# The Muon Time Dilation Experiment : Asymmetry in a Symmetric System

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07 June 2025

**Abstract**

One of the evidences cited for time dilation in Special Relativity Theory (SRT) is the muon time dilation experiment. This paper reveals an asymmetry in a symmetric system of muons in two labs moving relative to each other, by a rigorous application of Special Relativity Theory and Lorentz Transformation. Most of the arguments trying to defend or refute this experiment are based on intuitive or qualitative assertions of time dilation and length contraction, rather than on strict application of Lorentz Transformation.

## Introduction

One of the key experimental evidences cited for the time dilation of Special Relativity Theory (SRT) is the muon time dilation experiment. Atmospheric muons are created at about 10 km altitude as a result of bombardment of air molecules by high energy particles from space. The speed of muons is near the speed of light, typically 0.98 *c*. Muons decay into other particles and their half-life as measured in the laboratory is $\tau \approx 2.2$ μs.

Muon decay is governed by the following law:

$$\frac{N}{N_0} = e^{-\frac{t}{\tau}}$$

where τ is the half-life of muons measured in the laboratory.

The time it takes a muon particle to reach ground level will be:

$$t = \frac{10\ km}{0.98\ c} = \frac{10000\ m}{0.98 * 3 * 10^8\ m/s} = 34\ \mu s$$

Therefore, the percentage of muons expected to be detected at ground level would be:

$$\frac{N}{N_0} = e^{-\frac{t}{\tau}} = e^{-\frac{34}{2.2}} = 1.94 * 10^{-7} = 0.0000194\%$$

Therefore, almost no muons would be detected near the Earth's surface. However, significantly greater number of muons are actually detected near the Earth's surface and this was the puzzle faced by physicists. For example, if $N_0$ = 1000000 muons are created at an altitude of 10km, the number of muons detected at ground level would be:

$$N = 1.94 * 10^{-7} * N_0 = 1.94 * 10^{-7} * 10^6 = 0.194\ muons$$

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This problem was resolved by using time dilation of Special Relativity Theory as follows:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{\sqrt{1 - \frac{(0.98c)^2}{c^2}}} \approx 5$$

The half-life of muons as seen from the Earth's frame will be:

$$\tau' = \gamma\tau = 5 * 2.2 = 11$$

Therefore,

$$N = e^{-\frac{34}{11}} N_0 = e^{-\frac{34}{11}} * 10^6 = 45{,}460\, muons$$

## Rigorous Analysis of Muon Time Dilation Experiment

Next we present a rigorous analysis of muon time dilation experiment by a strict application of the Special Relativity Theory and Lorentz Transformation. We consider muons created in a lab on the ground (Lab A) and muons created in a hypothetical lab at an altitude of 10 km (Lab B) and moving towards the ground with velocity $v = 0.98c$ , and compare the half-life of muons in each lab as seen by an observer in the other lab. At first we will show that there is symmetry with regard to muon half-life in each lab, as seen in the reference frame of the other lab, in accordance with the principle and theory of relativity.

Consider two intertial reference frames: S and S' . S is the Earth's reference frame and S' is the reference frame of the muons moving towards the ground near the speed of light.

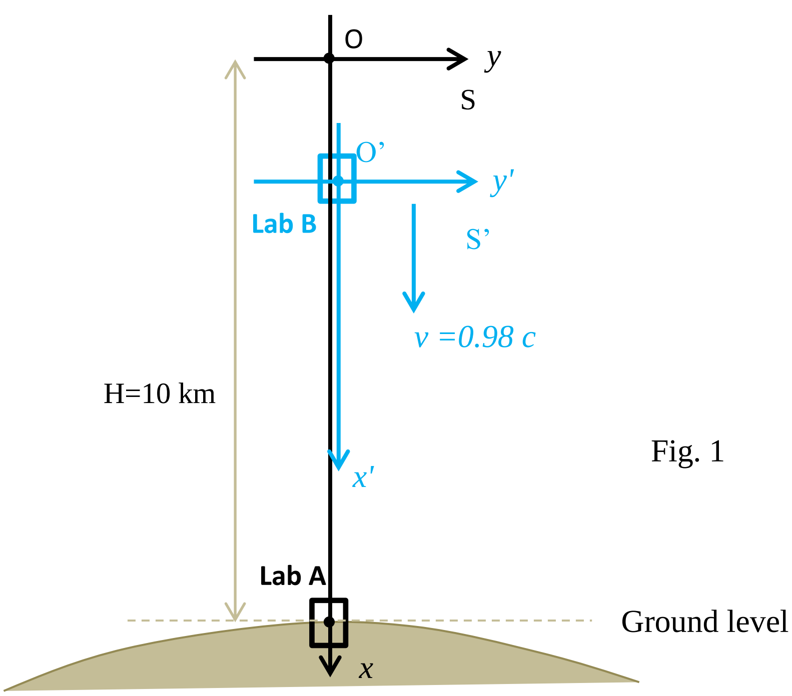


Fig. 1

Lab B is fixed at the origin of S', at $x' = 0$, and Lab A is fixed at $x$ = H =10 km in S (on the ground) .

