Inconsistency of the Special Relativity with the Principle of Relativity

Radwan M. Kassir

radwan.elkassir@dargroup.com

Abstract: The Special Relativity (SR) first postulate—the principle of relativity—states: The laws of physics are the same in all inertial frames of reference. Simple thought experiments in different areas of physics are examined showing how the SR predictions result in outcomes inconsistent with the principle of relativity. This contradiction is simply attributed to the fact that the length of an object is a physical entity whose description is governed by the pertinent laws of physics which are—according to the relativity principle—the same with respect to all inertial frames of reference.

Introduction

The laws of physics govern the description of all physical aspects of an object, like its mass, dimensions and state, as well as its thermal, electrical, and optical properties. If these governing laws of physics were somehow altered, the object will cease to have the same physical aspects. It follows that, when the relativity principle talks of invariant laws of physics in all inertial reference frames, it means the physical aspects of an object under certain physical conditions in an arbitrary inertial reference frame must be the same from the perspective of any other inertial frame of reference. However, with the predictions of SR, where the physical dimensions of an object are altered—by relative motions—from one inertial reference frame to another, this principle of relativity cannot hold, creating a predicament as the SR is developed relying on this principle. In this paper, the inconsistency of the SR with the principle of relativity is demonstrated through thought experiments showing how altered length dimensions, as predicted by the SR, generate results in contradiction with the principle of relativity. These thought experiments, dealing with different areas of physics, reveal that the SR results are inconsistent with the respective physics laws.

1. Pressure Vessel Discharge Time

Let $K(x, y, z, t)$ be a coordinate system related to an observer's reference frame K in the outer space. Consider a pressurized cylindrical gas vessel located in another reference frame K' (e.g. a space craft) (Fig. 1), in uniform translational motion with respect to K, attached to it a coordinate system $K'(x', y', z', t')$, with the coordinate axes being parallel to the corresponding ones in K. Let the relative velocity v be in the common x-x' direction. Let V denote the vessel's volume, P_o and T its initial absolute pressure and temperature (equal to surrounding's), respectively, all with respect to K'. Let the surrounding space pressure be P_s. The vessel is fitted with two identical circular nozzles, of cross sectional area A, connected to the vessel through isolating valves. The nozzles are mounted in such a way they discharge in opposite directions, so that the resultant of their thrust forces is zero, with their cross section planes being parallel to the y'-axis. The valves are then opened so as to let the pressurized gas discharge isothermally to the surrounding, bringing the vessel gauge pressure to zero (i.e., bringing the absolute pressure to surrounding pressure) at constant temperature. The objective is to calculate the gas discharge time duration using the applicable laws of physics. Accordingly, this duration, independent of the vessel orientation, can be measured in K' using the formula

$$\Delta t' = \frac{VM}{RTCA}\sqrt{\Gamma(k)\frac{P_o - P_s}{\rho_o}}. \qquad (1)$$

Where,
$\Delta t'$ = vessel's discharge time
V = vessel's volume
M = molar mass of the gas
R = universal gas constant
T = absolute temperature
C = flow coefficient (dimensionless)
A = nozzles cross sectional area
$\Gamma(k)$ = dimensionless parameter, a function of the gas specific heat ratio $k = c_p / c_v$
P_o = initial gas pressure in the vessel
P_s = surrounding pressure
ρ_o = initial gas density

Special Relativity Prediction

From the perspective of K, according to SR[1], the diameter of the vessel along the x-direction is contracted by the relativistic factor of γ [a], thus its cross sectional area as well as its volume are contracted by the same factor, given its dimension in the y-direction remains invariant. Whereas, the gas mass—as well as its molar mass—is increased (scaled) by the factor γ, hence its density is scaled by γ^2. According to the gas laws for an isothermal process, the vessel's initial gas pressure would then be augmented (scaled) by the same volume contraction factor γ. As for the nozzles cross sectional area, whether it's affected by the relative motion depends on the vessel's orientation and the respective nozzles position with respect to the relative motion direction.

