Disproof of Muon Time Dilation

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Abstract

One of the evidences cited for time dilation of Special Relativity Theory (SRT) is the muon time dilation experiment. In this paper, we present a refutation of this claim by strict application of Special Relativity Theory and Lorentz Transformation. Most of the arguments trying to defend or refute this claim are based on intuitive or qualitative assertions of time dilation and length contraction, rather than on rigorous 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, if one believes in the principle and theory of relativity, then almost no muons should 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 was finally resolved by using time dilation of Special Relativity Theory as follows:

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

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

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

Therefore,

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

Disproof of Muon Time Dilation

Next we present a disproof of muon time dilation by a strict application of the Special Relativity Theory and Lorentz Transformation. We consider muons created in a lab at ground level and muons created in a hypothetical lab at an altitude of 10 km 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. We will show an assymetry which is not supposed to exist according to 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.
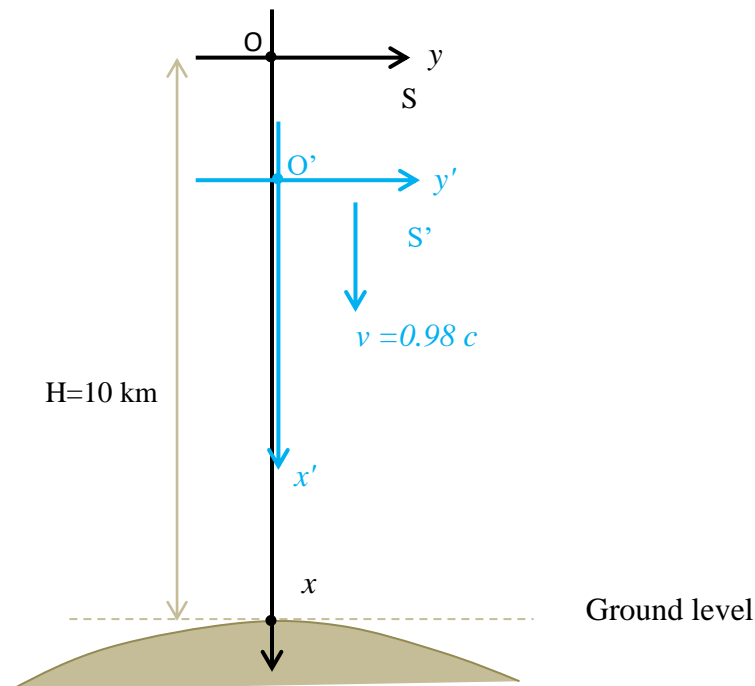
One lab is fixed at the origin of S', at $x' = 0$, and one lab is fixed at $x = $ H in S.

Suppose that at $t = t' = 0$ 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 a lab fixed at the origin (O') at $t' = 0$ in frame S', and the same number of muons are created in a lab fixed at $x = H = 10$ km (ground level) 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 S as seen by an observer in S' should be equal to the half-life of muons in S' as seen by an observer in S. We will show that this is not the case. That is:

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

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

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

$$The\ halflife\ of\ muons\ in\ S'\ as\ seen\ by\ an\ observer\ in\ S'\ =\ \tau$$

We identify the following events:

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

E_1 = muons in frame S reach their half-life, at $(x,\ t) = (\tau, H)$

$E_0{}'$ = creation of muons in frame S', at $(x',\ t') = (0,0)$

$E_1{}'$ = muons in frame S' reach their half-life, at $(x',\ t') = (\tau,0)$

The half-life of muons in S' as seen by an observer in S will be (using Lorentz Transformation):

$$t\ =\ \gamma \left(t' + \frac{v\,x'}{c^2} \right) = \gamma \left(\tau + \frac{0.98c * 0}{c^2} \right) = \gamma\,\tau = 5 * 2.2 = \mathbf{11\mu s}$$

The half-life of muons in S as seen by an observer in S' will be:

$$t' = \gamma \left(t - \frac{v\,x}{c^2} \right) = \gamma \left(\tau - \frac{0.98c * H}{c^2} \right) = 5 \left(2.2 * 10^{-6} - \frac{0.98c * 10000}{c^2} \right)$$

$$= -152.3\mu s$$

Therefore, not only is the half-life of muons in S as seen by an observer in S' not equal to the half-life of muons in S' as seen by an observer in S, but the half-life of muons in S as seen by an observer in S' is negative, which is absurd !

It can be shown that at *v = 0.066 c* , the half-life of muons in S as seen by an observer in S' will be zero (τ' = 0). At *v = 0.1 c*, τ' = 1.8667 µs. In both cases the half-life of muons in S' as seen by an observer in S is approximately: $\tau \approx 2.2$µs (because $\gamma \approx 1$ in both cases).

Having disproved the SRT explanation of muons, the question arises: then what is the explanation of the significant number of muons detected near ground level? Obviously, muons travelling near the speed of light have significantly greater half-life than the half-life of laboratory muons. This may also provide evidence of absolute velocity.

Conclusion

We have seen a refutation 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 claim 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 that this is not the case. This disproves one of the key evidences cited to support time dilation of the Special Relativity Theory.

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

Bibliography

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