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# In What Sense Is the Velocity of Light Constant?

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In earlier works [1,2] it was argued that although the velocity of light is constant within each inertial frame, it is not independent of the relative velocity between the source and the observer. This finding meets with the results of other researchers [5,6]. The current article which completes the latest article published in The General Sciences Journal, and which is excerpted from [1,2] highlights the fact that the velocity of light is not independent of relative motion between the source and the observer. We present here a particular case, namely the relative longitudinal motion. The general case was dealt with in section 3 in "the scaling transformation (II)" that appeared in GSJ on November 22, 2007.

Let $S \equiv OXYZ$ and $s \equiv oxyz$ be two inertial frames in standard configuration, with $s$ moving relative to $S$ with velocity $\vec{u} = u\vec{i}\ (u > 0)$, and endow $S$ and $s$ with spherical coordinates $(R, \theta, \phi)$ and $(r, \theta', \phi')$ respectively, with $\theta\,(\theta')$ is the azimuth angle between the radius vector $\vec{R}\,(\vec{r})$ and the polar axis $X$ $(x)$. Let $b$ be a stationary source of light in $s$, and take the zero of timing in both frame the instant at which the body $b$ is at the point $\mathrm{B}\,(R, \theta, \phi)$, i.e. $T = t = 0$ when $b$ is at $B$. It was shown [1-4] that the relations between the lengths and durations of the single light's trip $(b\,at\,B \to O\,and\,o)$ and its directional angles in $S$ and $s$ are given by the anisotropic scaling transformations

$$(5.1) \qquad \frac{r}{R} = \frac{t}{T} = \Gamma(\beta, \theta), \quad , \theta = \theta', \quad \phi = \phi',$$

with $\beta = v/c$ and

$$(5.2) \qquad \Gamma(\beta, \theta) = (1 - \beta^2)^{-1/2}(\beta\cos\theta + \sqrt{1 - \beta^2 \sin^2\theta}).$$

The scaling transformations (5.1) yield $r/t = R/T$, which guarantees that if the velocity of light in a frame is *c* then so it is in the other frame. Thus, the velocity of light when measured exclusively within each inertial frame, has the same value *c*. This result does not mean however that the velocity of light is independent of the source's velocity.

In the active view only the frame *S* is needed, in which case:
$R = cT$ is the geometric length of the virtual light trip $(B \to O)$ and *T* its duration were *B* a true source.
$r = ct$ is the length of the true trip $(b \to O)$ and *t* is its duration; these are called the proper (or mobile) length and duration of the trip.

For simplicity, consider a source of light *b* that is stationary at *O* in the frame *S*, and situated at the midpoint of the segment *PQ* of the *X*-axis, with *Q*(*X*,0,0) is on the positive side. If the source *b* emits at the same time two pulses of light towards *P* and *Q*, then each pulse will take the same duration $T = X / c$ to reach its target, or as to say, the two pulses reach their destinations simultaneously.

Suppose now that the source *b* is moving along the *X*-axis with a positive velocity *u*, and when at *O*, it emits two pulses towards *P* and *Q*. The question is: do the pulses reach *P* and *Q* simultaneously? To answer this question we have to calculate the period of each trip as observed in *S*. Let $t_+$ and $t_-$ be the durations of the trips $(b \rightarrow Q)$ and $(b \rightarrow P)$ respectively. By the active view[1-3] of the scaling transformations we have

$$t_+ = \Gamma(-u,0)T, \quad t_- = \Gamma(u,0)T \,, \tag{5.3}$$

since the source is approaching *Q* and receding from *P*. If the pulses are emitted at *T=0*, then they reach *Q* and *P* at $t_+$ and $t_-$ respectively, i.e. not simultaneously.

Consider now the following case: Assume that *b* and *b'* are two sources of light that are moving on the *X*-axis of *S* with velocities *u* and –*u* respectively, and when both at *O*, each source emits a pulse towards *Q*. We pose the same question, do the pulses reach *Q* at the same time? It is clear that the current problem is almost identical to the previous one, and that the pulse emanating from *b* reaches *Q* first, then followed by the pulse from *b'*. The delay period between the two pulses is

$$t_+ - t_- = T[\Gamma(-u,0) - \Gamma(u,0)] = -\frac{2u / c}{\sqrt{1 - u^2 / c^2}} \,. \tag{5.4}$$

If *O* emits simultaneously with *b* and *b'* a pulse of light towards *Q*, then *Q* will receive a sequence of three pulses at the instants $t_+, T, t_-$.

The result (5.1) is quite close to the Sagnac effect corresponding to electromagnetic transmission around the equator, which will discussed in the part (III) of this work.

It follows from the above discussion that the velocity of light is not independent of the relative motion between the source and the observer. Indeed, light emitted from a source that is approaching an observer requires less time than that associated with another contiguous source receding from the same observer. In fact, the greater the velocity with which a source approaches an observer, the less time light takes to reach the observer.

The dependence of the light's speed on the relative motion between a source and an observer was foreseen through a variety of arguments and methods by a number of researchers [5-9].

## References

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