Wave Collapse, Einstein's Age Gradient, and an Overlooked Equivalence

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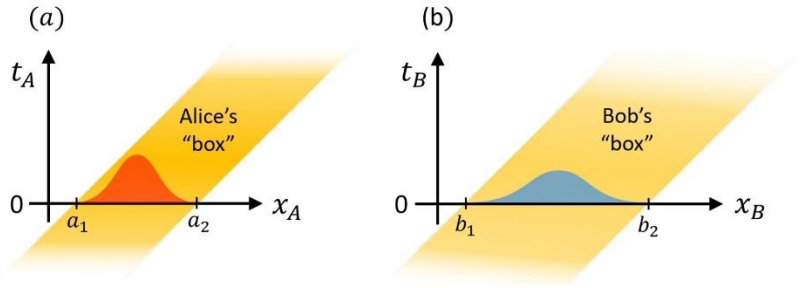

Figure 2. The figures show the spacetime diagram of a short light pulse permanently confined to a spacetime "box" from both Alice's (**a**) and Bob's (**b**) points of view. From Alice's point of view, the "box" extends from $x_A = a_1$ to $x_A = a_2$. The amplitude of the light pulse in Alice's frame is illustrated by the red waveform and remains within the box for all t_A. From Bob's point of view, the same "box" extends from $x_B = b_1$ to $x_B = b_2$. In Bob's frame, the width of the "box" is increased relative to Alice by a factor of $\gamma(1 + s\beta)$, where $\beta = v_B/c$. The waveform seen by Bob is shown in blue and remains in the "box" for all t_B.

Figure 2 from *A Simple Quantum Picture of the Relativistic Doppler Effect*.

Here's a great paper [1] for folks interested in photon quantum mechanics:

> D. Hodgson, S. Kanzi, and A. Beige, *A Simple Quantum Picture of the Relativistic Doppler Effect*, Symmetry **16** (3), 279 [Feb. 28] (2024). https://www.mdpi.com/2073-8994/16/3/279

This delightful paper addresses the oddly tricky question of what a photon wavefunction looks like, especially in the time dimension. I am not familiar with any of the authors, but am curious now what else they've been doing

I particularly like this paper because of its heavy reliance on the relativistic Doppler factor, $R = \sqrt{((c+v)/(c-v))}$, which is arguably a lot more fundamental than the kludgy Lorentz factor that is the average of the Doppler factor and its inverse. The relativistic Doppler factor has a delightfully simple geometric interpretation that I call the forward light paths ratio [2].

This approach to wave functions quickly gets into interesting turf, not just for photons but also for Schrödinger wave functions. The reason is that wave functions, in general, are profoundly linked to the nature of time, a point that becomes readily apparent once you realize there is an age gradient — a divergence of time — of the travel length of a moving wave function. [3] Here's something you likely have not heard, but which I assure you is nothing more than relativity applied to wave functions:

Moving wave packets resemble rotating helices (with the complex plane orthogonal to the axis of relative motion) because *the front of the wave is in the future relative to the back*.

What would have been a rotating, skip-rope-like wave function becomes oddly coiled because, from our perspective, the front of the wave has gotten ahead of itself in the most literal fashion imaginable.

Is this time divergence related to wave collapse?

Sure. Causality is singular, no matter what you may have heard (sigh!). The implication is that a particle with a time-divergent wave packet cannot survive if it comes into intimate contact with the far better "funded" (massive and energetic) timelines of entities such as ourselves and our instruments. Smaller objects can also collapse such divergent timelines; you certainly don't need consciousness. (That's just silly. If you hear someone spouting it, please hurry to the safety of an actual physics lab!) All you need to trigger wave collapse is a multi-scale mix of competing relativistic timelines, with a few 6000 kg elephant matriarchs sprinkled in to help drive everyone down the consensus time path.

And yes, you read that correctly: Wave collapse is a physical process caused by multi-scale competition to define time's direction. When such timelines collide, single-universe causality — the creation of information — requires a singular result, with the biggest players mostly winning by having more "time inertia," also known as mass.

Below are additional references, with references in the references, and a discussion of how Einstein failed to apply a particularly critical equation of his own making — or, more likely, he found the result so non-intuitive and disturbing that he orphaned his equation, never going back to it except by reference.

