On Reference Frames

Alejandro A. Torassa

Buenos Aires, Argentina, E-mail: atorassa@gmail.com

Abstract

In this work it is established, on one hand, that any reference frame should be fixed to a body and, on the other hand, that it is possible to agree that any reference frame fixed to a body should be non-rotating.

Keywords: classical mechanics, observer, body, center of mass, rotating reference frame, non-rotating reference frame.

Part One

It is known from the observations of a reference frame S that using the appropriate transformation laws it is possible to learn the observations of a different reference frame S'.

However, observations of reference frame S' obtained from the previous method are hypothetical, since the real observations of reference frame S' are the ones performed on the reference frame S' itself.

According to this work, in order to learn the real observations of a reference frame it is necessary for the reference frame to exist; and for the reference frame to exist it is necessary that it be fixed to a body.

Therefore, any reference frame should be fixed to a body.

Part Two

How should a reference frame be fixed to a body?

According to this work, if we consider that any body is a particle or a system of particles, then the origin of any reference frame should be fixed to the center of mass of a body.

Since the center of mass of any body is a point in space without rotation, then it is possible that the origin of a non-rotating reference frame be always fixed to the center of mass of any body. However, it is not possible that the origin of an inertial reference frame be always fixed to the center of mass of any body.

Therefore, if the origin of any reference frame should be fixed to the center of mass of a body, then it is possible to agree that any reference frame fixed to a body should be non-rotating.

Conclusions

According to this work, every non-rotating reference frame is defined by an origin that is fixed to the center of mass of a body, and three perpendicular coordinate axes, where each axis is parallel to the corresponding axis of a universal reference frame defined by four widely separated stars.

On the other hand, several laws of physics would take a simpler form if no reference frame were a rotating reference frame. However, the rotation of a body would be absolute; for example, the rotation of the Earth would be absolute. But, in the theory of relativity, the speed of light is also absolute.

In addition, according to this work, every body is a possible non-rotating reference frame. Therefore, every body is also a possible observer.

Finally, the laws of physics should be the same for all observers. Therefore, according to this work, the laws of physics should have the same form in all non-rotating reference frames.

Appendix

Transformations of Classical Mechanics

If any reference frame is a non-rotating reference frame, then each coordinate axis of a reference frame S will remain at a fixed angle to the corresponding coordinate axis of another reference frame S'. Therefore, to simplify calculations it will be assumed that each axis of S is parallel to the corresponding axis of S', as shown in Figure 1.
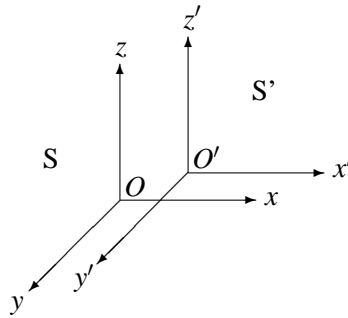

Figure 1

A change of coordinates x, y, z, t from reference frame S to coordinates x', y', z', t' from reference frame S' whose origin O' has coordinates $x_{o'}$, $y_{o'}$, $z_{o'}$ measured from S, can be carried out by means of the following equations:

$$x' = x - x_{o'}$$
$$y' = y - y_{o'}$$
$$z' = z - z_{o'}$$
$$t' = t$$

From these equations, the transformation of velocity and acceleration from reference frame S to reference frame S' may be carried out, and expressed in vector form as follows:

$$\mathbf{v}' = \mathbf{v} - \mathbf{v}_{o'}$$
$$\mathbf{a}' = \mathbf{a} - \mathbf{a}_{o'}$$

where $\mathbf{v}_{o'}$ and $\mathbf{a}_{o'}$ are the velocity and acceleration respectively, of reference frame S' relative to S.