International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Critical Analysis of Einstein's Special Theory of Relativity: Exploring Contradictions

Sangh Priya Gautam

Bachelor in Engineering (Electrical), the then Delhi College of Engineering, New Delhi-110042, India
Director (Electrical), Government of India
Email: *sanghpriyag[at]gmail.com*

Abstract: ***Albert Einstein's Special Theory of Relativity revolutionized physics by challenging the concept of an absolute frame of reference. This paper critically examines the contradictions inherent in its mathematical equations, particularly length contraction, mass transformation, and time dilation. These inconsistencies raise questions about the validity of the theory and call for a re-evaluation of its foundational postulates.***

Keywords: Special Theory of Relativity, Lorentz Transformations, Time Dilation, Mass Transformation, Length Contraction

1. Introduction

Lorentz Transformation Equations are based on the two postulates of Einstein's Special Theory of Relativity. These postulates are as below:

- The laws of Physics maintain the same form in all frame of reference in uniform relative motion i.e. for all the inertial frame of reference.
- Velocity of Light remains invariant during transformation from one inertial frame to another and has thus the same value (i.e. $3x10^8$ m/s) for all observers, irrespective of their state of motion.

Results flowing from Lorentz Transformation equations are:

- Length Contraction
- Time dilation
- Mass Transformation
- Velocity Addition
- Simultaneity
- Invariance of space-time interval

However, first three results, relevant to contradictions discussed in this article, have only been deliberated here.

1.1 Lorentz Transformations Equations [1][2]

Following is the Lorentz Transformation Equations, based on Einstein Special Theory of Relativity.

$x'=(x-vt)/\sqrt{1-v^2/c^2}$ [1][2]
$y'=y$ [1][2]
$z'=z$ [1][2]
$t'=(t-vx/c^2)/\sqrt{1-v^2/c^2}$ [1][2]

Results derived from the Lorentz Transformation Equation are discussed one by one, as below.

1.1.1 Length Contraction [2]

The length of a Rod (l_0), as measured in a stationary frame of reference S which is at rest w.r.t. observer, is called rest length of rod. When the length of rod is measured in a reference frame S', moving at uniform velocity (v) w.r.t. frame S, this new length comes out to be (l) which is smaller than rest length of rod i.e. $l<l_0$. This new reduced length of rod as observed in moving frame of reference can be related to l_0 by the following mathematical formula:

$$l=l_0\sqrt{1-v^2/c^2}$$ [2]

where c is the velocity of light in vacuum.

As the contraction effect follows the reciprocity effect, therefore it is concluded that the length of rod in a moving frame of reference S' (l_0) gets contracted when measured by an observer in a stationary frame of reference S.

1.1.2 Time Dilation [2]

Relative motion between two frames of references also affects the time interval between the occurrence of two events, in any frame of references, as measured from other frame of reference. It also means that, to an observer, a clock appears to run slower in motion than when at rest relative to the observer
OR

time interval between two events occurring at a given point in a moving frame S', moving at uniform velocity (v) w.r.t. stationary frame of reference S as observed by an observer in a stationary frame is dt' which is higher or dilated w.r.t. time interval between these two events as observed in moving frame of reference itself (dt). This is given by the following formula:

$$dt'=dt/\sqrt{1-v^2/c^2}$$ [2]

where c is the velocity of light in vacuum.

It follows from time dilation that passage of time and hence, all physiological processes that go with it, like pulse or heart beat or ageing itself, are slowed down in a fast-moving reference frame. Twin Paradox is one such result which follows the Time Dilation equation. This states that if one of the two twins, goes in space at a high speed in a rocket and second one is left on earth, then clock runs slower for one who is in rocket and travelling at high speed in space w.r.t. other one who is on earth. Thus, one who is in space is much younger than one who was on earth in same time elapsed. Further, time dilation also shows the reciprocity, similar to length contraction.

1.1.3 Mass Transformation [2]

As per this, mass of a particle in a moving frame (with velocity '*v*' w.r.t. stationary frame) as observed by an observer in a stationary frame is always greater than its rest mass. This is given by the following formula:

$m=m_0/\sqrt{1-v^2/c^2}$ [2]
where c is the velocity of light in vacuum.

Thus, mass of a particle is stated to be no longer the absolute invariant quantity but depends on the velocity with which particle is moving. Increase in mass, as observed in this formula, is confirmed when e/m ratio (charge to mass ratio for electron) of fast-moving electrons is found smaller than slow moving electrons because at fast speed, mass of electrons becomes increased, as per above equation. This mass relativity principle also follows the reciprocity, similar to first two transformations.