Suppose that the clocks are synchronized and set to $t = t' = 0$ at the moment the origins O and O' coincide. O is fixed at an altitude of 10km. Reference frame S' is moving along the $+x$ axis in the $+x$ direction with velocity $v = 0.98\ c$ relative to reference frame S.

Suppose that $N_0$ number of muons are created in Lab B at $t' = 0$ in frame S', and the same number of muons are created in Lab A at $t = 0$ in frame S.

According to the principle and theory of relativity, there should be symmetry regarding what an observer in S and an observer in S' measure. That is, the half-life of muons in Lab A as seen by an observer in S' should be equal to the half-life of muons in Lab B as seen by an observer in S. That is:

$$The\ halflife\ of\ muons\ in\ Lab\ A\ as\ seen\ by\ an\ observer\ in\ S'$$

$$= The\ halflife\ of\ muons\ in\ Lab\ B\ as\ seen\ by\ an\ observer\ in\ S$$

$$The\ halflife\ of\ muons\ in\ Lab\ A\ as\ seen\ by\ an\ observer\ in\ S\ = \tau = 2.2\ \mu s$$

$$The\ halflife\ of\ muons\ in\ Lab\ B\ as\ seen\ by\ an\ observer\ in\ S'\ = \tau\ = 2.2\ \mu s$$

We identify the following events:

$E_0$ = creation of muons in Lab A in frame S, at ( $x$, $t$ ) = (H,0 )

$E_1$ = muons in Lab A reach their half-life in frame S, at ( $x$, $t$ ) = (H, τ )

$E_0'$ = creation of muons in Lab B in frame S', at ( $x'$, $t'$ ) = (0,0)

$E_1'$ = muons in Lab B reach their half-life in frame S', at ( $x'$, $t'$ ) = (0, τ)

The time coordinate of event $E_0$ relative to S' will be:

$$t' = \gamma \left( t - \frac{v\,x}{c^2} \right) = \gamma \left( 0 - \frac{v\,H}{c^2} \right) = -\gamma\ \frac{v\,H}{c^2} \qquad \ldots\ldots(1)$$

The time coordinate of event $E_1$ relative to S' will be:

$$t' = \gamma \left( t - \frac{v\,x}{c^2} \right) = \gamma \left( \tau - \frac{v\,H}{c^2} \right) \quad \ldots\ldots.. \ (2)$$

Therefore, the half-life of muons in Lab A as seen from frame S' will be:

$$\gamma \left( \tau - \frac{v\,H}{c^2} \right) - \left( -\gamma \frac{v\,H}{c^2} \right) = \gamma\,\tau \quad \ldots\ldots\ldots.(3)$$

The time coordinate of event $E_0$' relative to S will be:

$$t = \gamma \left( t' + \frac{v\,x'}{c^2} \right) = \gamma \left( 0 + \frac{v * 0}{c^2} \right) = 0 \quad \ldots\ldots\ldots(4)$$

The time coordinate of event $E_1$' relative to S will be:

$$t = \gamma \left( t' + \frac{v\,x'}{c^2} \right) = \gamma \left( \tau + \frac{v * 0}{c^2} \right) = \gamma\,\tau \quad \ldots\ldots\ldots(5)$$

Therefore, the half-life of muons in Lab B as seen in reference frame S will be:

$$\gamma\,\tau - 0 = \gamma\,\tau \ \ldots\ldots\ldots.(6)$$

Thus, with a strict application of Lorentz Transformation, we have shown the symmetry required by relativity theory.

However, this is not to imply that Special Relativity Theory is a correct model of the speed of light. In another paper [1][2][3], I have shown that SRT contradicts experimental results, particularly in its application to moving observers. Also, we are not implying that the claimed experimental confirmation of muon time dilation is unquestionable and that it is exactly as predicted by SRT. Considering the many logical and experimental evidences against SRT, including experimental evidences of absolute motion, we believe that the muon 'time dilation' phenomenon may have an alternative explanation based on absolute motion.

