Special Relativity: a contradicting theory or an account for an optical phenomenon

László G. Mészáros
University of Kaposvár, Hungary, laszlogm@admarc.hu

Abstract

Despite of the broad acceptance of Einstein's Special Theory of Relativity (STR), the relation to reality of its predictions (such as length contraction, for instance) still seems obscure. Here, a simple thought-experiment is put forward, which illustrates that relativistic length contraction, if not considered only illusory, contradicts the law of energy conservation as well as the principle of relativity, one of the very postulates the STR is based upon. It is also shown that length contraction, if not considered only illusory, should consequently make a chemical clock tick faster, instead of slower as predicted by the STR. It is therefore suggested that the STR is to be interpreted as an explanation of an optical illusion produced by the invariance of light speed. Stimulating discussions on the true merit of the STR are thus called for.

Keywords: special relativity, length contraction, time dilation, contradiction, optical illusion

Introduction - special relativity and physical reality

Although the Special Theory of Relativity (STR) is now accepted by most physicists, some ambiguity still surrounds it, which—even if tacitly worded—seems to originate from a somewhat obscure relationship of its predictions (such as length contraction and time dilation, for instance) to reality. This is clearly illustrated by the mere fact that a number of paradoxes to scrutinize both length contraction and time dilation have surfaced and their solutions have sincerely been attempted. Recently, a *Nature* news article (1), when referring to experiments with Li^+ ions in a particle accelerator (2), decisively concludes: "*time moves slower for a moving clock than for a stationary one*". Although this solid statement demonstrates an obvious misunderstanding of the predictions of the STR[1], it also implies that the predictions of the STR are to be considered experimentally-proven and, therefore, physically real. On the other hand, when someone looks up various text books, quite cautious wordings regarding the implications of the STR are repeatedly found. Instead of stating that a meter rod and a clock (traveling with speed *v* relative to an observer) shortens and ticks slower, respectively, it is often said that the rod "appears" shortened and the clock "is seen" slowed down (see ref. 3, for instance). The question, whether or not the STR only provides a kind of kinematic description of meter rods and clocks from the perspectives of observers in different inertial frames or describes some dynamic effects exerted on the rods and clocks, is apparently still up to various interpretations (for a meticulous summary of these, see refs. 4 and 5).

[1] According to the STR, the correct sentence would be : "*time moves slower for a moving clock than for a stationary one*" from the perspective of a stationary observer.

When the question of reality in connection to length contraction was raised (6), Einstein responded (7): "*the question as to whether length contraction really exists or not is misleading. It doesn't 'really' exist* [... for] *a co-moving observer; though it 'really' exists* [... for] *a non-co-moving observer*". Instead of questioning the scientific legitimacy of a view that advocates the existence of "multiple, observer-determined realities", here a simple thought-experiment is put forward to show that length contraction, as the outcome of one of the "realities" of the STR, leads to contradictions, which seems to necessitate further discussion on the merit of the STR.

Length contraction of a gas-filled box

Instead of the usual 1-dimensional meter rod, let us first consider a 3-dimensional box of a given volume. The box stands still relative to the inertial frame *x*, *y*, *z* of Observer 1, while it moves with speed *v* in direction *x'* relative to Observer 2 in frame *x'*, *y'*, *z'* (Fig. 1). According to the STR, the edges of the box, that parallel the axis *x* (and *x'*), shortens for Observer 2 as compared to its rest length that is seen by Observe 1. As those edges shorten, the volume (*V'*) of the box decreases as well:

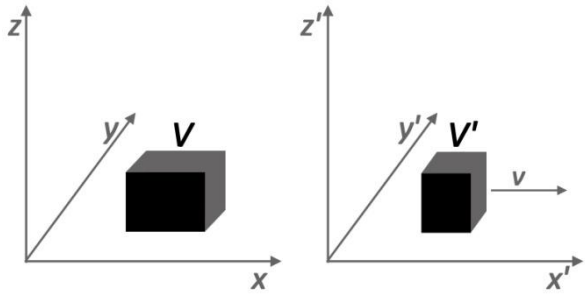

Figure 1: Volume change of a box according to the STR. Due to the length contraction in direction *x* (and *x'*), the volume (*V'*) is decreased (see also text).

$$V' = \gamma V, \tag{1}$$

where *V* is the rest volume, γ is the Lorenz factor, $\sqrt{1 - v^2/c^2}$, and *c* is the speed of light.

