Length contraction versus the
Special Theory of Relativity

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Abstract

An Examination of the postulates of the Special Theory of Relativity via a thought experiment uses Michelson interferometer has been done. An inconsistency between the two postulates of the theory has been revealed.

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1 Introduction

The two postulates on which the Special Theory of Relativity is based[see 1; 2, p. 50; p. 35]:

1. The laws of Physics are the same in all inertial frames of reference. No preferred inertial frame of reference exists. (The Principle of Relativity.)

2. The speed of light in vacuum is invariant in all inertial frames of reference and does not depend on the speed of the source. (The Principle of the Constancy of the Speed of Light.)

One of the important consequence of these postulates is the Lorentz-FitzGerald contraction. We are going to use this phenomenon to investigate The Special Theory of Relativity from point of view of its reality of its consequences.

2 Analysis

2.1 Is the length contraction a real physical phenomenon?

Discussing length contraction from point view of its reality may reduce to three physical cases:

1. Length contraction is a real physical phenomenon that happen to an object moves with relative velocity with respect to an observer, i.e., the length of the object really contract in the direction parallel to its relative motion.

2. Length contraction is an optical phenomenon that distorts information received by an observer.

3. There exists two different realities, one reality observed by an observer on the rest frame in which he observes a (1) really contracted length of an object moving with relative velocity with respect to him. The other reality is observed by an observer in the frame of reference of the moving object and in which he observes a (2) really noncontracted length.
2.2 Case (3): The existence of two different realities

We are going to start with case (3) and we are going to neglect it since it falls in the realm of philosophy. It is similar to dualism problem of mind-body in philosophy. Hence, does two different realities exist? and how they related? and how an object have two distinct and simultaneous reality, one of which is length contracted and the other is not?, these questions may have no answer in the world of physics.

2.3 Case (2): Length contraction as an optical effect

This case is really satisfies the two postulates of The Special Theory of Relativity. In this case the length contraction is just an optical illusion happens due to the distortion of the information carried from relatively moved frame of reference by a carrier (light) that can not compensate for the delay occurs due to extra displacement made by a relatively moved object since the carrier has a constant speed ( satisfaction of the second postulate of The Special Relativity.)

Since this optical illusion happens equally to any two observers moving with relative velocity with respect to each other and due to there using of the same information carrier, namely the light. Thus, the first postulate of The Special Relativity have been satisfied.

Therefore, in reality none of the two objects that are moving relatively to each other is length contracted in the direction of motion.

For further understanding of this case we mention the similar case of a partially submerged pen in a glass of water where an observer that sits on the frame of the unimmersed part sees the submerged part shorter (the apparent length) while in reality is not. That happens due to the delay of information carried by light since the speed of light have been reduced by the factor of refraction.

2.4 Case (1): Length contraction as a real physical phenomenon

To argue the first case we remind the readers that the dimensions of a body which are perpendicular to its velocity is invariance[see 1; 2, p. 53; p. 66].
Referring to Figure 1.a two rulers are setup perpendicular to each other in the $S'$-frame which is in rest with respect to $S$-frame. Similar configuration has been made in the $S$-frame for the reason of calibration of the rulers erected in the $S'$-frame (all rulers are equal in length). The $S'$-frame set in relative motion with uniform velocity in $x$-direction with respect to $S$-frame. Since in this case we assume the length contraction is really happen, i.e., the dimensions of an object which are parallel to its velocity are physical contract the observer will notice that the ruler that lays horizontally is shorter than the vertical one (see Figure 1.b). To further elaborate about this point we replace the rulers with Michelson interferometers as shown in figures 2.a and 2.b. Since the length contraction occurs only in the direction that parallel to the relative velocity, the distance $M'M'_1$ will shorten by a factor of $\gamma(u)^{-1}$, where $u$ is the relative velocity, while the distance $M'M'_2$ will remain unchanged. Therefore, an observer moves with $S'$-frame will be able to measure its absolute velocity using the interferometer that erected on $S'$-frame since the the light will travel in both arms of the interferometer with constant speed $c$ and the contraction happens only to the horizontal arm of the interferometer (remeber that contracted distance is only proportional to relative velocity, i.e., $M'M'_1\gamma^{-1} \propto u$). This is a pure contradiction to the first postulate of The Special Relativity.

3 Discussion

The results of the analysis suggest that the The Special Theory of Relativity is an optical effect phenomenon and if its consequence have real physical existence that leads the theory to contradict itself.
Fig. 1a

Fig. 1b

\[ x' \rightarrow u = 0.8c \]
References
