Special Relativity as an Account for an Optical Illusion

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Abstract

Although Einstein's Special Theory of Relativity (STR) is more than a century old, the relation to reality of its predictions – such as length contraction, for instance – still seems obscure. Here it is argued for that the STR does not provide a description of objective (physical) reality, but - by reason of its observer-dependence - it describes a particular relationship of an observer to reality. In support of this notion, it is also shown here that, if length contraction (one of the outcomes of STR) was considered real, then it is not reconcilable with some laws of nature and even with the relativity principle, one of the postulates the STR is supposed to be based upon. It is thus concluded that the STR should be looked at as an account for a special kind of 'optical' illusion.

Keywords: special relativity, relativity principle, Lorentz transformations, contradiction, illusion

1. 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). It is noticeable that the different interpretations, even if tacitly worded, originate from a somewhat obscure and mainly misunderstood 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 and explanations have sincerely been attempted, also seems to hint that there should be an atypical connection between the STR and reality (at least from a realist's point of view), thereby still leaving open the question whether or not it is a valid scientific theory and (if it is) how it should be interpreted.

A recent *Nature News* article [2] entitled "*Special relativity aces time trial*", after referring to experiments with Li^+ ions in a particle accelerator [3], concludes: "*time moves slower for a moving clock than for a stationary one*". Such a solid statement seems to decisively imply that the outcomes of the STR are to be considered experimentally-proven and, therefore, real. However, more cautious wordings are also 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 said that the rod "appears" shortened and the clock "is seen" slowed down, etc (see ref. 4). This latter type of wording clearly offers an option to see the results of the STR as only illusory.

When the Serbian physicist Varičak raised [5] 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 comoving observer; though it "really" exists* [... for] *a non-comoving observer*". Surprisingly, this view of an observer-dependent reality seems to be generally accepted among many, if not most, physicists. For example, Pauli stated [7]: "*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 went even further [8] 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, the validity of such views (expressed in [6-8]) is argued against and shown to be inescapably absurd, *i.e.* foreign to the very essence of science. Then, it is also shown here that the STR, if its predictions were considered real, would lead to contradictions, even including fundamental disagreements between the STR and the relativity principle, the postulate that the STR is claimed to be built upon (9). Taking these together, it is thus proposed here that Einstein's theory is not to be upheld as theory to describe and understand reality. Instead, it might be treated as an account for a special kind of optical illusion.

2. The 0bserver-dependent, multiple realities of the STR

The relation between reality and the outcomes of the STR, as summarized by Einstein (see ref. 6 and his comment above), is illustrated in Fig. 1. It is worth noticing that the figure (as well as Einstein's above statement) can be read two ways. According to the first reading, a rod and clock travels with speed $\boldsymbol{v}$ in direction $\boldsymbol{x}$ in the inertial frame of $\boldsymbol{x}$, $\boldsymbol{y}$, $\boldsymbol{z}$. A co-moving observer ($\boldsymbol{v_{obs}} = \boldsymbol{v}$) measures the proper length of the rod and registers the proper time kept by the clock (Panel A). At the same time, a non-co-moving observer in $\boldsymbol{x'}$, $\boldsymbol{y'}$ $\boldsymbol{z'}$, that moves with speed less than $\boldsymbol{v}$, sees the rod with contracted length and the clock keeping dilated time (Panel B). Thus, if we consider Einstein's comment on the co-moving *vs.* non-co-moving observer acceptable and, therefore, the STR as a valid scientific theory to describe reality, we are required to conclude that there are multiple, observer-dependent realities; *i.e.* a rod can have many different lengths and a clock can concurrently keep many different times.

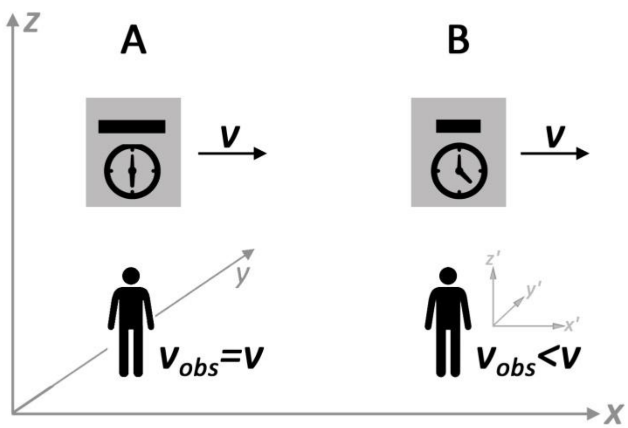

Figure 1: The observer-dependent 'realities' of the STR. See text for details.

According to the second reading of the figure, which should further assist us in rejecting the absurd claims of accepting multiple realities (as suggested in refs, 6-8), there is only a single observer, the co-moving one, who makes an observation and finds proper length and clock timing. Then, this same observer slows down ($\boldsymbol{v_{obs}} < \boldsymbol{v}$) and makes a second observation, while the rod and the clock keep traveling with same constant speed of $\boldsymbol{v}$. Then, according to the second observation the rod is contracted and the clock is slowed down. Now, if we consider the STR as a theory that describes physical reality, we are forced to conclude that a rod shortens and time dilates, just because the observer's state of motion changes (while both the rod and the clock keeps their same uniform motion).

