Bottom-Up Time Construction as a Unifying Physics Theme

Presented by: Terry Bollinger (Apabistia Press)
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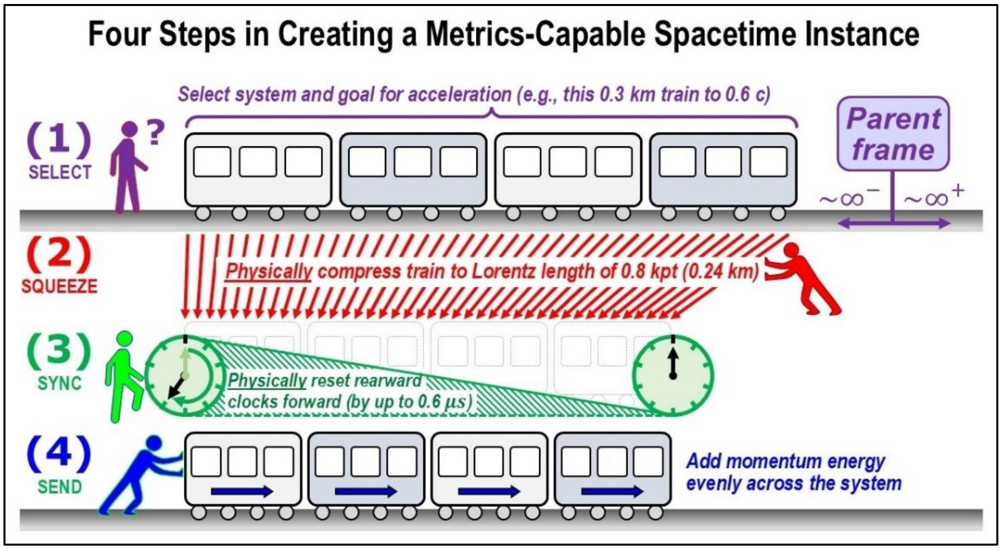


Understanding space and time requires a deeper understanding of transitions to boosted states.

[00:05] Ken Baclawski (KB): Welcome, everyone, to the Ontology Summit 2025. Today is May 7th, 2025. And we are thrilled to have Terry Bollinger today, who is going to give us a very, very interesting take on time in physics. So, now I will turn it over to Ravi, who will give you a proper introduction. Ravi, take it from here.

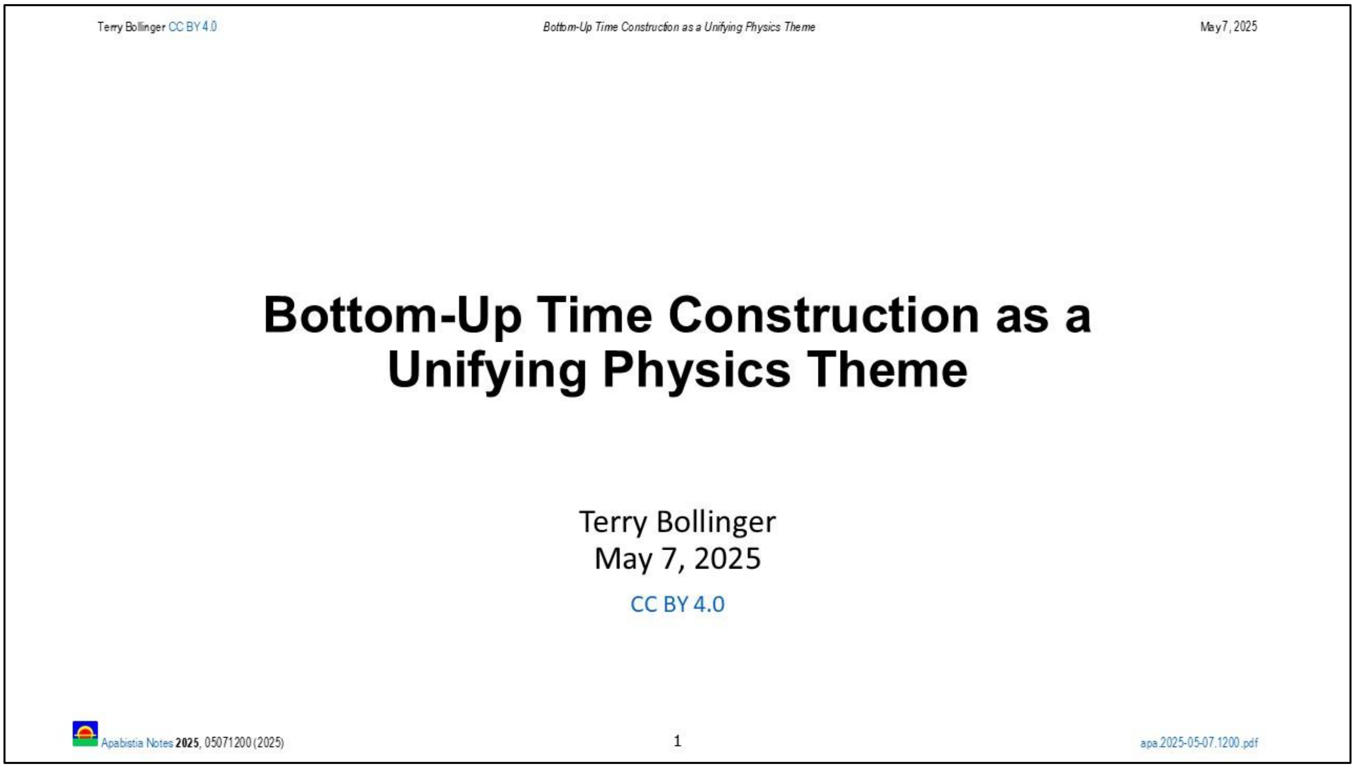
[00:43] Ravi Sharma (RS): Thank you. Can you all hear me?

It is amazing that I ran across Terry Bollinger and heard his talk in a couple of forums, especially the Washington Quantum Meetup, and my eyes opened. I said, “I have seen a lot of people talk about space and multidimensional space and particle theory. But here is one person who has understood the nature of time also, along with the nature of space, and has worked a lot on dissecting various ways of looking at time.”

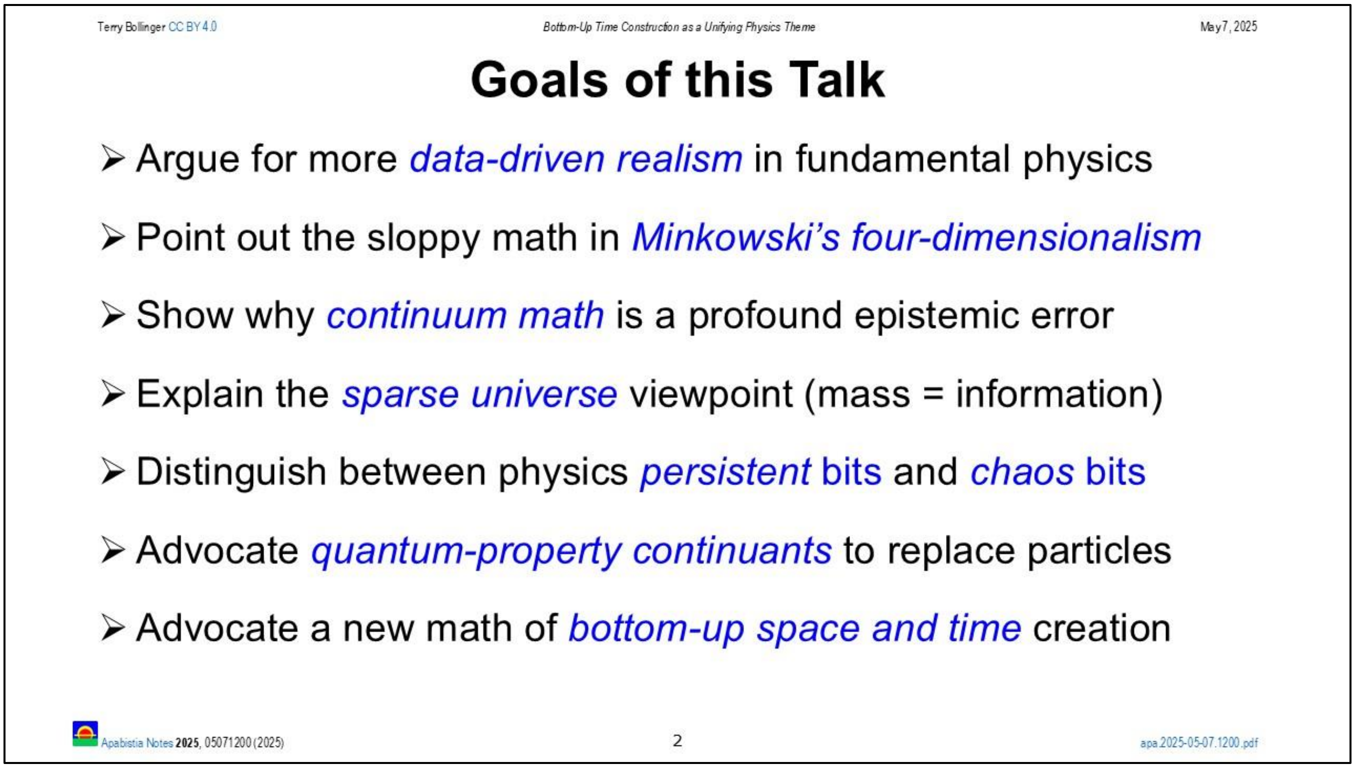
So, we are very delighted that we have such a distinguished retired chief scientist who has worked in the U.S. DoD venture capitalist and catalyst initiatives, and in the federal government in MITRE, which is a federally funded FFRDC, as you know. He runs a website called Apabistia Notes, where he self-publishes a lot of his research work, which is really mind-boggling. You can also ask him for more details than what is provided on the website by contacting him. He has brought some open-source initiatives into the DoD, and he has worked on large language models a bit, and also talked about them. The amount of qualifications is a full page in a brief form, but today, for our summit, he brings immense insight, something like that of a metaphysicist, mathematician, and a physicist, and takes us back to the days of relativity, the concept of time in space-time, and other scenarios.

So, it gives me immense pleasure to bring our last speaker of this summit for track four, Terry Bollinger. And we will request him after today’s talk, I’m sure, we’ll request him to come back and speak to us again. So it gives me great pleasure to introduce Terry to all of you. Please go ahead, Terry, and share your slides. Thank you.

[03:50] Terry Bollinger (TB): Thank you, Ravi, that is very kind. Confirming: Can everybody see my slides now? RV: No, not yet. [Press] that green button and share. KB: Now we're getting it. RV: Now we are getting it. TB: I have one more button to push, and I didn't quite push it. Are we good now? RV: Okay, I'm able to see. KB: Yes, everything's good. TB: All right, let's get started, then.



[4:54] "Bottom-Up Time Construction as a Unifying Physics Theme" is the original title. I will note that I actually wound up getting more deeply into issues of three-dimensionalism versus four-dimensionalism and, very specifically, the fascinating interactions between Einstein and Minkowski, and how those have affected both the metaphysical and the physics concepts that have gone into our understanding of time. And it *really* is an interesting story! It had a lot of twists in turns that, at first, I did not realize. Small events in history sometimes have a powerful effect, and I think this is absolutely one of those cases where a medical issue wound up affecting a century of physics in unexpected ways.



[5:45] I would like to start out bluntly, and not mince any words. The viewpoints I'm saying here are very different from standard physics, but that is *not* because of disrespect for standard physics. I have spent decades studying standard physics, quantum physics, and I *love* the topics. But what has happened is, in the process of going through some aspects of this, I can't get around that there's a problem. We see that in the lack of progress for the last, oh, gosh, 50 years, especially. We just don't seem to be *going* anywhere. We generate a lot of noise, a lot of papers, but we don't make experimentally predictive results. We lose that feeling of realism that was so profound in the early days of physics.

I think there are some reasons for that. In particular — and here's a radical statement right here — I'm talking about some sloppy math in Minkowski's spacetime.

How can I *dare* to say that? Because Minkowski's math does not encompass the *entire* problem. If you encompass only a subset of the problem, what happens is you *do* get a correct result — I mean, the Poincaré transformations work! That's not the issue. The issue is: When do they *work*, and when do they *not* work? If you don't look at the *full* problem — if you don't mathematically try to quantify *everything* — you wind up with problems. And this is very much a case of that.

[7:19] *Continuum math* is what I would call an "epistemic" error, in the sense that it *postulates* things that your model inside of your head says, "Okay, that *has* to be correct…" But the actual *data* doesn't support that! The simplest example of that — an incredibly simple example — is that classical continuums worked until we got down to atoms — and then, they didn't! All of a sudden, everything got fuzzy.

There was a choice, and people talked about it at that time, saying, "Well, does it *continue* to be point-like after that? Is there a point *hidden* in that cloud?" This was a discussion point once upon a time. There is a quote I still need to track down, from one of the greats, about just that issue. But [the debate] went toward the idea of saying, "Yes, *yes*: Everything is a *point*, and we'll go from that." This [decision] created this idea that continuum math is *always* applicable at *every* level, when the *actual* universe and the *actual* data always say, "Nah… I'm not going to give that to you. You can't have that level of detail." You get down to the atoms, then things start to fall apart.

[8:30] This leads to an idea of what I call a *sparse universe*. It's an incredibly simple concept, [which] is that the universe has a *finite* amount of information. It's not a many-worlds universe, it's not an infinitely detailed universe, it's not any of these things that require *unbelievable* amounts of information storage.

You can tell my computer background is coming through in this, saying, "Every storage device *I've* ever seen requires *matter* and requires some actual *substance* to it." And the universe seems to behave the same way, in terms of what we see from the *data*. You get a certain amount of *mass*, you get a certain amount of *information*, [and] you *can't store any more*. That's it! You have a *finite limit* to how you do it.

This is just taking that idea seriously; it's what I call the *sparse universe*. It's kind of the encompassing theme that I've come up with. That is in contrast to, for instance, the *spacetime continuum* universe, which assumes *infinite* information — literally, in some versions — at *every* point in space.

I would rather go with the idea that information is a *precious* and rather *unique* quantity, and that it's *not* something that just "happens randomly" or just "magically appears" [at no additional cost.] It is something that's part of the fabric of our [material] universe.

[9:48] I also make a distinction between *persistent* bits and *chaos* bits. Persistent bits, persistent information [bits], are the "continuants" that actually make the universe work. And *then*, you have these *chaos bits*, which are *generated* by certain combinations [of processes involving persistent bits].

Now, our math currently phrases that the *other way around*. We say that the *chaos* bits of the *real* bits, [that] the *infinite complexity* is there. But experimentally, that's *never* what happens. What happens is: We take something like an atom, we shoot an *enormous* amount of energy into it, and *then* we see a point-like electron. But until we shoot the enormous amount of energy into it, we don't see that!

So there's a difference in perspective. I'm saying that when you shoot the energy in, you're *creating* chaos bits — temporary, *transient* bits that *do not* store information. That's the key difference. If the bits cannot store information, *do not* think of them as being constituents of the universe. Instead [of focusing on those non-persistent bits], think of the things that are the "continuants" — the things that are *always* there, no matter what.

[10:48] This also gets to an issue [regarding the relationship between quantum theory and the concept of a local inertial frame.] We've seen discussions — everybody's seen discussions — about *wave-particle duality*, and everything like that. [Here's the part that folks usually miss in that debate:] Waves and particles are *both* part of a *local* spacetime continuum, [meaning] they *belong* to an inertial frame. [That is, waves and particles are *both* single-frame classical events, and thus not well-suited for the quantum world.]

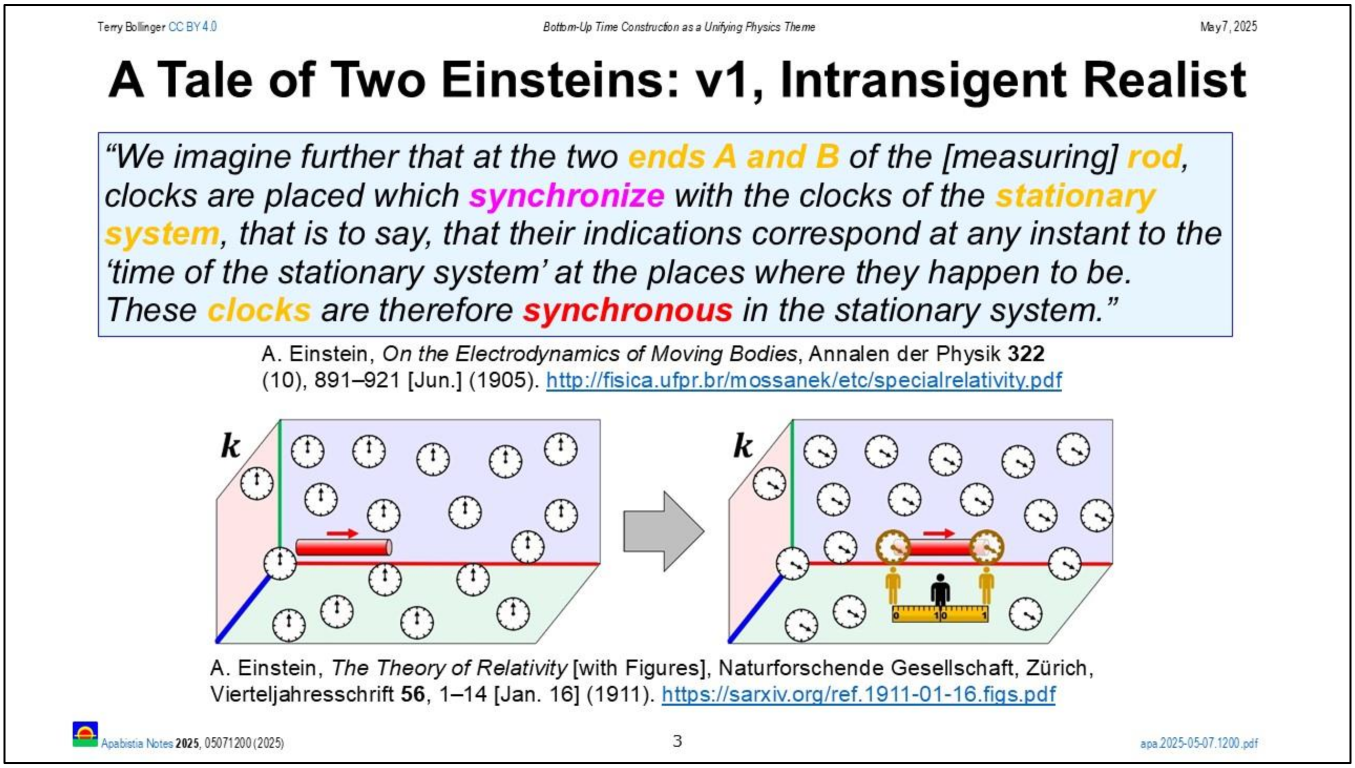
[11:03] You can't even define a *point* properly if you don't have a well-defined inertial frame, which is remarkable! That goes back to Euclid's very first definition, [his definition] of what a point is. It turns out that this definition doesn't work [for any frame that is not stationary relative to the observer frame]. (On this slide, I skipped [mentioning] this [issue of how to define points.]) You can't get [Euclid's first definition to] work because you wind up having an [asymmetric, topologically] biased definition that doesn't fit his first definition if you don't have a [shared inertial] frame. So even this [most fundamental of mathematical] properties, the idea of a point, is frame-dependent. You have to look instead and say, "What is it that actually *is* a continuant [— a property] that does *not* change?"

[11:36] And, as it turns out, [the continuants are more like] quantum properties: Ideas like the spin, the mass, the charge. Those are *bundles* that stay together. We *don't know* how they stay together; there's no good understanding of what makes them stay together. But in terms of observational characteristics, they can *fly apart*, from our perspective, and then, they come back together.

And of course, that's the wave collapse idea that we see in that. But trying to force this "wave" and "particle" definition on them is taking it in the wrong direction. There's a more fundamental set of continuants going on there.

[12:13] The bottom line is, we need to stop thinking of spacetime as being the all-encompassing framework that "comes down" and *creates* all these things. Spacetime is *complicated!* Look at the *data structure* for it! It's got all this *complexity* to it. What we're seeing is that you get good spacetime when you have a lot of matter. You have a lot of matter, all of a sudden, the definitions of length and time start making nearly-continuum types of sense. So it's interesting.

So there's my overview of the entire talk, just in the first slide.



[12:49] [There are] two Einsteins! If you haven't noticed this, … you really *need* to! … There are two very *different* Einsteins.

The first one was the special relativity of Einstein. He lasted until about 1911. … He was adamant to use *clocks*, and he was adamant to use *rulers*. He refused to analyze anything except in terms of actual *devices*. He was an *intransigent realist*.

[In effect he] said, "You know, if you can't do this [— if you cannot make your predicted results fully accessible to tests using real equipment in actual labs and controlled levels of experimental control over variables such as location and event times —] I don't trust the results." So [in this figure, the red rods act as rulers, and] you have the ends of these [rod] objects [measured simultaneously by pairs of observers in two different inertial frames. The first frame is that of two moving observers, one at either end of the rod, who previously synchronized their clocks after first reaching their new velocity. The second frame is that of a series of unmoving observers (or, just their clocks) who previously synchronized their clocks before the rod passed by very close to them. Notice that properly defining the needed states of all of these observers, both moving and unmoving, requires that] you have processes like the synchronization [before we can even begin to talk about measurement.] …

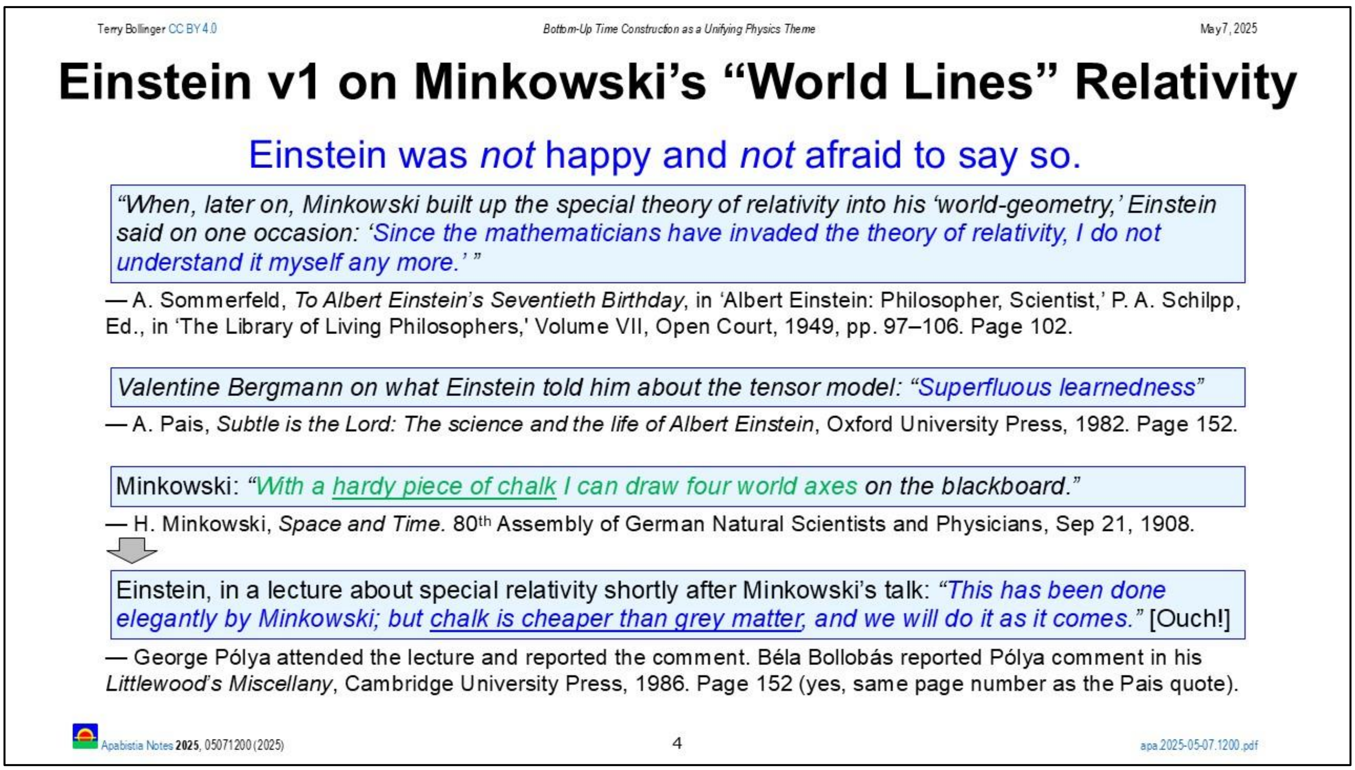
This figure [is one I prepared] from [a careful reading of] his 1911 talk. Again, [except for one,] the figures don't exist in the talk, but this is a very careful re-representation of what he talked about, … [and, by references made] in that talk, [seems to have drawn on a blackboard]. This was how he showed that Lorentz contraction is measured by *clocks* — by *actual clocks*.

And, even more interestingly, he said you have to use *synchronized* clocks. If we [used modern] phrasing [to describe] what he said now, we would call it a *program*; we would call it a *process*. And [it's] a rather *complicated* process, because you have to have a *master* clock, and you have to have a *cloud of clocks* that he goes out and synchronizes through a fairly complicated process — and *then* you send the object through that cloud.

I had used in my own work, the idea of a *clock cloud*, a whole bunch of "small observing particles" quite a while ago. And I was *delighted* when I found out that — and I did not know this — I was delighted [that] when I translated this German paper, [I found] out that Einstein had done the same thing.

Why this paper was never translated into English, I don't know, because it's a marvelous paper. It shows the complexity of his thinking up to that point.

But 1911 is a critical time, because *after that*… he pretty much abandoned clocks! Which is surprising in its own right.



[14:59] But pre-1911 — actually, more specifically, pre-1908, up until the end of 1908 — Minkowski came out with a *different* interpretation that everyone knows: *Minkowski spacetime*. Of course, spacetime is *not* Einstein's concept. It was *always* Minkowski's concept.

Einstein *did not like it!* He did not like it *one bit!*

So, the most famous quote is, "[Since] mathematicians have invaded my theory of relativity, I no longer understand it myself."

Now, you can spin that [by] saying, “Well, Einstein was a *bad* mathematician.” That’s kind of the arrogant way of doing it, but that’s nonsense. Einstein said that because he *knew* he couldn’t get precise results without going through some elaborate procedure like he had described. And then, when he looked at these [ideas from Minkowski], he’s like, “What are you *talking* about? You have no *reality* in this. … You have an abstraction, but there’s nothing *solid* there.” So this *bothered* Einstein *a lot*.