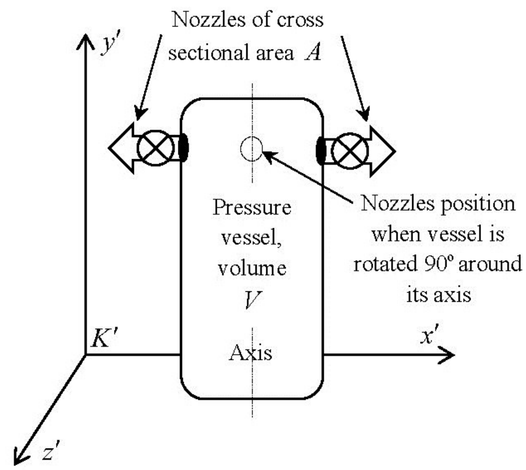

FIG. 1. Experimental arrangement

Case 1 — the nozzle cross section planes are parallel to the yz plane, i.e. perpendicular to the motion direction: Here, according to SR predictions, the nozzles diameter remains invariant, and, in accordance with the relativity principle, the discharge time duration with respect to K would be measured as

$$\Delta t = \frac{(V/\gamma)\gamma M}{RTCA}\sqrt{\Gamma(k)\frac{\gamma P_o - P_s}{\gamma^2 \rho_o}};$$
$$\Delta t = \frac{VM}{\gamma RTCA}\sqrt{\Gamma(k)\frac{\gamma P_o - P_s}{\rho_o}}, \qquad (2)$$

which is in contradiction with the SR prediction of $\Delta t = \gamma \Delta t'$.

Case 2 — the nozzle cross section planes are parallel to the xy plane, i.e. parallel to the motion direction: Here, in accordance with SR, the nozzles diameter along the x-direction is contracted by γ, hence their cross sectional area is also contracted by the

[a] $\gamma = 1/\sqrt{1 - v^2/c^2}$, where c is the speed of light in empty space.

same factor, whereas all the other parameters remain unchanged, and, in accordance with the relativity principle, the discharge time duration with respect to K would be measured as

$$\Delta t = \frac{VM}{RTCA}\sqrt{\Gamma(k)\frac{\gamma P_o - P_s}{\rho_o}}, \qquad (3)$$

returning a longer duration than equation (2) in case 1, thus contradicting the physics laws according to which the discharge duration should be independent of the orientation of the vessel in the space. In fact, this unrealistic SR outcome implies that as the cylinder is rotated around its axis in K', the gas discharge time will undergo changes with respect to K, since the nozzles cross sectional area varies according to their orientation with respect to the relative motion direction!

2. Optical Lens Properties

In this thought experiment, we keep our previous frames of reference, and we replace the vessel in K' with an optical convergent lens made of glass of refractive index n. The lens longitudinal axis is parallel to the y'-axis. The spherical boundary surfaces form a variable lens thickness along the longitudinal axis. Let d be the lens thickness at its optical center, and R the radius of each of the spherical boundaries. The objective is to measure the focal length of the lens, using the applicable laws of physics. Accordingly, this focal length, independent of the lens orientation, can be measured with respect to K' using the known formula

$$\frac{1}{f'} = \frac{(n-1)^2 d}{nR^2}. \qquad (4)$$

Special Relativity Prediction

From the perspective of K, according to SR, whether the lens thickness would contract depends on the lens optic axis direction with respect to the relative motion direction.

Case 1 — the optic axis is parallel to the x-direction: In this case, according to SR, the thickness of the lens is contracted by the relativistic factor γ at any point along the lens longitudinal axis. Consequently, the radii of the bounding surfaces will be extended (scaled) by the factor γ (i.e. inversely proportional to the thickness), since the lens curvatures are decreased. In addition, since the lens volume is proportional to the thickness, it will be reduced (divided) by γ, causing the lens density to be multiplied by γ^2, since according to SR the mass is also scaled by γ, hence its index of refraction would be scaled by γ, had we assumed it was proportional to the square root of the material's density for the used glass. Therefore, in accordance with the relativity principle, the lens focal length with respect to K would be measured as

$$\frac{1}{f} = \frac{(\gamma n-1)^2 d}{\gamma^4 nR^2}, \qquad (5)$$

returning a longer focal length than equation (4) with respect to K', which is in contradiction with the relativity principle, since the same governing physics laws in both frames (K and K') should result in the same focal length, a physical aspect of the lens.