1.1.4 Heisenberg Uncertainty Principle [3]

As per Heisenberg's Uncertainty Principle, there is inherent uncertainty in measuring variables of a particle. This principle generally applies to pair of ***position & momentum*** and that of ***energy & time***. Measuring position more precisely results in, more uncertainty in measuring the momentum and vice versa. As put in mathematical expression below, there is a lower limit to this uncertainty:

$\Delta p \Delta x \geq h/4\pi$ [3] …

Δp=uncertainty in momentum
Δx=uncertainty in position
h=Planck's constant

1.1.5 Principle of conservation of momentum

The law of conservation of momentum states that the total momentum of a system is constant, or conserved, till it not acted upon by an external force. In other words, we can say that momentum can't be created or destroyed.

2. Review of Literature

Walter Kaufmann (1901-1903), measured the increase in mass of a body with velocity which was consistent with the hypothesis that the mass was generated by its electromagnetic field when in motion.

Paul Ehrenfest (1909), He brought out a Paradox, known as Ehrenfest paradox while observing rotation of a "rigid" disc in the theory of relativity, rotating about its axis of symmetry. Radius R of the disc, as seen in the laboratory frame is perpendicular to its rotation and should therefore be equal to its value R_0 when stationary. However, the circumference ($2\pi R$) should appear Lorentz-contracted to a smaller value than at rest, by the usual factor $\sqrt{1-v^2/c^2}$. This creates a contradiction that whether radius of cylinder to be considered constant (i.e. R_0) or variable due to change of circumference (i.e. $2\pi R$) because of Lorentz length contraction.

Paul Langevin[4] (1911), showed that twin paradox (which is based on time dilation) can be completely resolved by consideration of acceleration in special theory of relativity. If two twins move away from each other and one of them is accelerating and coming back to other, then accelerated twin is younger than other on account of acceleration with which he is moving.

Max Von Laue (1913), demonstrated that the two frames of references (one during outbound journey by twin going in space and another, during inbound journey) alone are enough to explain the distinction between two twins, without having to account for acceleration.

Einstein (1908-1915), While postulating the General Theory of Relativity, Einstein himself concluded that Velocity of Light is not constant in extended gravitational field but is constant only area where gravitational influences can be neglected. This was against his basic postulate in Special Theory of Relativity.

3. Methodology

This review paper is completely based on analysis of results flowing from the mathematical equations representing Length Contraction, Time dilation and Mass Transformation. The results flowing from these equations are contradictory to each other; so is the reason of raising questions on these equations and hence need of revisiting the postulates of Special Theory of Relativity.

4. Discussion

4.1 The special theory of relativity dictates that the object that has mass cannot travel at speed of light. However, it is observed that photons, the particles of light, possess mass $2x10^{-34}$ kg and despite that they move at speed of light. Further, Mass of a particle becomes infinite when it reaches to speed of light, as per the Mass Transformation equation $m=m0/\sqrt{1-v2/c2}$ and as the common sense goes, speed of an object with infinite mass, cannot be such a high one. Moreover, it is also contradictory to the fact that light particle photons, which move at speed of light, don't have infinite mass but almost zero or negligible mass.

4.2 The increase in mass of an object while in motion, raises question where does the additional mass come from. Additional mass can't be generated and hence, cannot be added to the moving object. Still there is increase in mass of the object. As there is no creation of mass but still mass is increasing, prima-facie it appears that increase in mass is not due to actual increase in mass of moving object which is absolute one, but because of limitation/constraint in measuring the mass when the object is moving at such a high speed. These Limitations likely arises due to uncertainties in measuring position and momentum (momentum being product of mass & velocity) as per Heisenberg Uncertainty Principle. Uncertainty in position may lead to variation in length (i.e. length contraction) and uncertainty in momentum may lead to uncertainty in measuring mass (Mass Transformation).

4.3 As the mass of a moving body increases while in motion, its velocity should come down because of

conservation of momentum. Further, when velocity comes down, then its mass should get reduced. Thus, on one side, increase in velocity gives higher mass as per mass-transformation equation while increase in mass causes reduction in velocity, as per principle of conservation of momentum, unless acted upon by an external force. If these two contradictory effects of increase in velocity increasing mass and then increase in mass causing reduction in velocity, go side by side then ultimate result is no change in mass of the body. Thus, we see that Lorentz mass transformation equation gives result which refutes the principle of conservation of momentum.