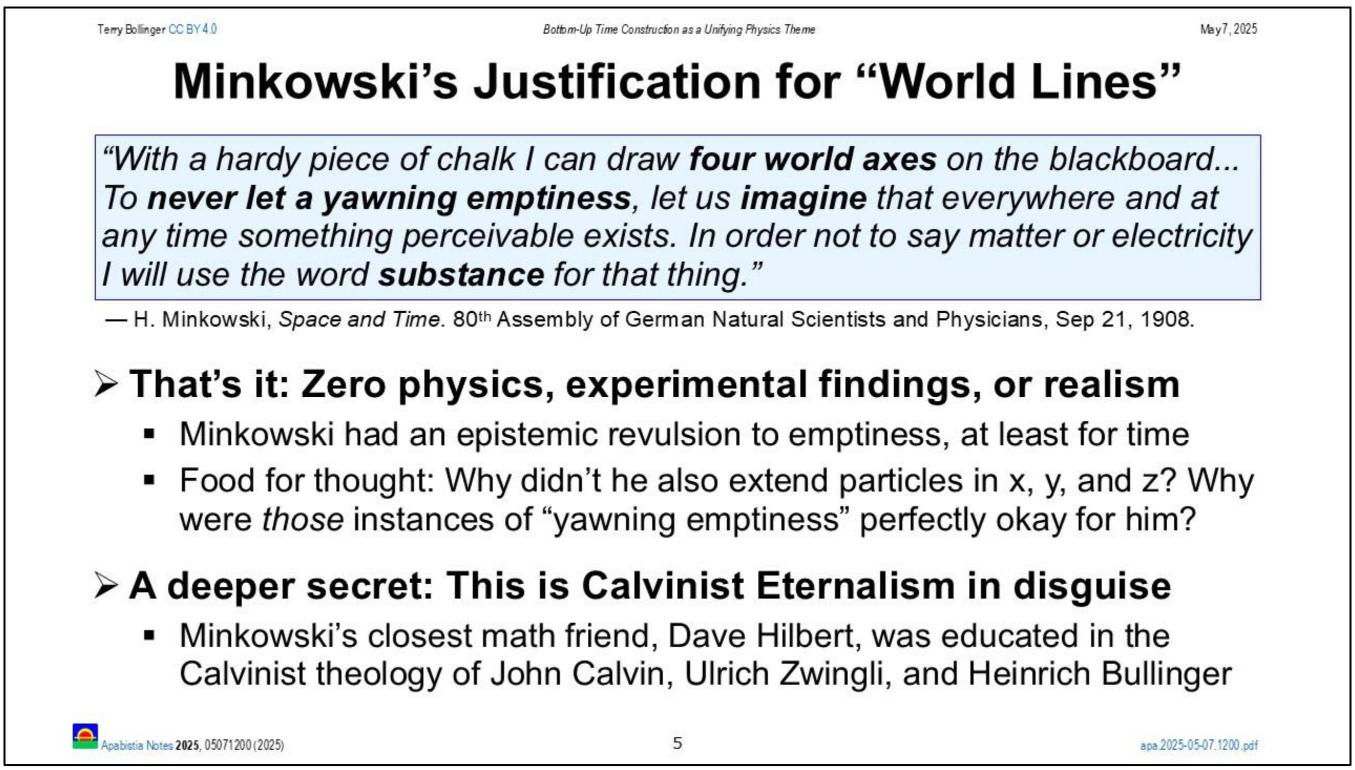
The quotes are interesting, [and sometimes it’s difficult] to track down who actually [first claimed that Einstein] said it. “Superfluous learning” [was one such quote on how Einstein felt about Minkowski’s spacetime.] I can’t see in my own slide, superfluous, superfluous learning. I’m trying to read my own slide, and there’s a little bit of covering it on this.

The most brutal comment he made was when he talked about, “This has been elegantly done by Minkowski, but chalk is cheaper than gray matter, and we will do it as it comes.”

Ouch! [That’s rough] because in his famous [Space and Time] talk, Minkowski had made a comment that, “with a hearty piece of chalk, I can draw four world axes.”

Pretty much, Einstein was saying that Minkowski was using the *chalk* for his *brain*. This was *extremely* sarcastic. Einstein was not impressed at all!

So, that is actually the bluntest comment I came [across] about just *how much* Einstein disagreed with the approach that was being taken by Minkowski. And again, the reasons for it are a little more complicated than, I think, people realize.



[17:18] When Einstein made this comment, when Minkowski made this comment, he also made his *justification* for it.

And this is just the most *amazing* justification! I remember the first time I ran across this, I just couldn't help but laugh. I'm going like, "That's *it*? That's *all*?": To 'Never let a *yawning emptiness*, *imagine* that everywhere there is a *substance* in time.'?"

[Indeed,] that's *it*. There's *no* attempt to refer to experimental results. There's *no* attempt to refer to *anything* except this philosophical concept that, "Oh, I don't *like* the idea of a *gap* in time! So, I'm just going to *stretch the particle out* infinitely in time!"

Now, he is *not* talking about [this infinitely stretched-out particle being] equivalent [to a clockwork universe]. He is talking about the [stretched-out] particle being an *actual substance*, which is the very word he uses.

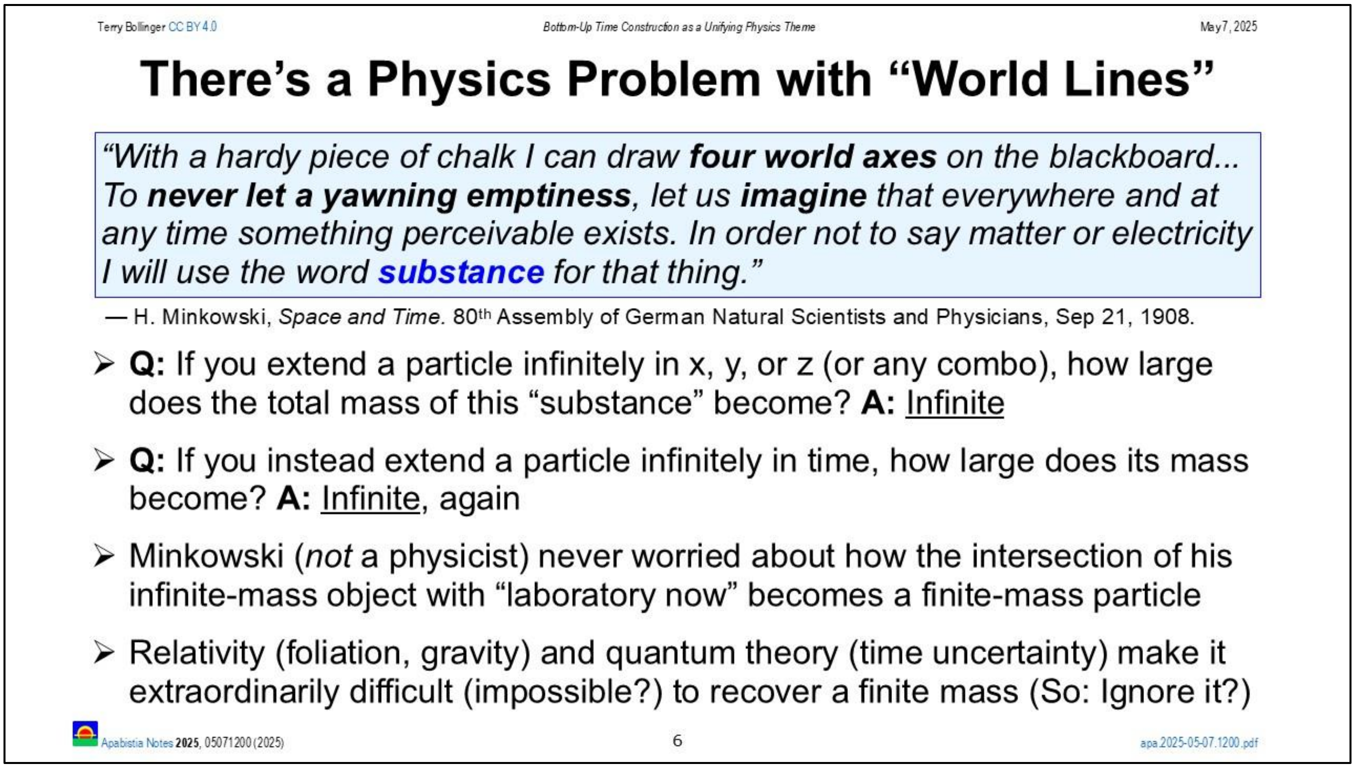
So, don't think of this as a clockwork universe. He's talking about an *actual world line* that is a *physical entity* that goes out there [to both the beginning and end of time]. That was Minkowski's presentation of this.

And so you wonder, "Where did he *get* that?" And, if you look carefully, you can see where he got that. He was a close friend to David Hilbert — a very famous mathematician, a brilliant man. David Hilbert was also *very much* educated in [the Protestant Christian theological teachings of] Calvinism, [which emphasizes the idea that all events and choices are predetermined and known in advance to an omnipotent God who resides outside of time]. To [Hilbert], it was the most natural thing in the world to think of the world, the universe, as predetermined, predestined, infinitely precise. This is just literally the education he grew up with. People like Calvin, Zwingli, and Heinrich Bullinger *all* taught this kind of philosophy.

Minkowski was from a Jewish background, but through Hilbert, it's very likely that this is where he came up with this mindset of saying everything is stretched out eternally. [But why was this view so attractive to Minkowski? Because it permitted him to launch a view that persists to this day, which is that all of physics is the domain of infinitely precise differential geometry — a universe of perfect equations. You can't get that with clumsy, material clocks whose size and dynamics forbid fully accurate representation by mathematically perfect four-dimensional geometric forms.]

The other question [everyone should ask] is, what happens? *"Why just time?"* If you're going to stretch particles out — I always just love this — well, why not stretch them out in *x*, too? Why not *x* and *y*? Why not in *xyz*, and just make the [single] particle into the entire universe?

There's an arbitrariness to this that is *remarkable*. Why stretch the particle out [*only*] in the *time* direction? Well, the answer is: Because you can *kind of* get away with it, because you can't see it *all at once*. But you're still just stretching a particle that was a *point particle* into an *infinite* size, and that has consequences that are not easily overcome experimentally.



[20:05] Infinite mass is a *problem* [in Minkowski's concept of world lines]! If you take Minkowski's idea of "a substance" seriously — *which nobody does!* — in terms of experiments, then just [ignore the experimental implications.]

There's a *dichotomy* here. *Why* do you take the idea of infinite world line seriously in terms of trying to say how physics works, but then you *never* bother to try to get an experimental test to determine what that world line *looks* like?

You can't have it both ways!

So, if you say, "A particle is actually an infinitely long string in time," that has consequences, both in relativity and quantum physics. For one thing, you can no longer determine the *mass* of the particle, because, *which part* of that infinite string are you looking at? How do you dissect it? How do you get a cross-section of it?

There're all sorts of experimental questions you could ask about the idea of a *real* worldline, but *nobody asks them*. They just say, "Um, eh, *okay*… you know… that's just the way it *works*!"

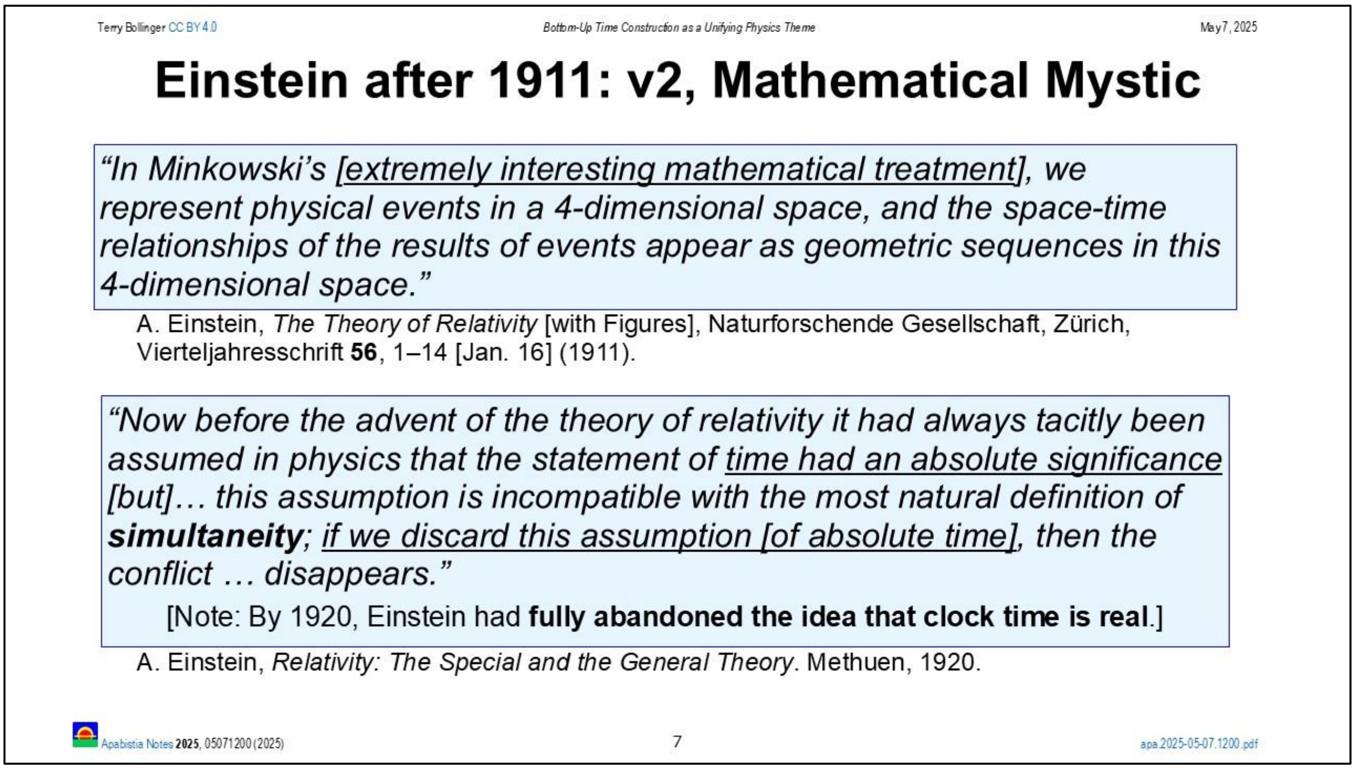
And this is the *danger*. You can't just throw out something *that* radical, [something that much] of an abstraction, and not bother to *quantify* it experimentally.

Which, as you can see from Minkowski's quote, he didn't bother. This is why Einstein was *so* sarcastic. He was *not* impressed. He was going for reasons … very much like these, "What are you *talking about*? [What] is this *substance*? What is this *yawning emptiness*? Does your *chalk* justify your "yawning emptiness?" And he was *bitter* about this.

[Finally, there's] foliation. That's where you slice across [Minkowski's bundle of worldline for *every object in the universe* and then define the resulting set of space-like "points" as the state of the universe as seen from one specific inertial frame. For decades, this idea pretty much ruled the roost for how to interpret the universe from the various inertial frame "boosts" defined by Minkowski's spacetime. There's a reason why you no longer hear much about it these days: It *doesn't work*. You end up with and impossible infinity of mutually conflicting causality definitions that no one has ever figured out how to resolve mathematically. Declaring everything to be a "block" universe doesn't solve this, but instead just asserts, "Somehow, it all works out."]

[The point is, this massive causality-resolution problem exists *only* as result of accepting Minkowski's idea "filling a yawning vacuum" as an unalterable given, mostly because it makes every detail of the entire universe into beautifully clean set of differential equations, and thereby also makes math more fundamental than experimental reality.]

[The list of difficulties caused by assuming worldlines to be physically real entities goes on, and includes its baffling implications for gravitational mass and why the universe does not instantly collapse into a black hole.] Take your choice [of which one to worry about]. If somebody wanted to put an experimental program to *look* for worldlines, [and potentially resolve all these issues in one swoop], they could, [but] no one has bothered.



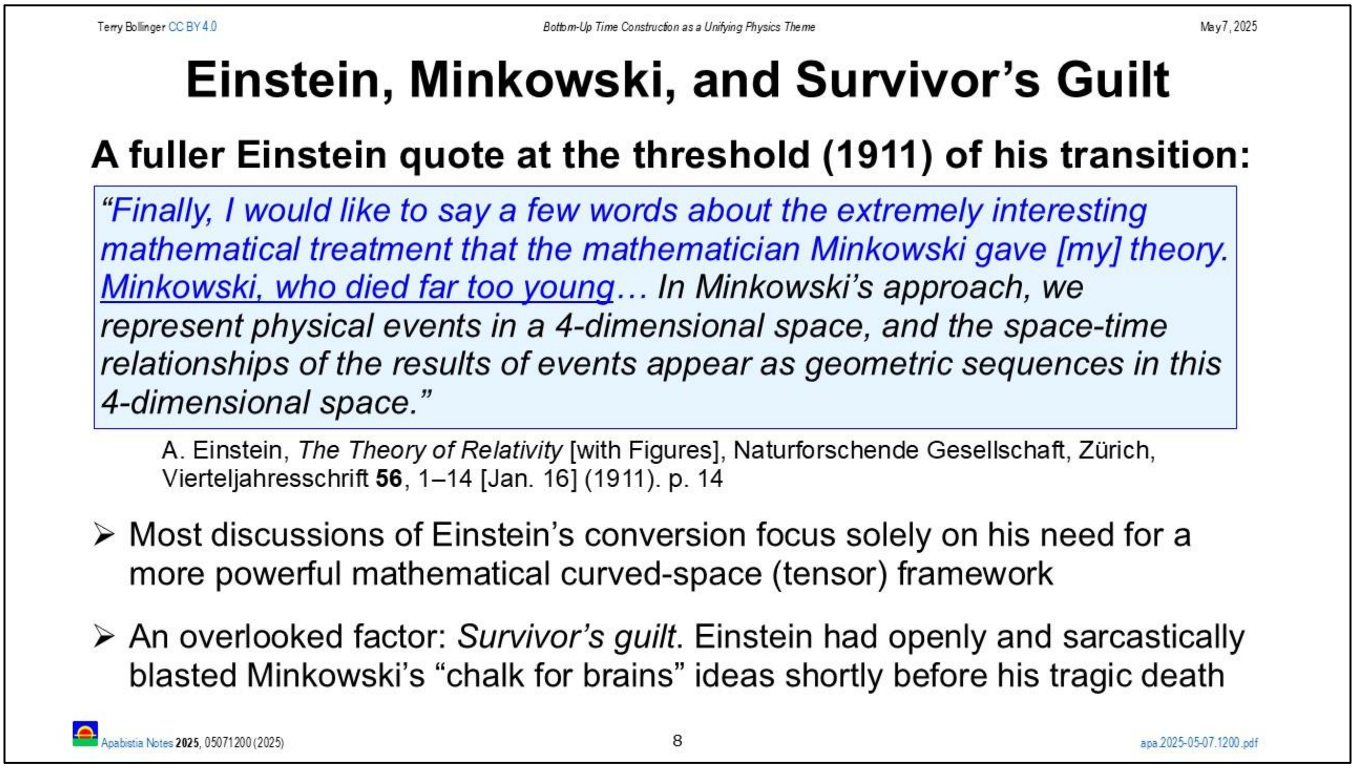
[21:53] Now, a curious thing then happened. Einstein *completely flipped!*

It was about 1911 when it happened. [His] 1911 … paper was the last one where he *seriously* worked on the complex formalization of the clock, which was getting very messy. I'm sure he was *extremely* frustrated with it, because it looked like a [what we would now call a] giant computer program. It looked like a giant *process*. He was hoping for something simple, [a few equations, and] and that's it. Instead, he was getting this complicated … *process* to replace the simplicity he was looking for.

So, if you look at the other thing he invokes, it's the *simultaneity* issue. Einstein had shown, very correctly, very provably, that simultaneity is not a property that you can give [to share across a diverse,] different set of [inertial frame] viewers. That was one of his key findings, one of his most famous findings: The idea that simultaneity is, essentially, an *indeterminate* concept if you, [for example,] throw in different trains [with different motions and inertial frames.]

So: He went this route, where he went from looking at *clocks*, to saying that, "Well… if we can't *prove* simultaneity, one way to get rid of that, one way to solve it… is to just *discard* the concept of *absolute time*, [even for local observers looking only at their own clock.]"

But when you do *that*, you're *abandoning* the idea of a physical clock. You're replacing the physical clock with the *worldline*. The worldline has little notches on it, but you no longer have this idea of an *actual* clock that is beating, ticking, and measuring off the time.



[23:41] If you look at the [final] full quote [— the one] Einstein said this at the *end* of his last attempt [in a paper] to be a clock-ruler realist — he makes an interesting statement about what happened to Minkowski.

Most people don't realize this: Four months — *less* than four months — after Minkowski gave his electrifying talk, [the talk] in which he introduced [his] space and time [interpretation of Einstein's work] — *during which time*, Einstein was *bitterly* antagonistic to what [Minkowski] had said, and did not like the concept *at all* — Minkowski died, unfortunately, of appendicitis, in January of the next year.

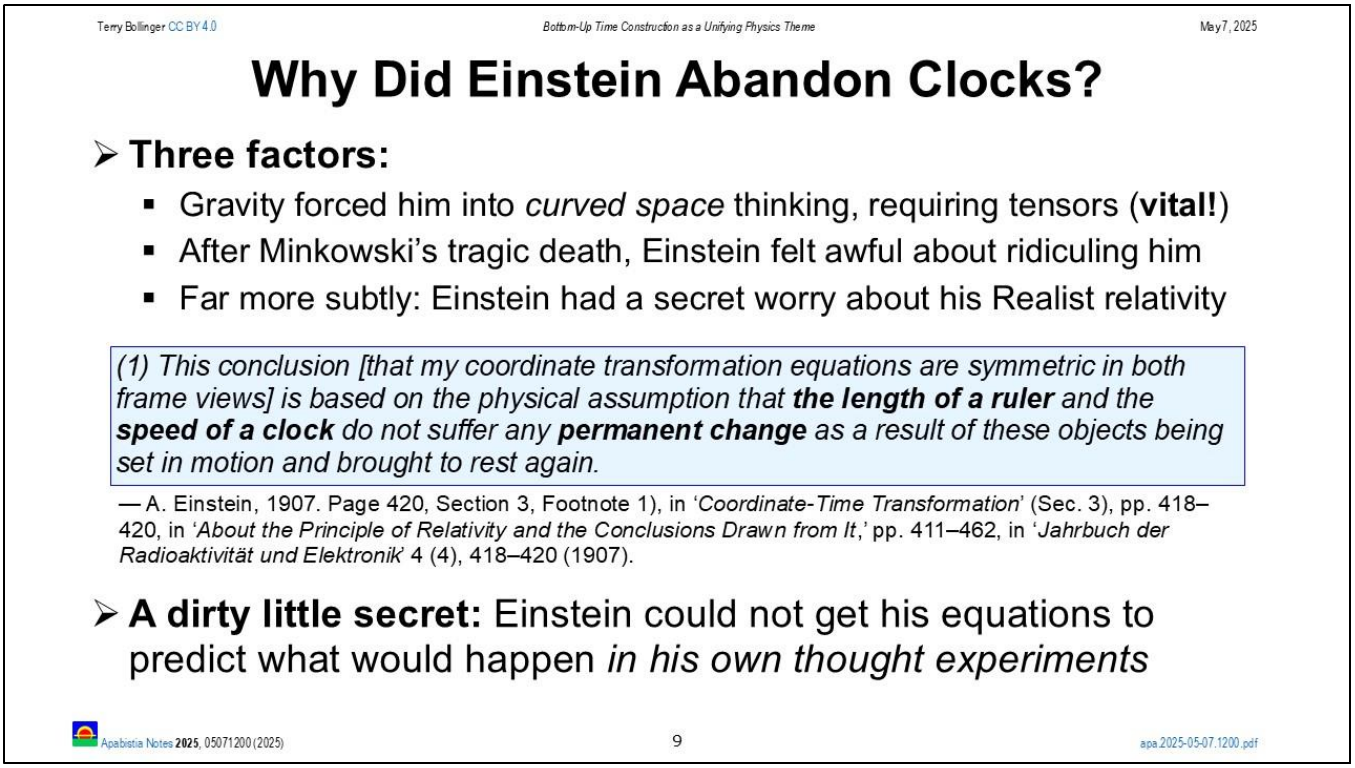
And I think this *really* bothered Einstein. You can see it in this quote, because the same theory that he had disdained, he suddenly, at the end of this paper, says, "*And…* maybe we ought to start taking a closer look at [Minkowski's ideas]" — which is *exactly* what he then did.

This is the transition part. He had this whole lecture — a whole presentation about using an extreme, a hyperrealist approach to how to measure time — [and,] suddenly, [begins] transitioning to Minkowski's much more abstract worldline approach, which turns [your ideas] into a geometry of entities that [arbitrarily seem to have] have *indefinite* mass [and length in time].

And I would say that this is a case of survivor's guilt. Imagine, if you did this yourself: Someone gives a lecture [about *your* work], and you come in and say [about his lecture on your work], "This guy has *chalk* for *brains*!" And you're *that* blunt about it! You just come in and say, "Oh, yeah, *come on*, this is *nonsense!*"

And then the guy *dies* the next day — abruptly, unexpectedly! And you *like* the guy; you just didn't agree with his ideas. That's devastating, because Einstein was not the kind of person to take joy in … other people getting hurt like that. This was his old teacher, … and he respected Minkowski.

So there's a factor here that went outside of bounds of just a mathematical part.



[25:55] But there's more to it [than psychological factors]! There were other things. Einstein was looking at gravity. This is the most important, and also the most valid [reason to abandon clocks in favor of spacetime,] by far. He was looking at the whole issue of how space *curves*, when you try to encompass gravity. [This desire to include gravity was the source of] some of the most breathtaking insights Einstein had, [such as] the whole equivalence principle, [were a consequence of this kind of thinking]. But those things require tensor math.

What is tensor math? I think the simplest description of tensor math [is this:] If you imagine an image on a balloon that's not blown up… and then you blow up the balloon. What coordinate system do you use to describe the image on [the ballon before, during, and after] the transition between those two [coordinate system states]?

Well, tensors, as the name implies, are what happens to the coordinate system when it's under *tension*. So if you have a balloon and you blow it up, the image becomes gigantic, [but] it still maintains certain relationships. So you still get the same image. It's a little bit distorted, but it's [not *fundamentally*] different. You [let the air out to shrink] it back down, [and it's] still the same image.

[In trying to include gravity,] Einstein was seeing a need for that kind of mathematics, where the whole coordinate system becomes relative. … And so, [the need for such tension-tracking mathematics] that was one factor [in why a cloud of clocks wasn't a path that gave him the kinds of transformations he needed] — and [probably] the most important factor, because this is what led to general relativity. So this was the *good* part.

