Theory of Special Relativity
vs.
Preferred Reference Frame Theory:
A Theoretical Distinction

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We show that there is a simple experiment whose outcome as predicted by the Theory of Special Relativity will differ from the prediction of the Preferred Reference Frame Theory. This shows that Einstein's Theory of Special Relativity is not mathematically equivalent to modern Ether theories, as is often claimed. This experiment can therefore discriminate between the two theories.

1. Introduction

For many years, there has been an ongoing battle between the Theory of Special Relativity (TSR) and Ether theories. Many modern Ether theories are claimed to be, in most respects, equivalent to or observationally indistinguishable from TSR [1,2,3,4]. We show here, that such Ether theories are not equivalent to TSR. The class of Ether theories we deal with here is the class of Preferred reference Frame

Theories (PFT), namely those of Lorentz, Selleri [1,2], Levy [5], and the present author [6] among others. In such theories, it is postulated that the speed of light is isotropic in only one reference frame, and non-isotropic in other reference frames. It is also often postulated that there is a "real" contraction of objects in the direction of motion by the Lorentz contraction factor. These postulates give rise to sets of equations which are considered by several authors to be "equivalent" to TSR's equations, but give a different view of the underlying "reality" of our universe.

Some authors have suggested experiments that can distinguish between TSR and PFT's [7,8,9]. These experiments often utilize variables such as voltage, capacitance, refraction, absorption, cosmology and rotations as well as distance and time. With such diverse concepts, it can become quite difficult to interpret the observed results.

Here we propose a simple thought experiment that utilizes only the basic variables of distance, time and speed. Since this setup does not utilize any other variables, it does not have the drawback of an alternative explanation. We will see that TSR and PFT differ in their predictions of the outcome of the experiment. This would theoretically give us a way to discriminate between the two theories.

We first introduce the basics of the PFT. We then describe the experimental setup. Next, we analyze the outcome of the experiment using TSR and PFT. We will conclude that their predictions differ.

2. Basics of Preferred Reference Frame Theory

A PFT is one in which:

1. There is a preferred reference frame in which the speed of light is isotropic. In other reference frames in uniform motion relative to the preferred frame, the speed of light is not isotropic.

2.   There is a *real* contraction of objects in the direction of motion of the object, relative to the preferred frame. The contraction factor is the Lorentz contraction factor $\sqrt{1 - v^2/c^2}$, where *c* is the speed of light in the preferred frame and *v* is the speed of the object relative to the preferred frame.

In such theories, clocks in motion with respect to the preferred frame slow down by the Lorentz factor. The space-time transformation equations connecting two inertial reference frames moving wrt one another are nothing but the Galilean transformations, in which one must compensate for real contraction of objects and clock slowdowns. The usual process for measuring lengths always gives the non-contracted length (often referred to as proper length) of the object, even though the object is contracted by the Lorentz factor. The value of the speed of light *c* with respect to the preferred frame is 299792458 m/s. With respect to other reference frames in uniform motion relative to the preferred frame the speed of light is not *c*. Yet, due to systematic distortions entailed by length contraction, clock retardation and clock synchronization, it is shown that the speed of light is *measured* to be *c* in all frames. For further information on these topics, see ref [5,6].

3. Experimental setup

The experiment consists of two rockets *initially at rest* wrt each other as depicted in figure 1. The distance between them is measured to be *D* meters. The frame in which they are initially at rest will be called the *initial frame*. A "rigid" rod joins the rockets, such that one end is firmly attached to rocket #1 and the other end is in contact but not attached to rocket #2. Thus, the rod also has a measured length of *D* meters. The rockets are caused to *accelerate identically* at the same

instant wrt the initial frame for a specified amount of time, after which they will maintain a constant speed *V*. The speed *V* is the (final and constant) speed of the rockets as observed from the initial frame. For simplicity, all trajectories will be collinear as depicted in figure 1 and figure 2. The rockets will move to the "left" wrt the initial frame. For the PFT analysis, we analyse the case in which the initial frame has a speed v_1 to the "right" wrt the preferred frame.

What is meant by "accelerate identically" is that the accelerations of the two rockets are identical, as observed from the initial frame. This is theoretically possible, although difficult to achieve in practice. One way to ensure that both rockets have the "same" acceleration wrt the initial frame is to have two detectors, one fixed at $x=0$ of the initial frame and the other fixed at $x=D$. Each detector observes the position (motion) of its respective rocket as a function of the detectors' hypothetical clocks (which are clocks in the initial frame and thus tick at the same rate). The two detectors' logs are then compared. If they are the same, then the acceleration of the rockets are the same wrt the initial frame.