Case 2— the optic axis is parallel to the z-direction: In this case, according to SR, the thickness of the lens remains unchanged. However, the lens width will be contracted by γ, resulting in volume decrease, hence an increase in the lens density and, as in case 1, in its refraction index, whereas all the other parameters remain unchanged, and, in accordance with the relativity principle, the formula for measuring the focal length f with respect to K becomes

$$\frac{1}{f} = \frac{(\gamma n - 1)^2 d}{\gamma n R^2}, \tag{6}$$

returning a shorter focal length (higher lens power) than equation (5) in case 1—and equation (4) with respect to K'—thus contradicting the physics laws according to which the lens focal length—a physical property governed by the laws of physics—must be independent of the orientation of the lens in the space. In fact, this unrealistic SR outcome implies that, with respect to K, as an object-lens set is rotated in K' around the lens longitudinal axis, the formed image will undergo changes in size and distance from the lens, since the focal length varies according to the optic axis orientation with respect to the relative motion direction!

3. Electrical Resistance

Here, a cylindrical object made of a certain material of electrical resistivity ρ is considered in the reference frame K'. The object has a length l, and a cross sectional area A. With respect to K', the electrical resistance of this object can be measured from the formula

$$R' = \rho\left(\frac{l}{A}\right). \tag{7}$$

Special Relativity Prediction

From the perspective of K, according to SR, the dimensions of the object are altered depending on its orientation with respect to the direction of the relative motion.

Case 1 — the cylinder axis is parallel to the x-direction: In this case, according to SR, the length of the object is contracted by the relativistic factor γ, whereas its cross sectional area remains the same. Hence, the resistance with respect to K becomes

$$R = \frac{\rho}{\gamma}\left(\frac{l}{A}\right), \tag{8}$$

returning a lower resistance than equation (7), which is in contradiction with the relativity principle, since the same governing physics laws in both frames should result in the same electrical resistance, a physical aspect of the object.

Case 2 — the cylinder axis is perpendicular to the x-direction: Here, according to SR, the length of the object is unaltered by the relative motion, whereas its cross sectional area is contracted by the relativistic factor γ. Hence, the resistance with respect to K would be changed to

$$R = \rho\gamma\left(\frac{l}{A}\right), \tag{9}$$

returning a higher resistance than equation (8) in case 1(scaled by γ^2)—and scaled by γ relative to the resistance in K'— thus contradicting the physics laws according to which the electrical resistance—a physical property governed by the applicable physics laws—must be independent of the orientation of the object in the space. In fact, this unrealistic SR outcome implies that as an electric circuit in the x'-z' plane is rotated in K' around an axis perpendicular to the relative motion direction, the circuit current will undergo changes in magnitude with respect to K, since the circuit resistance varies according to its elements orientation with respect to the relative motion direction!

4. Thermal Conductivity

A similar contradiction could be concluded from the SR predictions with respect to the conduction heat transfer through an object, in terms of exhibiting different heat flow rates in different inertial reference frames and in different orientations in the space with respect to the "stationary" frame.

Conclusion

It follows that the SR predictions result in contradictory outcomes when applied in accordance with the relativity principle. This is simply attributed to the fact that the length of an object, being a physical dimension, is a physical property governed by the pertinent laws of physics; hence, according to the relativity principle, an object must have the same physical dimensions with respect to all inertial frames of reference, which is in contradiction with the SR predicting length —and mass—variations of the same object from one inertial reference frame to another.

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[1] A. Einstein, Ann. Phys. 322, 891 (1905).