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Speed or Time Dilation?

Pavle I. Premović
Laboratory for Geochemistry, Cosmochemistry and Astrochemistry,
University of Niš, pavleipremovic@yahoo.com, Niš, Serbia

Time dilation and length contraction are two important concepts of the Special relativity (SR). These two depend upon the second postulate of this theory that the speed of light c ($\approx 3 \times 10^8$ m sec^{-1}) is the same in all inertial frames of reference.

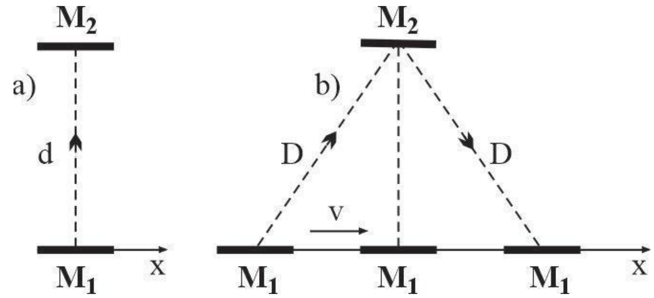

Fig. 1. (a) The light clock is at rest and (b) this clock is moving at speed υ along a positive x-axis.

In elementary physics textbooks, time dilation of SR is imagined using a device known as a light clock.[1] This light clock consists of two plane-parallel mirrors, M_1 and M_2, that face each other and are separated by a distance d (Fig. 1a). A light signal originating from mirror M_1 will reach mirror M_2 within a time interval, ΔT_0. This interval would be measured by an observer with the same reference as the light clock. If the same light clock moves with a certain relative speed υ in the direction of the positive x-axis, then an observer in the rest frame of reference who is watching this clock could design the following diagram**,** Fig. 1b. Clearly, the photon will travel a longer distance D for a longer time interval ΔT to reach mirror M_2. SR states that ΔT and ΔT_0 are related by the formula

$$\Delta T = \Delta T_0/\sqrt{(1 - \upsilon^2/c^2)} \quad \ldots (1)$$

where $1/\sqrt{(1 - \upsilon^2/c^2)}$ is the Lorentz or time dilation factor.

A simple consideration would show that the light clock would travel a distance $d = \upsilon\Delta T_0$ for an observer comoving with it. For an observer at rest, this clock would travel a distance $D = \upsilon\Delta T$. Combining these two equations and eqn. (1) and after a bit of algebra, we get

$$d/D = 1/\sqrt{(1 - \upsilon^2/c^2)}.$$

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[1] The author of this communication has previously expressed some dilemmas about this visual phenomenon in several of his communications [1-3].

This equation is the well-known equation of the relativistic space contraction.

As far as we know, no direct or indirect experiments showing relativistic spatial contraction have ever been performed. It is then reasonable to assume that there is the relativistic time dilation but not the contraction. In other words, both observers calculate the same distance or d = D. In that case, the speed of the moving light clock, say υ_0, has to be greater by $1/\sqrt{(1 - \upsilon^2/c^2)}$ than the speed of this clock υ measured by the observer at rest. This is because T_0 is by the same factor less than T. Mathematically speaking,

$$\upsilon_0 = [\upsilon(T/T_0)] = \upsilon[1/\sqrt{(1 - \upsilon^2/c^2)}].$$

In conclusion, this equation appears quite weird, but “that’s way it is” (the late Walter Cronkite, CBS).