**Asymmetry in a symmetric system**

Although there is symmetry with regard to the half-life of muons in each lab as seen by an observer in the other lab, as we have already shown, there is an asymmetry regarding the space and time coordinates of events. The time of event $E_0$ as seen in S' is negative, whereas the time of event $E_0$' as seen in S is positive. That is, by the time the origins O and O' coincide (at $t = t' = 0$) , event $E_0$ will have already occurred (negative time) relative to S', but event $E_0$' is yet to happen relative to S.

Let us see a physical meaning of this.

From equation (2), relative to S', the muons in Lab A reach their half-life at:

$$t' = \gamma \left( \tau - \frac{v\,H}{c^2} \right) = 5 \left( 2.2\mu s - \frac{0.98c * 10000}{c^2} \right) = -152\,\mu s \quad ...... \quad (7)$$

From equation (5), relative to S, the muons in Lab B reach their half-life at:

$$t = \gamma \left( \tau + \frac{v * 0}{c^2} \right) = \gamma\,\tau = 5 * 2.2\mu s = 11\ \mu s \quad ...... \quad (8)$$

Suppose that each lab transmits a light signal to the other lab when its own muons reach their half-life. From the above results, Lab A will receive the signal from Lab B. However, Lab B will never receive a signal from Lab A, because at $t = t' = 0$ the muons in Lab A will have already reached their half-life in the past (whatever that means), and this is a physical proof of asymmetry.

It can be shown that, by only changing reference frames, one can change which lab physically receives the signal and which one doesn't, which is unphysical.

It can be shown that at $v = 0.066\,c$, the half-life of muons in Lab A relative to Lab B (relative to frame S') will be zero. For $v \leq 0.066\,c$, the time coordinate of the event of half-life of the muons in Lab A as seen from Lab B (relative to S') will be positive. Let us take $v = 0.03\,c$.

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{\sqrt{1 - \frac{(0.03c)^2}{c^2}}} = 1.000450304 \approx 1$$

In this case, from equation (2), relative to S', the muons in Lab A reach their half-life at:

$$t' = \gamma \left( \tau - \frac{v\,H}{c^2} \right) = \gamma \left( 2.2\mu s - \frac{0.03c * 10000}{c^2} \right) \approx 1.20054\,\mu s \quad ...... \quad (9)$$

From equation (5), relative to S, the muons in Lab B reach their half-life at:

$$t = \gamma \left( \tau + \frac{v * 0}{c^2} \right) = \gamma\,\tau \approx 2.201\,\mu s \quad ...... \quad (10)$$

This is again an asymmetry because the time coordinates of the events of muons reaching their half-life as seen from the other lab should be equal. That is, if muons in Lab A reach their half-life at *t'* = 1.2 μs as measured by the clock in S', then muons in Lab B should also reach their half-life at *t* =1.2 μs as measured by the clock in S. Or, if muons in Lab B reach their half-life at *t* = 2.2 μs as measured by the clock in S, then muons in Lab A should also reach their half-life at *t'* = 2.2 μs as measured by the clock in S'. Therefore, the above results are proof of asymmetry.

Unlike the twin paradox, it is possible to create a thought experiment of a perfectly symmetric system. Lab A and Lab B are spatially separated, and initially inertial and at rest relative to each other. Then both labs begin accelerating toward each other, undergoing equal but opposite accelerations for equal durations as measured by their own clocks, eventually reaching final, constant relativistic velocities. Reference frames are set up and their clocks set to *t* = *t'*= 0 and synchronized, at which instant muons are created in each lab, as discussed for the system in Fig.1. Each lab then transmits a light signal to the other lab when its own muons reach their half-life. The theory of relativity requires symmetry regarding the time each lab receives the signal from the other lab. That is, if Lab A receives the signal from Lab B at *t* =100μs according to its own clock, then Lab B must also receive the signal from Lab A at *t'* = 100μs according to its own clock. This set up is perfectly symmetric except for our choice of reference frames, which should not have any role in the outcome of the experiment. However, using strict application of Lorentz Transformation, we have demonstrated an asymmetry , thus disproving the Special Theory of Relativity and Lorentz Transformation.

To make this thought experiment even more 'physical', suppose that each lab transmits a light signal to the other lab when its own muons reach their half-life, so that we can compare the time of reception of the signals in each lab, which should be symmetric.

