Isotropy Of Light In Reference Frame

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The speed of light is identical in all directions in the rest frame of the light source. In a different inertial reference frame, the direction of light may change due to the motion of the light source. The speed of light in the longitudinal direction of the motion of the light source is compared to the speed of light in the transverse direction. The result shows that these two speeds are equal only if the speed of the light source is greater than the speed of light.

I. INTRODUCTION

An isotropic light source radiates the same intensity of radiation in all directions. This is possible only if the light source is stationary. The light from a moving source may have a different velocity due to the motion of the light source. Such velocity can be determined with the transformation of reference frame from the rest frame of the light source to another inertial reference frame.

The velocities from two different reference frames are related by the relative motion between reference frames. For reason of simplicity, only light in two particular directions are transformed. One direction is parallel to the motion of the light source. The other direction is vertical to the motion of the light source.

The speed of light in each direction is calculated based on transformation rules. The comparison of two speeds generates the required condition for them to be identical to each other. For light that is in a new direction in the new reference frame, its direction will show how the distribution of the light intensity should be for a moving light source.

II. PROOF

Consider two-dimensional motion.

A. Reflection Symmetry

Let an observer \( P_1 \) be stationary at the origin of a reference frame \( F_1 \). Let another observer \( P_2 \) be at a position \((x,0)\) in \( F_1 \).

Let the rest frame of \( P_2 \) be \( F_2 \). \( P_2 \) is stationary at the origin of \( F_2 \). From the relative reflection symmetry, \( P_1 \) is at the position of \((-x,0)\) in \( F_2 \).

Let \( P_2 \) move at the velocity of \((v,0)\) relative to \( F_1 \). From the relative reflection symmetry, \( P_1 \) is moving at the velocity of \((-v,0)\) relative to \( F_2 \).

B. Elapsed Time

\( P_1 \) is equipped with a light source to radiate light in all directions. The light in the x-direction reaches \( P_2 \). Let \( T_1 \) be the elapsed time for light to reach \( P_2 \). The speed of light is \( C_1 \) in \( F_1 \).

\[ C_1 * T_1 = x + v * T_1 \]  
(1)

\[ x = (C_1 - v) * T_1 \]  
(2)

The light in the y-direction travels the distance \( L \) for the duration of \( T_1 \).

\[ L = C_1 * T_1 \]  
(3)

In \( F_2 \), the elapsed time for the light from \( P_1 \) to reach \( P_2 \) is \( T_2 \). Let the speed of light in the x-direction be \( C_2 \).

\[ C_2 * T_2 = | - x | \]  
(4)

C. Speed Of Light

The light in the y-direction in \( F_1 \) is in a new direction in \( F_2 \). Let the speed of light in this direction be \( C_3 \).

\[ (C_3 * T_2)^2 = L^2 + (v * T_2)^2 \]  
(5)

\[ C_3 = \frac{\sqrt{L^2 + (v * T_2)^2}}{T_2} \]  
(6)

From equations (2,4),

\[ C_2 = \frac{(C_1 - v) * T_1}{T_2} \]  
(7)

From equations (3,6),

\[ C_3 = \frac{\sqrt{(C_1 * T_1)^2 + (v * T_2)^2}}{T_2} \]  
(8)
**D. Isotropy**

From equations (7,8),

$$\frac{C_3}{C_2} = \sqrt{(C_1 T_1)^2 + (v T_2)^2} \frac{(C_1 - v) T_1}{(C_1 - v) T_1}$$  \hspace{1cm} (9)

The condition for $C_2 = C_3$ is

$$\sqrt{(C_1 T_1)^2 + (v T_2)^2} = (C_1 - v) T_1$$  \hspace{1cm} (10)

$$(v T_2)^2 = (v^2 - 2 C_1 v) T_1^2$$  \hspace{1cm} (11)

$$T_2 = T_1 \sqrt{1 - \frac{2 C_1}{v}}$$  \hspace{1cm} (12)

The condition breaks down if

$$1 - 2 \frac{C_1}{v} < 0$$  \hspace{1cm} (13)

$C_2$ is equal to $C_3$ only if

$$v > 2 C_1$$  \hspace{1cm} (14)

Equation (12) indicates that $C_2$ is equal to $C_3$ only if the time dilation from Lorentz transformation[1,2] is false.

**E. Intensity**

The direction of transverse light in $F_1$ changes by an angle $\theta$ in $F_2$. From equation (5),

$$\sin(\theta) = \frac{v T_2}{C_1 + \frac{x v}{c_1}}$$  \hspace{1cm} (16)

For $v$ much smaller than $C_1$, $\sin(\theta)$ is proportional to

$$\frac{v}{C_2}$$  \hspace{1cm} (17)

The angle increases if the light source moves faster.

**III. CONCLUSION**

The speed of light depends on the choice of reference frame. The motion of the light source not only changes the direction of light but also the speed of light.

The direction of light becomes closer to the direction of the movement of the light source. The movement of the light source causes its light to be concentrated toward the direction of its movement. The intensity of light in front of the light source increases upon acceleration of the light source.

For a slow moving light source, the speed of its longitudinal light is different from the speed of its transverse light.

