A Simple Thought Experiment Saying No to Length Contraction and thus to the Theory of Relativity

Laszlo G. Meszaros
laszlogm@admarc.hu

Abstract

In a thought experiment, in which transit-times of light signal propagation over given distances are measured, it is demonstrated that the length of an object in motion is independent of the object's (relative) velocity and, consequently, equals its resting length, *i.e.* its 'proper' length. Thereby, after discussing Einstein's two (essentially different) light speed postulates, the scientific merit of the Special Theory of Relativity (as well as that of the Lorentz transformations) is questioned.

Keywords: special relativity, length contraction, Lorentz transformations, optical illusion

1. Introduction

The idea of length contraction of a body in uniform motion (often termed as Lorentz contraction or Lorentz-FitzGerald contraction) first surfaced to explain the conflict between the null results of the Michelson-Morley experiments and the ether theory (se ref. 1 and refs. therein) . Then, Einstein introduced (2,3) his Special Theory of Relativity, which proposes to explain the phenomenon of length contraction (and the coupled time dilation) by rendering space and time relative, *i.e.* the dependence of space and time on motion (relative to some resting reference frame). As clearly seen from his derivation of the Lorentz transformation (see Appendix I in ref. 3), this required the introduction of a Light Speed Postulate (LSP)[1], according to which the speed of light (in vacuum) is the same in all inertial reference frames (which implies that it is independent of the motion of both the light source and an observer).

The relationship between length contraction (together with that of the associated time dilation) and objective reality still merits discourse. For instance, the question whether or not length contraction reflects any real dynamical change or only change in perspectives continues to see open discussions. Consequently, if length contraction is to be considered as a result of some dynamical effect, then what force, if any, would be responsible (see ref. 4 and refs. therein). To resolve these issues, it has been recently proposed (5) that the outcomes of the STR, *i.e.* length contraction and time dilation, should only be considered as optical illusions, as they would require the acceptance of multiple, observer-dependent (objective) realities and are clearly in conflict with some other laws of nature, even with the relativity principle, which latter together with the LSP(s) were supposed to provide the basis to the development of the STR (2,3).

A simple thought experiment, in which the length of an object is measured by determining light transit-times, is presented here to challenge the idea of relativistic length contraction (whether it is illusory or not). In these measurements, it is shown that the length of an object in uniform motion (being independent of the speed of the object) is equal to its

[1] It is important to note that Einstein's first LSP (LSP No. 1; see ref. 2 and the text below) is not sufficient to derive the Lorentz transformations (see Appendix I in ref. 3). On the other hand, it is also to note that the assumption of LSP No. 2 implies that of LSP No. 1, but not *vice versa*.

'proper' length; *i.e.* the length that is measured in its rest frame. This unavoidably raises the question whether the STR (together with the Lorentz transformations) has any physical significance.

2. '*Gedanken*' length measurements

For the purpose of these measurements, let us first determine the length of a stationary object (Fig. 1, A) and that of the same object, when it is in uniform motion with speed $\boldsymbol{v}$ (Fig. 1, B), by using a technique, in which transit-times of light signals (s_1 and s_2) are measured. Consider an experimental setup, in which light detectors equipped with a clocking device to register the time of light signal arrival are placed at points $\boldsymbol{a}$ and $\boldsymbol{a'}$, respectively, while light sources are located at the two ends of the objects (at $\boldsymbol{c}$, $\boldsymbol{b}$ and $\boldsymbol{c'}$, $\boldsymbol{b'}$, respectively). For measuring the length of the stationary object ($\boldsymbol{\ell}$), the light sources are simultaneously[2] turned on to send two light signals (s_1 and s_2) towards the detectors, which then record the signals' arrival times. Subsequently, the difference of the recorded arrival times ($\boldsymbol{\Delta t}$) provides a direct measure of the length of the stationary object:

