

# Special Relativity: a Theory of Contradictions or an Account for an "Optical Illusion"

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## Abstract

Although more than a century has passed since Einstein introduced his Special Theory of Relativity (STR), the relation to reality of its predictions, such as length contraction, for instance, still seems obscure. This might not be surprising, if one considers the strangeness of physical reality, whose features are allowed to vary depending on the observer. Here, a simple thought-experiment is put forward, which shows that relativistic length contraction (a prediction of the STR) leads to contradictions, if considered real. Taking this together with the Einstein-proposed observer-dependent reality, it is suggested that the STR is simply an account of an "optical illusion", a result of the assumed invariance of light speed.

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

## Introduction

An astonishingly wide array of interpretations of the Special Theory of Relativity (STR) is found throughout the scientific literature (see, for instance, ref. 1 and refs. therein) and even in textbooks. It is noticeable that the different interpretations, even if tacitly worded, originate from a somewhat obscure, not easily comprehensible relationship of the outcomes of the STR to reality. The mere fact, that the widely known and frequently referred to "twin" and "ladder" paradoxes have surfaced and that their solutions have sincerely been attempted, also seems to hint that there must be an atypical connection between the STR and physical reality.

A recent *Nature News* article (2) entitled "*Special relativity tests time trial*", by referring to experiments with  $\text{Li}^+$  ions in a particle accelerator (3), concludes: "*time moves slower for a moving clock than for a stationary one*". Such a solid statement (as in ref. 2) seems to decisively imply that the outcomes of the STR are to be considered experimentally-proven and, therefore, real\*. However, when someone looks up various text books, more cautious wordings 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. 4, for instance). These latter type of wording clearly offers an option to see the results of the STR as illusory.

When the Serbian physicist Varičak (5) raised the question of reality in connection to the STR, Einstein responded (6): "*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*". Surprisingly, this view of an "observer-dependent reality" seems to be now generally

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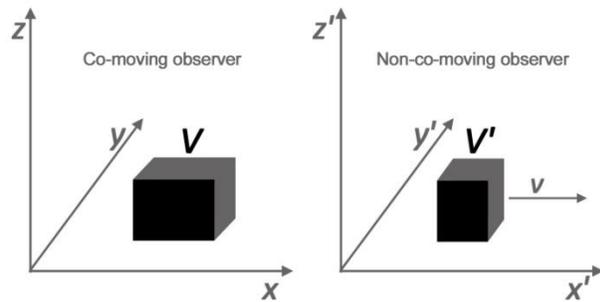
\* It is to note, that the spectral measurements carried out in the so-called "laboratory frame" (as in ref. 2) cannot be considered as a proper "control" experiment, which would be an observation that co-moves with the accelerated  $\text{Li}^+$  ions.

accepted among most physicists. For example, Pauli (7) stated: "If a state is called real only when it can be determined in the same way in all Galilean, then the [...] contraction is indeed only apparent [...]. But we do not consider such a point of view as appropriate, and in any case the [...] contraction is in principle observable". Born (8) went even further and called it "naive" and "unreasonable" to differentiate between real and apparent: "a rod [...] has various lengths according to the point of view of the observer. [...] The application of the distinction between "apparent" and "real" in this naive sense is no more reasonable [...]".

Here a simple thought-experiment is first put forward to show that STR, once its predictions are considered real, leads to contradictions. Then, the validity of a view, which considers reality as observer-dependent and eventually equates "real" with "apparent", is argued against. Taking these together, it is proposed that Einstein' theory is to be considered as an account for an optical illusion, a direct consequence of the assumption that the speed of light is invariant.

### **Length contraction of a box filled with an ideal gas**

Instead of a 1-dimensional meter rod, let us first consider a 3-dimensional box, that stands still relative to the co-moving observer, *i.e.* in inertial frame  $x, y, z$ , On the other hand, it moves with speed  $v$



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

in direction  $x'$  relative to the non-co-moving observer 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 the non-co-moving observer as compared to the rest length that is seen by the co-moving observer. As those edges shorten, the volume ( $V'$ ) of the box also decreases:

$$V' = V \sqrt{1 - \frac{v^2}{c^2}} \quad (1)$$

where  $V$  is the rest volume and  $c$  is the speed of light. In addition, let us now assume that the box is (thermodynamically) isolated and filled with an ideal gas of pressure  $P$  and temperature  $T$ , which (according to the co-moving observer) equal the outside pressure ( $P_{out}$ ) and temperature ( $T_{out}$ ), respectively, of the same gas in the environment. In other words, according to the co-moving observer, the box is at equilibrium with its environment (as far as the pressure and the temperature are concerned).