"At the same instant" means that as a rocket starts to accelerate, the other does so too. Explained differently, for a fixed observer in the initial frame, both rockets start their engines as the observer's clock indicates, say, zero.

Algebraically, "accelerate identically" and at the same "instant" means the following: Let there be a fixed observer in the initial frame. Let the position of rocket #1 in the initial frame be given by $x_1(t)$ where *t* is the time indicated on the observer's clock. We require that the position of rocket #2 within the initial frame be given by $x_2(t)= x_1(t)-D$. Thus, the distance between the rockets remains *D* for an observer in the initial frame.

We can remove the requirement that the rockets leave at the same instant, in which case the rod should be replaced with a "long ruler,"

so we can do position comparisons, but this does not change the essence of our experiment.

We now ask the main question of interest to us:

Will the free end of the rod still be in contact with rocket #2 after the acceleration has ceased?

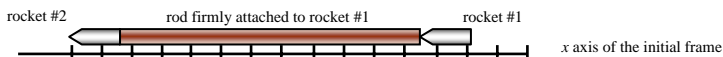# 4. Analysis of the experiment
Analysis according to TSR

Figure 1. The initial setup within the initial frame

We will do the analysis from: 1° the point of view of an observer in the initial frame, 2° the point of view of an observer in the rockets' (final) frame.

1° Analysing the situation from the point of view of an observer in the *initial frame*. After acceleration, the distance between the rockets remains *D*, as posed by our experiment. Since the rod now has a speed *V* wrt the initial frame, its length is now D/γ_V, where $\gamma_V = 1/\sqrt{1-V^2/c^2}$. Since the rod's length is $D/\gamma_V < D$ and is attached to rocket #1, an observer in the initial frame concludes that the other end of the rod is no longer in contact with rocket #2. In other

words, an observer in the initial frame concludes that the rod is shorter than the gap between the rockets[1].

2° Analyzing the situation from the point of view of an observer in *rockets' frame*. After acceleration, since the distance between the rockets is D in the initial frame, it is thus $D\gamma_v$ in the rocket's frame, as measured by either one [10,11,12]. Since the length of the rod must not vary for an observer at rest wrt the rod, the rod maintains a length of $D < D\gamma_v$. Once more, an observer in the rocket's frame concludes that the free end of the rod is no longer in contact with rocket #2 and is shorter than the gap between the rockets.

Analysis according to PFT

rocket #2   rod firmly attached to rocket #1   rocket #1

x axis of the initial frame travelling at speed v_1 to the right wrt the preferred frame

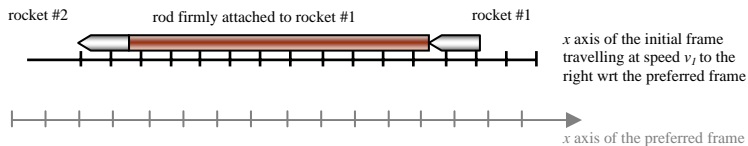*x* axis of the preferred frame

Figure 2. The setup as viewed from the preferred frame

In the initial frame, which has speed v_1 wrt the preferred frame, the true length of the rod and the true distance separating the rockets is D/γ_1. Since the rockets accelerate identically, their true distance remains the same. After acceleration, their new speed wrt the

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[1] Some might argue that since "space" is contracted, the separation between the rockets is also Lorentz contracted as viewed by an observer in the initial frame. Hence the rod is still in contact with rocket #2. However, this conclusion will still contradict the conclusion drawn from PFT.

preferred frame is now some $v_2 < v_1$ (v_2 being positive or better yet, zero). Since the rod is an "object," it is contracted to a new length $D / \gamma_2 > D / \gamma_1$. Therefore the free end of the rod overlaps rocket #2. Put simply, the rod "decontracts" because its speed is diminished and thus overlaps rocket #2. This contradicts the conclusion of TSR.

Hence TSR and PFT are not mathematically equivalent theories.

5. Conclusion

In Einstein's Theory of Special Relativity, a moving rod in the x or $–x$ direction will be contracted by the Lorentz factor. This symmetry does not exist in the Preferred Reference frame Theories. Using this fact, we have shown that there are thought experiments that can discriminate between the Theory of Special Relativity and the Preferred Reference Frame Theory. We therefore conclude that TSR and PFT are not equivalent theories since their predictions differ. Although we have given a thought experiment that can discriminate between the two theories, similar experiments based on the same concept may be feasible, thus permitting an experimental verification of the existence of a preferred frame or a falsification of the relativity principle of TSR.

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