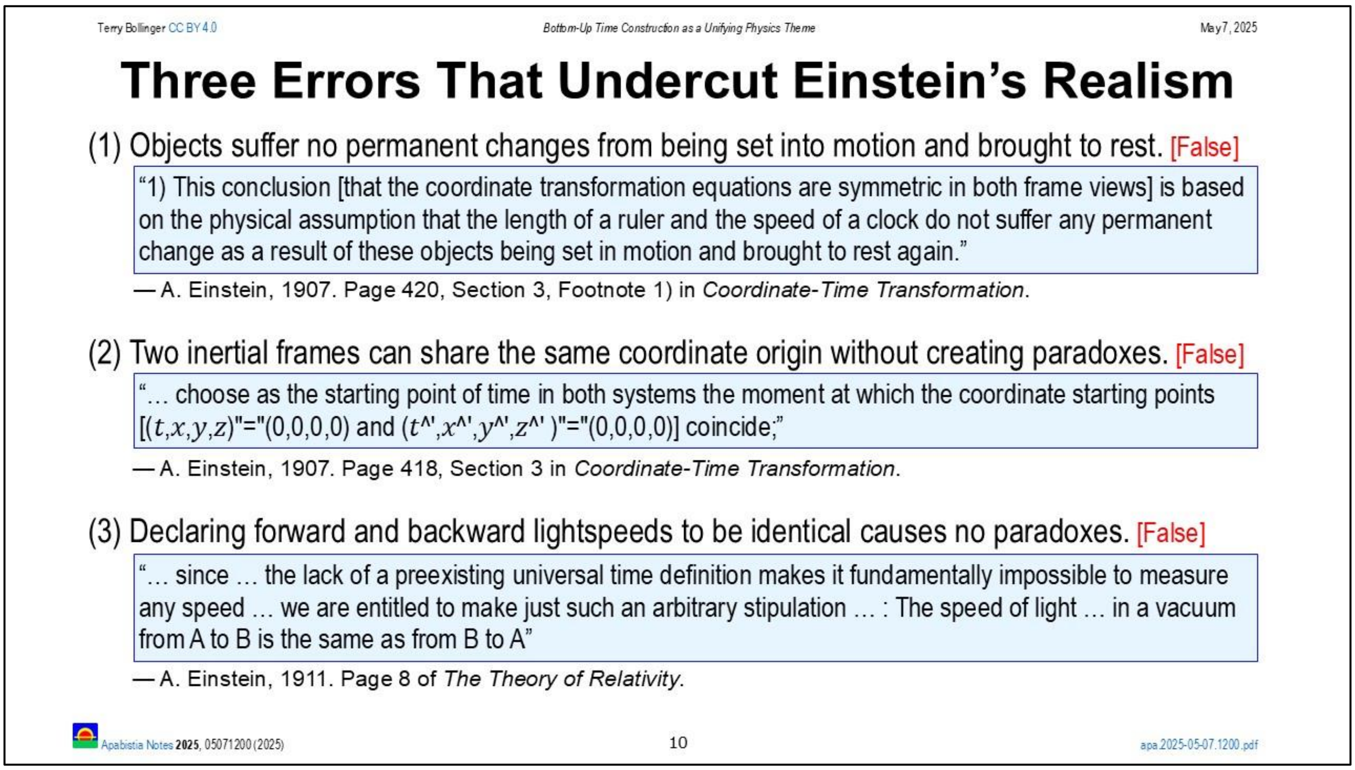
The [second] part, though, was that Einstein felt *bad*. He said [to himself], like, "Oh, the Minkowski stuff… I just kind of dissed it, and didn't even *look* at it. [I] didn't look at it beyond a certain point. [I just kind of] said, 'No, *come on*, that's not *right*.'"

The [third and] neatest [factor that influenced Einstein to abandon clocks — and the most hidden of the factors —] is [that] Einstein had a little *secret problem*. And the problem was [that] he could not predict *outcomes* in his own thought problems — literally could not predict them!

You know how you can tell that? Because he *never put clocks in [large moving objects]*.

[When he was instrumenting large unmoving frames,] Einstein put clocks in *everything!* Like that [cloud-of-clocks] figure I showed you earlier [in Slide 3], he put clocks *here*, he put clocks *there*, [he put clocks *everywhere*.] But when he gave that train example, and said, “If you have a train moving by, and you have the lightning flashing,” this is the one where he *showed* [the train] was not simultaneous.

You know what’s odd about that thing? He never put a clock in the *front* of that train. He never put a clock in the *back* of that train. He never put a clock in the *middle* of the train. But he *did* [use this very problem to] prove that there was non-simultaneity. Why didn’t he write the *equation?* … Why didn’t he put the equation in there?



[28:11] And [this is all the more baffling because] *he had the equation!*

There’s another one of those ones where it’s a little surprising.

[A couple of years back] I had laboriously derived this [equation — a bit of the work] is one of my other presentations — … for how you figure out the non-simultaneity relationship across [the length of] a moving train [as viewed from the embankment].

And I thought, “It’s odd that Einstein never *got* that…” [For several months,] I referred to it as his “forgotten homework.”

He didn’t forget it! He knew *exactly* what it was.

I [went] back and looked at his equations and said, “Oh, crap! It’s right there! It’s the middle of this time transformation equation! There’s just a factor in there. All you have to do simple factoring, and there it is!” In fact, the derivation is much easier than the way I did it.

So, this presented another issue. If he knew it, why didn’t he *quantify* it?

And *this* gets *sneakier*. It goes back to *another* little problem, which is that he had assumed, very reasonably, that a couple inertial frames could share the *same* coordinate origin.

Why not? It seemed like the most obvious assumption in the world. And, in fact, it was so “obvious” that, as far as I can tell, Einstein *never* thought to go back and re-examine that assumption, because it’s such an innocent-sounding assumption. [Why would] he [not be able to] make the two coordinates into the *same thing*?

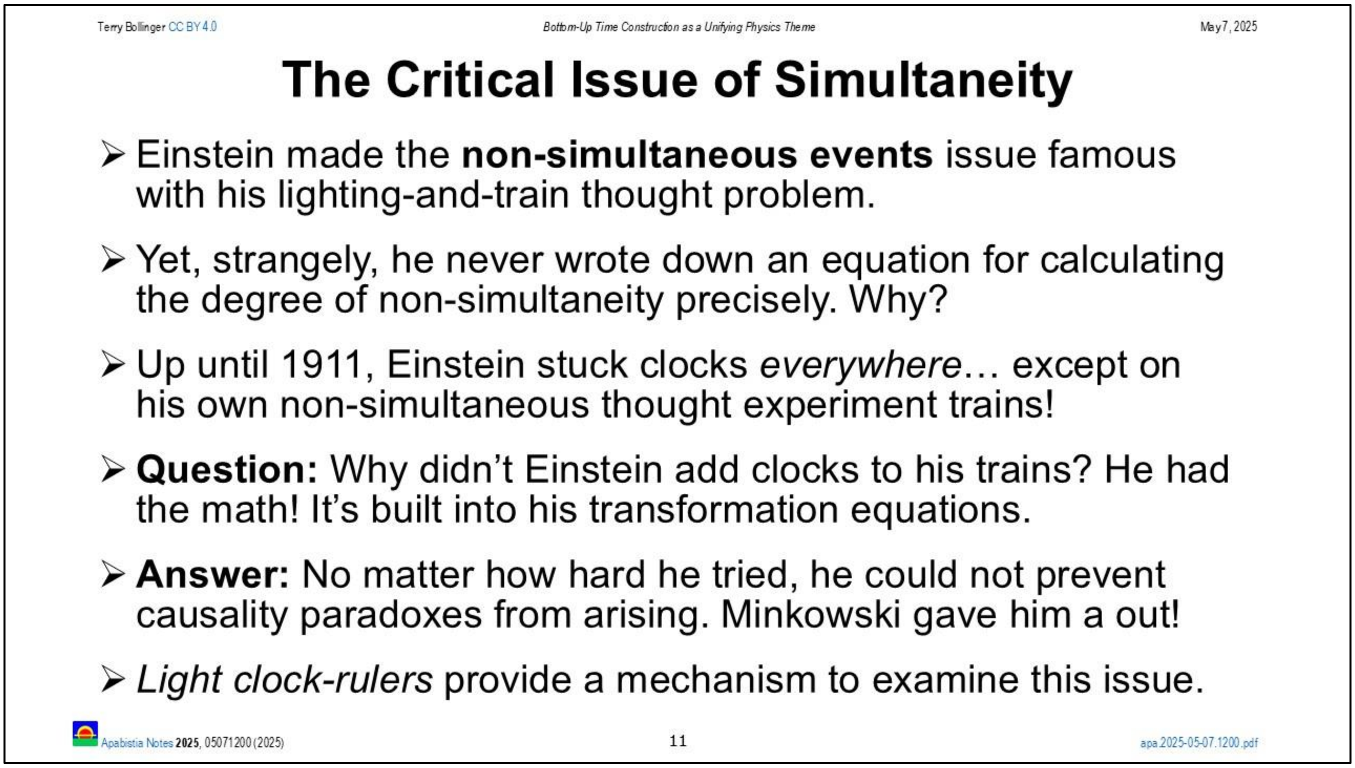
[I just realized that] I skipped over the first [false assumption, which is] the idea that objects do not suffer permanent changes [when boosted into a new inertial frame]. I get into that more in another presentation, but then I’ll have some slides on [that later here].

That [assumption that no irreversible physical change occurs when you boost a system into a new inertial frame] ***is** just not true*. When you do a Lorentz contraction, [for example,] if you do it with satellites, you have to do the Lorentz contraction *ahead* of time, not *after*. Or during [the boost], at some point. You have to do it as *an actual physical step* of moving the satellites closer together. That’s the most vivid way I can say why it is a physical transformation, because if they’re in large distances in space and you get separate objects doing it, you have to put them *together*.

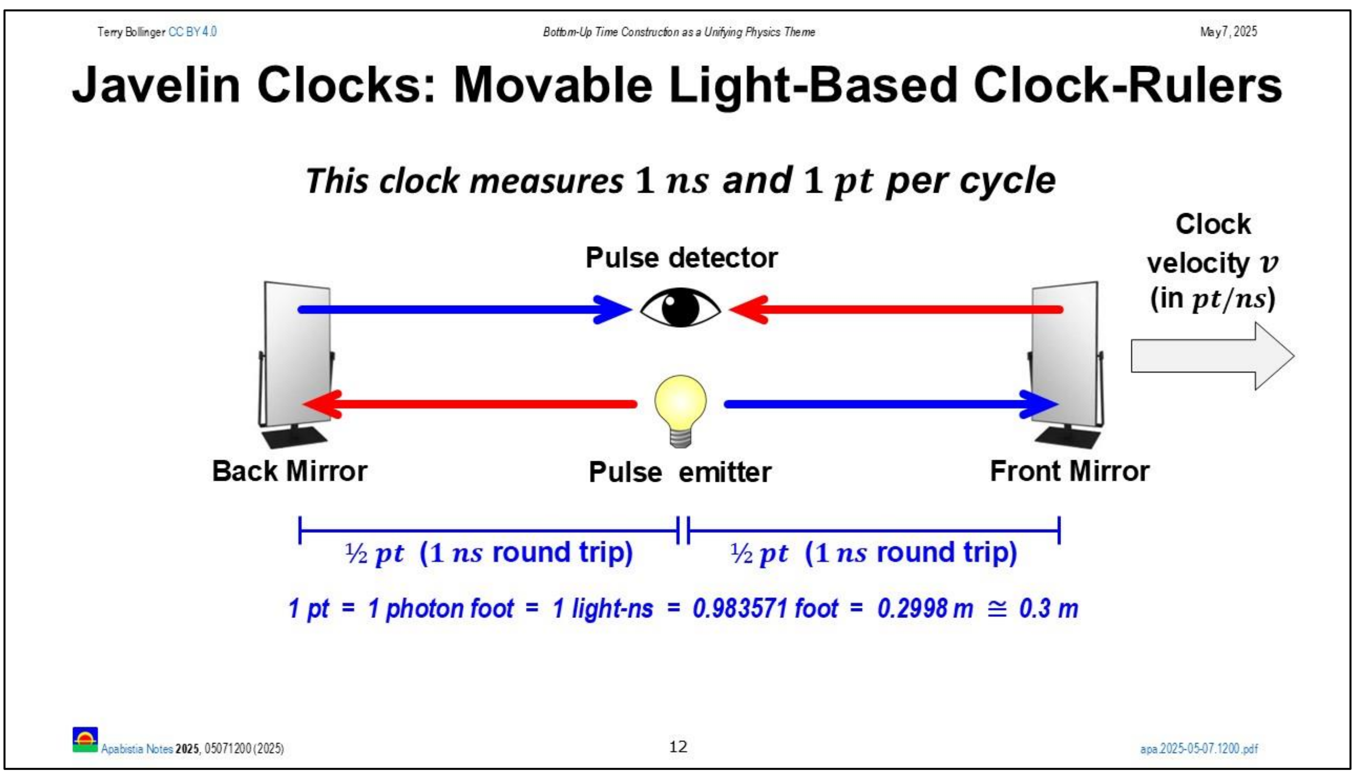
So they *do* suffer a permanent change — and that’s important, because it makes a difference in [Einstein’s] derivation.

And with these issues about that… And I just realized I’ve got the same title on two of those [bullets]. Speed was the same. Oh, no, my apologies. On the third one where it says object suffering, no permanent changes. That’s that is a huge typo that should be saying that he made the assumption that speed of light is the same in both directions. So, I’ll make a change to notes on that. But that…

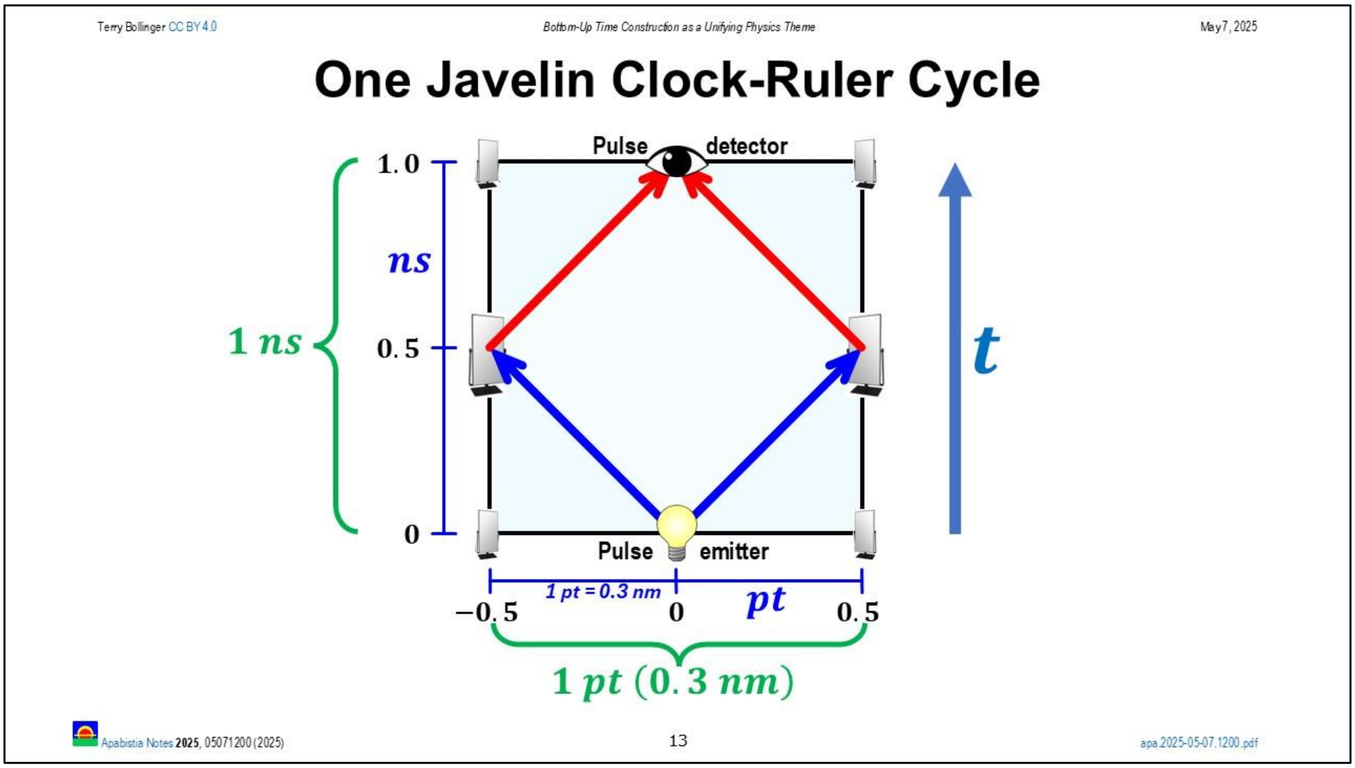
[The] third [bullet] one, read the text of it, not the header on that. This [in which Einstein inserts the assumption that since he could not see a ways to detect the difference, he could simply declare that lightspeed is identical in the forward and backwards directions. This] was an assumption that was important [to Einstein] for distinguishing [his approach] with Lorenz’s [earlier model, which permitted different lightspeeds in the forward and backward directions. A likely part of his motivation in adding this assumption was that it made his theory more distinct from Lorentz’s model.] It turns out, though, that [Einstein’s new] assumption [is an oversimplification of the situation that] causes interesting problems with the math. [In particular, it oversimplifies how *other frames* view lightspeed in the forward and backward directions. Without the ability to assert that the information impacts of lightspeed can vary in the forward and backward direction when you are examining a small object moving rapidly through your larger, better-instrumented frame, it becomes difficult to explain phenomena such as the Twins Paradox that are little more than extremely slow “effective” lightspeeds in the moving object due to light in the forward direction needing to race with the object as it moves at a large fraction of lightspeed.



[31:16] [I'll go quickly through this slide since it's] talking about the same [measurement issues I covered in the last slide]. The point [of this slide is] that if you're trying to deal with simultaneity equations, you need a technique for [measuring time and space simultaneously]. And the particular technique that helps to make these a lot easier to understand is something called a light clock, or a light pendulum.

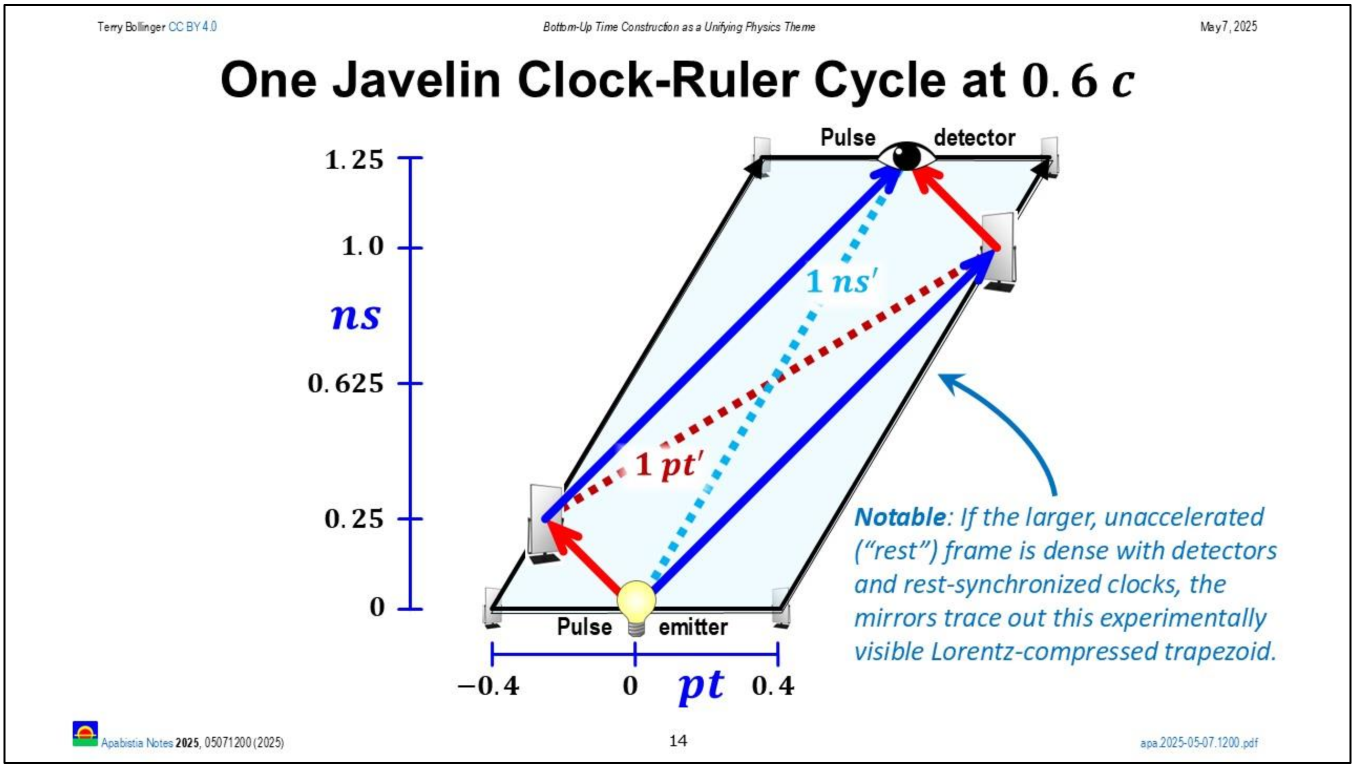


[31:42] This is a particular version of a light pendulum that I call … a javelin clock. The idea is that [light pulses go] out from a pulse emitter, [touch two mirrors whose separation] measures out a [well-defined] distance, [then reflect] back to the detector [where their synchronized arrival measures] out a certain time. The nice thing about a javelin clock — a light clock [designed to move in one direction] — is that it simultaneously measures both space and time for the frame of motion that you're in. So it's a very handy little device.



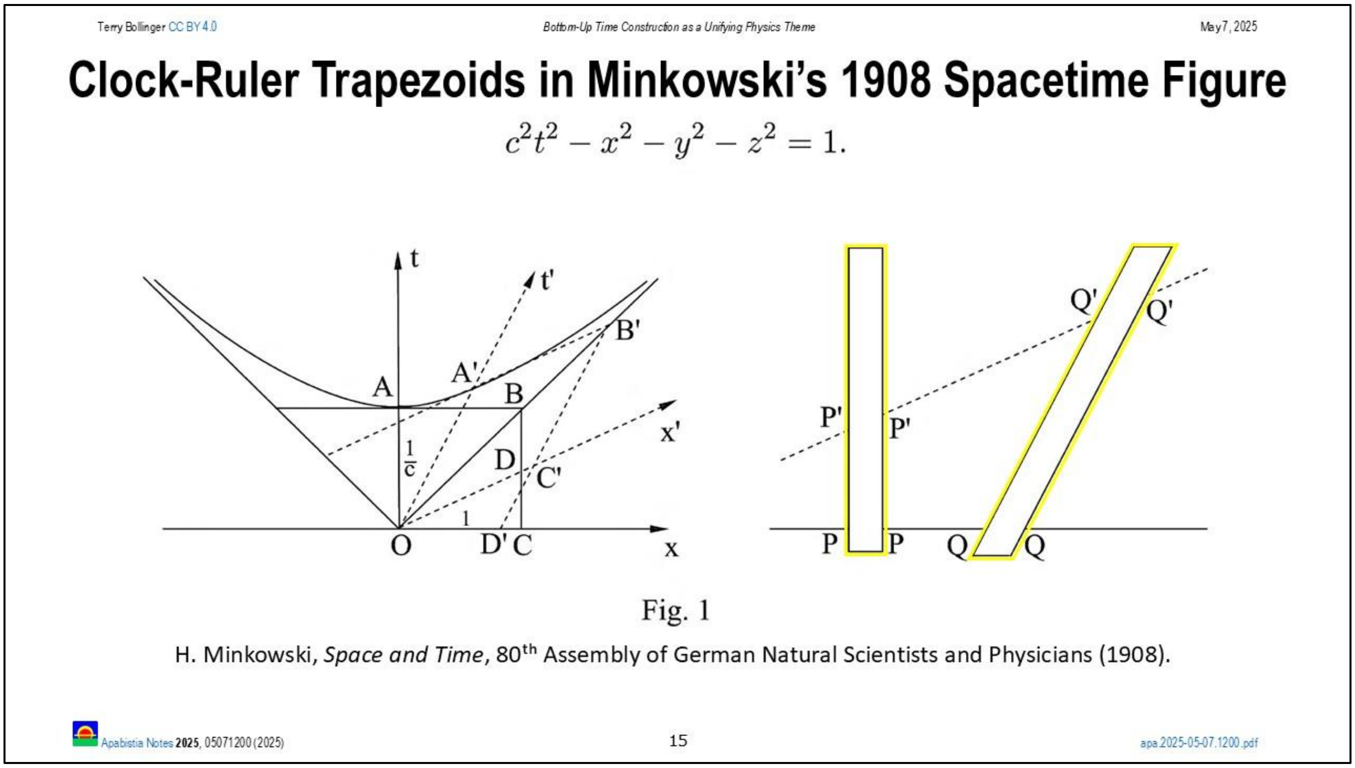
[32:13] As you can see in this [figure], if you put the time dimension [vertically], you get a [horizontal] length that's determined by where the mirrors [are located after you after you] adjust [them] so they have a certain relationship: [You] adjust [the mirrors] to make sure [the pulses are] simultaneous [when] they're received. And that also gives you your clock time.

So, in one combination, you wind up measuring *both* space and time, and you're doing it using *light in a vacuum*. So this is a value that remains invariant for all situations. You can apply it back to the atomic level, but it [also] gives you a large-scale way of representing or looking at these issues.



