolute frame, the propagation velocity of the wavefronts equal to the propagation velocity of the waves, c. The waves have the wavelength $\lambda_o = (c \mp v_s)T$, period T, and frequency $f_o = \frac{c}{\lambda_o} = f\frac{c}{c \mp v_s}$, correspondingly. For $\mp v_s$, the minus sign is when the source travels towards the observer, and the plus sign is when the source travels away from the observer. In the inertial frame, the waves travel at the speed $c_{sa} = c \mp v_s$ with wavelength $\lambda_o = (c \mp v_s)T$, period T, and frequency f, correspondingly, which are different in both directions and in any other direction, as shown by the wave traveling along the path S_2O_4 of Figure 4.

For the kinematics of light, the propagation of the light as a wave in the absolute frame gives the frequency $f_o = f\frac{c \pm v_s}{c}$, where f_o is the observed frequency, and v_s is the speed of the source. The speed of the observer v_o affects the observed frequency by affecting the relative speed of the source with respect to the observer. Therefore, the frequency formula including v_s and v_o is:

$$f_o = f\frac{c \pm v_s \pm v_o}{c} = f\frac{c \pm v_r}{c} \tag{1}$$

where the velocity $\pm v_r = \pm v_s \pm v_o$ is the relative velocity between the inertial frame of the observer and that of the star. The frequency is different from that for sound waves. For $\pm v_r$, the plus sign is when the source and the star travel towards one another, and the minus sign is when the source and the observer travel away from one another. The velocities v_s and v_o are unknown; therefore, it is reasonable to replace them with the relative velocity $\pm v_r$, which gives the observed frequency shift.

The classical Doppler explanation does not distinguish between the propagation of light as a wave and as a wavefront, but the Doppler effect phenomenon for light does. The propagation of the light as a wave in the absolute frame yields the frequency $f_o = f\frac{c}{c \mp v_s}$. For $\mp v_s$, the minus sign is when the source travels towards the observer, and the plus sign is when the source travels away from the observer. The light waves look like those of sound waves, and the formula for frequency f_o, as well, because light waves travel at a constant speed, as sound waves do, according to the classical Doppler effect and special relativity.

The actual phenomenon of the wavefront and wave-points propagation of each wave in the absolute frame and in the inertial frame of the star is unobserved; the propagation of the wave hides it. The frequency shift of light is used to calculate the relative velocity between observer and star, and it cannot support formulas for the observed frequency f_o predicted by either theory. A key distinction between the two theories is how light propagates as a wave in the absolute frame and in inertial frames, including its speed, wavelength, period, and frequency. Therefore, this distinction made by the Doppler effect of light and its results verifies the correctness of a theory. This is a test passed only by the kinematics theory of light, not by the classical Doppler effect or special relativity.

According to the kinematics of light, at the local or cosmic scale, light waves propagate in the inertial frame of a star at the same speed c in any direction with respect to the moving star. In the absolute frame, the spherical wavefronts travel at the velocity of the star v, expanding in space at the rate of ct, and are always centered at the star. The classical Doppler effect assumes the velocity of light is constant c, which yields, in the inertial frame of a star, waves that travel at variable speeds and wavelengths, and at a constant period and frequency. Consequently, the spherical wavefronts have their centers at the instant of emission, not at the source, and the waves resemble the sound waves. This is an unacceptable result, which also applies to Ritz's ballistic theory, the ether theory, and special relativity. Note that the sound waves propagate through local wave cycles of air, balancing back and forth, while the light wave travels through air. The reflected ones do not disturb the air's reflecting particles because light is a massless entity.

The observed frequency shift is independent of any theory. Between the inertial frame of the observer and that of the star, there is a relative velocity. Thus, the inertial frame of the star can be considered a stationary frame, and the inertial frame of the observer travels away from the stationary frame at the relative velocity v_r, as presented in special relativity. In this case, the Doppler effect indicates for each theory a specific frequency shift, and each one proves that the observed wave in the inertial frame of the observer does not travel at velocity c with wavelength λ, period T, and frequency f. This result is consistent with the kinematics of light, but it rejects special relativity, which claims that the speed of light c from the star is constant in any other inertial frame. Note that the Ritz ballistic theory gives the same results as the kinematics of light for a wave emitted along the velocity v of the star and opposite to it, but ignoring any other direction.

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