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 reality, but it describes a particular relationship of an observer to reality. In support of this notion, it is also shown here that, if length contraction, for instance, was considered real, then it is not reconcilable with the Gas Laws. It is thus suggested that the STR is 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) and even in textbooks. 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 have sincerely been attempted, also seems to hint that there should be an atypical connection between the STR and reality, thereby still leaving open the question whether or not it is a valid scientific theory and/or how it should be interpreted.

A recent *Nature News* article [2] entitled "*Special relativity aces time trial*", by 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, 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). This latter type of wordings 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. Taking these together, it is thus proposed 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. Observer-dependent outcomes 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 important to recognize that the figure (and Einstein's above statement) can be read two ways. First, a rod and clock travels with speed v in direction x in the inertial frame of x, y, z. A co-moving observer ($v_{obs} = v$) measures the proper length of the rod and the proper time kept by the clock (Panel A). At the same time, a non-co-moving observer in x', y' z', that moves with speed less than 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, which is supposed to deal with reality, we are required to conclude that there are multiple, observer-dependent realities; *i.e.* a rod can simultaneously have different lengths and a clock can concurrently keep different times.

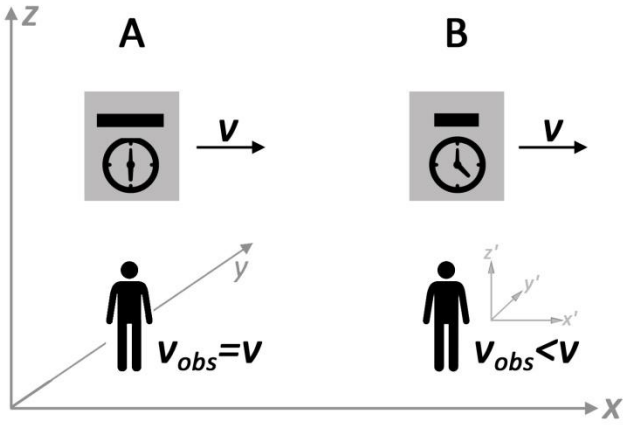

Figure 1: The observer-dependent realities of the STR. See text for details.

According to the second reading of the figure, which might further assist us in rejecting the absurd claims of multiple realities (as suggested [6-8]), there is only one observer, the co-

moving one, who makes an observation and finds proper length and clock timing. Then, this same observer slows down ($v_{obs} < v$) and makes a second observation, while the rod and the clock keep traveling with speed v. Then, the observer finds that the rod is contracted and the clock is slowed. Now, if we consider the STR as a theory that describes reality, we are forced to conclude that a rod shortens and time dilates, just because the observer's state of motion changes.

The second reading suggests a different interpretation, as it clearly shows that the STR does not inform the observer about the physical length of a rod or the time kept by a clock. However, it draws attention to the fact that, depending on the relative speed of the observer, the data collected about space and time is necessarily 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. The difference is that the appearance of the latter depends on the relative position of the observer, while the outcomes of the STR manifest depending on the relative speed of the observer[1].

3. The Gas Laws and the STR

The phenomenon of a mirage, which is observable under certain conditions, is real. However, what is seen in the form of a mirage is not. Such non-reality is immediately recognized because of two reasons: first, it is observable by certain observers, but not necessarily by others, or from a certain relative position, but not from others. Second, it seems to disobey some laws of physics, like gravitation, for instance. So, the question is if there is some well-established physical law, with which the consequences of the STR – such as length contraction, for instance – would not be reconcilable.

What might first come to mind is a thermodynamically isolated box, which is filled with an ideal gas of a given pressure (P_{in}) and temperature (T_{in}), and in which, according to a co-moving observer, the gas is – as far as the pressure and the temperature are concerned – in equilibrium with the environment; *i.e.*:

[1] In both cases (in the case of the STR and that of a mirage) the method of gaining information about a particular object is optical, being light the information 'carrier'. Nevertheless, certain properties of light propagation lead to misinformation in both cases.

$$P_{in} = P_{out} \text{ and } T_{in} = T_{out}. \quad (1)$$

However, according to the non-co-moving observer ($v_{obs} < v$), the edges of the box, which parallel axis x, should contract resulting in a decrease in the volume of the box:

$$V' = V/\gamma \quad (2)$$

where V is the rest volume, $\gamma = 1/(1-v/c)^{-1/2}$, v is the speed of the box (relative to the observer) and c is the speed of light. As the Gas Laws require, the volume change of the box should result in the changes of the pressure and/or the temperature inside the box:

$$P'_{in} \neq P_{out} \text{ and/or } T'_{in} \neq T_{out}, \quad (3)$$

where P'_{in} and T'_{in} are the pressure and the temperature of the gas, respectively, in volume V' of the contracted box[2].

Thus, if the contraction of the box was considered real, then the above relations (3) 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, as a Gas Laws-required effect of the volume change. Such "creation" of a pressure and/or temperature gradient would be a clear violation of the law of energy conservation. Second, the contraction of the box results in a shift from thermodynamic equilibrium to disequilibrium (as far as the box and its environment are concerned; see relations 3), which is a clear violation of the principle of relativity, one of the postulates leading to Einstein's theory [9]. Taking all these together, the STR – if its outcomes are considered real – is in definite conflict with the Gas Laws, which again supports the view that its consequences should not be considered real, but some kinds of optical illusion.

4. **Conclusion**

The above gas filled box example reveals some contradictions between the STR and the Gas Laws, which certainly calls for some further discussions on the scientific merit of Einstein's

[2]According the basic tenet of the kinetic theory of gases, the average (squared) speed of the particles (molecules or atoms) comprising the gas is the same in any directions, which explains the isotropy of pressure, for instance. However, once relativistic effects on the gas particles inside the box are considered, the isotropy of the speed- and, thereby, the pressure-distribution ceases to hold, indicating an irreconcilable difference between the STR and the kinetic theory of gases as well.

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.

If one considers the strict observer-dependence of the outcomes of the STR (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 (under certain conditions) decides whether or not the observer sees an object displaced in space. 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, in both cases the observer is simply tricked by certain properties of light propagation. In the case of the STR, such properties are both the invariance and the finiteness of light speed (whose contribution to the development of the theory might be up to further analysis).

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 is "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 is nothing else but to provide a non-contradicting, unambiguous description of physical reality. Considering the proposal put forward here, according to which the STR's outcomes must be considered illusory, 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]).

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