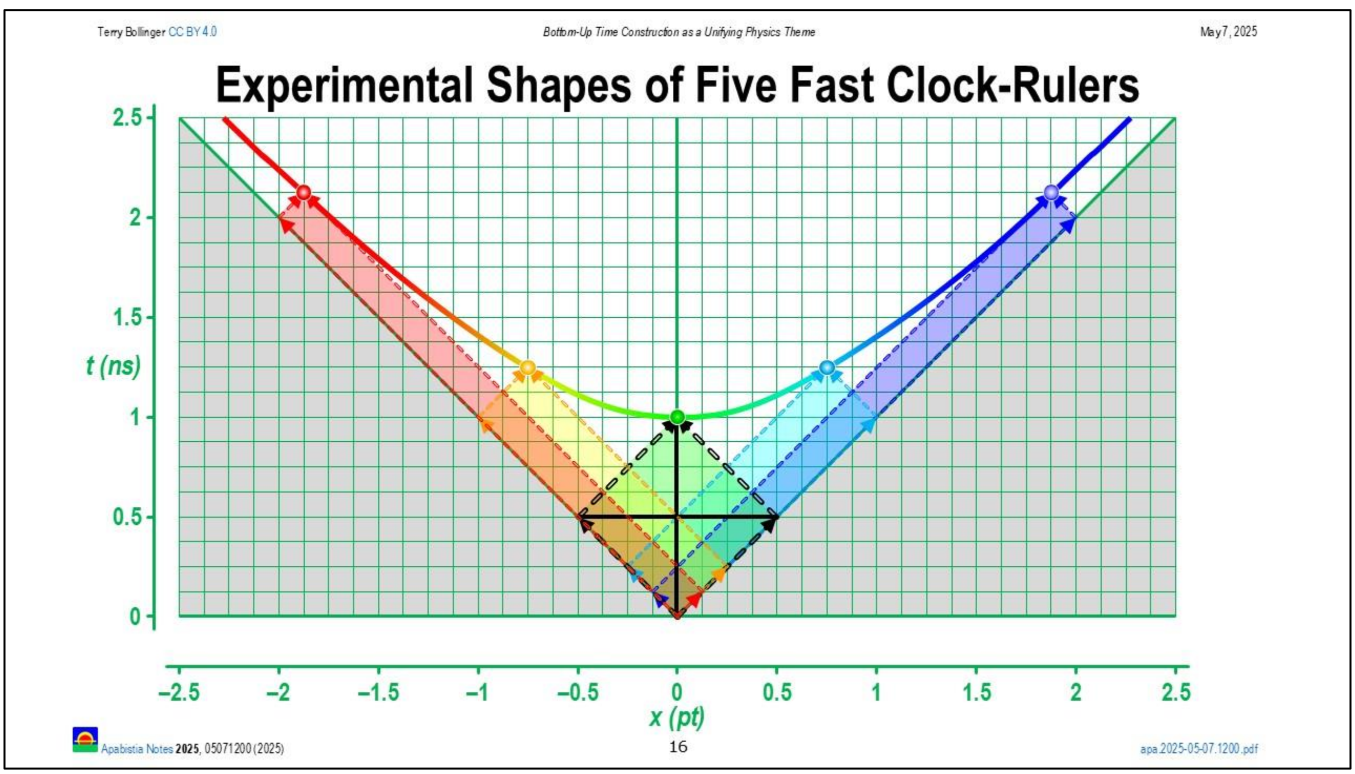
[32:50] What happens if you *move* this thing? If you have it moving at 0.6 c, here's what it looks like. This is the actual diagram of how the light flow works [at that particular velocity]. And you can start to see why there are some strange issues that happen with your light clock at this point. Your … mirrors are literally running *toward* and *away* from the initial pulse of light [as it travels on the left-mirror and right-mirror paths]. [That's] because you are seeing everything from the initial launch frame. The speed of light is invariant [in the launch frame], so the second mirror [on the right] doesn't [see] the light pulse … hit it until much later in the future [as defined by the launch frame observer.]

If you want to understand where time dilation comes from in terms of observing a moving object, *this is it*, right here. You really need no further explanation. If light is invariant in your perspective, [and] you're trying to … synchronize [the arrival of the left-path and right-path light pulses at the final detector], you *cannot help* but have a delay. [That's] because your [right mirror and detector are] *running away* from the [right and left pulses on the] light beam. … By the time you average [the backward and forward path components of the left and right paths] together, you wind up getting the relationship you expect from the *Lorentz* time dilation.



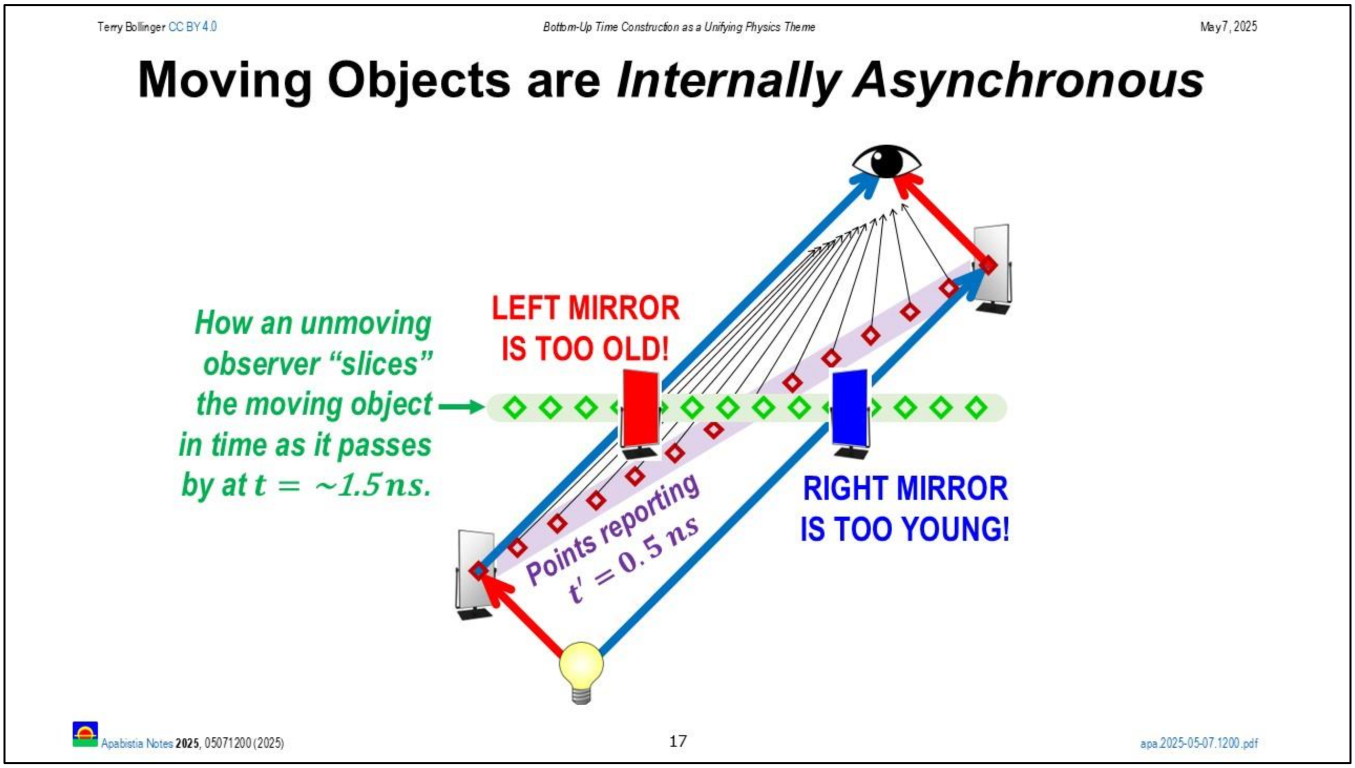
[34:04] Now, what's interesting is that Minkowski *saw these same trapezoids*. If you look especially at the one on the right — the one on the left is essentially a clock at *rest* — the one on the *right* is a clock that's in *motion*.

So this is directly from Minkowski. The only thing I've done to Minkowski's diagram is add the yellow highlight [to] the trapezoids that he was using.



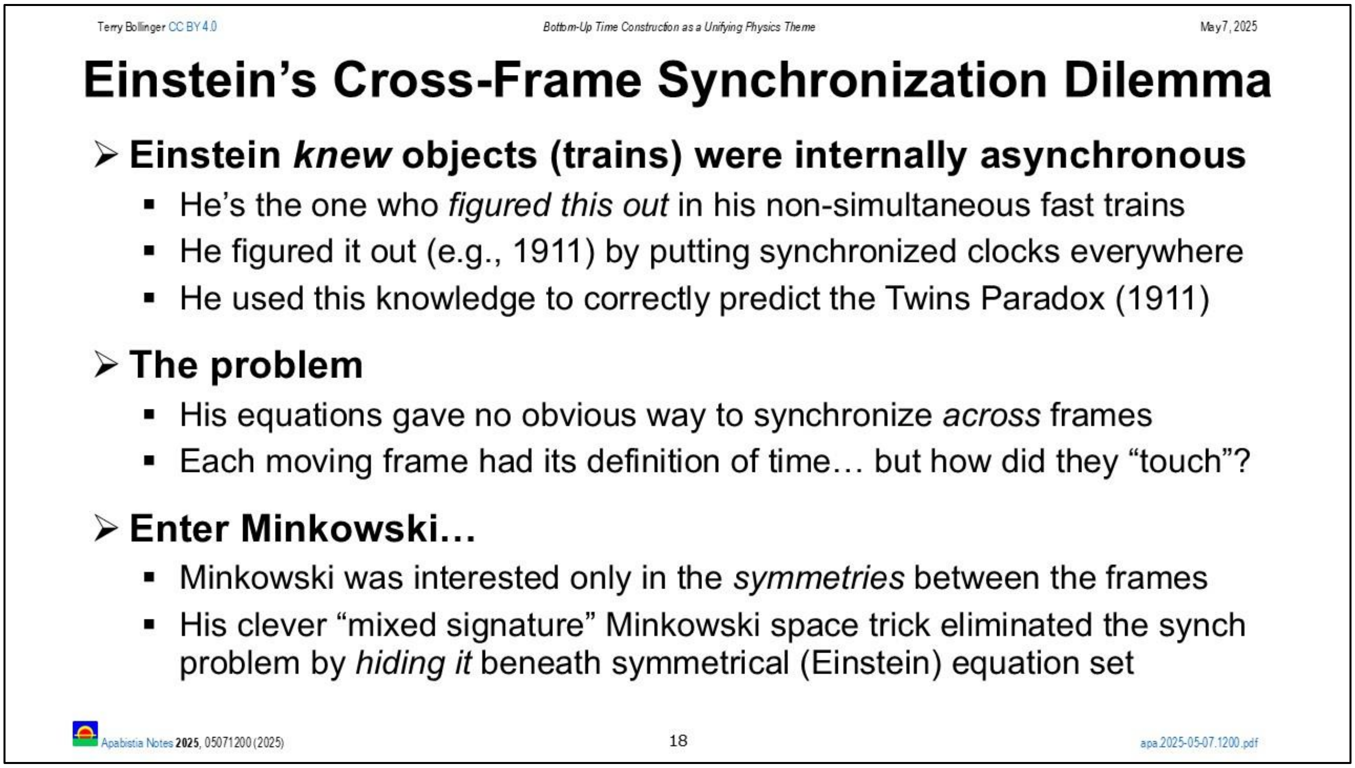
[34:27] But Minkowski never explored that further. If he had gone a little bit further with this, and looked at the light beams that are inside of those rectangles, he would have found out that there is an *invariance* going on there. If you look at the areas of each of these rectangles — the purple, and the blue, and green, yellow, red — all of those are the *same* area. It's a curious little invariance that you get with these clocks.

So, it's unfortunate that Minkowski *didn't* explore it a little bit further. He hints at it, but then he went off in another direction, and didn't correlate this [invariance] to the actual devices.



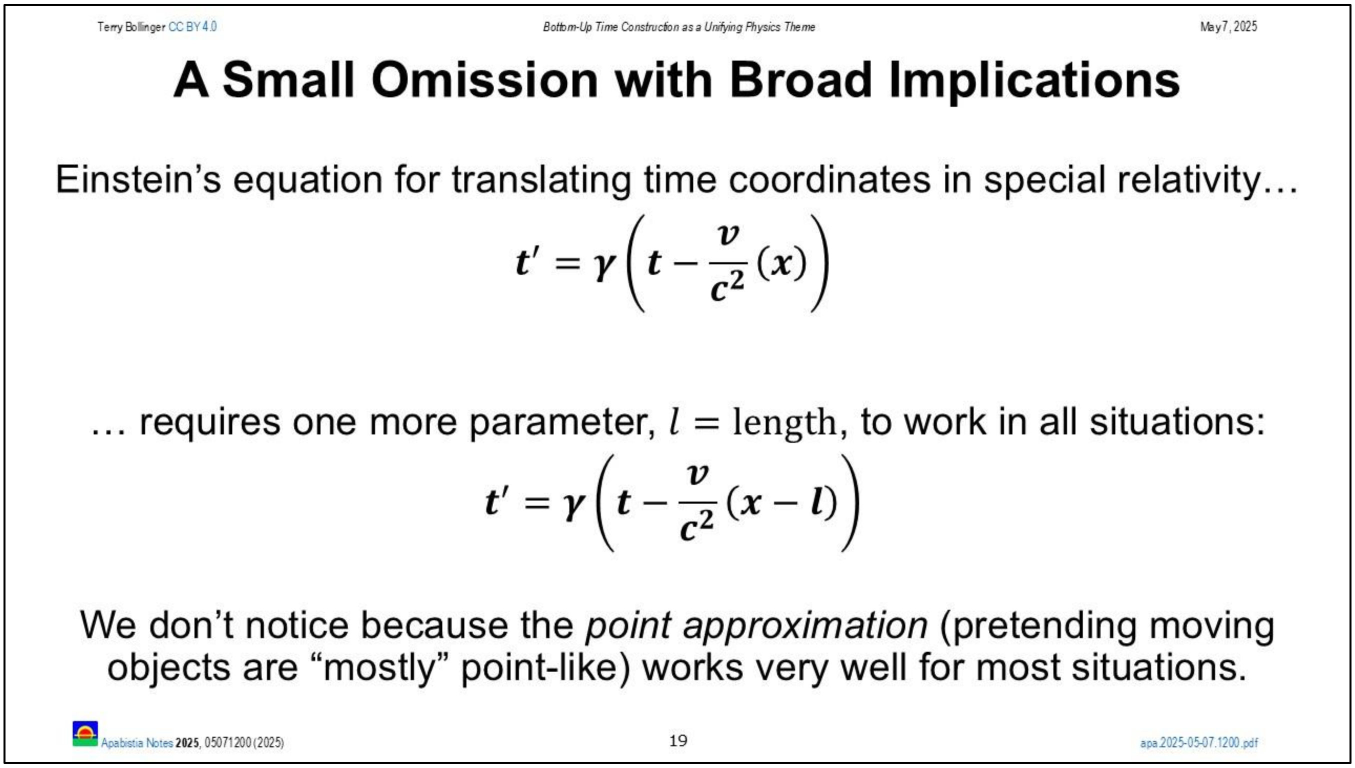
[35:06] And if you look at it even closer, here's where you get to the non-simultaneity issue. Because, in terms of what the person *moving* sees, *he's* getting a *single* set of results *at all times*. He sees simultaneity as defined by those two mirrors.

But for the person who's instrumenting all the space [around the] long train, that's *not* what they're seeing. They're seeing a difference in time where the left mirror, the trailing mirror, is *too old*, and the right mirror is *too young*.



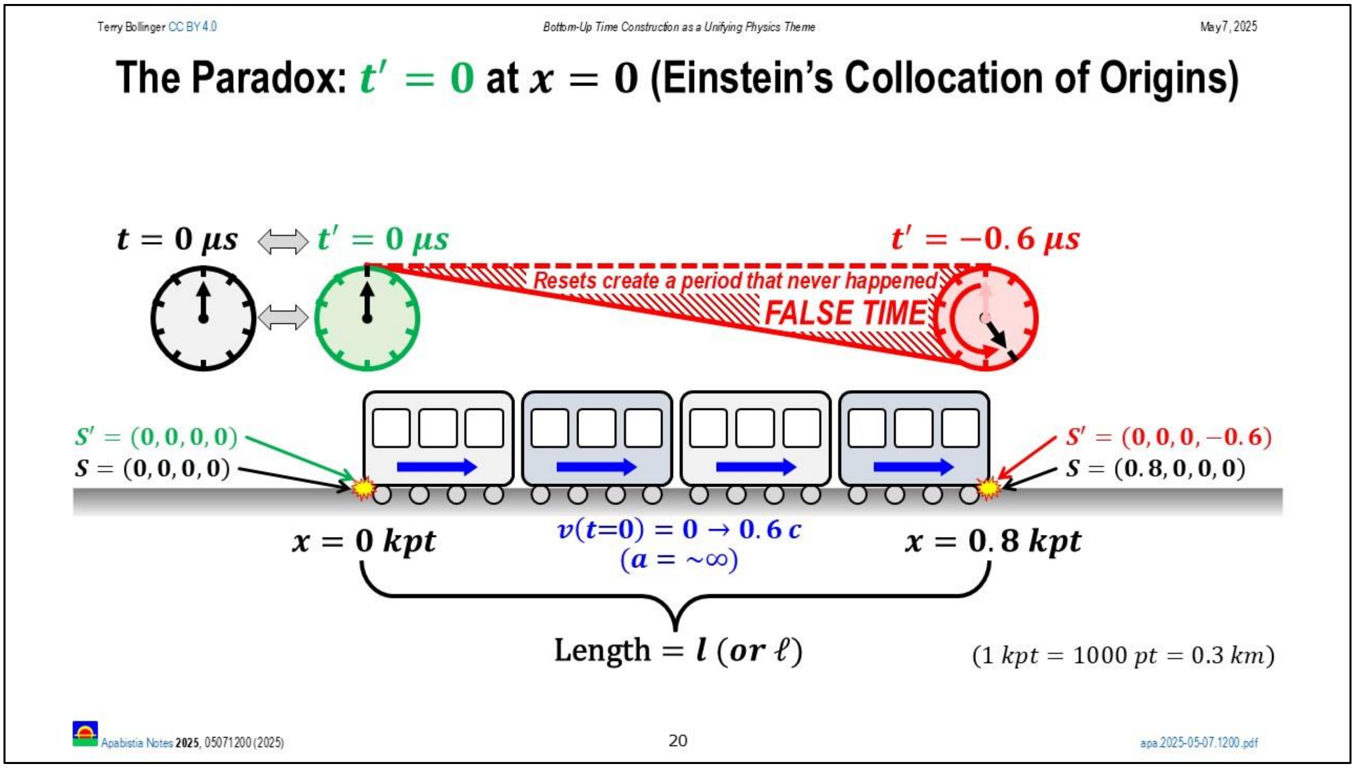
[35:42] Einstein *knew* this, and he had a problem with how to synchronize across the frames. He couldn't figure out a way to [do this]. He predicted the fact that you have a twin's paradox. He could predict the *degree* of delay that you would get. But he couldn't figure out a way [to] get a correct definition of what time looks like *across* these two different frames.

Hermann Minkowski, in contrast, was interested just in the symmetries. He knew how to take these transformations and flip them back and forth between the two [frames]. He didn't worry so much about the idea of, well, "What is the actual clock prediction? What does the actual clock come out to say?"

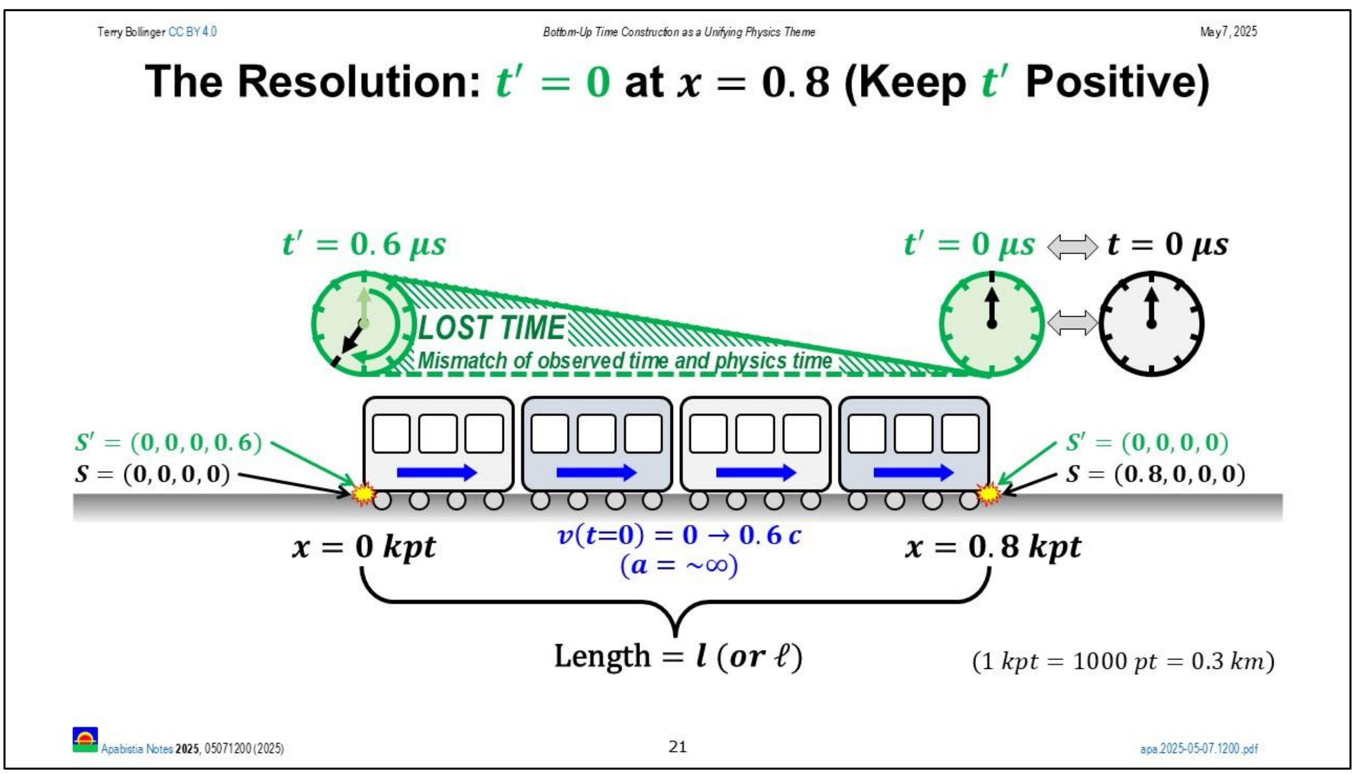


[36:30] If you combine the [implications of the missing parameter, you get] a corrected equation for how you [make specific, experimentally testable predictions]. The missing parameter in the slide — it would be better if I put the sign a little later — the correction you need to do is that you need to take into account the length of the object that you're trying to accelerate.

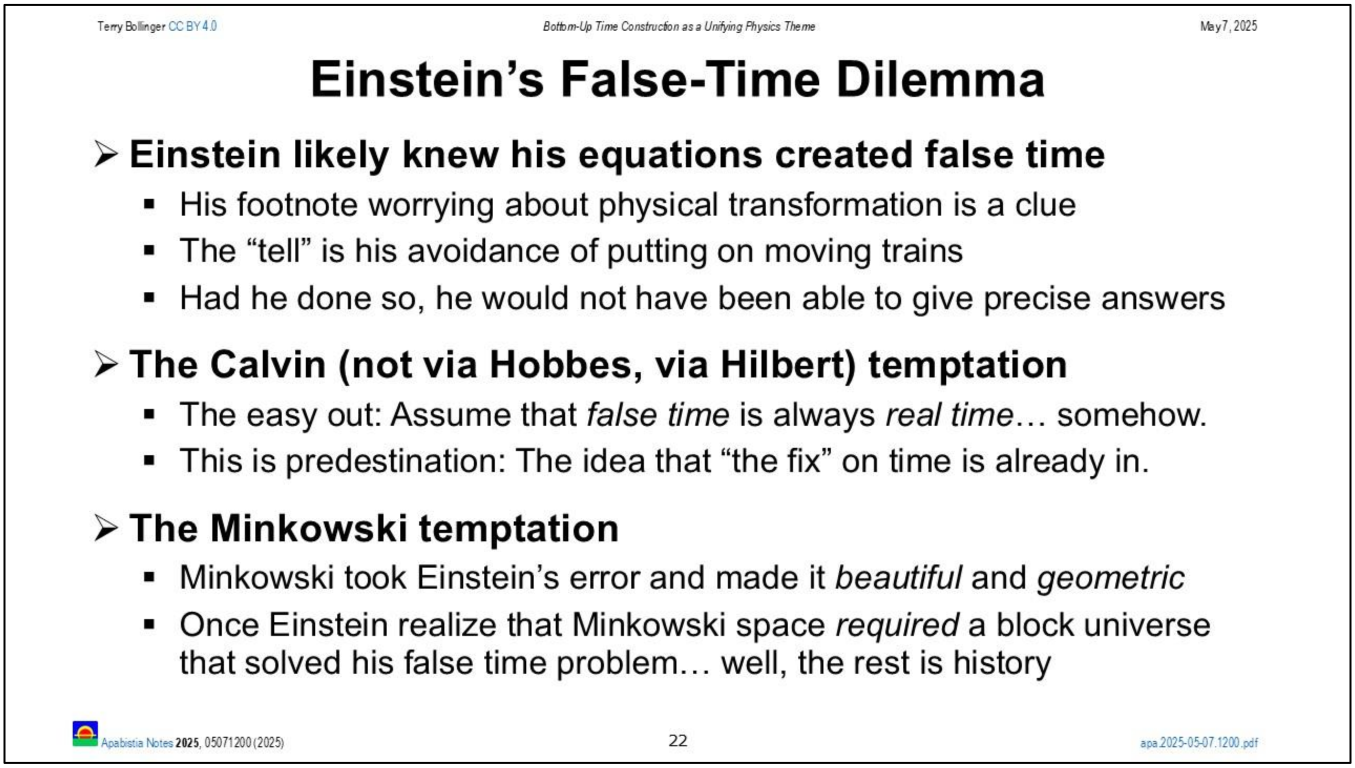
[36:52]
RS: Excuse me, Terry.
TB: Yes.
RS: We have had the most 15 more minutes to speak.
TB: So I will go (laughs) as [fast as I can.]
RS: Go ahead and make your major points.
TB: Too many slides!



[37:10] What this predicts — the reason that Einstein couldn't get this resolved — was that his use of a single origin created a false time issue. You had to set the clocks backwards into a time that did not exist — [a time for which] you don't have any information.