The Ideal Gas Law (IGL) requires that, as the volume of the box decreases, either the pressure inside the box should increase (isothermal process), resulting in

$$P' > P_{out}, \quad (2)$$

or the temperature of the gas inside the box should decrease (isobaric process) leading to

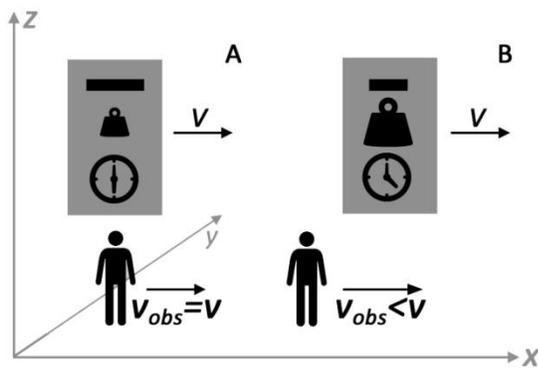
$$T' < T_{out}, \quad (3)$$

or both, where  $P'$  and  $T'$  are the pressure and the temperature of the gas, respectively, in volume  $V'$  of the contracted box<sup>\*\*</sup>.

Thus, if we accept the shortening of the box as real (instead of only apparent), then equations 2 and 3 should have remarkable consequences. First, if the box indeed shortens, then the STR directly contradicts the relativity principle, one of the postulates the STR is based upon: the non-contracted box is at equilibrium with the environment, while the contraction of the box slips it into a non-equilibrium state<sup>\*\*\*</sup>. Second, the STR also violates the law of energy conservation, since the contraction of the box creates pressure and/or temperature gradients between the box and its environment. Therefore, according to the STR, the change in the "position" of an observer (see also below) is capable of creating energy.

### ***Special relativity and the observer***

The relation to reality of the STR, as summarized by Einstein (see ref. 6 and the comment with the co-moving and the non-co-moving observer above), is illustrated in Fig. 2. A meter rod with a given



**Figure 2: The observer-dependent reality of the STR.** See text for details.

mass and a clock travels with speed  $v$  in direction  $x$  of an inertial frame of  $x, y, z$ . First, a co-moving observer, who also travels in the same direction with the same speed ( $v_{obs} = v$ ), measures the proper length and mass of the rod and the proper time kept by the clock (Panel A). Then, as the observer becomes non-co-moving by slowing down (while the rod and the clock continue traveling with the same speed  $v$ ), the meter rod shortens, its mass increases and the clock shows time dilated (Panel B). Now, if we consider Einstein's comment on the co-moving and the non-co-moving

observer acceptable (as well as the STR as a valid scientific theory), we are forced to conclude that there are multiple, observer-dependent realities, in which objects' length and mass change and time passes slower or faster depending on the relative speed of an observer.

### ***Discussion***

The box example presented here reveals some major contradictions that are inherent to the STR, which clearly shows that the STR is difficult to uphold 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, time dilation and increase of mass, are only illusory. They all

<sup>\*\*</sup> To the contrary of the predictions of the IGL, because of the relativistic increase of the mass of the gas molecules  $T'$  should increase (if  $T$  is derived from the Kinetic Theory of Gases).

<sup>\*\*\*</sup> This consequence of the length contraction (*i.e.* the slipping into non-equilibrium from equilibrium) results in a quite different "*course of development*", making it certainly incompatible with the relativity principle (see also ref. 9).

are results of an unavoidably distorted image of reality, *i.e.* a kind of optical illusion, which is caused by the invariance of the speed of light, the major postulate the STR is based upon.

If one considers the kind of "perspectival" nature of the outcomes of the STR (see Fig. 2), it is not farfetched to compare them to some other optical phenomenon, like the Fata Morgana, for instance. In the latter, the change in the relative position of the observer (under certain conditions) decides whether or not the observer sees a distant church building floating in midair on the Great Hungarian Plain on a nice Sunday morning. In the case of the STR, the change in the relative speed of the observer determines how large that church would measure and how its clock ticks.

At the same time, the above conclusion, which considers the outcomes of the STR only illusory, 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 box example 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 (see also ref. 9). Such reinvestigation should also include tests on light speed invariance.

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