To determine the time of reception of the light signal from Lab A in Lab B, we determine the space coordinate (*x'* ) in frame S' of the event of light signal transmission from Lab A.

$$x' = \gamma\ (x - v\,t) = \gamma\ (H - 0.03\,c * \tau) = \gamma\ (10000 - 0.03\,c *\ 2.2\mu s)$$

$$= 9980.2\,m$$

Therefore, the light signal from Lab A will reach Lab B at:

$$T_B = 1.20054\,\mu s + \frac{9980.2}{3 * 10^8} = \mathbf{34.468\ \mu s}$$

Next we determine the time coordinate of reception of the light signal from Lab B in Lab A.

For this, we determine the space coordinate of the event of signal transmission from Lab B relative to frame S.

$$x = \gamma \ ( x' + v \, t' ) = \gamma \ ( 0 + 0.03 \, c * \tau ) = \gamma \ ( 0.03 \, c * 2.2 \mu s ) = 19.8 \, m$$

But in frame S , Lab A is at:

$$x = 10000 \, m$$

Therefore, the signal from Lab B will reach Lab A at:

$$T_A = \ 2.2 \, \mu s + \frac{10000 - 19.8}{3 * 10^8} = 2.2 \, \mu s + \frac{9980.2}{3 * 10^8} = \mathbf{35.467 \, \mu s}$$

Therefore, $T_B$ = 34.468 µs whereas $T_A$ = 35.467 µs and this violates the principle and theory of relativity itself. The system of the two labs , Lab A and Lab B , is perfectly symmetric except for our choice of reference frames, and yet we obtained $T_A \neq T_B$ .

Additional theoretical and experimental evidence against Special Relativity Theory and Lorentz Transformation can be found in the APPENDIX.

**Conclusion**

We have seen an analysis of the muon time dilation evidence of the Special Relativity Theory, using a rigorous application of the Special Relativity Theory and Lorentz Transformation. Most of the arguments so far trying to defend or refute this experiment are based on intuitive or qualitative assertions of time dilation and length contraction, rather than on strict application of Lorentz Transformation. If the half-life of muons travelling towards the ground, as seen by an observer in the Earth's frame of reference, is greater than 2.2 µs (the half-life of muons as measured in the laboratory) by a factor of gamma, then according to the principle and theory of relativity, the half-life of muons in the laboratory on the ground as seen by an observer in the frame of the relativistic muons should be greater than 2.2 µs by the same factor of gamma. In this paper, we have shown such symmetry regarding muon half-life. However, although there is symmetry regarding the half-life of muons in each lab relative to the other lab, we have shown an asymmetry regarding the time coordinates of the events , for example the event of muons in each lab reaching their half-life relative to the other lab. This paper also serves to show the approach to be used regarding the claims evidences of Special Relativity Theory, by indicating how to strictly apply Lorentz Transformation rather than use intuitive and qualitative assertions about time dilation and length contraction. Such vague assertions about time dilation and length contraction have been the source of endless debates and confusions.

Glory be to God and His Mother, Our Lady Saint Virgin Mary

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**APPENDIX**

# Disproof of Special Relativity Theory and Lorentz Transformation

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01 June 2025

**Abstract**

If Special Relativity is a correct theory of the speed of light, then it should reduce to classical models for non-relativistic speeds. In this paper, we reveal a glaring error in the prediction of the Special Relativity Theory (SRT) and Lorentz Transformation (LT) . A 'stationary' light source emits a short light pulse at time $t = 0$, at which instant an observer/detector is at distance $D$ from the source and moving away from the source with velocity $v$. For non-relativistic velocities, the time of detection of the light by the observer/detector is equal both in the reference frame of the light source and in the reference frame of the moving observer/detector. Using strict application of Lorentz transformations, we will show that SRT makes inconsistent predictions in the two reference frames.

## Introduction

One of the many confusions and controversies with regard to the Special Relativity Theory (SRT) concerns the constancy (or non-constancy) of the speed of light and the time of detection of a light pulse relative to a moving observer/detector, such as in the Global Positioning System. Although many researchers are increasingly questioning the Special Theory of Relativity and are trying to point out its logical contradictions, its decisive disproof remains to be extremely elusive. In this paper, we present such decisive disproof which has eluded researchers and physicists for more than a century.

## Disproof of Special Relativity Theory

In this paper, we present a disproof of special relativity theory by using a simple thought experiment of a light source and a moving observer. S is the reference frame of the light source and S' is the reference frame of the moving observer/detector.

Suppose that at time $t = t' = 0$, the origins ( O and O') of the two reference frames coincide and that S' is moving along the $x$-axis with velocity $v$ relative to S in the $+x$ direction. The light source is fixed at the origin of reference frame S and the observer/detector A is fixed at the position $x' = D$ in reference frame S'.

