the general science journal

Theory of Inertial Frames Relativity

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Abstract: The theory of inertial frames relativity postulates that in each inertial frame of reference the laws of physics are applied as to a fixed frame of reference; and in a fixed frame of reference, light propagates in a vacuum with a definite velocity c which is independent of the motion of its source. The theory of inertial frames relativity applies the Galilean transformations of coordinates to electromagnetic phenomena as they applied to mechanical phenomena. Consequently, according to the theory of inertial frames relativity, there is no space and time contraction/dilation or clock synchronization as the theory of special relativity predicts.

Keywords: Galilean transformations of coordinates, Lorentz transformations of coordinates, Theory of special relativity.

1 Introduction

With the knowledge that the speed of light is independent of the motion of its source and has a constant value c in a vacuum, the derivation of the Michelson-Morley experiment [1, 6] predicts a fringe shift. The null result of the experiment did not confirm the predicted result. The Michelson-Morley experiment exemplifies the impasse in physics at that time. Based on observations and experiments, the conclusions were that not only mechanical experiments cannot put in evidence the motion of the Earth around the Sun but also experiments with light and that the speed of light in each inertial frame has the same value c in any direction.

G. F. Fitzgerald [2, 6] explained the null result of the Michelson experiment by considering that there is a space contraction.

H. A. Lorentz concluded from his studies regarding the transformations of coordinates between two inertial frames, named the Lorentz transformations [3], that there is a contraction of space on the common direction of light propagation and the motion of an inertial frame, named the Lorentz-Fitzgerald contraction [2, 3, 6]. Lorentz also concluded that there is a local time that in special relativity becomes the relative time.

A. Einstein [4-6] had a broader view. Through his theory, he summarized the knowledge of that time and applied it to all phenomena, mechanical as well as electromagnetic. Einstein based his theory on two main postulates. The first postulate, in his words, states that "… the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good". The second postulate, in his words, states that "… light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitted body". Einstein disregarded the concept of the reference frame at absolute rest. In his words "… the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest".

Later, Walter Ritz proposed his ballistic hypothesis [6] that is a classical approach in which the velocity of light depends on the motion of its source. This hypothesis was rejected based on astronomers' observations of the stars that the velocity of light is independent of the motion of its source.

2 Lorentz transformations

To avoid confusion, when we refer to fixed frames, we call them as mentioned, and when we refer to inertial frames, the fixed frames are excluded. An inertial frame can be considered a stationary frame or a frame at relative rest for other inertial frames, for study convenience only, without being entitled to any other privileges from an ordinary inertial frame.

Lorentz considered a stationary frame $Oxyz$ and an inertial frame $O'x'y'z'$. Both frames are moving in the same direction of their common axes Ox and $O'x'$. Axes Oy and $O'y'$ have the same direction, and also axes Oz and $O'z'$. The inertial frame $O'x'y'z'$ is moving away from the stationary frame $Oxyz$ with the relative speed v. The initial instance is when the origin O of the stationary frame and the origin O' of the inertial frame coincide, and a wavefront of light starts to spread out in space from this common point.

Lorentz considered that in the stationary frame, at any time, the wavefront of light is on a sphere with the center at the origin O, a sphere with its center as they are understood in geometry. Furthermore, he considered that in the inertial frame, at any time, the wavefront of light is on the same sphere with the center at the origin O', which is different from the geometric center.

Lorentz exemplified the transformations of the coordinates for the front of the ray of light that travels along the common direction of axes Ox and $O'x'$.

The law of propagation of the front of the ray of light in the stationary frame is the equation of a spherical wave:

$$x^2 + y^2 + z^2 = r^2.$$

The radius $r = ct$ and the equation is defined by the quantities x, y, z, t, and c.

The law of propagation of the front of the ray of light in the inertial frame is also considered the equation of a spherical wave:

$$x'^2 + y'^2 + z'^2 = r'^2.$$

The radius $r' = c't' = ct'$, and the equation is defined by the quantities x', y', z', t' and c.

The transformations of coordinates from the stationary frame to the inertial frame for the front of the ray of light along the direction OO', not presented here, yield the following formulas for the quantities x', y', z', and, t':

$$x' = \frac{1}{\alpha}(x - vt)$$
$$y' = y$$
$$z' = z$$

$$t' = \frac{1}{\alpha}\left(t - \frac{vx}{c^2}\right),$$

where $\alpha = \sqrt{1 - v^2/c^2}$.

There is a multitude of stationary frames similar to the stationary frame $Oxyz$ that may have their origin at the same common point at the initial instance. We can accomplish the transformations of coordinates from all of these stationary frames to the inertial frame $O'x'y'z'$. In the inertial frame, the quantities x', y', z', and t' depend on the quantities x, y, z, and t that have the same values for these stationary frames, and on the relative speed v that is different for each of these stationary frames. In the inertial frame, the law of propagation of the front of the ray of light for these stationary frames has the same form, $x' = ct'$, but the formulas of the quantities x', y', z', and t' generate different sets of data from one stationary frame to another due to different values of the relative speed v.

We can do another study by considering the frame $O'x'y'x'$ as the stationary frame in which the wavefront of light is on the sphere with its geometric center at the origin O', and the frame $Oxyz$ as the inertial frame in which the wavefront of light is on the same sphere with its center at the origin O, which is different from the geometric center. In this case, each frame ends up with two sets of formulas; one set of formulas for the quantities x, y, z, and t, and another set of formulas for the quantities x', y', z', and t'.

We can conclude that the Lorentz transformations of coordinates give a law for the propagation of the wavefront of light in the inertial frame $O'x'y'z'$ that is not uniquely defined. Thus, the Lorentz transformations of coordinates cannot be accepted as well as the theory of special relativity.