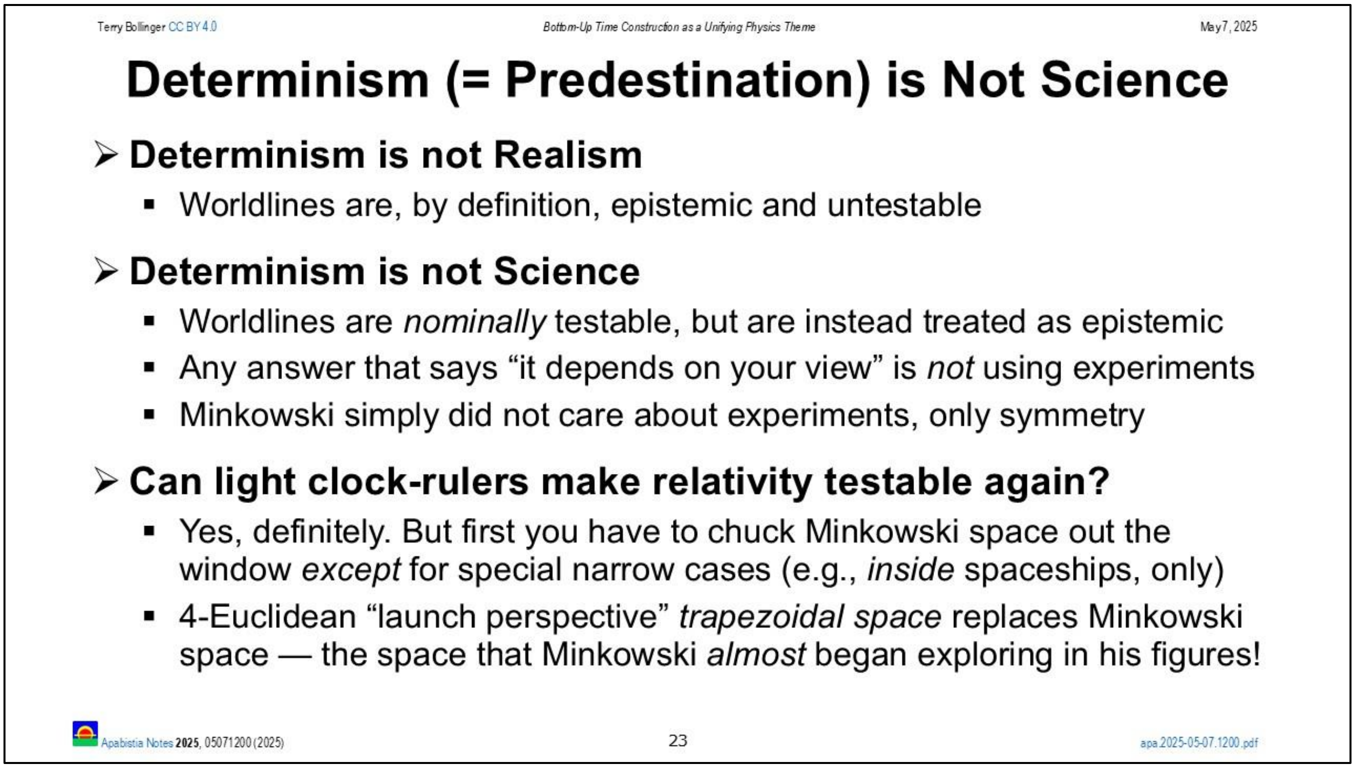


[37:25] The fix for that is to add the length of the object that you accelerated. This allows you to come out with something that's a little more [plausible]. It's still not perfect, but at least it doesn't create false causality; it doesn't create time that didn't exist.



[37:40] Einstein knew his equations created false time, and that was why he was uncomfortable with [them]. The Minkowski temptation was that he could go to Minkowski formalism — which essentially *codified* his original error of using that same origin and creating false time — and just say, "Well, the obvious resolution is that everything's just *fixed* — everything is already *there*. The world lines *exist*, and the world lines are *fixed*. It's what they call a block universe.

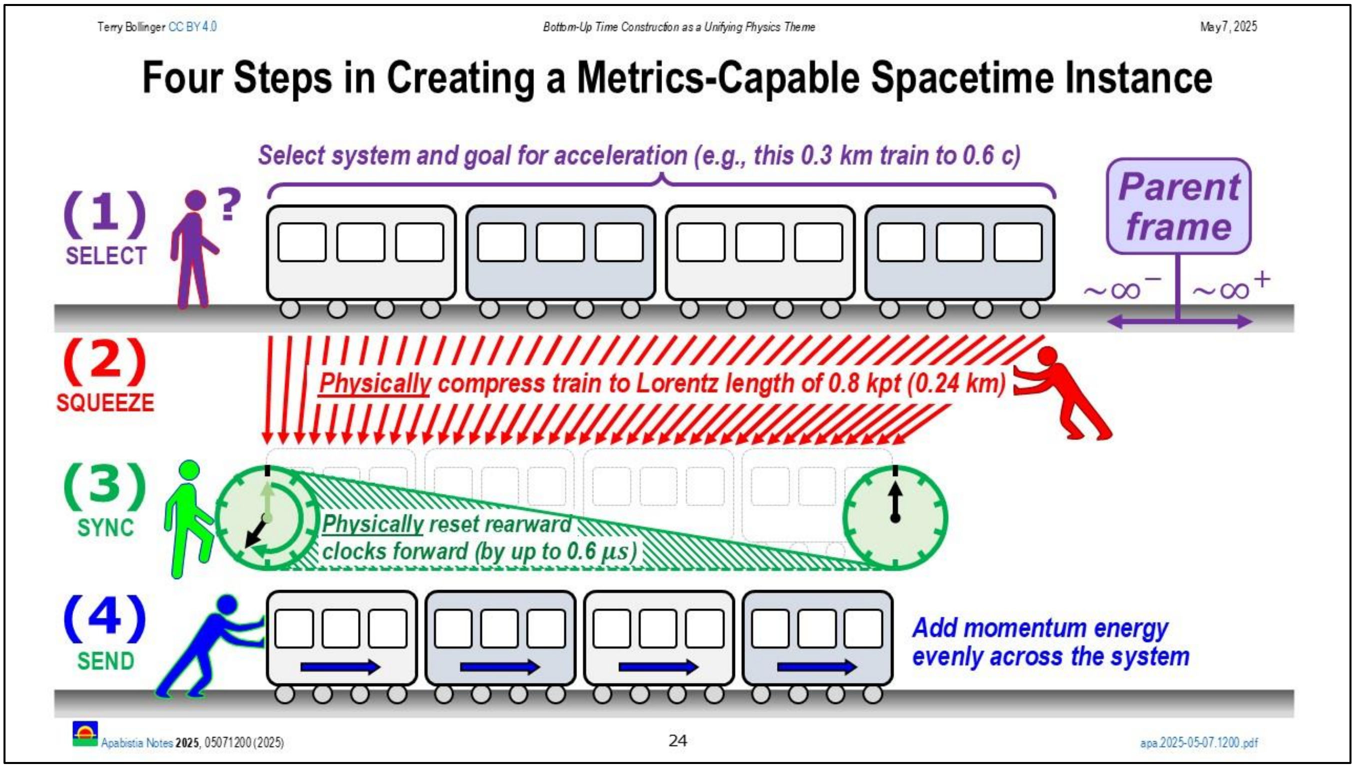
Eventually, that temptation won him over. He said, like, "Well, okay — I don't have to worry about this anymore. I can just do it [Minkowski's] way."



[38:20] The trouble with that approach, again, is [that] you *can't* make [determinism] into an actual science. The idea of determinism is … a philosophical concept, but you can't make it into a testable concept. You always go back to clocks and rulers; that's how [science] works. You can't [test determinism because] there's no [worldline] that you can [access experimentally] that goes into the future in the past.

[However], with that said, [if you take Minkowski's speculation that material worldlines exist, it] is nominally testable. [That is,] if you take [worldlines as a] serious, [experimentally testable hypothesis] and say, “If I really believe that, what are the tests?”, you could do some things to check on [the testable implications of such material worldlines.]

The replacement for the Minkowski viewpoint is this trapezoidal space that Minkowski actually started to explore, but didn't really get into. [If you work through its implications, the trapezoidal approach] says whatever the largest frame is, that's where you have to make your [broadest, most causally encompassing] definition of space and time.



[39:07] Here's the actual procedure that you go to, to create a quantifiable time.

Terry Bollinger CC BY 4.0 *Bottom-Up Time Construction as a Unifying Physics Theme* May 7, 2025

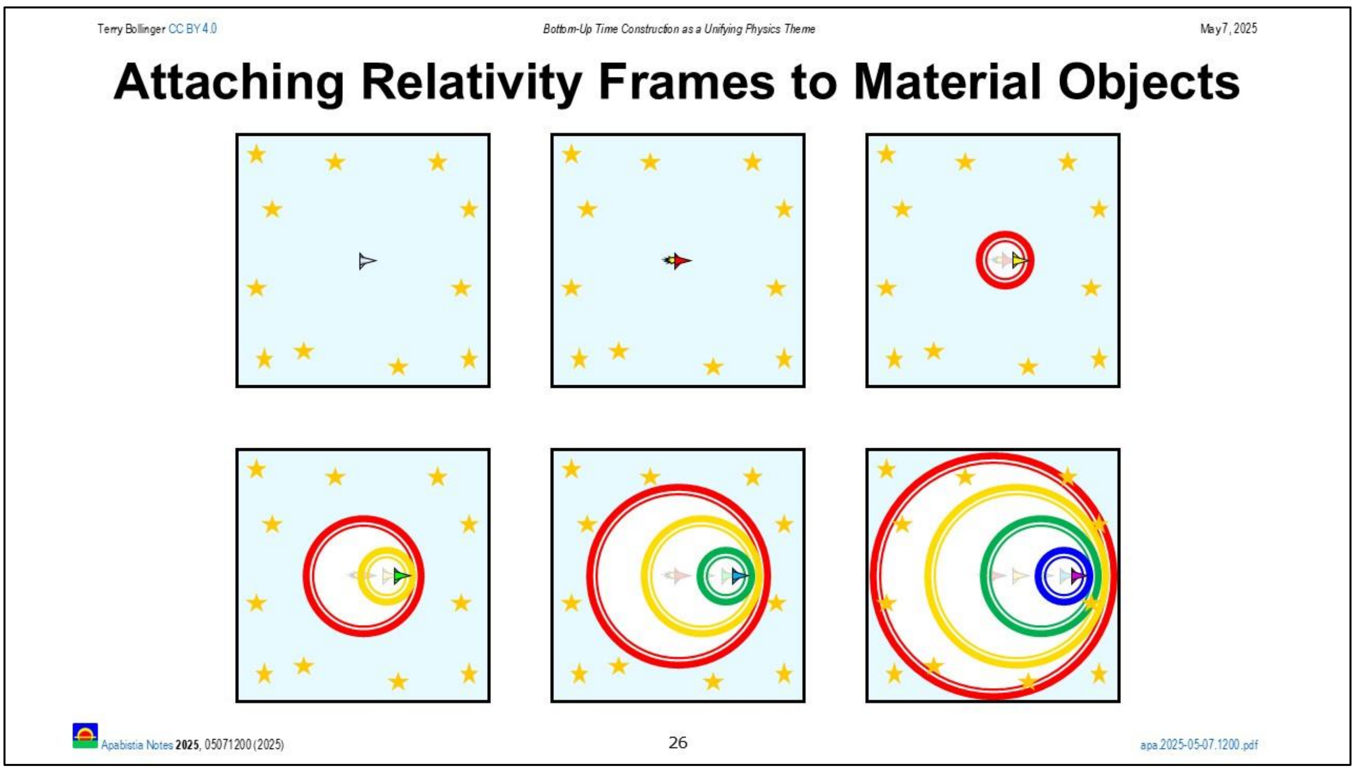
Acceleration Is Complicated

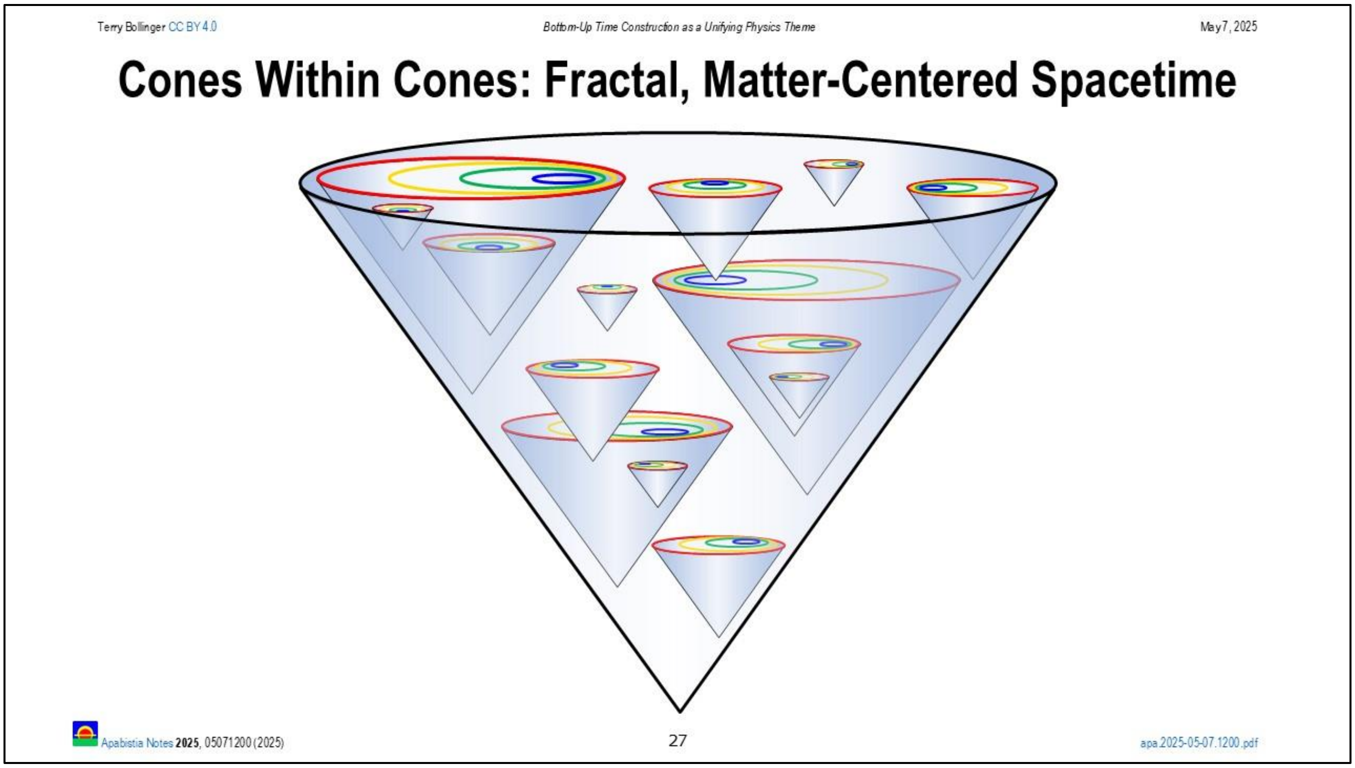
- Einstein co-located the origins of two inertial frames.
- Applying origin co-location when creating (accelerating) a Child frame from a Parent *necessarily* creates "false stories".
- Even worse, every such Child origination (acceleration) brings two fundamental definitions of time into direct conflict:
  - *Experienced time* is time witnessed continually by an observer, even if it passes at differing rates.
  - *Physics time* is the time required to replicate the full range of physics, from particle physics up.
  - Ironically, it is the *physics time* that can never be restored immediately after an acceleration (!)

[39:15] That procedure creates a conflict between two definitions of time. [The problem is that we] consider *both* definitions to be extremely important. The *experienced time* is what you witness — how much time has actually passed by [according to your clock]. The *physics time* is defined by how any kind of physics test [that involves measurements of length and duration as experienced by the experimenter], as Einstein addressed [in his 1911 paper *The Theory of Relativity*.

In that paper, Einstein defined a complicated, time-consuming set of data exchanges over distributed sets of clocks and rulers that are motionless relative to the experimenter. His point was that without creating these distributed definitions of length and duration in advance of physics experiments, special relativity makes it impossible to obtain meaningful, reproducible measurements of essentially any quantity known to physics, including issues as simple as the shape and mass of an atom or particle].

That's a pretty major conflict because we think of those as being the same [definitions of time], and it turns out they're not. [More specifically, any experimenter residing in a system with non-zero length, such as a train, that undergoes a period of acceleration finds that their previously fully synchronized clocks and rulers used in experiments undergo transformations that correspond to introducing asymmetric, arbitrary resets of clocks proportional to the location of the clock. This, in turn, means that the definitions of elapsed time recorded by those same clocks no longer match the new, reset definitions required to continue performing valid, reproducible experiments.]



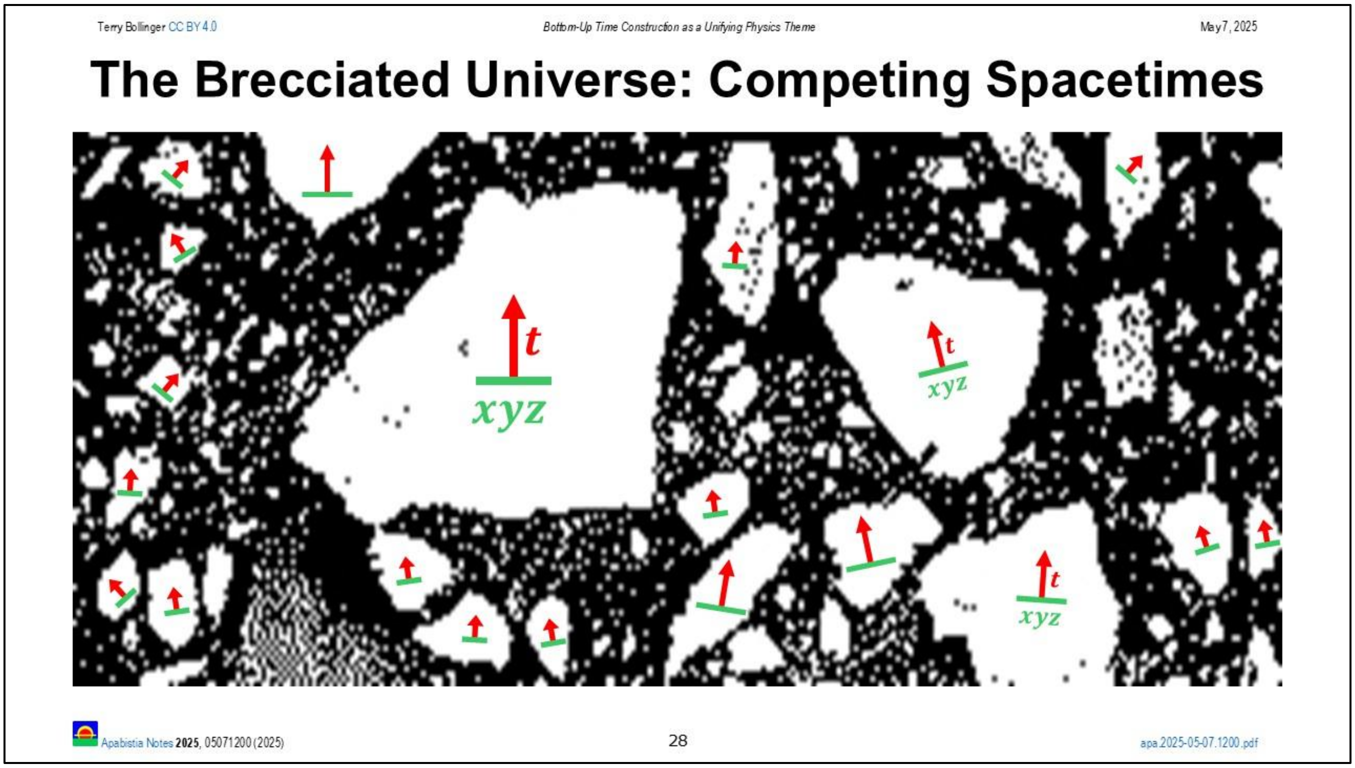


[39:40] One of the results of attaching the matter to the attaching space and time to the matter is that you get these shapes: You get this fractal structure in which you can never get outside your light cone, but you do have to have different definitions [of space and time] moving [around] in these different parts.

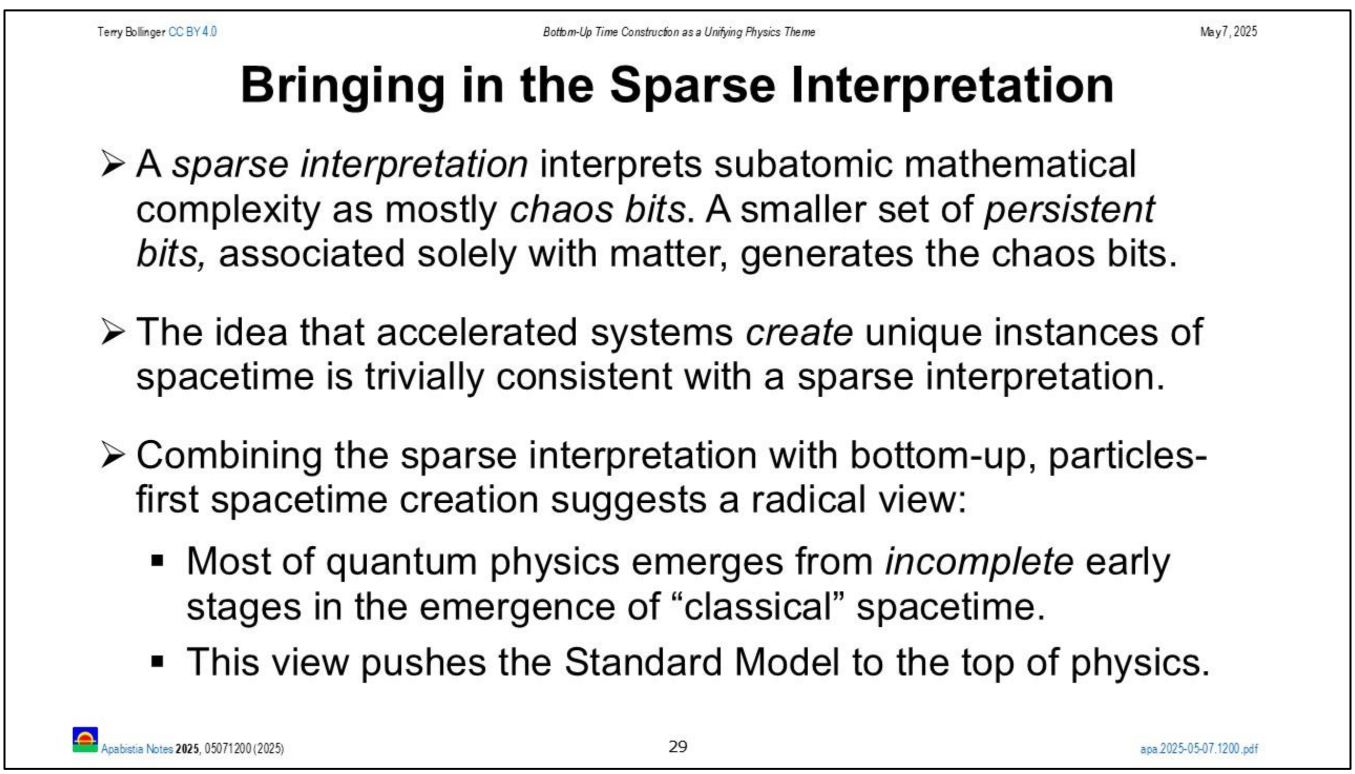
[Slide 26 shows how special relativity strictly limits not only the rate at which information flows out from an event, but also the limits of the newly minted *definitions* of space and time created by accelerating a system. Any interpretations of the new spacetime instance that attempt to apply those definitions outside the acceleration event light cone necessarily create false time and false data scenarios.

Bluntly, the universe as a whole could not care less about your new definitions of space and time. That is both because you are so tiny and, more importantly, because the rest of the universe doesn't *know* about your new definitions. You can use your new coordinates to *interpret* light and information from the outside universe — in particular, to see it as relativistic Doppler compressed (not Lorentz!) in the forward direction — but at no point can you change causality outside of your expanding light-cone "wave puddle."]

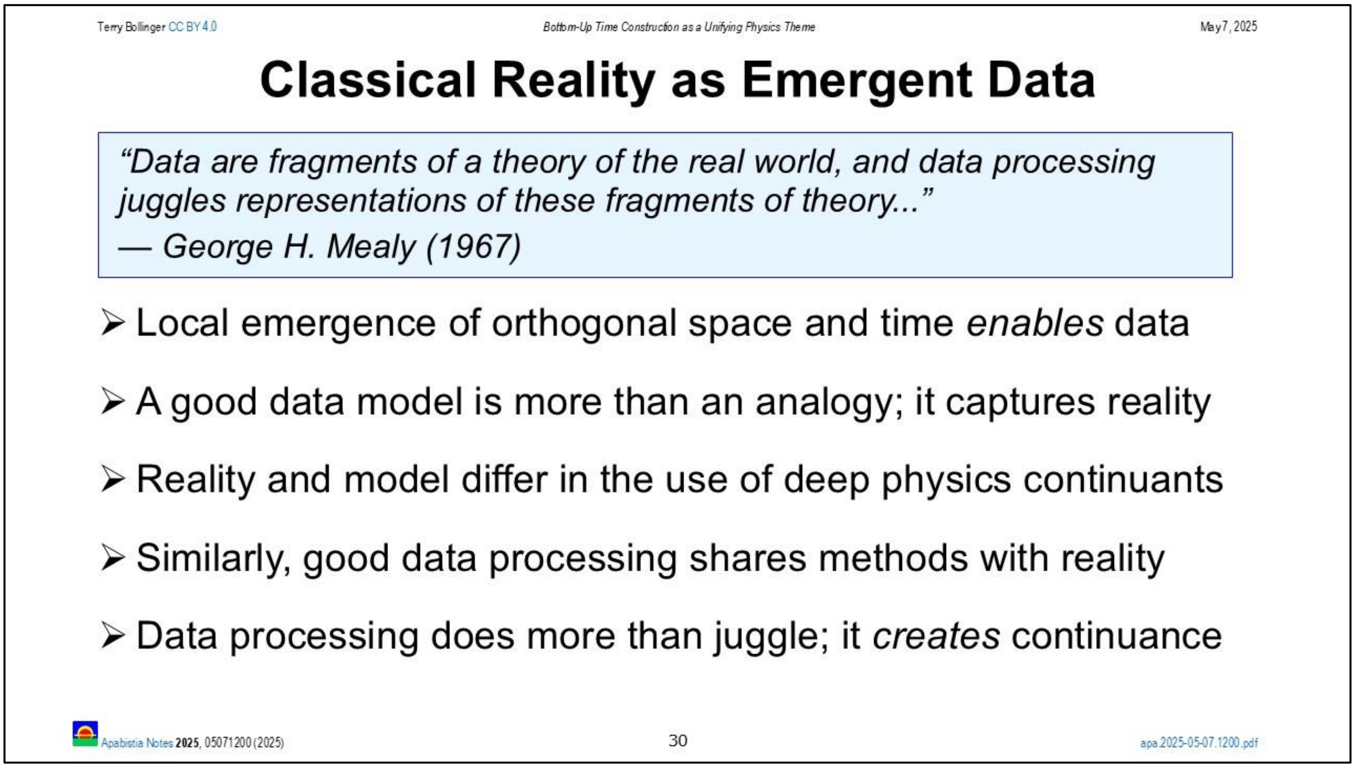
[Slide 27 shows this same effect in three dimensions, thus giving a slice of what happens in the four-dimensional space owned by the largest (or parent) inertial frame. For any locally Euclidean definition of spacetime, the largest, most encompassing parent frame available is the one that eliminates the red-blue dipole of the Cosmic Microwave Background (CMB). For experiments done on Earth, the (rather imprecise) Earth frame dominates.



[40:01] You wind up with a *fractal universe* as a result, [one in which different frames] *don't* have the same orientations of space and time. Sometimes [these] frames are quite large. This [fragmentation of large-scale definitions of space and time is surely] related to … dark energy issues, [and] it would be interesting to explore this further.