References

[1] D. Hodgson, S. Kanzi, and A. Beige, *A Simple Quantum Picture of the Relativistic Doppler Effect*, Symmetry **16** (3), 279 [Feb. 28] (2024). https://www.mdpi.com/2073-8994/16/3/279

[2] T. Bollinger, *The Forward-Path Ratio R in Special Relativity*, Apabistia SFL **33**, 202301292100 [Jan. 29] (2023). https://sarxiv.org/sfl.33.2023-01-29.2100.pdf

I did not mention the relativistic Doppler factor in the article because I was unaware of its existence then. My derivation of R was an accidental result of trying to find the best possible parameter for describing clock-and-ruler-related area invariants in relativistic 4-space. It also showed up when correcting the (in retrospect, incredibly naïve) view that "everything" around you slows down by Lorentz factor around you when you speed up. The apparent external time behavior of an extended (e.g., universe average) pre-existing collection of mutually at rest objects is a far more complicated and experimentally verifiable, relativistic Doppler 3-sphere. Only the forward direction time is fully predictable since only on that path does the motion coincide fully with the spacetime allocation created by your motion. It's not just light that's blue-shifted, but time itself — which is kind of "duh!" since light frequency vibrations are a form of clock that, once observed, can never be wound back again.[4]

[3] T. Bollinger, *Why Age Gradients are Useful in Special Relativity*, Apabistia Notes **2022**, 09210000 [Sep. 21] (2022). https://sarxiv.org/apa.2022-09-21.0000.pdf

Regarding these age gradients, contrary to what I thought even a couple of months ago, Einstein derived an exact equivalent to the age gradient equation. He documented it in Section 3 [5] of his massive 52-page paper [6] summarizing the state of special relativity (then called "the relativity theory") in 1907.

If you want to see Einstein's equation, it is in the first one after "must be of the form" on page 18 of [5]. To add delightful historical confusion, he used β (beta, which now means *v/c*) to represent the Lorentz factor that we now call γ (gamma). Multiply his gamma by the negative factor before the *x*, and voila! You get (in modern notation) the age gradient, $\alpha=-\beta\gamma/c$. If you do no more than interpret *x* as a *length* instead of a coordinate location, you get the time divergence between the front and back of any moving object. It is as much a part of the math as the Lorentz contraction.

But if Einstein had this marvelous little equation, why did he never apply it to the train in his famous thought experiment disproving simultaneity?

He certainly had no reluctance to look at both ends of a moving rod in terms of *length*, so why not add *clocks* to the front and back rod ends to quantify the nature and degree of the non-simultaneity more precisely? All he had to do was apply the length-to-time conversion equation to the length of the train. The result of his equation is *not* a factor you can safely ignore, especially in astronomy. At astronomical scales, such as in quasar jets, this divergence can grow enormous, at least in tens of thousands of years, and likely far greater.

Given the delightfully persistent way in which Einstein approached all such thought problems, it's a bit difficult to accept that he *never* attempted to put clocks on both ends of his rods and trains. What is more likely is that he had difficulty fully accepting, or perhaps making sense of, the clear result of his own time divergence equation. He seems not to have addressed the topic any further after 1907, preferring instead (as he did in 1911) to refer back to Section 3 of his 1907 paper as "fully" explaining the issue.

He would have seen — and likely did see — that applying his equation of the length of the train resulted in a massive time divergence that placed its engine in the future of the train and the caboose in its past. Anyone watching the train shoot by would see this divergence, yet the same divergence would be utterly invisible to anyone on the train — just as invisible, in fact, as the fact that the train was in smooth linear motion.

Thus, he overlooked an additional and rather remarkable equivalence principle: If you pick any arbitrary axis in space around you, there exists *no physical test* by which you can ever establish that the speed of light is not dramatically different in the forward and backward directions, provided only that these effects meet specific ratios.

He likely overlooked this symmetry of spacetime because *it violated his own added assumption* [7] that he was free to "declare" the velocities of light in opposite directions always to be identical [8]. Since his equal-velocity assumption is equivalent to declaring that the entire train always resides at a *single* moment, he likely had difficulty seeing an age divergence as a valid result despite it being the simplest possible interpretation of his time transformation equation. It always goes back to his added extraneous assumption. Ironic, that.

[4] T. Bollinger, *The four observable time ratios for A launched to B at velocity v*, Apabistia Notes **2023**, 1212102 [Jan. 21] (2023). https://sarxiv.org/apa.2023-01-21.2102.pdf

[5] A. Einstein, *Coordinate-Time Transformation* [Sec. 3 of *About the Principle of Relativity and the Conclusions Drawn from It*], Apabistia References **1907**, 04040418 [3 pages] [Apr. 4] (1907). https://sarxiv.org/ref.1907-04-04.0418.engl.pdf

[6] A. Einstein, *Über das Relativitätsprinzip und die aus demselben gezogenen Folgerungen*, Jahrbuch der Radioaktivität und Elektronik **4** (4) 411-462 [52 pages] (1907). https://www.google.com/books/edition/Jahrbuch_der_Radioaktivit%C3%A4t_und_Elektro/e-0tAQAAIAAJ?hl=en&gbpv=1&pg=RA1-PA418

[7] T. Bollinger, *Einstein's added stipulation defines all opposing lightspeeds to be identical*, Apabistia Figures **2024**, 0229231005 [Feb. 29] (2024). https://sarxiv.org/fig.1911-01-16.figs.05.jpg

[8] A. Einstein, *The Theory of Relativity [with Figures]*, Apabistia References **2024**, 02292310 [Feb. 29] (2024). https://sarxiv.org/ref.1911-01-16.figs.pdf. See page 8, final paragraph before Fig. 5.