3 Theory of inertial frame relativity

3.1 Postulates of the theory of inertial frames relativity

Based on the experimental results, the principle of classical relativity or Galilean relativity [6] states that the laws of mechanical phenomena are not affected by the motion of the inertial frame in which the laws are studied. The theory of the inertial frames relativity extends this principle to the laws of electromagnetic phenomena.

There is no fixed point in space to call it the origin of the reference frame at absolute rest, but we can visualize the imaginary fixed points with each of them as the origin of a fixed frame of reference. The same visualization applies to each inertial frame and its origin.

Classical physics considers the fixed frames as a particular case of the inertial frames and as part of the theory. In the theory of inertial frames relativity, the concept of the fixed frame of reference is essential because this concept is employed to formulate the postulates of the theory.

First postulate: In each inertial frame of reference the laws of physics are applied as to a fixed frame of reference.

Second postulate: In a fixed frame of reference, light propagates in a vacuum with a definite velocity c which is independent of the motion of its source.

The first postulate applies to mechanical as well as to electromagnetic phenomena including the propagation of light through the moving mediums. It implies that in all inertial frames the speed of light in a vacuum is the constant c in any direction, even if this is not mentioned directly in the postulate.

The second postulate affirms that the velocity of light is independent of the motion of its source but does not claim that the velocity of light is invariant for all observers.

With these two postulates, the laws of physics have the same form in all inertial frames as in all fixed frames, for mechanical phenomena as well as for electromagnetic phenomena, without understanding why the speed of light has the same constant value c in any inertial frame.

3.2 Transformations of coordinates

The propagation of light behaves like a mechanical phenomenon. Thus, the theory of inertial frames relativity employs the Galilean transformations of coordinates for which the time is invariant, and that requires a vector calculation.

We employ the same frames of reference as for the Lorentz transformations of coordinates with the difference that the stationary frame is a fixed frame, but it may also be an inertial frame. We apply the Galilean transformations of coordinates to the same front of the ray of light that travels along the common direction of axes Ox and $O'x'$.

According to the theory of inertial frames relativity applied in the inertial frame, the wavefront of light propagates on a sphere spreading out in space with the speed c and having one center that is the geometric center at the origin O' of this frame.

The propagation of the wavefront of light in the inertial frame is the equation of a spherical wave that is written here in vector form:

$$\boldsymbol{x}' + \boldsymbol{y}' + \boldsymbol{x}' = \boldsymbol{r}'.$$

The magnitude of the vector $\boldsymbol{r}'$ is $r' = c't' = ct$.

The propagation of the wavefront of light is observed in the fixed frame on a sphere spreading out in space with the center at origin O' that is moving away from origin O with the relative speed v. The propagation of the wavefront of light observed in the fixed frame is the vector sum of the vector $\boldsymbol{r}'$, and the vector $\boldsymbol{OO}'$ that has the magnitude $OO' = vt$ and the direction given by the common direction of axes Ox and $O'x'$. Thus,

$$\boldsymbol{x} + \boldsymbol{y} + \boldsymbol{z} = \boldsymbol{OO}' + \boldsymbol{r}' \quad or \quad \boldsymbol{x} + \boldsymbol{y} + \boldsymbol{z} = \boldsymbol{OO}' + \boldsymbol{x}' + \boldsymbol{y}' + \boldsymbol{x}'.$$

The transformations of coordinates from the inertial frame to the fixed frame for the front of the ray of light along the direction OO' yield, for the quantities x, y, z, and c_1, where c_1 is the speed of light observed in the fixed frame, the following set of formulas:

$$x = x' + vt$$
$$y = y'$$
$$z = z'$$
$$c_1 = c' + v.$$

The formula $c_1 = c' + v = c + v$ does not contradict the second postulate because it does not claim that the velocity of light is invariant for all observers.

The Galilean transformations of coordinates from the inertial frame to the fixed frame do not define the law of the propagation of the wavefront of light in the fixed frame; instead, the transformations offer the observation of the propagation of the wavefront of light from inertial frame to the fixed frame. The law of the propagation of the wavefront of light in the fixed frame is uniquely defined by the equation of a spherical wave with its geometric center at origin O.

4 Conclusions

In the theory of inertial frames relativity, we can consider other inertial frames that travel in the same direction as the inertial frame $O'x'y'z'$ but at different speeds, and that at the initial instant their origins coincide with the origin O' of the inertial frame. In this situation, the same wavefront of light is perceived on multiple identical spheres with each sphere having its geometric center at the origin of its inertial frame. We cannot understand with our reasoning why the wavefront of light starting from the same point is on two or more spheres, depending on the number of inertial frames in which the same wavefront of light is studied. However, in special relativity, we cannot understand with our reasoning why the wavefront of light starting from the same point is on one sphere with two or more centers. In the inertial frames relativity, the unreasonable is limited only to the wavefront of light belonging to multiple independent spheres, but there is no space and time contraction/dilation or clock synchronization as the theory of special relativity predicts.

In the theory of inertial frames relativity, in the fixed frame the speed of light along the axis Ox for multiple inertial frames under consideration is observed as $c_{1,2,3,\ldots} = c + v_{1,2,3,\ldots}$. This result of the Galilean transformations supports the Walter Ritz hypothesis that explains the unreasonable result of this theory.

The theory of inertial frames relativity may be based only on the first postulate. The second postulate looks to be right today but may be wrong tomorrow as the conclusion of the previous paragraph suggests. According to this reasoning, we can let the speed of light in a fixed frame to be as it is currently understood without making it a postulate.

Nevertheless, the theory of inertial frames relativity can help us to move towards a rational and complete understanding of the behavior of light.

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Note: The paper was revised on 25 February 2019.
Typing and grammar mistakes were corrected.