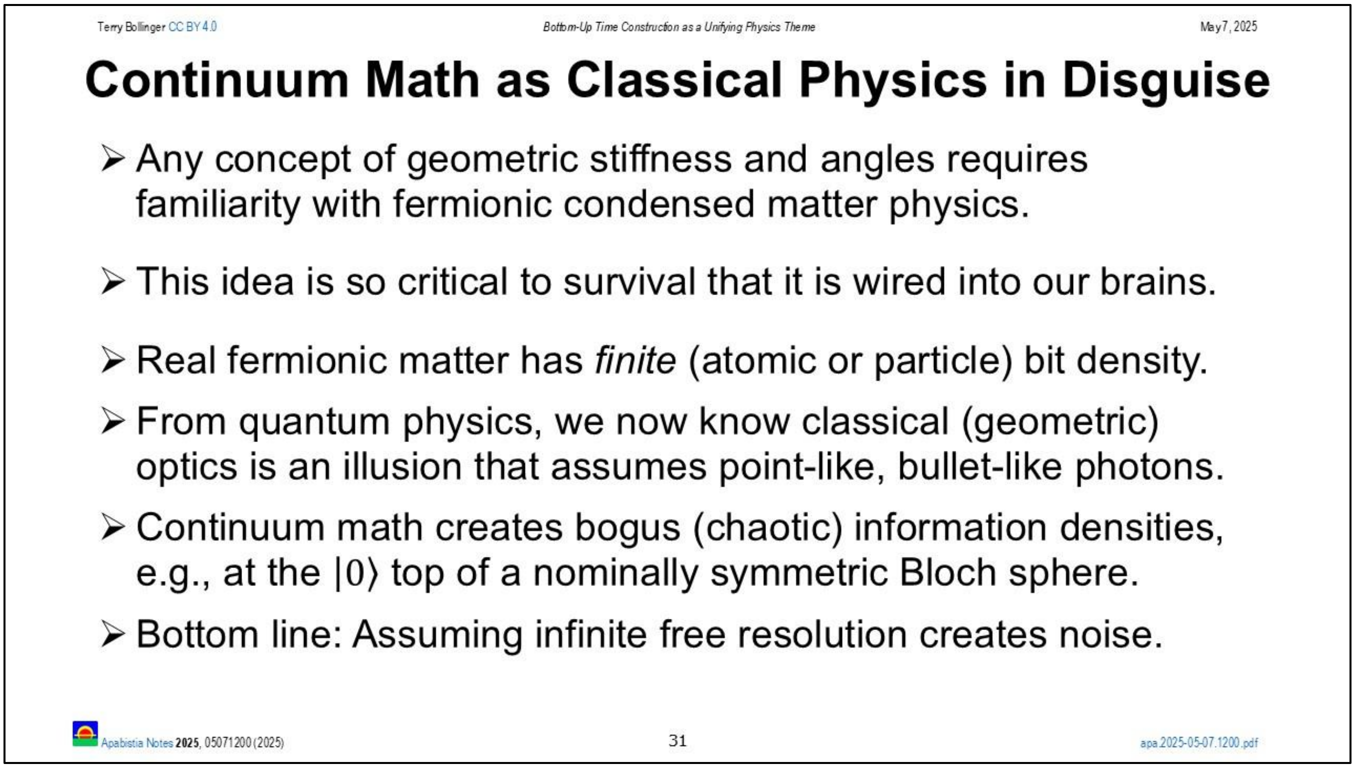
[40:18] Sparse interpretation, I already talked about before. It's saying that you just go by the number of bits that you have, based on matter. You *abandon* the concept that space is anything more than a relationship between particles. So, how do they interact with each other? We don't know that. We don't understand that part. That's what we need to look into: How are these relationships done, *before* [defining] what we usually think of as space and time? You still have change, you still have separation, but they're not the same definitions that we use in an [information-intensive — that is, classical —) universe.



[40:53] One of the things I find fascinating about this approach [is that] when you have information as the *most* critical emergent concept from local definitions of space and time, information becomes the *bond* between the different fragments of space and time.

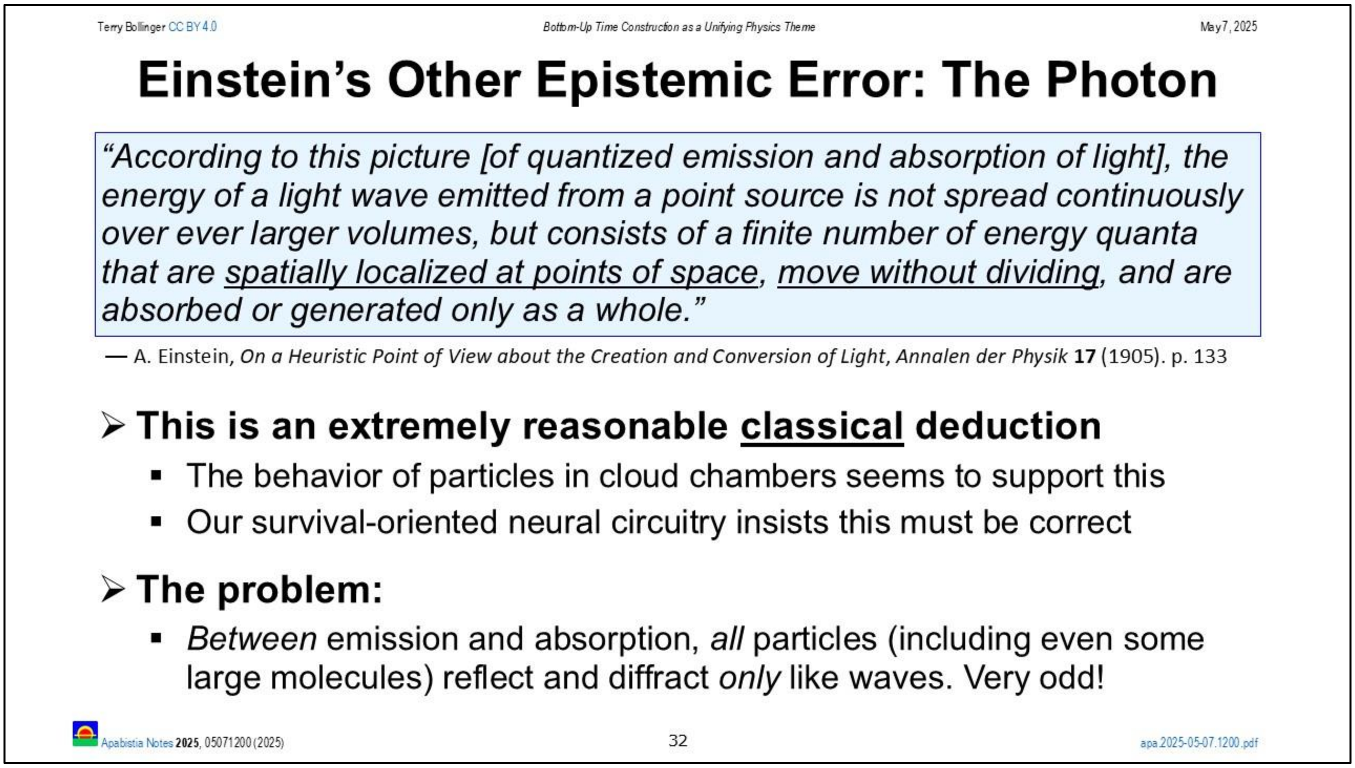
So you have this bonding entity across these fractal definitions [of space and time, which] is *information*. And that, in turn, says that the representations that we use for information are more fundamental than we probably would expect. They're actually capturing, with a different basis, the same patterns [that *create* classical reality,] if we've done them right.

So I think that's an intriguing idea: That data processing actually creates models that share [the same] information that underlies space and time reality.



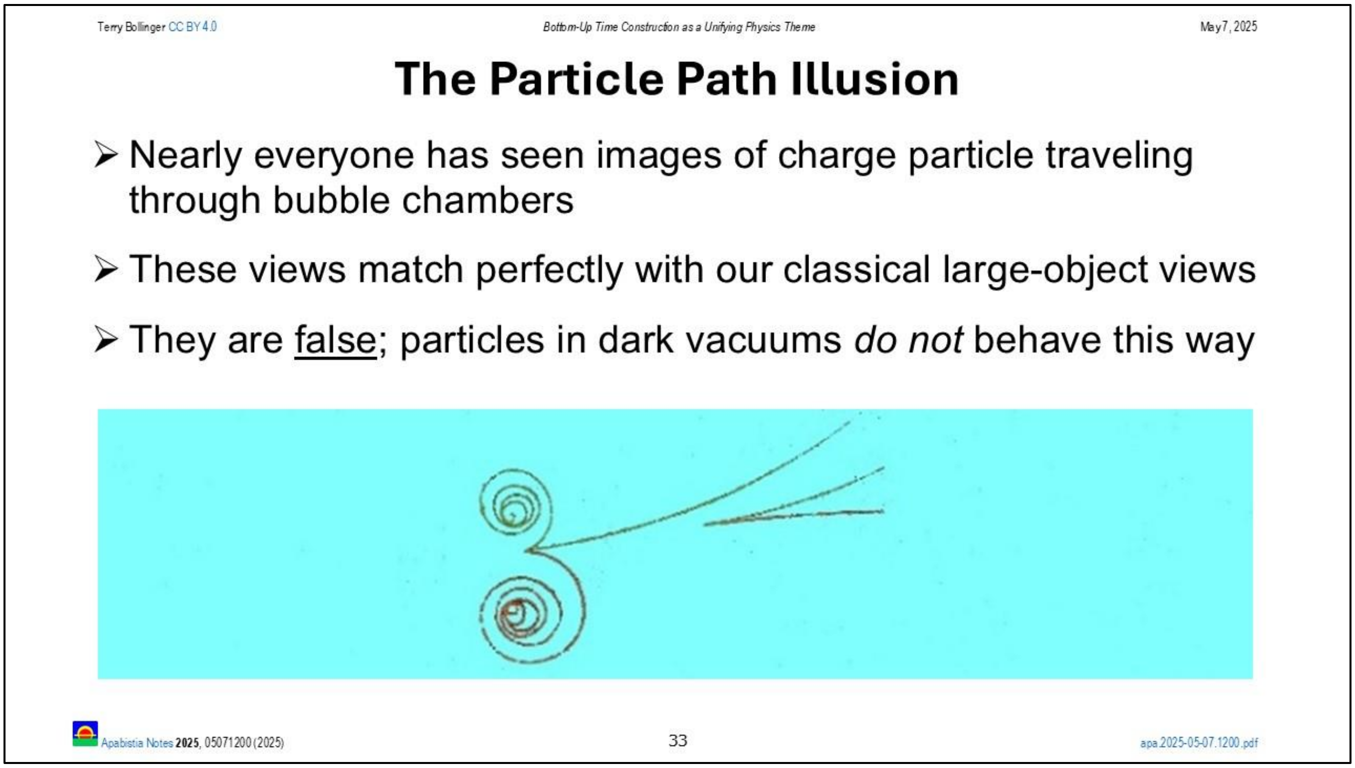
[41:45] [For a universe composed of sparse information,] continuum math is a problem because it generates *infinite* information, and [implicitly makes the incorrect] assumption that infinite storage is [available in the physical universe]. The Bloch sphere is an example [of how continuum math assumptions can subtly introduce non-physical epistemic modeling that assumes information density is an irrelevant parameter when modeling simple parts of the real universe].

It's very easy to arbitrarily assume infinite detail that does not exist, and it's hard not to. But that's where the direction we need to go.



[42:09] Different area: I'm going to … (chuckle) … Okay, I've just gone through [turning] relativity [upside down in just a few slides,] so *now* I'm going to bring up *quantum mechanics.* Yeah, right! Okay, so [my coverage of both topics in this short of a time span is going to be] a little bit too short [on both].

Einstein was the one who came up with the concept that photons are particles. It's a very reasonable deduction, [but] it *does not match* what we actually *see*.

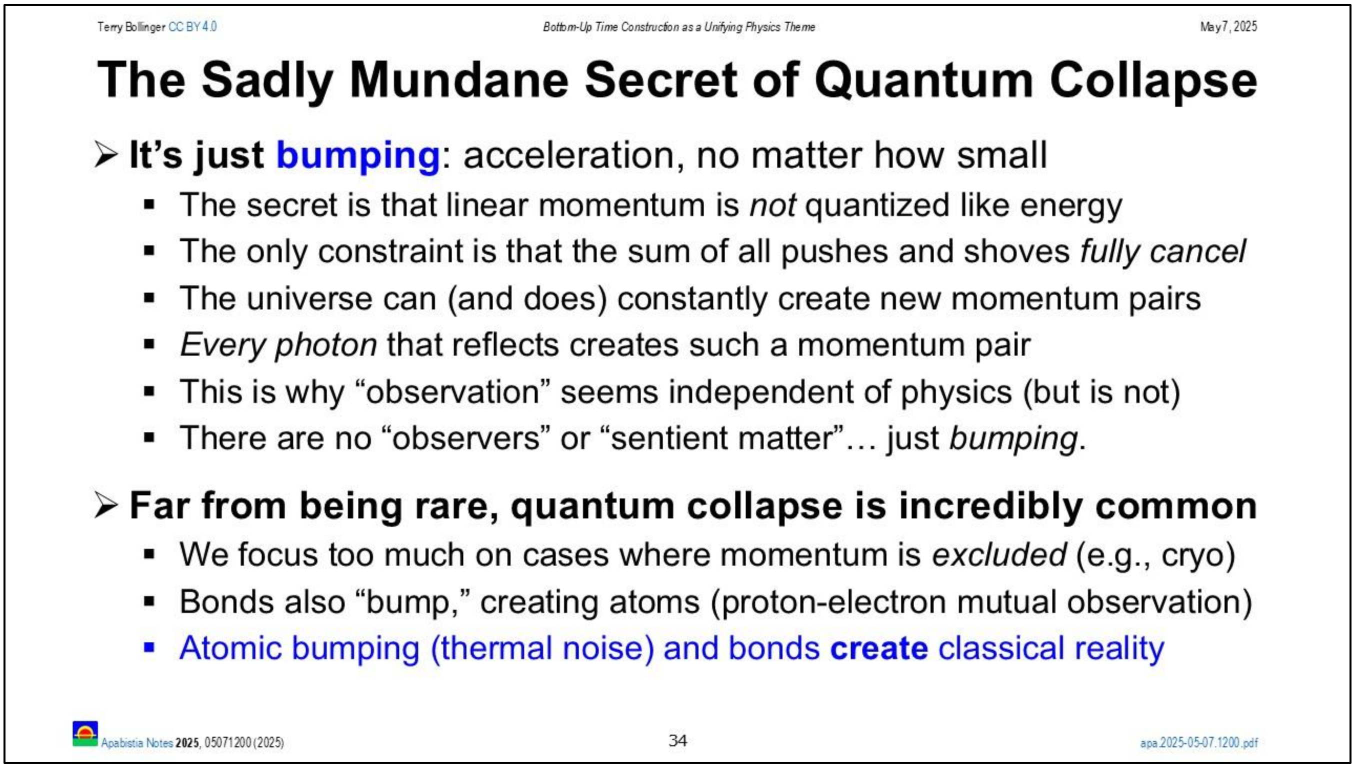


[42:31] What [the idea that a photon is a particle] *does* match is this picture. [This is an image of] electrons or [other charged] particles [traveling through] a [bubble] chamber [while under the intoxicating influence of a strong magnetic field. The charged particles clearly take well-defined curved paths! How can anyone look at images like these and *not* conclude that electrons and other subatomic particles, including photons, must be point-like entities that travel in well-defined paths?]

The trouble is that you're *bumping* the particle [— removing a bit of momentum — every time it creates a new bubble.] That [means] you're making [a long series of individual] detections as [the particle] goes through [the chamber.] Each time [the charged particle deposits a bit of momentum], you get a detection [of that particle — a "collapse" of its wave function, if you prefer to use that terminology.]

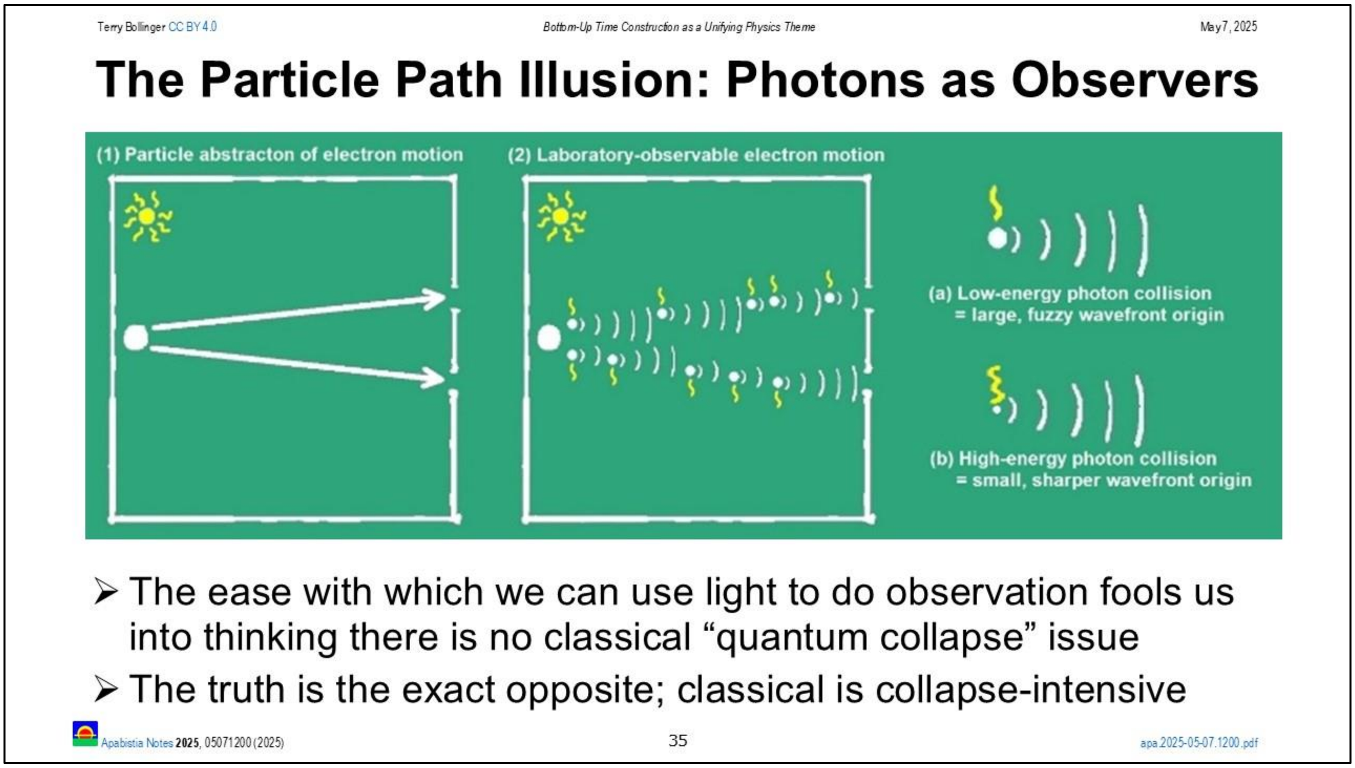
[Here's the kicker, though:] If you do the *same* operation in a *dark vacuum*, you *do not* get the same result. This [non-particle result in a dark vacuum] is *not* an abstraction. [The non-particle, wave-like outcome in a dark vacuum] is an actual experimental result. That is, what you see in *this* figure is *not* what you see if you let [the particle travel] without detections, without light, without [impacting] particles, you will instead get *diffraction effects*. And that [critically important point] is easily lost. [I'll show what this difference between many-detection travel using light and no-detection travel using darkness looks like in the slide after next, Slide 35. But first, I must talk more about the role of momentum in distinguishing between these two cases (Slide 34).]

[In summary,] you can see the temptation to make everything into a particle that's traveling, but that's *not* what we see [in cases where point-by-point detection is absent.]



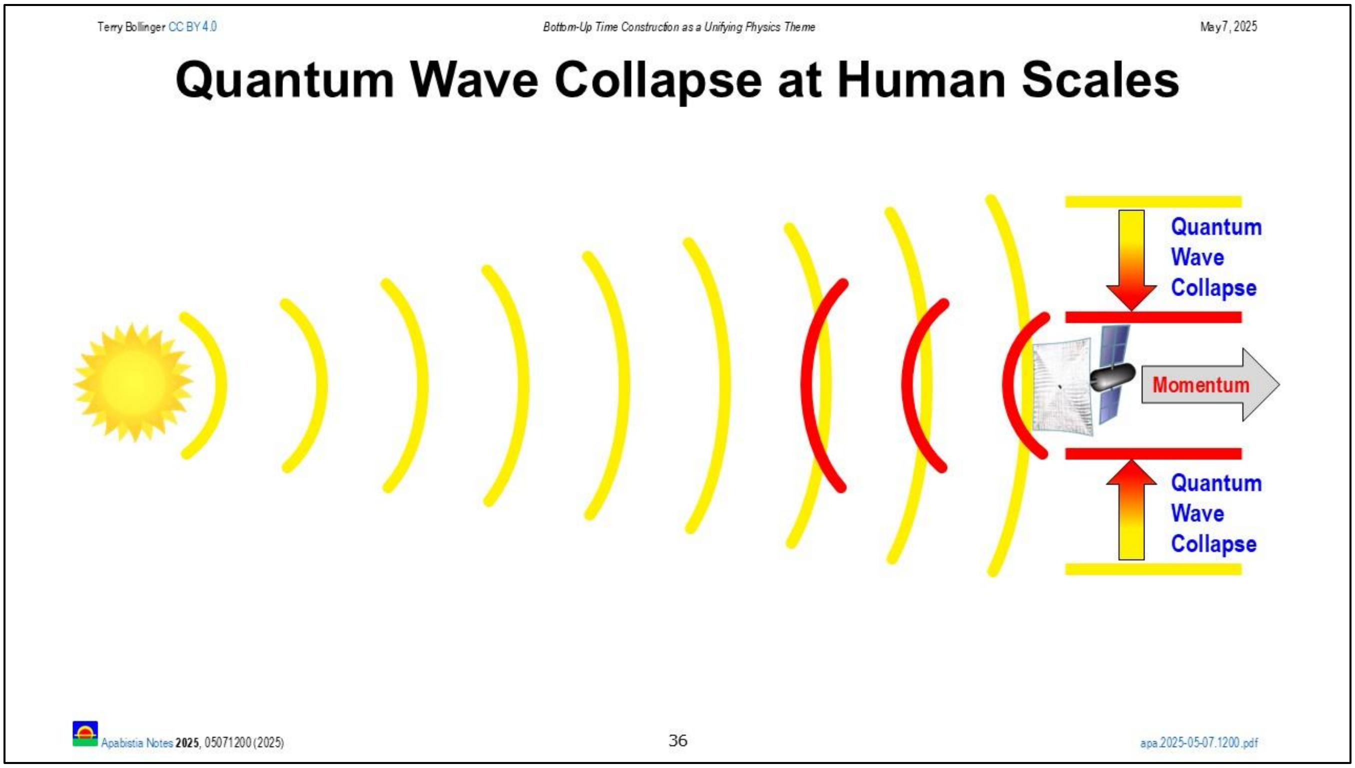
[43:19] The result [of carefully assessing the difference between particles traveling through media such as bubble chambers or light-filled vacuums that record traces of their passage versus travel through similarly shaped vacuums that record *nothing* about their passage] is the assertion that you don't need to get exotic about what quantum collapse is caused by. Any time, in any experiment, if you *bump* [a particle], you get a wave collapse. You get — if you transfer momentum, if you create a little bit of momentum — you will [*always*] get a detection.

You can, [of course, always find ways to] talk yourself out of that [conclusion] by all sorts of convoluted arguments, and try to make the world more quantum than it is. But the realist view is: *No*. The way you get it quantum is to *keep it* from bumping into anything. You *keep it* from doing momentum transfers. You'll see that persistently when they try to make interference effects with large molecules.



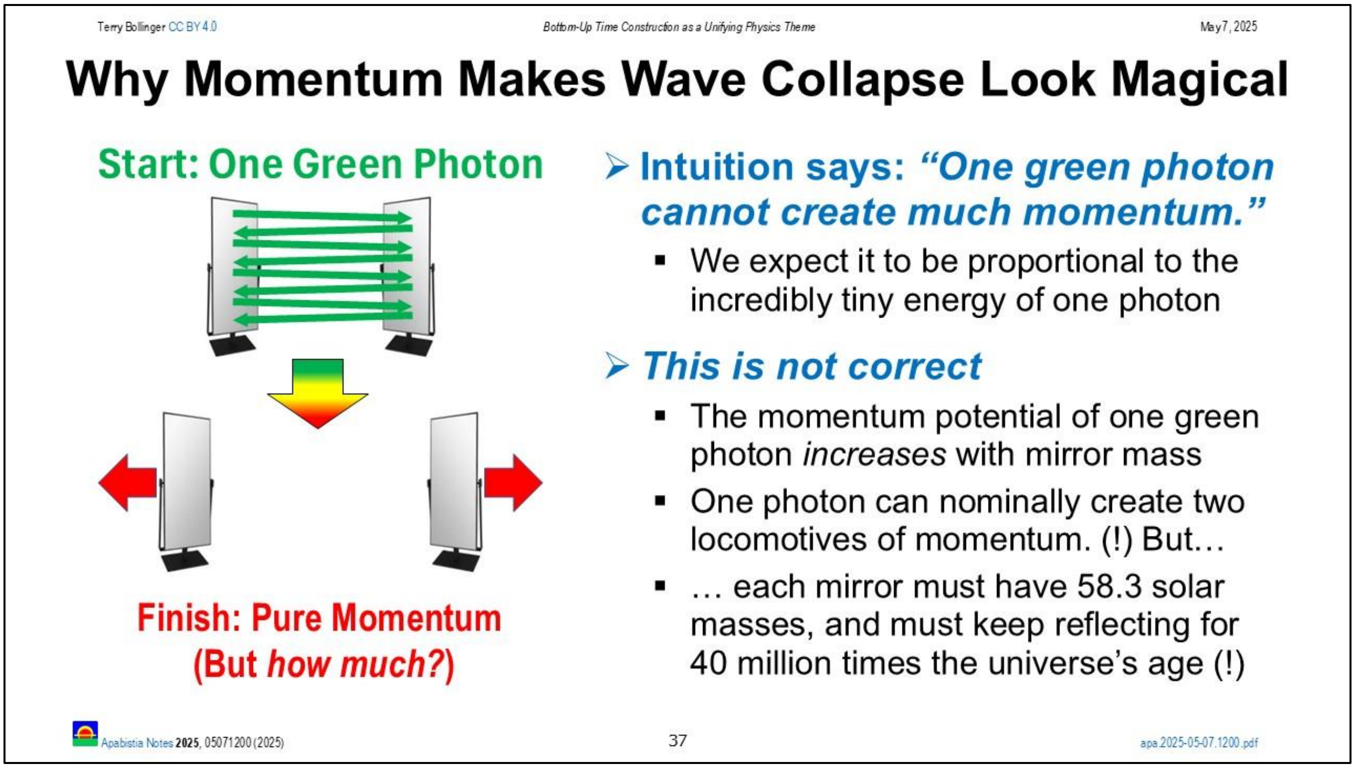
[44:02] [As mentioned earlier, Slide 35 shows how photons in a vacuum box impart momentum to traveling particles. Such overlooked interactions are the most common source of the incorrect but classically more intuitive moving] particle abstraction. The particle detections show here using light are the] same idea here [as in the bubble chamber two slides back, Slide 33, except with photons replacing bubbles.]

