On the Importance of Derek Muller's Asymmetric Light Speeds

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https://www.youtube.com/watch?v=pTn6Ewhb27k&lc=Ugx_ooIbbm0XlcpMpk94AaABAg

A Comment on the Veritasium post:
Why No One Has Measured The Speed Of Light
https://youtu.be/pTn6Ewhb27k

[4:46] "It's possible that the speed of light is half c in one direction, and … instantaneous on the return." No, it's not, but the reciprocal lightspeeds of c/R forward (zero) and Rc backward (infinite) work together in special relativity to create measurable, causally irreversible time dilation. The ½-to-infinity scenario "feels right" but ultimately fails by assuming that space can be isolated from time. You cannot get a relativistic universe if you permit that version of variable lightspeeds. On the bright side, you cannot get special relativity without creating detectable and genuine lightspeed pairs, though there are visible only in the lower-energy launch (or, less carefully, "rest") frame.

A Tale of Two Spaceships

So what is this R number? It's a ratio of distances traveled by a forward-moving light pulse between a mirror in motion and a mirror at rest.

Imagine two identical 100-meter spaceships ready to race:

```
Ship Uno:  o------------|
Ship Dos:  o------------|
```

Both have light-pulse generators ("o") in the back and mirrors ("|") in the front.

The judges trigger a light pulse in both ships to start the race. Alas, Ship Dos' engines fail, so its light pulse ("x") travels only 100 meters before hitting its front mirror.

```
Ship Dos:  o-----------x|
```

Ship Uno has a better maintenance crew and instantly reaches 0.6 c. At that speed, its length is only 75 meters due to Lorentz contraction. Its high velocity means the light pulse must travel farther to catch up with Uno's mirror. It finally does so 200 meters down the track, as seen by the judges:

```
Ship Uno:                  o------->|  ➔
```

The overall race result of Uno over Dos looks like this:

```
Ship Uno:                 o-------->|  ➔
Ship Dos:  o----------->|
```

The judges used fog machines to track both light pulses and saw them like this. While the crew of Uno believes the light pulse originated at the back of their contracted Ship, the judges with their fog machines see a different story:

```
Ship Uno:  o------------------------>
Ship Dos:  o------------>
```

Thus from the judge's perspective, the start-to-finish light pulse of Uno is twice as long as that of Dos. This ratio is R, the forward-backward lightspeed reciprocal of Ship Uno.

But that's only half of the mirror cycle! The reflected pulse of Uno then travels back towards a detector that is rushing forward. Thus this time, the pulse is shortened rather than lengthened. Again using their fog machines, the judges watch the return pulse travel a mere 50 meters before reaching the back of the Lorentz contracted Ship Uno:

```
Ship Uno:                    o----------|  ➔
Ship Uno:                    <------o
```

That gives this ratio of _return_ light paths for Uno over Dos:

```
Ship Uno:  <-----o
Ship Dos:  <------------o
```

The return path for Uno thus is half that of Dos, that is, 1/R.

Now here's the critical part. As far as the _judges_ are concerned, the light paths they measure with the fog machines tell them how fast light moves relative to the interiors of Ship Uno — and they _don't_ get the same results for forward and backward!

As best the judges can tell, the forward velocity of Ship Uno slows its "effective" lightspeed down to c/R. This slower lightspeed is, to the judges, an irreversible and fully recorded historical event. Similarly, the judges see and record the accelerated "effective" backward lightspeed of Ship Uno as Rc.

Curiously, the crew of Ship Uno doesn't see any of this. As best they can tell, light travels at the same speed forward and backward. To them, the fog is weird since it has time tags that sometimes seem to come from the past and sometimes from the future.

But surely, these "effective" light speeds don't mean anything physical!

Yes, they do. When added and averaged, the forward and backward versions of R, that is, 1/R and R, give $(\frac{1}{2}+2)/2=0.75$. This number is better known as the Lorentz factor for a ship traveling at 0.6 c, and it creates an _irreversible_ time delay for any object launched at this speed from the judges' frame of reference. In other words, time dilation is not a singular quantity. It is instead a direct result of light traveling at two reciprocal speeds when an object is in motion.

I suspect the ½ c papers never interpreted this as an inertial frame problem and thus overlooked the impact of Lorentz contraction and forward motion. At high R, the backward path shortens in space until backward light catches up almost instantly, corresponding to light velocity Rc. Conversely, light must "catch up" to the moving object in the forward direction. This chase can extend to infinity at high velocities, resulting in c/R slowdowns, not just ½ c. Think of it as time dilation, which is pretty much just what it is. The fixed-distance version of making ½ c the limit is not advisable since it assumes the existence of entirely classical, fully space-like distances, and those don't exist.

For folks in moving frames, such as our solar system, such numbers are hidden [16:13] from any experiments they can do internally due to special relativity. There's no getting around special relativity, ever. On the other hand, these ratios are fully observable from the launch frame, especially if that frame previously set up a well-synchronized, cloud-of-clocks definition of what it interprets as simultaneous points in its "space." In that launch frame, the varying forward and backward velocities look like ordinary asymmetric delays introduced by motion. This situation is hierarchical since the launch frame can never know whether some earlier frame launched it. Again, there's no getting around special relativity.

Why the Launch Hierarchy is Important

The only thing that stays invariant in these increasingly asymmetric light speed reciprocals is their launcher/launched relationships. These form a hierarchy going back to the origin of the universe. This "linear momentum energy excitation hierarchy" — you can also call it an "inertial frame ball," but one with an intricate branching network of historical launch events drawn inside it — ensures well-quantified determinations of extreme relativistic problems. Without it, special relativity is incomplete and ends up encouraging rather dumb, mystical-sounding assertions that fail to give clarity or results.

