

# Lorentz Transformation and Elastic Collision

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An isolated physical system of elastic collision between two identical objects is chosen to manifest the physics law, conservation of momentum, in two inertial reference frames. In the first reference frame, the center of mass (COM) is stationary. In the second reference frame, the center of mass moves at a constant velocity. By applying Lorentz transformation to the velocities of both objects, total momentum before and during the collision in the second reference frame can be compared. The comparison shows that conservation of momentum fails to hold when both objects move together at the same velocity.

## I. INTRODUCTION

Elastic collision between two identical objects is an excellent physics system for demonstration of the concept of conservation of momentum. The collision will be examined in two inertial reference frames, the center of mass (COM) frame and a random inertial reference frame. Conservation of momentum is expected to hold in both reference frames.

Lorentz Transformation[1] transforms the velocities of both objects from COM frame to a random inertial reference frame. The total momentum, before and during the collision, will be calculated in this random inertial reference frame to verify if conservation of momentum still holds when both objects move together at the same velocity.

The concept of relativistic mass becomes less popular in modern physics. The momentum of an object is represented by either  $\gamma(v) * m(0) * v$  or  $m(v) * v$ . Both representations are equivalent to each other mathematically. In this paper,  $\gamma(v) * m * v$  is chosen to emphasize Lorentz Factor,  $\gamma(v)$ , in Lorentz Transformation.

## II. PROOF

Consider one-dimensional motion.

### A. Elastic Collision

Two identical objects move toward each other to make head-on collision. In the COM frame (Center Of Mass), both objects move at identical speed but opposite direction. At the moment when two objects make contact, there is a repulsive force between them. Both objects eventually slow down to become stationary. The repulsive force continues to push both objects away until there is no further contact between objects.

### B. Before Collision

Let a reference frame  $F_1$  be stationary relatively to this COM frame.

TABLE I. Velocity and Momentum in COM Frame

Object	Frame	Value
The velocity of object 1, $O_1$ , in	$F_1$	is $V$
The velocity of object 2, $O_2$ , in	$F_1$	is $-V$
The momentum of $O_1$ in	$F_1$	is $\gamma(V) * m * V$
The momentum of $O_2$ in	$F_1$	is $\gamma(-V) * m * (-V)$

### C. Lorentz Transformation

Let another reference frame  $F_2$  move at the velocity  $-u$  relatively to  $F_1$ . The velocity of  $F_1$  relative to  $F_2$  is  $u$ . According to Lorentz Transformation, the velocity of  $O_1$  in  $F_2$  has to be  $\frac{V+u}{1+\frac{V*u}{C^2}}$ . The velocity of  $O_2$  in  $F_2$  has to be  $\frac{-V+u}{1-\frac{V*u}{C^2}}$ .

TABLE II. Velocity Transformation

Object	Frame	Velocity
The velocity of $O_1$ in	$F_1$	is $V$
The velocity of $O_2$ in	$F_1$	is $-V$
The velocity of $F_1$ relative to	$F_2$	is $u$
The velocity of $O_1$ in	$F_2$	is $\frac{V+u}{1+\frac{V*u}{C^2}}$
The velocity of $O_2$ in	$F_2$	is $\frac{-V+u}{1-\frac{V*u}{C^2}}$

### D. During Collision

Upon collision, both objects in  $F_1$  will slow down and come to stand still before moving away. As both objects become stationary in  $F_1$ , both objects move at the same velocity in  $F_2$ .

TABLE III. Both Objects Are Stationary to Each Other

	Object	Frame	Velocity
	The velocity of $O_1$ in	$F_1$	is 0
	The velocity of $O_2$ in	$F_1$	is 0
The velocity of $F_1$ relative to	The velocity of $O_1$ in	$F_2$	is $u$
	The velocity of $O_2$ in	$F_2$	is $u$

### E. Conservation of Momentum

Let  $v_1$  be the velocity of  $O_1$  in  $F_2$  before collision. Let  $v_2$  be the velocity of  $O_2$  in  $F_2$  before collision.

$$v_1 = \frac{V+u}{1+\frac{V*u}{C^2}} \quad (1)$$

$$v_2 = \frac{-V+u}{1+\frac{-V*u}{C^2}} \quad (2)$$

Total momentum in  $F_2$  before collision is

$$\gamma(v_1) * m * v_1 + \gamma(v_2) * m * v_2 \quad (3)$$

Total momentum in  $F_2$  during collision when both objects move at the same velocity is

$$\gamma(u) * m * u + \gamma(u) * m * u = 2 * \gamma(u) * m * u \quad (4)$$

Conservation of Momentum demands, (from equations (3),(4)),

$$2 * \gamma(u) * m * u = \gamma(v_1) * m * v_1 + \gamma(v_2) * m * v_2 \quad (5)$$

$$2 * \gamma(u) * u = \gamma(v_1) * v_1 + \gamma(v_2) * v_2 \quad (6)$$

Equation (6) fails to hold for  $u=V=\frac{C}{2}$ .

$$2 * \gamma(u) * u = \frac{2}{\sqrt{3}} * C \quad (7)$$

$$\gamma(v_1) * v_1 + \gamma(v_2) * v_2 = \frac{5}{3} * \frac{4}{5} * C + 0 = \frac{4}{3} * C \quad (8)$$

Total momentum before elastic collision is different from total momentum when both objects move at the same velocity if

$$\frac{V}{C} = \frac{1}{2} = \frac{u}{C} \quad (9)$$

### III. CONCLUSION

Lorentz Transformation violates conservation of momentum.

Conservation of momentum fails to hold if Lorentz Transformation is applied to an isolated system of elastic collision. The failure of this physics law is due to the addition of velocity from Lorentz Transformation. The correct formula for velocity addition has been derived by Eric Su in 2018[2][10].

Lorentz Transformation was proposed on the assumption that the speed of light is independent of inertial reference frame.

As the result of this incorrect assumption[3], Lorentz Transformation violates Translation Symmetry[4] in physics. Translation Symmetry requires conservation of simultaneity[5], conservation of distance[6], and conservation of time[7]. All three conservation properties are broken by Lorentz Transformation.

Therefore, Lorentz Transformation is an invalid transformation in physics. Consequently, any theory based on Lorentz Transformation is incorrect in physics. For example, Special Relativity[8][9]

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