That is, if you have [enough light of sufficiently high frequency] light in the box, all of a sudden, you detect [the passage of the electron as if it were a moving particle.] [This] is *not* the same effect [seen when the *same* electron travels through the *same* chamber with *no* light]. The [degree of wave-like] diffraction [of the electron] *changes* depending on whether you have even the tiniest bit of [photon-mediated] detection.



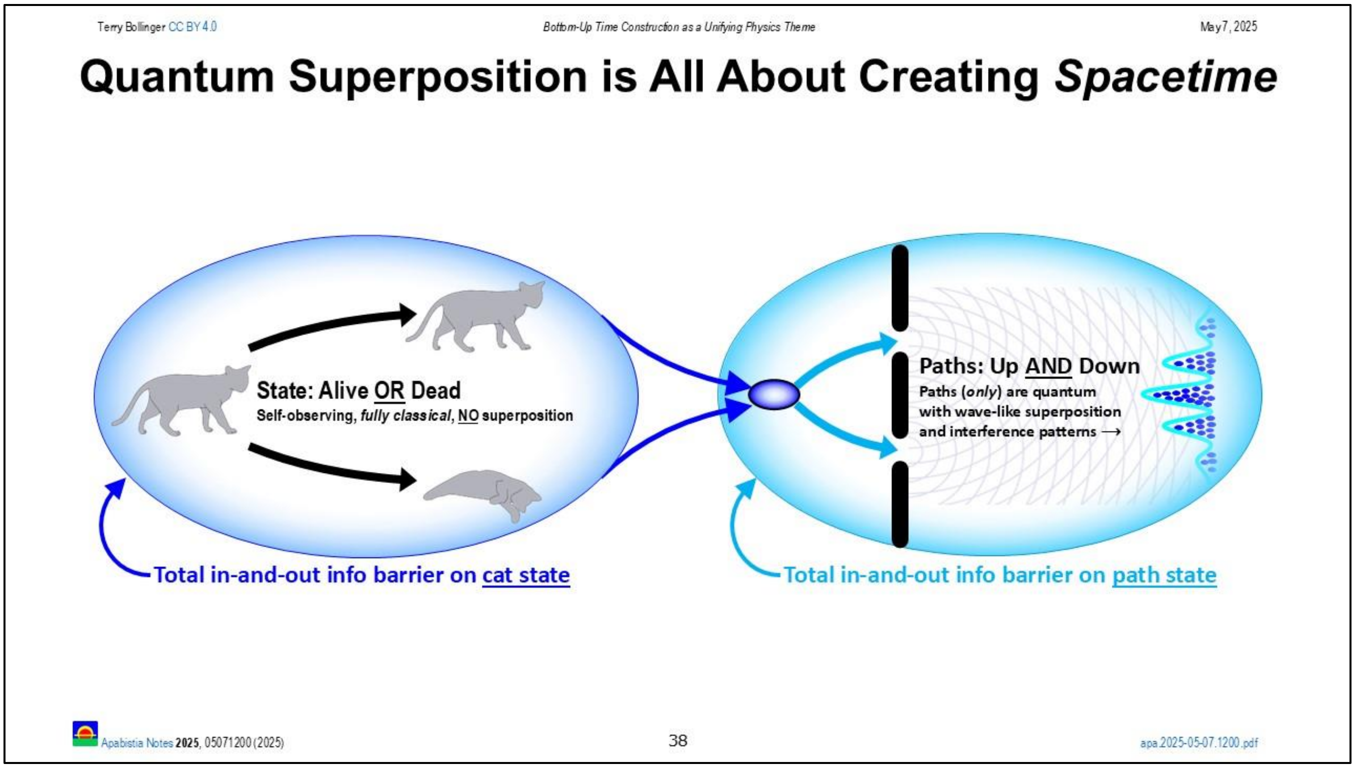
[44:18] [Here's a shocker:] Quantum collapse is *not* always *quantum* in scale. If you have the sun shining on a satellite that has a [light sail] reflector [attached, the sail] reflects the light back in the other direction. The satellite acquires momentum from that [event, even if only one photon reflects]. In doing so, [transferring a tiny bit of photon momentum to the satellite] also restricts the [photon] wave function to a [vastly] smaller area. [Think about that huge reduction in photon wave function size when comparing that small mirror to the vastness of the photon radiation across the entire solar system.]

[Thus, the reflection from the human-scale light sail] has collapsed the wave function. So this [phenomenon of quantum collapse does] not always [occur solely] on an [atomic or smaller] scale. If you have coherent reflection, you get human-scale versions of [wave collapse, only from solar-system scales to human scales instead of from human scales to atomic scales.]



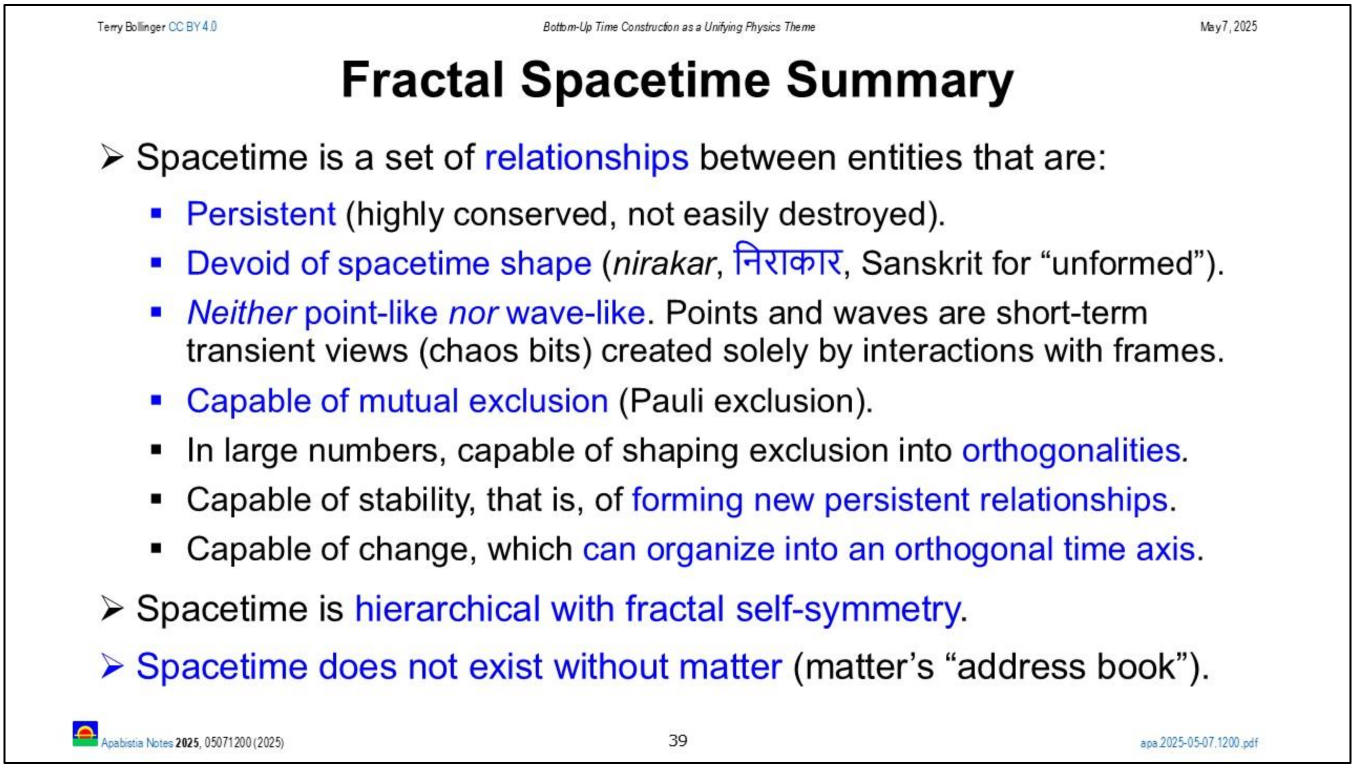
[44:50] The other reason to point out [why the unique properties of linear] momentum [are so important to understanding quantum mechanics] is [that linear] momentum has a remarkable property: You can create almost infinite amounts of it, [though always] in pairs, from extremely small amounts of energy.

This is where you get the effect in quantum mechanics [of] observation seeming like magic. [However, observation] actually [always using] very small amounts of [linear] momentum that have a negligible effect on the [total] energy involved in the system. That's an important point, because it [explains part] of the mystery [of] what quantum detection is. Linear momentum is not quantized in the same way energy is. That's an important [point to remember for] recognizing how these systems work.



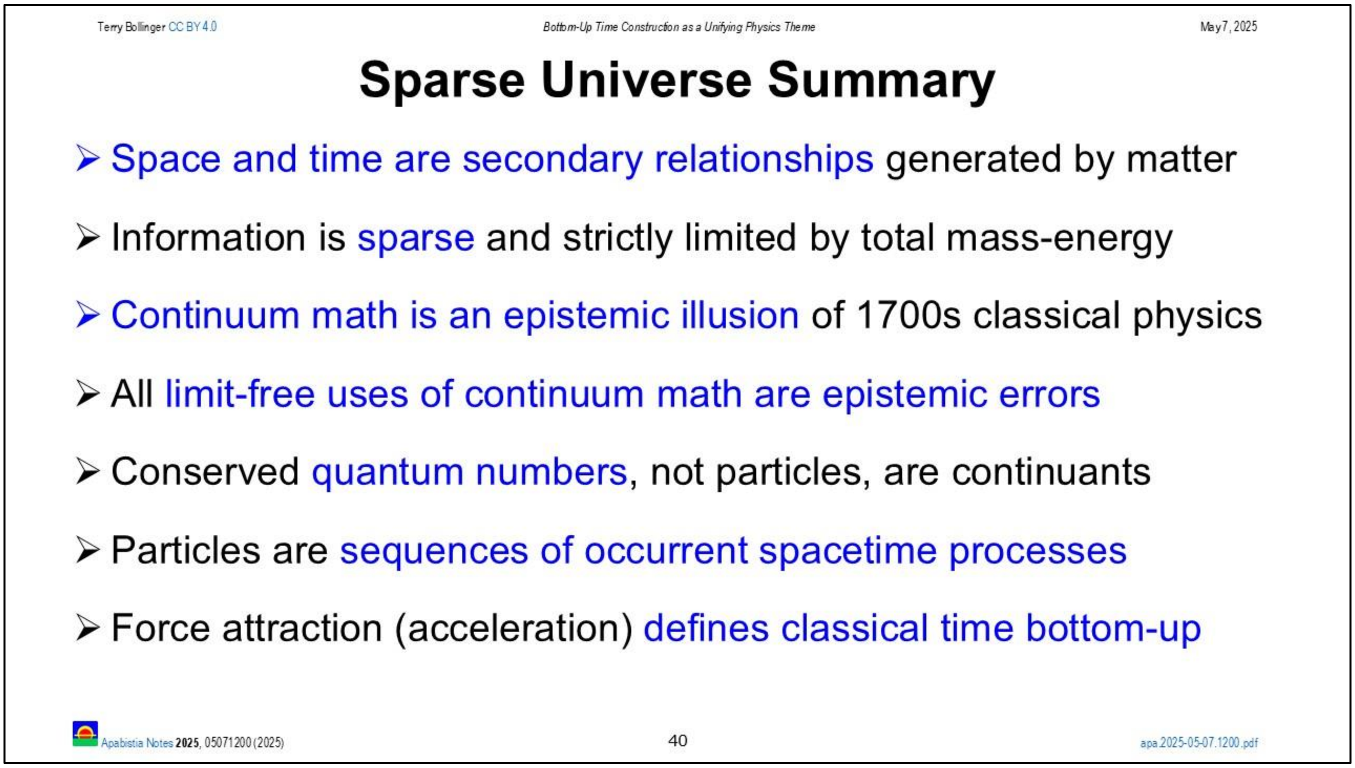
[45:24] It also affects issues like Schrödinger's cat. In this sparse interpretation, the cat is either dead or alive. It has bottom-up [causality, so] it doesn't care. It, [or perhaps its fleas,] knows whether it's dead or alive.

But its *position* in the spacetime [of the much larger spacetime frame from which it was initially accelerated] is a *created* entity, and that *does* matter. So [regardless of whether] the cat is dead or alive [according to its own internal definition of time], as long as the cat isn't bumping into anything [outside of its box], it can interfere, [and] it can reflect [— but only in terms of its location in the larger frame, *not* its internal dead-or-alive state.]



[45:41] The underlying relationship is something that we need to look at a little more closely. It has [this property I call "nirakar."] I love the [apt Sanskrit] word, "nirakar," which means "devoid of shape, devoid of form." It is an apt description. [Importantly, this quantity is] *absolutely conserved*. That [absolute conservation is] where the [complicated] properties [of ordinary matter] come from [as the various conserved quantum numbers jockey around for positions and situations that enable that conservation, which in turn creates the consistent algorithms that we perceive as the laws of physics.]

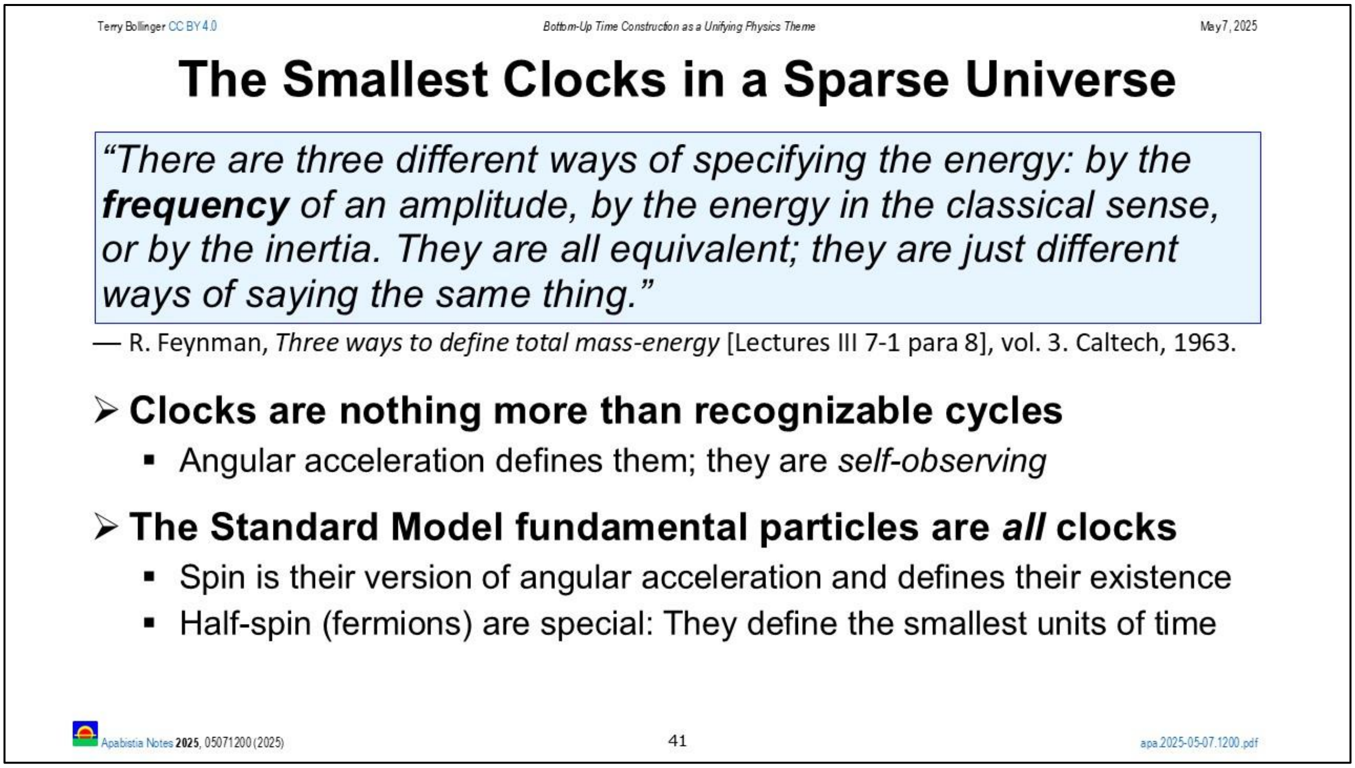
But nirakar also [means] *unshaped*, and, [thus,] *not* what we think of as a traditional object in classical mechanics. … Classical mechanics is all about *shaping* this [nirakar] into the forms that *we* see — that we think of as rulers and clocks. And there's some interesting physics going on there. Until we recognize that [nirakar is] *neither* particles *nor* waves, we can't really get to that [deeper physics].



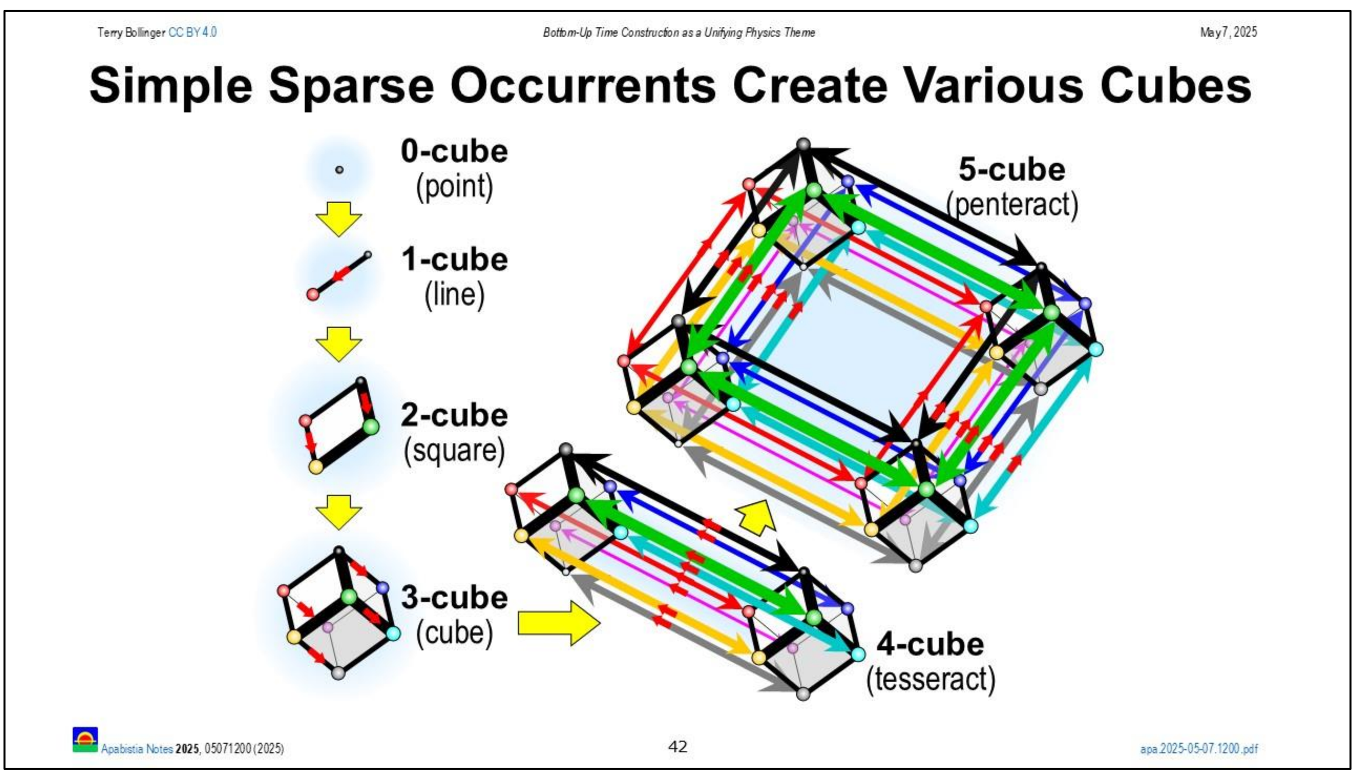
[46:37] [The key points for the sparse information universe approach are:] Space and time are *secondary* relationships; information is *sparse*; [and] continuum math is an illusion. [Mind you, the illusion of continuum math can] be a *very good* illusion. [For example,] if you [are modeling the dynamics of] solid matter [with its mind-boggling densities of information created by having so many fermions interacting and mutually bumping in close proximity,] you might as well just call it continuum math. But if you're in *sparse* situations, [such as] individual particles going through [vast stretches of dark, empty] space, you should *not* be accepting continuing math as the best representation.

The continuances [— the stubbornly persistent entities that refuse to disappear except through pairwise mutual annihilation of negative and positive forms —] are quantum numbers [that bundle together to form what we think of as "particles"]. Particles are interesting because, as I showed in that earlier picture [in Slide 35], what we think was the particle going through a bubble chamber [in Slide 33] is actually a sequence of occurrent processes [that, when concatenated in a closely spaced sequence by repeated "bumping" observations that initiate and terminate each occurrent process, simulate the view that the bundles themselves — the "particles" — are fundamental *continuant* features of the system. Instead,] they [are just a] continual sequence of these [very-short-range occurrent] processes [that] give the illusion of a particle at a large scale.

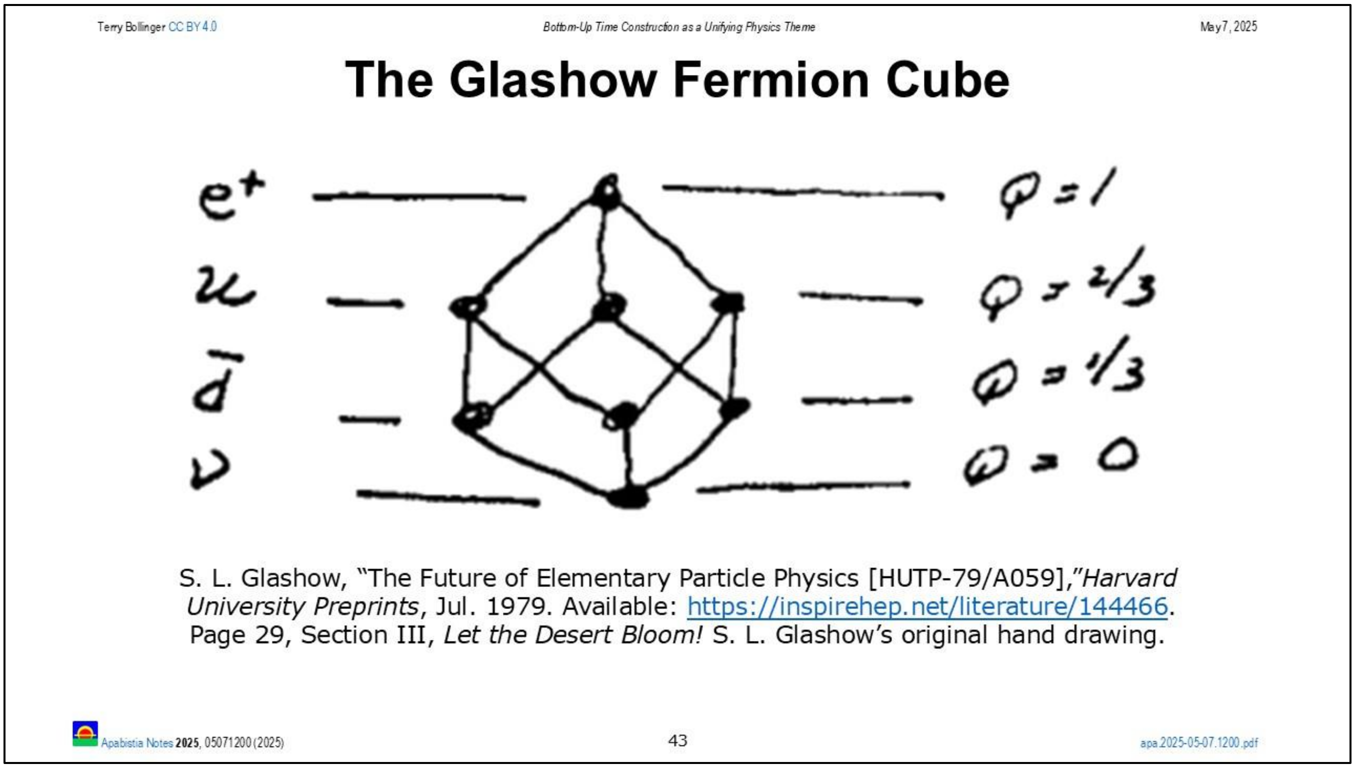
A lot of classical mechanics is defined in just that fashion: [dense sequences of very-short-range wave collapses precipitated by thermal or radiation bumping, collectively giving the illusion of an independently persistent (or continuant) entity. Such entities are *not* independently persistent in the universe at large, however, since without constant observation, they revert to time and location waves. Their *internal* structures of such entities *are* self-persisting, however. The earlier example of this was Schrödinger's Cat carrying on with life or death despite also, if fully isolated from observation (bumping), becoming a location uncertainty wave in the spacetime of the broader universe.]