4.4 The theory further says that length of a rod resting in a frame of reference S, will get shortened for an observer in a moving frame of reference S'. If this is in order, then its mass should also get reduced in proportion to decrease in its length. However, converse is found as per mass-transformation equation i.e. mass of rod moving at some speed gets increased as per Mass Transformation equation discussed in 1.1.3 above. Einstein's Special Theory of Relativity does not address this contradiction.

4.5 Twin Paradox is based on ground of Time Dilation as explained in 1.1.2 above. Further, this slower ***rate of change of time*** due to time dilation, points that rate of change of time & hence, time interval between two events occurring at same point varies depending upon the relative speed of two frame of references. Thus, the passage of time becomes fast or slow depending upon in which frame of reference the observer is located. Hence, it can be safely concluded that time is not absolute invariant but a varied one in different frame of references.

Secondly, in twin-paradox, if relativity is applied to twin on earth [5] and observations are made by twin in space, then twin who is on earth should look younger as he will be aging slowly as compared to other in space. But practically, we know that aging is such a process which can't be applied vice-versa when seen from two relative frames of references. This raises question on validity of time-dilation equation.

Moreover, prima-facie, it appears that slow aging of twin in space is due to slow physiological changes occurring in his body and that may be due to change in gravitational forces in space or due to acceleration, as was already disputed by **Paul Langevin**.

Having explained the slow aging, time dilation may be explained on account of limitation/constraint in measuring the time interval between two events when the object is moving at high speed. These Limitations likely arises because of uncertainty in measurement of time-energy conjugate as per Heisenberg Uncertainty Principle.

5. Result

1) Changes in mass of a body when in motion are not on account of actual addition to mass of body but appears to be so, because of uncertainty in measuring mass at high speed.
2) Einstein Special Theory of Relativity and Mass Transformation equation in turn, refutes the Principle of Conservation of Momentum.
3) Length contraction may be due to Uncertainty in measuring position.
4) Similarly, time dilation may also be the result of uncertainty in measuring energy-time conjugate.
5) Twin Paradox is unexplainable when applied to twin on earth because aging is a physiological process which can't be applied vice-versa to two twins, when observed from each other's frame of reference.

6. Conclusion

The analysis reveals significant contradictions within Einstein's Special Theory of Relativity, particularly concerning mass transformation and time dilation. These findings suggest a need for experimental validation and theoretical revision to address these inconsistencies effectively.

7. Significance

Thus, the study highlights the need for revisiting foundational theories in physics, encouraging further experimental validations and theoretical refinements to resolve inconsistencies in the mathematical equations of the Einstein's Special Theory of Relativity.

References

[1] V.A. Ugarov, "Special Theory of Relativity", MIR publisher, Moscow, 1979, ISBN 9785855011159 (Book Chapter Style)
[2] D. S. Mathur "Mechanics", S.Chand, Delhi, 2000, ISBN 9788121905992(Book Chapter Style), revised by Dr.P.S.Hemne in 2006
[3] David Cassidy, "Uncertainty: The Life and Science of Werner Heisenberg", W.H. Freeman, New York, 1992, (Book Chapter Style)
[4] Langevin, "L'évolution de l'espace et du temps", Scientia, Vol. X, pp. 31–54, 1911, (translated by J. B. Sykes, 1973 from the original French with title as "The evolution of space and time") (Book Chapter Style)
[5] Perkowitz, S. (2013, June 14). twin paradox. Encyclopedia Britannica. https://www.britannica.com/science/twin-paradox

Author Profile

Sangh Priya Gautam, received his Bachelor in Engineering (Electrical) from Delhi Technological University (the then Delhi College of Engineering) in the year 2001. He has also obtained Basic Aircraft Maintenance Engineering License from DGCA. He is Alumni of International Anti-corruption Agency (IACA), Vienna. He started his professional career after joining Tata Power Group. He has also worked in Indian Airlines as Aircraft Maintenance Engineer during 2005-2009 after getting DGCA Approved License on Air Bus A-320. Later, he joined prestigious Indian Engineering Service in 2009 and joined Indian Railways. Presently, he is working as

Director (Electrical) in Ministry of Railways, Government of India and looking after mammoth task of 100% electrification of Railways' Broad-Gauge Network. He has deep interest in knowing space and its attributes since his days of working in aviation sector in Indian Airlines. This paper is out of his curiosity to know the space.