Muon Decay Special Relativity Proof Debunked

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Abstract

The cosmic ray muon decay in the upper atmosphere is claimed by relativists to be an evidence of the relativistic time dilation. They consider it as a reliable experimental proof of the special relativity. This paper reveals the unviability of this claim, using an analytical approach. The time and space intervals between the events of the muons formation and their arrival to the Earth surface are analyzed by the means of the Lorentz transformation. Contradictory findings are obtained.

Introduction

Muons are unstable particles created in the upper atmosphere, at an altitude of about 15 Km, when cosmic rays collide with the nuclei of the air molecules. With their relatively short mean life of about 2.2 μs, and a velocity of about 0.994*c*, they should decay considerably during their relatively long trip to Earth before reaching its surface. However, the rate of muons that can still be detected near the Earth surface per a certain area is too high for their relatively short mean life and long trip from the upper atmosphere. In this connection, relativists claim that due to time dilation, the muons, being moving at relativistic speed, have their mean life extended relative to the Earth frame, so most of them will survive the whole trip duration, before they're completely decayed. And, conversely, the distance the muons have to travel is contracted relative to the muons rest frame, so their trip duration is reduced for the relatively shorter distance to be traveled.

Hence, according to relativists, from the perspective of an Earth observer, most muons will last longer than their trip duration to the Earth surface, because their mean life time is dilated. On the other hand, from the muon rest frame perspective, most muons will survive the trip, because the distance they have to travel is contracted, and their trip duration becomes shorter than their life time.

Quantitative Analysis

Let's quantify the above concept using the special relativity predictions. Let the Earth frame of reference be $K(x, t)$ and that of the muon be $K'(x', t')$, where the *x*- and *x'*- axes are coinciding, and oriented upwards in the vertical direction. The frames K and K' are relatively moving towards each other at the muon relative speed v.

Let τ be the mean life of muons at rest (in the muon rest frame), L the altitude at which muons are formed relative to K, corresponding to L', the altitude relative to K'. Let T be the muon travel time to the Earth surface, relative to K, corresponding to the time T', relative to K'.

The muons undergo decay according to the following formula:

$$N = N_o\, e^{-t/\tau}$$

where,

$N_o =$ the initial number of muons

$N =$ the number of muons remaining after time t has elapsed

If we neglect the relativistic effects, the muons flux created in the upper atmosphere would be reduced after their trip duration of $T = L/v$ by the decay factor of

$$\frac{N}{N_o} = e^{-T/\tau} = \; e^{-L/v\tau};$$

$$\frac{N}{N_o} = \; e^{-15000m/(0.994\times 8\times 10^{8} ms^{-1}\times 2.2\times 10^{-6}s)} = 1.89\times 10^{-4} \cong 0.0002$$

This means 0.02% of the initial flux would reach the Earth surface (99.98% of the muons would have been decayed upon reaching the surface), leaving hardly any chance for the muons to survive the decay on the way to the Earth surface. However, in reality, the measured muon flux near the Earth surface is substantial relative to the created flux in the upper atmosphere.

As to resolve this discrepancy, relativists claim that the muon mean life must've dilated by Lorentz factor γ with respect to the Earth frame $K,$ since the muon are moving with a high relativistic speed. Therefore, $\gamma\tau,$ instead of $\tau,$ should be plugged in the decay factor formula above, when computed from the perspective of K. For the given speed of the muon $(v/c = 0.994)$, the Lorentz factor is

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} = 9.142$$

The muons dilated mean life becomes equal to $2.2\times 10^{-6}\times 9.142 = 2\times 10^{-5}s$, and, by plugging this mean life in the above formula, the muons flux decay factor will be increased to 0.3894. Therefore, about 39% of the initial flux will reach the Earth surface (61% of the muons will have decayed upon reaching the surface), which is supposed to be in line with the actual measurements.

This conclusion should be equally reached when the decay factor is calculated from the perspective of the muon rest frame K'. To demonstrate that this is the case, relativists claim that the altitude must undergo the relativistic length contraction, and be reduced to

$$L' = \frac{L}{\gamma} \qquad (1)$$

relative to K'. The mean life remains τ $(2.2\times 10^{-6}s)$ in the muon rest frame. Therefore, the above decay factor formula will result in the same value with the mean life being dilated by the Lorentz factor from the K perspective, as in the case with the altitude being contracted by the same Lorentz factor from the perspective of K':

$$e^{-L/v(\gamma\tau)} = \; e^{-(L/\gamma)/v\tau}$$

Inconsistent Finding

It sounds convincing so far, doesn't it? Well, not until you realize the error committed in the above argument. The altitude where the muons are created is the initial distance between the origins of the relatively moving frames K and K', at the instant muons are created. Does this distance contract with respect to K'? Let's examine this assumption, given by Eq (1), in parallel with the considered events of the muons formation at this altitude and their arrival to the Earth surface.

According to the Lorentz transformation (LT), we have

$$\Delta x' = \gamma(\Delta x - v\Delta t) \qquad (2)$$

For the event of the muons formation, the relevant coordinates of the muons $(x'_\mu, t') \equiv (x_\mu, t)$ and the Earth surface $(x'_E, t') \equiv (x_E, t)$ can be written as:

$$(x'_{1-\mu} = 0, t' = t'_1) \equiv (x_{1-\mu} = L, t = t_1)$$

$$(x'_{1-E} = -L', t' = t'_1) \equiv (x_{1-E} = 0, t = t_1)$$

And the coordinates for the event of the muons arriving to Erath surface will be:

$$(x'_{2-\mu} = 0, t' = t'_2) \equiv (x_{2-\mu} = 0, t = t_2)$$

$$(x'_{2-E} = 0, t' = t'_2) \equiv (x_{2-E} = 0, t = t_2)$$

Using the above LT eq (2), we can write

$$\Delta x'_\mu = \gamma\left[\Delta x_\mu - v(t_2 - t_1)\right] \qquad (i)$$

$$\Delta x'_E = \gamma[\Delta x_E - v(t_2 - t_1)] \qquad (ii)$$

Plugging the coordinates of the above two events in the above equations (i) and (ii), we get

$$(i) \Rightarrow \quad x'_{2-\mu} - x'_{1-\mu} = \gamma[(x_{2-\mu} - x_{1-\mu}) - v(t_2 - t_1)]$$

$$0 - 0 = \gamma[(0 - L) - (-v)(t_2 - t_1)];$$

$$L = v(t_2 - t_1)$$

$$(ii) \Rightarrow \quad x'_{2-E} - x'_{1-E} = \gamma[(x_{2-E} - x_{1-E}) - v(t_2 - t_1)]$$

$$0 - (-L') = \gamma[(0 - 0) - (-v)(t_2 - t_1)];$$

$$L' = \gamma v(t_2 - t_1) = \gamma L \qquad (3)$$

But, according to the altitude contraction assumption provided by Eq (1), we have

$$L' = \frac{L}{\gamma}$$

Therefore, Eqs (1) and (3) lead to the contradiction

$$L' = \frac{L}{\gamma} = \gamma L \Rightarrow \gamma = 1 \text{ or } v = 0$$

Conclusion

It follows that applying the LT spatial equation to the muon decay between the events of their formation in the upper atmosphere and their arrival on the Earth surface, results in contradictory predictions, refuting the claim of the relativistic time dilation verification through the atmospheric muon decay phenomenon. A simple explanation of the phenomenon could be that the lab measurement of the muon half-life results in different value than its actual half-life in the atmosphere.