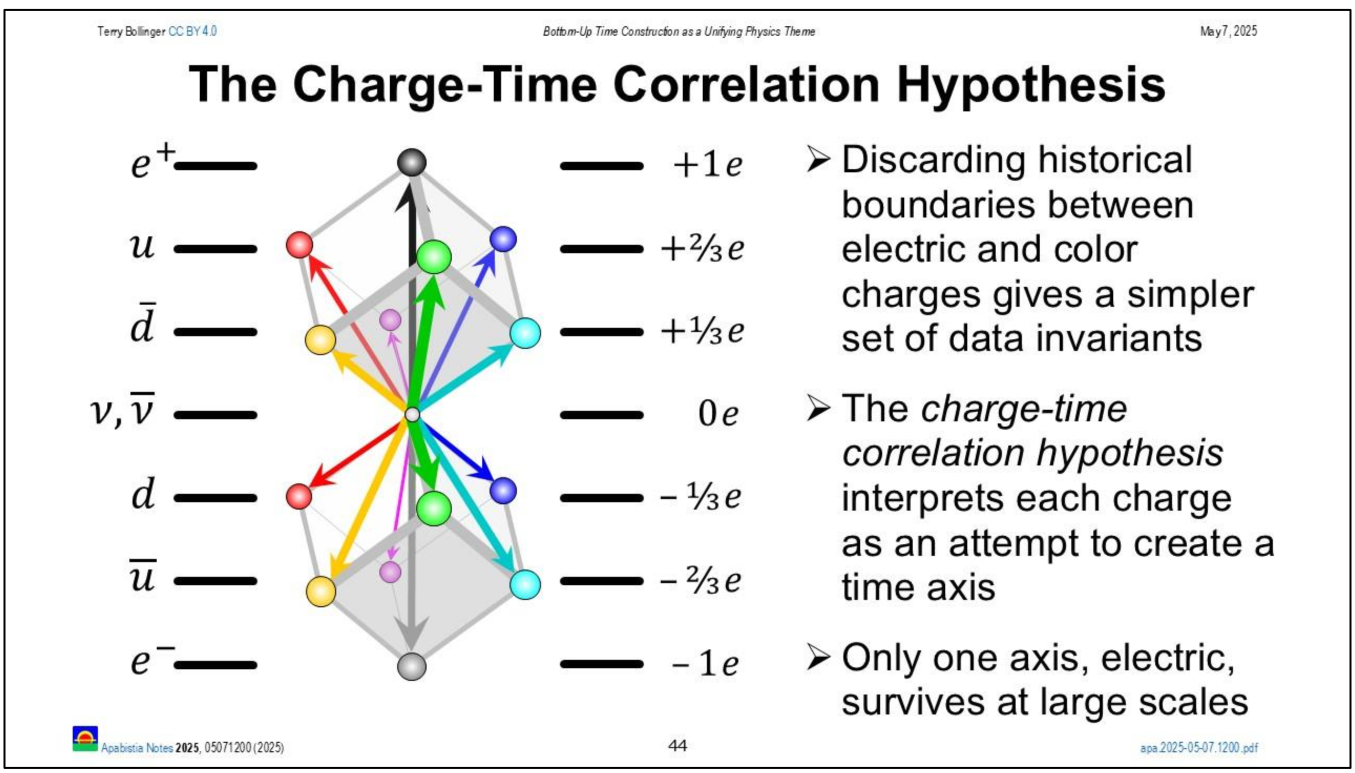
[47:25] Clocks are nothing more than recognizable cycles, [with] the smallest recognizable cycles [defining the smallest possible clocks]. You can build them with just a small amount of information.



[47:34] Here are some cubes — different scales of cubes. Why are these relevant?



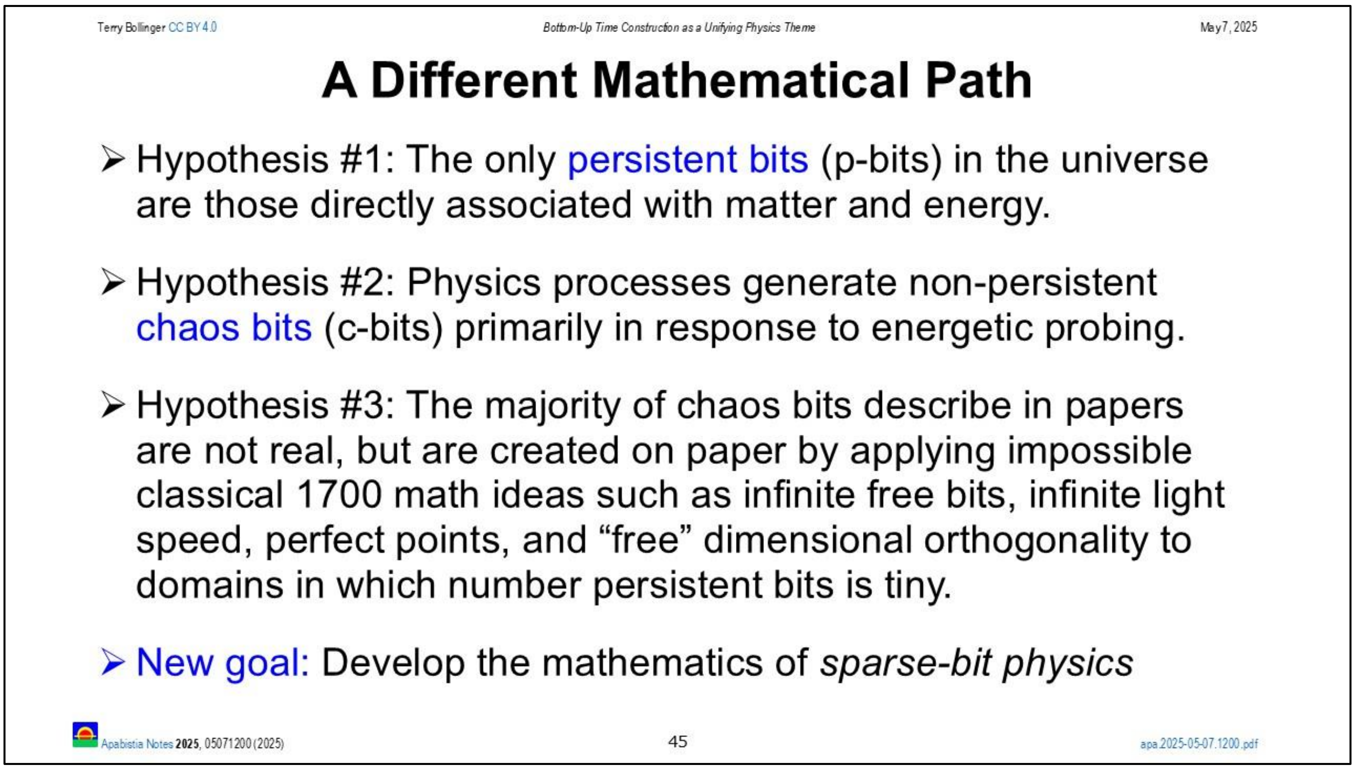
[47:38] Because it turns out [these are] the basis, apparently, of where fermions come from. All of the fermion models can be mapped into a very simple cube pattern that follows the ones that I just showed.



[47:52] When you take these patterns and just look at them at face value, [you need to ask,] "What is the data saying about charges in these systems?" [If you do that,] you come up with these simplified versions of particles in which they have *combined* charges of electric and color [type]. These [simpler combined charges,] as a hypothesis, are related to time. Obviously, [I] don't have *time* to get into that, but this makes an intriguing way of getting at bottom-up time.

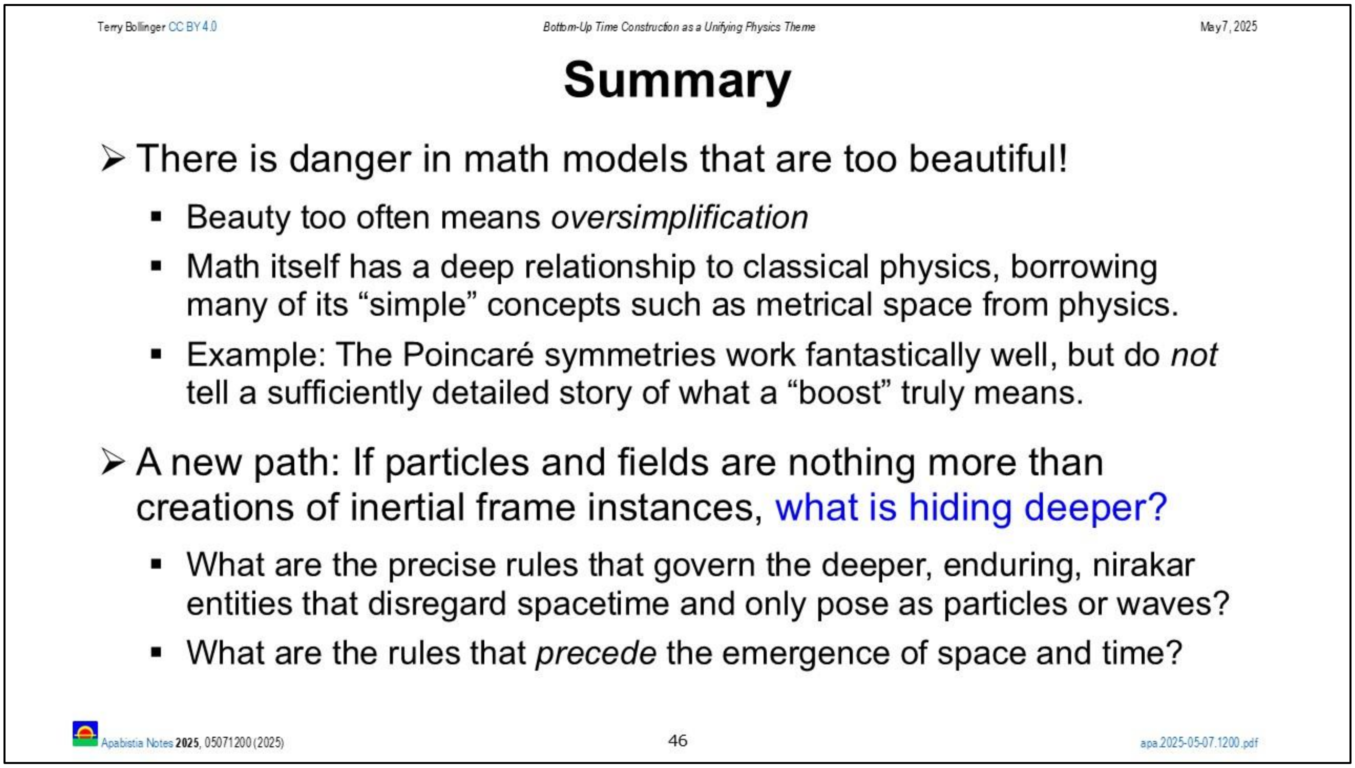
The idea is that a proton, for instance, actually has its own definitions of time *competing* with each other internally. Each one of the color charges corresponds to its *own* attempt at a direction of time that is *not* the same one we use. It's only when you have the [rotating] synthesis of all three of [these attempted definitions of time] that you get the electric charge, which turns out to be a sum of these three.

So, it's a hypothesis. Notice [that] I [explicitly] call this one a "hypothesis." I'm kind of blunter [and more assertive] about some of the other [aspects of] sparse [information] being the approach we need. But this one is an intriguing one for exploration about where our time emerges, [going] all the way back to these individual particle levels: [the idea] that you have little clocks *competing* with each other. [It] is a fascinating prospect, and, [if valid, one that] also provides [additional detailed] structure to [how] the universe.



[49:17] So, persistent bits [persist and carry information across time, while] chaos bits are generated by processes [and do not carry persistent information. The goal is to] try to get a mathematics that uses *sparse-bit* physics.

That's *harder*. It's like taking a smaller number of tinker toys and [asking,] "How do I make these work, [using them] to [create] a complex [structure]?" … You have to … do it with a smarter structure.



[49:43] Final summary: *Watch out for math that is too beautiful!*

The Minkowski spacetime is *beautiful*, but it is also an oversimplification. *You can't get around that!* It doesn't deal with *acceleration*. It doesn't deal with how the frames *come into existence*. It doesn't deal with *how [frames] relate to each other*. And it turns out that it's perfectly valid [only] for *very narrow cases*, like a muon going through a spaceship, [which] follows the [Minkowski] symmetries. [However,] a muon outside of the spaceship *does not* follow the [Minkowski] symmetries, and is a much more complicated equation.

And until you recognize that the universe is more complicated, you have to be careful. Once you do that, you're forced back into [into a more complicated framework], but you know what? That [more complicated framework is] where [all the beautiful symmetries are] coming from! The beauty that we *see* is emerging from these [far more complicated, bottom-up] interactions. And until we understand how these processes wind up creating these persistent [and beautifully simple] properties, it's hard to get a good feel for [the location of the deeper, more generative physics that] we're trying to understand.

I think that's one of the reasons why [we've] had this block in physics for the last 50 years.

With that — [which was] too many slides [in] too short a time — I'll wrap it up with that.

Questions?

[51:15] Ravi Sharma (RS): Wow! The pace increased a bit faster towards the last few slides, 20 slides or so. We're trying to catch up with it. Yes, it is hard, but it is a fantastic presentation. I have a lot of questions, but I am going I request John Sowa, our distinguished member and trustee, to be brief and to the point of this talk, and address the speaker with his questions. You probably know about John Sowa, but if not, I will tell you later. Okay.

[52:06] John F. Sowa (JS): Well, I took graduate-level courses in quantum mechanics and relativity many, many years ago. But all this has passed by so rapidly in one hour. It's basically a one-hour summary of a graduate-level course. So there's a *huge* amount of points that just went right past.

So, I would ask about the one sentence. The top sentence in your summary is very important: "There's a danger in math models that are too beautiful."

And as you know, the title of this seminar series is about ontology and representations in nice, precise mathematical ways. And some people are trying to push the math far too beautifully, far too precisely, than what I believe is even possible.

And so, I think that we have to allow for much more vagueness in our theories — that any attempt to pretend that our theories are *precise* is going to be dangerous. I'd like to know your comments about that.

[53:29] TB: I absolutely agree with that. The precision that we're doing right now is based on 1700s classical mathematics that assumed *infinite* detail, *infinite* space, *perfectly* flat space, *perfectly* defined time — [and those] are all assumptions. All of those are assumptions that are based on the fact that the atomic structure of our universe allows that [idea of infinitely smooth and precise space] as a very, very good first approximation. But that's *all* it is.

The 1700s did not know anything about relativity. They did not know anything about quantum mechanics. They did not know that the space model *blows up* when you get to the level of the electrons, and everything becomes vague and fuzzy. They did not know that there was a curvature of these spaces when you go farther [from Earth].

Now think about that. If your entire mathematical structure is based on 1700s classical physics and you're trying to apply it to post-relativity, post-quantum physics, how in the world do you expect that mathematics to be sufficiently comprehensive to understand what it's *talking* about? Because it *doesn't!* It skipped over all the good, juicy details. It just gave them all as *assumptions*. It *assumed* that infinite detail is fine.

The biggest one that gets me about classical math is its just *total* disregard for information storage. It just *doesn't care!* You know, if you want to have an *infinite* density of bits on one end of a Bloch sphere, and you have zero, or just one bit, on the other end, that's just *hunky-dory*.

No, it's *not! No*, because you're using a representation that is drawing mathematical fantasies that have nothing to do with the physical world. Because Bloch spheres are quantum bits, they're something simple. They're not infinitely complex. I even saw a fellow once who was sincerely trying to put relativistic, general relativistic curvatures onto qubits. Why? Because the math model said he could!

But *no*, that's *not realistic* in terms of how we actually *do* it! So, yeah… a blunt statement: We're using 1700s math with an *utter indifference* to information density issues, in particular.

[55:42] RS: Very good, fantastic. I think we'll come back to this point, but Janet has a hand up.

[55:54] Janet M. Singer (JMS): Yes, this is wonderful, and I want to follow up with lots more of your stuff.

Are you familiar with the work of C. K. Raju, a quantum physicist who [is a] similar careful critic of assumptions in Newton's [physics:] Wanting to have God's homogeneous space and time, and not using clocks and rulers, and therefore trying to make a *religious* point about God's universe being perfect? [It's] a similar theme to your Calvinist connection here. So, we'll follow up later on that.

But I think the important thing for ontology, aside from the fascinating analysis that you present here, and it just resonates so well, is that in both physics and ontology, there's a pretense that you're dealing with exact truth. And if you are gonna make assumptions and use oversimplifications, and then *pretend* that you're dealing with the exact truth, you're gonna get yourself in trouble.

So, you need to keep, you know, *foregrounding* and *surfacing* assumptions.

I think, in the ontology effort, starting in the 1980s, there was a hope that, "Oh… we'll get to the deeper level of what our assumptions are." And instead, we just sort of bumped from one set of assumptions to *another* set of assumptions (chuckle), and then were surprised that our different, you know, framings are not compatible.

I think this has really profound lessons for ontology work: That we should use more "clocks and rulers." We should *not* assume that we … can just apply a Calvinist set of simplification assumptions.

So, I'll leave it at that…

Oh, and I did have a technical question for you: Your p-bits, c-bits, and nirakar entities. How are those three concepts related?

[58:16] TB: The persistent bits, [the p-bits,] are essentially identical with mass-energy. Every bit of mass has a certain information capacity to it. It also acts as a clock. So matter is where you get the p-bits.

The example I usually give on that is a proton. The simplest model of a proton is *three* quarks that connect together using a color force. And that was the original model. And since then, they've turned it into an *incredible swarm* of *gluons* and *stuff* and *things* that's *always* going on.

And I would say that those are *chaos* bits. It's not that they're unreal, it's that they're only real, for instance, in [the time briefly] after you insert *incredible* amounts of energy… which is what [folks] do experimentally.

But then they take that and say, "Oh, but that's how it is *all the time*." And they're like, ["That's perfectly okay!"]

No, *no!* It's *not* alright. We should *not* be happy with how it is. It's *not* some enormous complex of things. It's a *potential* to do [such things]. So it's a switch in the perspective.

[59:21] JS: Okay. [Also,] I was wondering about your choice of the word "chaos" there, because it has various connotations. It's probably sufficient, it's nice and short, and I think your story about it is very compelling. But I don't know if people would say, "Oh, chaos!" and then go off in some other direction.

[59:41] TB: I'm using [chaos, but] noise might be a better [name]. [It is] noise. It's *generated* noise. It's *transient*. It *doesn't* store data. That's the key criterion: Chaos bits *don't store data*.

[59:56] JS: How is it related, then, to the notion of entropy, noise, and uncontrollable perturbation effects?

[1:00:07] TB: Somehow, in [addressing the role of noise in time], Boltzmann had it more correct than, I think, than any physicist — certainly [more correct] than Mach. Mach was a perfectionist, and he wanted a perfect universe — and drove Boltzmann to suicide as a result. Boltzmann said that from that [it is from entropic] chaos, from those [all those momentum-exchanging] interactions [at the atomic and molecular levels], is where these [amazing] invariants emerge, like time.

I think Boltzmann really had it right. … The added ingredient that I would toss in there is just a simple idea that ordinary momentum is the binding ["cooperation"] force that allows all these things [not-quite-space and not-quite-time separation and change activities] to interact [cooperatively with each other] and come to a [shared, mutually agreeable, fully conservative] conclusion. And that conclusion is what *we* call "classical physics."

I think there's power in analyzing this [interpretation] in more detail: How do we get that [transition to classical physics?] The chaos is part of how it stabilizes. But there's some kind of — [at least,] you can think of it as — *quantum mechanical* computation going on there. That *certainly* is true in biological cells! They seem to have *figured out* how to control that; *we* haven't, yet. But that chaos works together [with this subtle form of quantum computation,] and [together, they] provide a balance [from which classical physics emerges], just like time is a nice emergent property.

[Repeating that point,] *time* is a nice emergent property, oddly enough. I think there are some *intriguing* [options for further analysis there, in particular].

By the way, you also asked about the *nirakar*. That goes back to the idea that conservation principles are the *deepest* that we can go in terms of how the universe is structured — and they are *extremely* rigid.

So, when you talk about conservation of *charge*, that's a nirakar issue. And, rather than Noether's theory that symmetries come from the, you know, can be put it in reverse, conservation rules come from the symmetries, *no*. [You can put her ideas in reverse:] No. The symmetry, the Conservation *drives* the symmetries, and actually *creates* those [symmetry] equations [through competing micro-definitions of space and time. These rigidly conserving, multi-level competing definitions of space and time, beginning all the way down at the particle level, then force the instantiation of physical versions of algorithms such as the Taylor series. At sufficiently high matter densities and enough iterations, these forced-cooperation agreements, mediated by small exchanges of linear momentum ("observation"), generate the approximations that we think of as "perfect" symmetries.]

In terms of where ontology could go, I think there's some real potential for ontology to keep focusing on, say, "What is this [set of] relationships in physics [that creates the persistence and process behaviors that we see in all higher-level ontologies?"] … I'm starting to think that [is a] pretty solid [approach.]

[1:02:24] JS: I missed what you said there. What is this relationship in physics?

[1:02:30] TB: Relationship between ontology and physics?

[1:02:43] JS: I missed the second part of your statement there, but I think this is wonderful work and very helpful. But someone else has a question.

[1:02:55] RS: Anyone else? Todd, you have a question? I have a lot of questions, I'm saving them for the end, but one or two high-heating ones I want to ask.

One is the fermionic statement. It is not without basis. The matter that concerns us, meaning anything that we stand on, we need solid matter. Solid matter implies fermions, the proton-neutron combination at least. And therefore, the problem comes with understanding bosons properly. And that way, I agree with your statement that the photon is really not being fully understood well.

In one of the theories I propose, which I will publish and then send you, is that the photon is a composite particle, it has mass, and similarly, so is the electron. So, these are the things, when we get into going through the quantum field theory description of space-time, which obviously involves discrete handling, a quantum way of handling math.

I like your comments. I would like to learn how you think Fock today stands with his influence through math on the quantum field theory space, or the quantum space. Because the same Fock is influencing, today, the particle physicists a lot.

[1:04:53] TB: I didn't catch the name that you said there? Who were you talking about?

[1:04:58] RS: F-O-C-K, Fock. You mentioned him in your talk on one of the slides, the Calvin school of thought. The one who followed Minkowski, the one who influenced Wigner, also. F-O-C-K, I guess.

[1:05:43] TB: Yeah, no… I can't answer that one. [I don't recall mentioning Fock.]

[1:05:47] RS: Anyway, what is important is to come to reality of quantum world, you need new kind of math, and you need ability to handle discrete math, and we can't just go to older continuum concepts like thermodynamics and expect to describe fractional charges, quarks, quark pairs, quark antiquark pairs, etc. So I get that message from your slides, and I appreciate that.

But how did you connect charge with time?

[1:06:31] TB: Charge with time… Again, I [should emphasize that I only] put that one down as a hypothesis, just because it keeps showing up in the relationships.

The fact [is] that if you look at electromagnetic charge, there are a number of arguments you can make that it is a *displacement*. Maxwell called electromagnetic charge a displacement. If you look at what *kind* of displacement, you have to ask questions: So, it's a displacement in *what*? What are you *displacing?*

It turns out that if you say it's a displacement in *time*, it works pretty well. You can say that, "Oh, it's actually pushed *a little bit* into the future frame." So, that seems to be plausible — I won't say it's an answer — but it seems [to be a] plausible [hypothesis].

[1:07:29] RS: Does it? Okay, I understand where you're going with that.

[1:07:32] TB: But if you *say* that, and then you look also in … what happens with that is the, the color charges — which are actually *combined* with the electric charges in the actual particles — they *also* seem to be displacements in some kind of a space.

Well, if the net result is the displacement is time as see it on a large scale, then the interesting conclusion is that those are attempts to define time in *other* dimensions that [never emerge beyond the boundaries of nucleons and define the very-short-range color forces, but which] collectively combine to form classical time [and the infinite-range electric charge displacement].

[1:08:06] RS: Would you put parity and other such properties, CPT symmetry, in the same way, and relate them to time?

[1:08:20] TB: Yes…

[1:08:34] RS: I'm hearing your voice break up. Your voice is breaking up.

[1:08:43] TB: Yes, I think I'm getting interference. Can you hear me now?

[1:08:48] RS: Yes, very much better.

[1:08:53] TB: When you get the full symmetries that you mentioned, the easiest structure — if you place priority on conservation — is what's called a dual universe model, in which there are two universes. Both of them — Depending on the details, the simplest version is that, literally, you have a universe that is going geometrically *backward* in time compared to ours, although causally it's in *parallel* with us.

And this is the one that cancels out all of the strange properties that people worry about, that they say we have too many protons in our universe. Well, that's because they're canceled by these anti-protons in the other universe.

Except they're not quite anti-protons! They're anti-protons with a *twist:* They have *negative* energy. And everything just [combines, eventually,] back to one null state.

So again, that goes back to the [idea] that everything we're doing is a result of [pair] creation, at some point. That's it. You have to start *somewhere*, and pair creation seems to be [that starting point;] pairs of properties.

Some of these pairs of properties, at some point, got stable enough that they could stay separate, [specifically through this emergent mechanism we call classical time]. They could build complexity, so they could become *continuants*. When you get that time property, you get that continuant property — although it's actually a *process*, if you look at the details. That's when you start getting these properties, such as CPT — the charge, parity, and time symmetries.

[1:10:34] RS: Yes.

[1:10:35] TB: So, I think those are … very important, but I think you have to look at them [from the larger perspective of how absolute conservation rules create algorithms that converge to our classical definitions of space and time].

[1:10:41] RS: We need to have the opportunity to discuss some of these [ideas,] maybe in a special series or session in the future.

I see Todd's hand up. Todd Schneider?

[1:10:55] Todd Schneider (TS): Yes. Thank you, Ravi. Terry, this was a very intriguing talk, to say the least. However, you covered a *huge* amount of material, and I have to admit, I could not follow some of your arguments. So my question to you is: Do you have a more fully developed paper that I could read through, rather than just looking at some slides?

[1:11:21] TB: Apabistia Notes, A-P-A-B-I-S-T-I-A. If you look that up, you can find all sorts of things I've published. Apabistia Press is actually the best one, because there are also some papers in what I call the TAO Journal.

[1:11:38] RS: And, it is on our website, on our session page today — the spelling of Apabistia, as well as your links to various talks. So those are all from your website, Terry. Just adding to Todd's information.

[1:12:00] TB: If you look at the lower left-hand [corner]; if you follow the link, and you click on the lower left-hand icon, that will take you to Apabistia Press.

[1:12:10] RS: Very good.

[1:12:11] TS: Lower left icon of what?

[1:12:14] TB: Of the slides.

[1:12:16] RS: Of any slide.

[1:12:18] TB: [On the slide] on the screen; right, [Ravi, on any slide]. Any of the slides [work]. The little green, blue, and yellow [icon is what you should look for.]

[1:12:26] TS: Ah, I see. Yes, got it.

[1:12:28] TB: It also shows you the spelling. Apabistia Press is the more complete one.

[1:12:37] TS: Ah, I found it. Thank you.

[1:12:39] TB: [At some point,] I desperately need to write a book. I'm working with somebody about that.

[1:12:42] RS: There's a tremendous amount of information. It took me two or three sessions of listening and seeing his slides to be able to understand what he's trying to convey to us today. But finally, it does come through to someone who is a little oriented to physics, like me. Thank you. Thank you so much.

I think it is time, if there are no more questions… Todd, are you okay? Yes, so it is time. Thank you very much, Terry, and we [will] invite you again. Also, we invite you to participate in our Summit sessions. We will have two synthesis sessions, and Ken will tell us more about them.

For me, I just want to thank you profusely, and thank everybody for coming. Thank you.

[1:13:38] TB: Thank you. Thank you, Ravi. …

[1:13:42] KB: So, with that, we have ended the fourth track of the summit. We now move on to the Synthesis session next week on the 14th, where we will attempt to synthesize all of this enormous amount of material that has been presented at our summit.

And then, in the following week or perhaps more, we will begin the process of creating our communique, where we will publish the findings that we have come up with from all of these sessions, [focusing on] findings particularly of relevance to those in ontologies. I would ask everyone to help us with this process, to join in with the synthesis and the communicate development. We want this to be a communique that is produced by our community.

With that, I believe we can adjourn. So thank you again. It was a wonderful talk. Thanks to everyone who participated, and I hope to see you all next week and the following weeks.

[1:15:25] RS: Thanks to all tracks, all speakers, whoever is present: Thank you for bringing it to a good conclusion today. And thank you, Terry, once again. Thank you. Have a nice day.

[1:15:41] KB: Bye, everyone.