Thus, the second reading of the figure clearly shows that the STR does not (cannot) inform us about the physical length of a rod or the time kept by a clock. Instead, it simply draws attention to the fact that, depending on the speed of the observer (relative to the observed object/clock), our estimates on length and time are misleading. In other words, it provides a description of a phenomenon, which is quite comparable to that of an optical illusion, such as a mirage., for instance. While the appearance of a mirage depends on the relative position of the observer, the emergence of the "mirage-like" outcomes of the STR (*i.e.* the length contraction and the associated time dilation) manifest depending on the relative speed of the observer. As the outcomes of the STR are also produced by a certain (although assumed) property of light propagation[1], they are rightfully looked at as illusions, which are optical in nature.

3. If length contraction was real...

A mirage is real as a phenomenon. However, what is seen in the form of a mirage is not. Such non-reality is immediately suspected because it is observable by certain observers, but not by others, or from a certain relative position, but not from others. In other words, a mirage is observer-dependent. Another reason to suspect such non-reality is due to its controversial relation to some laws of nature. For instance, when the mirage of a sailboat floating high up in midair above the sea is seen, a violation of the law of gravitation is rightfully suspected. So, the question is if there is some well-established law of nature or principle, with which the consequences of the STR – such as length contraction, for instance – would be in conflict.

[1] Such property is the postulated (presumed) invariance of light speed (as seen from Einstein's derivation of Lorentz transformations; see Appendix I in ref. 9).

What might first come to mind as an example of such conflict is the unavoidable structural distortion of objects that undergo relativistic length contraction. For the sake of simplicity, consider a crystal structure (like diamond, for instance), where the atoms are strictly arranged in a particular spatial lattice, and in which this atomic arrangement yields its certain physical and chemical properties. Relativistic length contraction acting in the direction of the movement of the crystal, would certainly distort the structure of its 'proper' lattice, and thereby its physical, chemical properties. Then, as a consequence, the principle of relativity, one of the postulates leading to Einstein's theory [9], is infringed[2].

Another example could be a thermodynamically isolated box, which is filled with an ideal gas of a given pressure (P_{in}) and temperature (T_{in}). According to a co-moving observer, the gas – as far as its pressure and temperature are concerned – is in equilibrium with the environment; *i.e.*:

$$P_{in} = P_{out} \text{ and } T_{in} = T_{out}.$$

However, according to the non-co-moving observer ($v_{obs} < v$), the edges of the box that parallel axis x should contract resulting in a decrease in the volume of the box, which - as the Gas Laws require - results in changes of the pressure and/or the temperature inside the box[3], yielding:

$$P'_{in} \neq P_{out} \text{ and/or } T'_{in} \neq T_{out}$$

where P'_{in} and T'_{in} are the pressure and the temperature of the gas, respectively, in volume of the contracted box[4].

Thus, if the contraction of the box was considered real, then the above inequalities has some odd consequences. First, a pressure and/or a temperature gradient across the walls of the box would build up in an observer-dependent way due to the relativistic volume change.

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[2] The same argument holds for any object (atoms, molecules and even living organisms, for instance), whose structure and physical/chemical properties are mutually dependent.

[3] As the result of the volume decrease, the entropy of the gas in the box also decreases (if T = **const.**)

[4] If relativistic effects are considered on the level of individual atoms or molecules of the gas inside the box, another conflict emerges. According to the basic tenet of the kinetic theory of gases, the average (squared) speed of the atoms or molecules comprising the gas is the same in all directions, which explains the isotropy of the pressure inside a given volume. However, as the 'relativistic' speed of the atoms or molecules of the gas increases (relative to an observer), such isotropy ceases to hold, indicating an irreconcilable difference between the STR and the kinetic theory of gases as well.

Such "creation" of a pressure and/or temperature gradient would be a clear violation of the law of energy conservation. Second, this relativistic decrease of the box volume also results in a shift from thermodynamic equilibrium to disequilibrium as far as the box in the moving frame and its environment (being the stationary frame) are concerned, which is a clear violation of the relativity principle. These together again supports a view, according to which the consequences of the STR should not be considered real, but as some kind of illusion.

4. **Conclusion**

The above examples reveal contradictions between the STR and some laws (and principles) of nature, which certainly calls for some further discussions on the 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, are only illusory, *i.e.* they are the results of a kind of 'optical' illusion. In other words, they might be real as observable phenomena (if light speed invariance holds), but there are no corresponding real physical (objective) changes.

If one considers the odd observer-dependence of the outcomes of the STR (as discussed above; see Fig. 1) and, of course, keeps in mind the role of some particular properties of light propagation in observing those outcomes, it is not farfetched to compare them to some other optical phenomenon, like a mirage, for instance. In the latter, the change in the relative position of the observer 'decides' whether or not the observer might see an object displaced in space due to light refraction. In the case of the STR, the change in the relative speed of the observer is the one that leads to a distorted perception of space and time. Nevertheless, since the observer is simply tricked by some properties of light propagation in both cases, it seems appropriate to also consider the outcomes of the STR as 'optical' illusions.

The above conclusion, which regards the outcomes of the STR only illusory, also argues against such (anti-realist) views, according to which making distinctions between "real" and "apparent" in connection to the implications of the STR is "misleading" [7] or "naive" and unreasonable (8). The above conflicts between some laws of nature and the outcomes of the STR here clearly illustrate that to make such distinction must be an essential element of the scientific approach, whose aim is nothing else but to provide a non-contradicting, unambiguous description of (objective) reality, which – by definition – must be observer-independent.

Considering the present conclusion that considers the STR as an account for an optical illusion, it is also necessary to propose that the alleged experimental proofs of the STR (like the one in ref. [3], for instance) are likely misinterpreted and need to be rethought and/or reinvestigated (see also ref. [10]).

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