Second, let us now assume that the box is a (thermodynamically) closed and isolated system filled with an ideal gas of pressure *P*, which (according to Observer 1) equals the outside pressure (P_{out}) of the same gas in the environment. In addition, we also assume that the gas inside the box is in thermal equilibrium with its environment (*i.e.* $T_{in} = T_{out}$). Thus, Boyle's law applies:

$$PV = P'V', \tag{2}$$

where *P'* is the pressure in volume *V'* of the contracted box. It is then evident that, as the volume of the box decreases, the pressure inside must increase. In addition, it is also important to note that, as the pressure in the box increases, it also becomes larger than the pressure of the gas in the environment:

$$P' > P_{out}. \tag{3}$$

Then, if we accept the shortening of the box as physically real (as it would be proposed by Einstein and many others for Observer 2, see ref. 7 and 5, respectively), equations 2 and 3 should have remarkable consequences. First, if the volume of the box decreases, leading to an increase of the inside pressure, then the STR would obviously contradict the relativity principle, one of the very postulates, on which the STR is based upon. According to an appropriate phrasing of the relativity principle (8), "*all physical phenomena should have the same course of development in all system of inertia*". It is, however, evident that above consequences of the length contraction in the case of the box results in a fundamentally different "*course of development*" (see equations 2 and 3).

Second, as a "side effect" of this fundamentally different "*course of development*", the law of energy conservation is also violated. The shortening of the box generates an inside *vs.* outside pressure difference (see equation 3), *i.e.* it generates energy[2]. In other words, according to the STR, the change in the perspective of an observer is capable of creating energy.

Third, let us assume that the gas inside the box undergoes a kinetically first order chemical reaction, whose rate thus depends on the concentration of the gas, *i.e.* its pressure inside the box. Once the progress of the reaction is monitored, the gas-filled box could thus serve as a chemical clock. As the pressure in the gas is raised by the shortening of the box see equation 2), the rate of the chemical reaction should increase, making the clock tick faster. In other words, length contraction would, if considered real, lead to time contraction, instead of time dilation as the STR predicts.

Conclusion

The thought-experiment presented here reveals some major contradictions that are inherent to the STR, which raises the question whether the STR can be upheld as a fundamental theory of physics. On the other hand, these contradictions clearly call for further discussions on the true scientific merit of Einstein's theory. In order to initiate such discussions, it is now proposed that the implications of the STR, such as relativistic length contraction and time dilation, for instance, are only the results of an "optical phenomenon", an unavoidably distorted image of reality, which is caused by the invariance of the speed of light[3], one of the postulates the STR is based upon.

At the same time, the above conclusion, which considers the outcomes of the STR only illusory[4], also argues against views, according to which making distinctions between "real" and "apparent" in connection to the implications of the STR would be "misleading" (7). The example of the contracted gas-filled box presented here clearly illustrates that to make such distinction must be an essential element of the scientific approach, whose aim should be nothing else but to provide a non-contradicting description of physical reality. Consequently, it is also necessary to suggest that the alleged experimental proofs of the STR (like the one in ref. 2, for instance) are likely misinterpreted and need to be rethought and/or reinvestigated.

References

1. Witze, A.: *Special relativity aces time trial, Nature News* doi:10.1038/nature.2014.15970 (2014)
2. Botermann, B. *et al.*: *Test of Time Dilation Using Stored Li^+ Ions as Clocks at Relativistic Speed*, *Phys. Rev. Lett.* 113:120405 (2014)
3. http://hyperphysics.phy-astr.gsu.edu/hbase/relativ/

[2] For instance, after punching a hole on the back side of the box (opposite to the direction of its movement), the contracted box should start accelerating, as the gas of the increased P' (relative to P_{out}) should steam out and propel the box.

[3] The "distorting effect" of light speed invariance is evident from Einstein's derivation of the Lorenz transformations, for instance (see ref. 9).

[4] Illusory in the sense as a *mirage* is considered illusory. Both a mirage and the STR result in a distorted image of reality, which is—in both cases—due to given properties of light propagation.

4. Redžić, D.: *Relativistic length agony continued*, http://arxiv.org/abs/1005.4623v1
5. Redžić, D.: *Towards disentangling the meaning of relativistic length contraction, Eur. J. Phys.* 29:191-201 (2008)
6. Miller, A.I.: *Albert Einstein's special theory of relativity. Emergence (1905) and early interpretation (1905–1911)*, Reading, Addison–Wesley Press, pp. 249–253 (1981)
7. Einstein, A.: *Zum Ehrenfestschen Paradoxon. Eine Bemerkung zu V. Variĉaks Aufsatz*, *Physikal. Zeitschr.*, 12:509–510 (1911)
8. Møller, C.: *The Theory of Relativity*, Oxford, Clarendon Press, p. 4 (1955)
9. Einstein, A.: *Über die spezielle und die allgemeine relativitattheorie*, Druck und Verlag von Friedrich Vieweg und Son, Braunschweig, Germany (1921)