Lorentz Compression Times and Beaded Velocity Frames

Terry Bollinger
2023-06-25.16:40 EDT Sun

Abstract: Acceleration can never be instantaneous, even during particle emission. Furthermore, the complexity, time, and energy costs of creating traditional local-observer Lorentz-Einstein xyzt frames means that any math model that discards origin information by treating bodies with similar motion as residing in the same spacetime frame needs replacement with a more realistic hierarchical model that recognizes the acceleration histories of each internally bound xyzt unit. A specific example is treating quasar jets as beads of smaller, internally-bound velocity frames embedded in their originating galaxies' much larger non-accelerated xyzt frame.

Since Lorentz contraction is a *physical* process, compressing the length of a system at rest to the shorter length needed for its moving version requires finite time. To accelerate a system at rest with length ℓ in the direction of its new velocity v ($\beta = v/c$), the length $\Delta\ell$ to remove during compression is:

$$\Delta\ell = \ell - \frac{\ell}{\gamma} = \ell\left(1 - \frac{1}{\gamma}\right) = \ell\left(1 - \sqrt{1 - v^2/c^2}\right) = \ell\left(1 - \sqrt{1 - \beta^2}\right)$$

Lightspeed provides an upper limit for how short this *Lorentz compression time* can be. Compressing the system *before* acceleration begins allows it to apply inward from both ends, cutting the time needed in half at the cost of temporarily accelerating half of the system backward before accelerating all of it forward:

$$\Delta t_{[\rightarrow\leftarrow]} = \frac{\ell\left(1 - \sqrt{1 - \beta^2}\right)}{2c}$$

This value doubles if only forward acceleration is used, e.g., by using a profile that temporarily accelerates rear points faster than front points until all points reach the positions needed to create a self-consistent, self-synchronous moving system. (The other step needed to create a consistent xyzt system is adding an age gradient.)

$$\Delta t_{[\rightarrow]} = \frac{\ell\left(1 - \sqrt{1 - \beta^2}\right)}{c}$$

Accelerating all components of a rest system to near light speed makes the final Lorentz length negligible. In that case, the minimum Lorentz compression time approaches the time for light traverse object's rest length:

$$\Delta t_{[\rightarrow]} \rightarrow \frac{\ell}{c}$$

This limit gives, for example, one microsecond of inherent delay for accelerating a 0.3 km train instantly to near lightspeed. While this minimum delay is negligible compared to the delays created by slower, more realistic acceleration methods, it's important to note that it can never reach zero, even for nominally point-like particles. The reason is that the only experimentally meaningful version of nominally point-like particles is compact Schrödinger wave packets that (presumably) must remain internally synchronous and self-consistent in their local definition of xyzt spacetime.

The time light takes to traverse the wave packet length, as estimated by the evolution of the wave function since its last detection event, is the Lorentz contraction delay most likely to apply to the rapid acceleration of a point-like particle. It would mean, for example, that the emission of a muon takes a finite time that depends on its energy (and thus wave function compactness) at the time of its emission.

While negligible at human scales, the fact that Lorentz compression times scale linearly with length means they cannot be ignored for fast-moving cosmic-scale systems such as quasar jets since, for such systems, they can grow quite enormous. For example, in March 2021, NASA's Chandra X-ray Observatory observed a quasar jet 160,000 light-years long in the PJ352-52 galaxy, about 12.7 billion light-years from Earth. One *could* interpret such a jet as a single inertial-frame system since all its components are moving in roughly the same direction at roughly the same speed. However, since all of these components originated from a black hole at rest relative to the jet, they don't provide a cohesive xyzt interpretation unit without adding the other two components of a Lorentz-Einstein frame, which are Lorentz compression and adding an age gradient. Notably, since such jets can travel at up to 97% of lightspeed, the Lorentz compression time required to compress the entire jet into a single Lorentz-Einstein frame system is in the order of 160,000 years, even if a method of performing the compression existed, which it does not. In the absence of such compression, all of the components in the jet would see themselves as anisotropically separated along the direction of travel. One can define this as a single system, but doing so does not adequately acknowledge that the parts were never part of a single system, despite their similar velocities.

Similarly, the age gradient needed to convert the PJ352-52 jet into a proper Lorentz-Einstein frame requires re-interpreting the most recent emissions as *older*, rather than younger, than the components emitted 160,000 years earlier. A fiat declaration can, once again, declare them to be part of one frame, but this adds nothing to further a better understanding of the jet.

A better way to understand a quasar jet is as a dissected stream of smaller, internally bound systems, such as stellar systems, that formed and became gravitationally bound within the stream. Like beads on a necklace, these smaller-scale units exhibit strong internal xyzt coordinate structures because they have formed bound systems and exchanged sufficient matter and energy. The individual beads, however, have different ages determined by the surrounding galaxies. Beaded same-velocity frames provide a more helpful way to describe the jet, with the most recent units of the jet remaining, as expected, its *youngest* parts and its most distant components, its *oldest* parts.

The broader message is that spacetime frames are *always* local and dependent on what matter and energy participate. Any mathematical model that defines frames based solely on shared velocities is too simplified due to its oversimplification of the history-rich acceleration process and binding processes that ultimately define usable xyzt definitions.