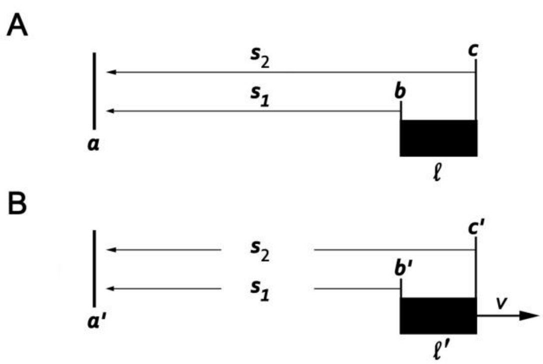

Fig. 1: Length measurement by light transit-time recording. For details, see text.

$$\boldsymbol{\ell} = \boldsymbol{\Delta t c}, \qquad [1]$$

where $\boldsymbol{c}$ is the speed of light. If "*light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body*" (Einstein's LSP No.1, see ref. 2), then it is evident that $\boldsymbol{\Delta t}$ is also a direct measure of the length of an object in uniform motion ($\boldsymbol{\ell'}$):

$$\boldsymbol{\ell'} = \boldsymbol{\Delta t c}. \qquad [2]$$

[2] At this point, "simultaneously" simply means that one single switch turns both light sources on. However, it is interesting to point out that, according to Einstein's definition of simultaneity (see the 'train *vs.* embankment' example in ref. 3), the firing of the light sources in our length measurements, even if a single switch turns both sources on, would not be considered simultaneous in either frames (not even in the resting frame).

Thus, the above experiment clearly shows the absence of length contraction in the case of a moving object. Instead, it shows that the 'relativistic' length of a moving object does not depend on its (relative) speed and, accordingly, equals its 'proper' length, *i.e.* the length that is measured in its own reference frame:

$$\boldsymbol{\ell}' = \boldsymbol{\ell}. \qquad [3]$$

3. Discussion – Einstein's LSPs

As presented here, a rather simple (although not necessarily meant to be practical) measurement of the length of an object in uniform motion clearly contradicts the Special Theory of Relativity, even though the methodology applied here is based on Einstein's (original) LSP No. 1, which was initially claimed to be an essential assumption to the development of his theory (see ref. 2). However, as Einstein himself must have realized later (see Appendix I in ref. 3), this assumption (*i.e.* LSP No. 1), although necessary, is not sufficient to make space and time relative. Thus, he restated his postulate by saying that "*the velocity of transmission of light in vacuo has to be considered equal to a constant* ***c***", meaning that the speed of light is the same in all reference frames, regardless of their state of motion (LSP No. 2; see ref. 3).

LSP No. 1 is an assumption, which one can accept as confirmed without any difficulty (see, for instance, Einstein's own argument in ref. 2)[3]. However, LSP No. 2 is not (6), but has been acutely argued against (7 and refs. therein). To those arguments, it might be interesting to add that such constancy of ***c*** (as is LSP No. 2) seems to be in conflict with the very concept of motion, as we unavoidably define 'motion' as relative to a single specific reference frame, while LSP No. 2 requires that the 'motion' of light is an exemption and it should be looked at as simultaneously ''relative" to all possible reference frames.

In summary, the 'Theory of Relativity'[4], which – among its other outcomes – presents us with the relativistic phenomena of length contraction (and the linked time dilation) of moving objects, is based upon an "*untenable*" (7) assumption on the propagation of light (LSP No. 2). To

[3] Or see the (Doppler) red/blueshift.
[4] The Special Theory of Relativity together with the consequential General Theory of Relativity (see ref. 3).

the contrary, as shown here, length contraction would not 'emerge' from length measurements, which only relies on the assumption of LSP No. 1 as tenable (and does not depend on LSP No. 2[5]). Therefore, the merit of the Theory of Relativity (and of the Lorentz transformations) should be questioned.

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[5] Which would, of course, also suffice (see also Fottnote 1(.