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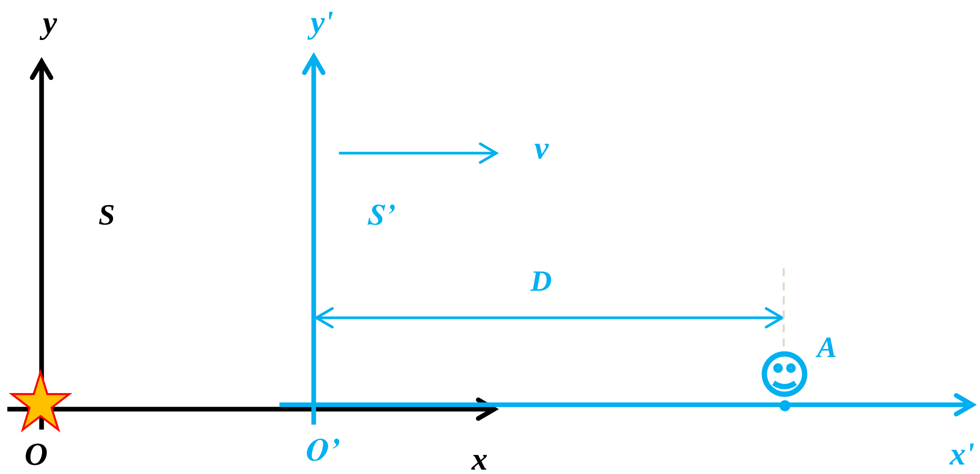
The light source emits a short light pulse at $t = t' = 0$. According to SRT, the speed of light is constant $c$ in the moving reference frame S'. Therefore, the light will be detected in frame S' at:

$$x' = D \quad and \quad t' = \frac{D}{c} \quad . \ . \ . \ . \ . \quad (1)$$




The Lorentz transformation is given by:

$$t' = \gamma \left( t - \frac{v\,x}{c^2} \right)$$

$$x' = \gamma \left( x - vt \right)$$

To determine the space and time coordinates of the event of light detection in frame S, we use Inverse Lorentz Transformations:

$$t = \gamma \left( t' + \frac{v\,x'}{c^2} \right)$$

$$x = \gamma \left( x' + vt' \right)$$

Therefore, the time coordinate of the event of light detection in frame S will be:

$$t = \gamma \left( t' + \frac{v\,x'}{c^2} \right) = \gamma \left( \frac{D}{c} + \frac{v\,D}{c^2} \right) = \gamma \frac{D}{c} \left( 1 + \frac{v}{c} \right)$$

For non-relativistic speeds,

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \approx 1$$

Therefore, the time coordinate of the event of light detection in frame S will be:

$$t = \gamma \frac{D}{c} \left( 1 + \frac{v}{c} \right) \approx \frac{D}{c} \left( 1 + \frac{v}{c} \right) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Therefore, the time of light emission in both reference frames is $t = t' = 0$. However, the time of light detection in the reference frame of the light source is different from the time of detection in the reference frame of the observer. That is,

$$\frac{D}{c} \neq \frac{D}{c} \left( 1 + \frac{v}{c} \right)$$

This disproves Special Relativity Theory (SRT) and Lorentz Transformation (LT) because, if SRT was a correct theory of the speed of light, it would reduce to classical models at non-relativistic speeds which predict the same time in both reference frames.

From experience and experiments, the time in the reference frame of the source and the time in the reference frame of the observer/detector are both equal to:

$$t \approx \frac{D}{c} \left( 1 + \frac{v}{c} \right) \approx \frac{D}{c - v}$$

Numerically, the two sides of the above equation are almost equal, the right hand side being the classical model. ( one can check this using $c$ = 300,000 km/s and CMBR velocity $v$ = 390 km/s )

**Conclusion**

The Special Theory of Relativity is perhaps the most confusing and controversial theory in the history of science. Ever since it was proposed by Albert Einstein in 1905, it has caused endless confusions, paradoxes and debates. Countless articles have been written, proposing logical contradictions in the theory, and yet failed to pinpoint what exactly is wrong with the theory, and therefore only led to more debates rather than settle the issue once and for all. This paper has finally uncovered a decisive disproof of Special Relativity Theory that leaves no room for proponents of the theory. By applying Lorentz Transformation to a simple thought experiment involving a light source and a moving observer, we have been able to show that SRT does not consistently reduce to classical models for non-relativistic speeds.

Glory be to God and His Mother, Our Lady Saint Virgin Mary

**Notes and references**