

Cosmic Ray Muons and Age Gradients

Terry Bollinger

2022-09-29.22:40 EDT Thu

https://www.youtube.com/watch?v=rVzDP8SMhPo&lc=UgyjAI1K0zedG7_jr9p4AaABAg

A Comment on the minutephysics post:

Impossible Muons

<https://youtu.be/rVzDP8SMhPo?t=3m2s>

[2:19](#) "At 99.995% [c] 50 km of our atmosphere [becomes] half a kilometer [which is] thin enough [to traverse in] 2.2 microseconds." Yes, but why do earthbound muons *decay* by the time the sky muon reaches the ground? Special relativity does not permit choosing which frame gets time dilation and which gets Lorentz contraction. What's amiss?

Time Dilation is Not Time Travel

The problem is that relativistic time travel is not due to time dilation but traversing *age gradients* in moving objects [\[1\]](#). Age gradients arise from tilting the time axis of the moving object. They are the third member of a trio of transformations — length compression, time dilation, and age gradients — that translate objects into new frames. Time dilations, in contrast, are fully symmetric for both frames and play no significant role in relativistic time travel. Many of the "paradoxes" of special relativity originate from confusing the traversal of an age gradient with time dilation.

For example, the muon in the minutephysics example traverses 50 km of the earth's atmosphere at 0.99995 c. From the perspective of the muon, the earth's atmosphere approaches the muon at 0.99995 c. As described in the video, this velocity Lorentz compresses the 50 km of atmosphere into a pancake only 0.5 km thick, which the muon traverses in mere 1.67 microseconds. This brief interval is well below the muon's average life, so almost all such muons get through the earth's atmosphere.

The problem is that this same velocity also slows the decay of ground and atmosphere muons by a factor of 100, making it extremely unlikely that the sky muon sees *any* earth muons decay during its brief passage. Yet on earth, we know the opposite to be true: Any muons in our atmosphere perish long before the sky muon arrives at the ground. How can *both* points of view be correct? With age gradients, it's pretty easy.

In addition to compressing the atmosphere's thickness and slowing time for all of its atoms by a factor of 100, the rapid approach of the atmosphere creates a steep age gradient [\[2\]](#) of $\alpha = 333.6$ ns/m across the entire half-kilometer distance. Age gradients work like time zones: They apply different settings to clocks as you move across space but don't change how fast the clocks tick. The same is true here: the sky muon sees different "age labels" on earth muons, but all of the earth muons seem to age at the same slow rate, and all seem to exist simultaneously in "sky time."

Age Gradients and Irreversible Time Travel

The crucial point is this: Crossing an age gradient is an irreversible form of time travel. Once crossed, it cannot be uncrossed, and the observer moves irreversibly into the future of the traveling frame.

The age gradient for the minutephysics example is $\alpha = 333.6 \text{ ns/m}$, and the gradient distance traversed by the sky muon is 500 m, meaning that as the sky muon travels in space across the age gradient, it also time-travels 166.8 microseconds into earth's future.

This time travel by way of the age gradients eliminates almost all earth muons by the time the sky muon hits the ground. Every earth muon passed along the way becomes, to the sky muon, a part of earth's past.

Time dilation does add an incredibly tiny bit of additional time passed to the earth's history, which is the 1% of the time it took to cross the half kilometer: 16.7 nanoseconds, as compared to 166.8 microseconds of age-gradient time travel. This addition can be ignored in this case, though for lower velocities, such as 60% of lightspeed, it must be added to the time travel component to get a correct total elapsed time.

Age Gradient Symmetries and Anti-Symmetries

Fine: Age gradients, not time dilations, cause relativistic time travel. But what about symmetry for the age gradients? If age gradients are the third leg of special relativity transforms, shouldn't the earth see a *muon* age gradient, and shouldn't it be possible for the earth to travel into the future of the sky muon?

In this case, size truly matters.

The answer is, of course, yes. Just as the sky muon travels 166.8 microseconds into the earth's future, the earth travels 166.8 microseconds into the muon's future... *where nothing exists*. The rest of the universe is still there, but it has its *own* frame and time definition. The muon, in contrast, is an exceedingly local one-time event lacking any "network" of other particles to share its definition of future time. It has the potential for a future, but without further energy, information, volume, and clocks that share its definition of time and space, that future is an abstraction without physical meaning.

The other consideration is frame mass. Large frames encompass much space and matter to create new, smaller frames, and the matter in those smaller frames can quickly rejoin the larger frame. However, the opposite is more complicated and impossible in cases with insufficient reaction mass to halt an extensive system. The earth can quickly stop the sky muon and thus force it to rejoin the earth frame, but the opposite scenario of boosting the earth into the muon's 0.99995 c frame would require 199 more earth masses: one to serve as an equal and opposite earth projectile, and another 198 masses of pure energy to launch both earth and its new twin in opposite directions at $\pm 0.99995 \text{ c}$. The very implausibility of this scenario says a great deal about why some frames dominate others.

Summary

The complete trio of special relativity transformations is time dilation, length contraction, and age gradients. Leaving off age gradients destroys the symmetry of the Poincaré transforms by forcing a sort of jumping back-and-forth between perspectives and, worse, picking and choosing which transform applies to which frame. All three SR transforms — dilation, contraction, and gradient — apply equally in *all* situations to *all* frames.

Distinctions between frames arise not from anything in the Poincaré symmetries but the histories, relative sizes, and spacetime volumes of different frames. In this perspective, the idea that there are infinitely large “abstract” frame spaces has no meaning. Such equation-only frames do not pay sufficient attention to the need for *detectable* clocks and *detectable* energy when defining spacetime frames.

In the future, the concept of spacetime frames must move away from meaningless “empty” space concepts and into the idea that all spacetime frames are excited states of matter. They cannot be defined meaningfully apart from the matter they contain, which impacts other parts of physics, including quantum mechanics and general relativity.

[1] The age gradient of an incoming system is:

$$\alpha = \frac{d t_{incoming}}{d x_{observer}}$$

... where $t_{incoming}$ is the moving-frame clock time, and $x_{observer}$ is the observer-frame distance to the clock.

[2] For a stable, internally synchronized, constant (negative) velocity incoming system, the age gradient simplifies to:

$$\alpha = -\frac{\beta\gamma}{c} = -\frac{\beta}{c\sqrt{1-\beta^2}}, \quad \text{where} \quad \beta = \frac{v}{c} \quad \text{and} \quad \gamma = \frac{1}{\sqrt{1-\beta^2}}$$

Terry Bollinger [CC BY 4.0](#)

2022-09-29.22.40 EDT Thu

PDF: <https://sarxiv.org/apa.2022-09-29.2240.pdf>