The extreme space slopes of the highest-energy inertial frames cause their seconds to scrape up vast swaths of our timeline, so they see us moving slowly, too. It's authentic time-dilation. However, the clocks of these _created_ and energized frames don't begin ticking until launch. While they can instantly begin reinterpreting photon data from the rest of the universe, they cannot change how it looked before their launch. The total mass, enclosed space, and length of existence as measured in their launcher frame often are limited. The higher the frame energy, the lonelier it tends to be.

In combination with the perspective symmetries of Poincaré and Lorentz, the constructive symmetries of the launcher/launched momentum hierarchy nicely resolve classical time paradoxes without invoking a deterministic universe, and reciprocal forward-backward lightspeed pairs are at the heart of how this works.

The Angular Excitation Hierarchy and Mach's Bucket

By symmetry, there is also an _angular_ momentum hierarchy. This one unexpectedly resolves Mach's bucket conundrum: The bucket creates its "own" rotating frame as a collective state without help from distant stars or a pre-existing spacetime fabric. The angular excitation hierarchy is essential to particle physics because it's quantized, unlike the linear momentum hierarchy.

Other Impacts of Reciprocal Light Speeds

[16:44] "Or maybe, when physics takes the next paradigmatic leap, our inability to measure the one-way speed of light will be the obvious clue to the way General Relativity, Quantum Mechanics, space, and time are all connected, and we'll wonder why we didn't see it before."

I broke out laughing when I read this! Sorry, it's just that I think you made quite a point there. I commented on this video a year ago and then forgot about it. I've worked on this topic for years but never noticed the reciprocal light velocity interpretation of the issues until last week. That's why I looked at your video again.

You may have noticed that I keep talking about frames as small, local, created entities composed mainly of ordinary matter. That's because it's what they are. Frames are always functions of matter, not nebulous pre-existing continuums. They integrate with other matter and frames, but without creation points that consume energy, they don't exist. They even create reciprocal definitions of the velocity of light.

Here are a few more consequences of matter creating reciprocal light velocity frames:

Spacetime Becomes Low-Resolution and Bottom-Up

If isolated systems of matter implement their own linear and rotating inertial frames, large-scale spacetime becomes the bottom-up cooperation of many smaller units. Large-scale flat space and curved space thus become functions of matter and energy, not independently-existing structures. This soft universe is one without Planck foams.

General Relativity Becomes Approximate

If energy and matter define the local rules of spacetime, then General Relativity necessarily loses resolution and predictive power at both tiny (not enough mass available; think electrons) and immense (mass is too scattered; think cosmic voids). There's nothing wrong with the equations of General Relativity. One cannot assume that the mass and energy that creates spacetime can support infinitely dense information (resolution) at zero energy cost.

Quantum Mechanics Becomes a Subset of Special Relativity

Mentioning quantum was remarkably prescient of you.

The asymmetric light speeds resolve in the space representation to what I've been calling _age gradients._ These form in every Lorentz compressed object, and they are just what they sound like: the back of a moving object becomes older than the front end, with reciprocal light speeds ensuring no time paradoxes ensue.

But here's the kicker: Age gradients make Schrödinger wave structure and dynamics a subset of special relativity.

The at-rest wave function of a massive particle rotates symmetrically in what looks amusingly similar to a one-loop skip rope whose volume encompasses its region of highest probability, and the rotation rate defines its mass. Boosting the wave into linear motion means it Lorentz contracts and so forms an age gradient.

But what does this initially simple skip rope loop look like after adding a time gradient?

It becomes a helix, a Schrödinger momentum wave function.

The point is this: There's no "complex plane" or "imaginary" axis in any physical quantum wave function. Those are just handy math abstractions and somewhat noisy ones at that. Quantum phases are instead _age gradients,_ the shapes of waves forced to exist at multiple points in time. This age gradient is directly visible in the launch frame but remains intransigently invisible in the moving frame due to special relativity.

So again, yeah, you were spot on with that one. Add age gradients due to reciprocal light speeds, and big chunks of quantum mechanics start looking a _lot_ like some form of special-relativity temporal mechanics waiting for further exploration. Wave functions become little time travelers — but then so do we, ever so slightly, every time we launch into a faster frame.

Why XYZT makes a Lousy Model of Quantum Reality

Finally, there's this:

[16:33] "And does it even make sense to talk about things happening at the 'same time' if they're separated by distance."

Well, no, it doesn't. If you think a bit about it, even _saying_ "xyzt" violates special relativity by assuming, for example, that "space" has a well-defined meaning in all situations.

Here's a seldom-used physics unit: meter-seconds. Why is it interesting? Because it's the unit of area for the three relativistically invariant surfaces that describe the location of an object relative to some encompassing rest frame. No space or time, just three mutually orthogonal _areas_ — areas, not vectors — each of which is inherently Lorentz invariant.

Any detectable spacetime event, such as one clock tick, has a length along its axis of motion. That length is _divided_ by the Lorentz factor. The duration of the event is _multiplied_ by that Lorentz factor. Multiply these two measures, and the Lorentz factors cancel out, leaving a meter-second "coordinate area" that better captures the interchangeability of event length and duration along that axis. Adding all three Lorentz areas, one for each axis, gives Lx, Ly, and Lz. These create a non-vector space from which the more familiar xyzt space emerges as a cooperative and context-dependent venture.

Are Lorentz area coordinates useful, however? That's to be seen, but for a start, they have the same structure as relativistic electromagnetic fields.

Whether or not Lorentz areas are a better choice for relativistic coordinates, I rather like the idea that at some deeper level, we may live in a 3-space of area-like quantities rather than a 4-space of vector-like quantities, with time and space as we know them emerging as a sort of cooperative approximation. That's just funny!

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PDF: https://sarxiv.org/apa.2022-08-29.0030.pdf